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SOIL SURVEY

Woodward County Oklahoma



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

How to Use the Soil Survey Report

THIS SURVEY will serve several groups of readers. It will help farmers plan management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; serve as a reference for students and teachers; and add to our fund of knowledge about soils.

Locating the soils

Use the index to map sheets to locate areas on the soil map. The index is a small map of the county that shows the location of each sheet of the soil map. When the correct sheet of the soil map is found, it will be seen that the boundaries of the soils are outlined and that there is a symbol for each soil. Suppose, for example, an area on the map has the symbol CcB. The legend for the map shows that this symbol identifies Carey silt loam, 1 to 3 percent slopes. This soil and all others mapped in the county are described in the section "Descriptions of the Soils."

Finding information

This report has special sections for different groups of readers, as well as sections that may be of value to all. The "Guide to Mapping Units, Capability Units, and Range Sites," at the back of the report, lists the soils in the county and the map symbol of each and gives the page where each soil, its capability unit, and its range site are described.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of the Soils," and then they can turn to the section "Management of the Soils." In this way they first identify the soils on their farm, and then they learn how these soils can be managed and what yields can be expected.

The soils have been placed in capability units; that is, groups of soils that need similar treatment and respond in about the same way. For example, in the section "Descriptions of the Soils," Carey silt loam, 1 to 3 percent slopes, is shown to be in capability unit IIe-1.

The management suitable for this soil, therefore, will be described under the heading "Capability unit IIe-1," in the section "Management of the Soils."

For the convenience of those who manage rangeland, the soils have been placed in range sites, each of which has a given potential for production of grasses and other vegetation. Carey silt loam, 1 to 3 percent slopes, is in the Loamy Prairie range site. Each range site in the county is described in the section "Range Management."

Foresters and others interested in woodlands can refer to the section "Woodland." In this section the kinds of trees in the county are described and the factors affecting the management of woodland and windbreaks are explained.

Engineers will want to refer to the section "Engineering Uses of the Soils." Tables in this section show characteristics of the soils that affect engineering.

Soil scientists and others interested will find information about how the soils were formed and how they are classified in the section "Formation, Classification, and Morphology of the Soils."

Students, teachers, and other users can learn about soils and their management in various parts of the report, depending on their particular interest.

Newcomers to Woodward County will be especially interested in the section "General Soil Map," which describes the broad patterns of soils. They may also wish to read the section "General Nature of the Area," which gives general information about the county.

* * * * *

The Woodward County Soil Conservation District was organized in 1942. As part of the assistance to the district, this soil survey was made by the Soil Conservation Service of the United States Department of Agriculture in cooperation with the Oklahoma Agricultural Experiment Station. Fieldwork was completed in 1960, and, unless otherwise specified, all statements in this report refer to conditions in the county at that time.

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SOIL SURVEY OF WOODWARD COUNTY, OKLAHOMA

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EXPERIMENT STATION

General Nature of the Area

WOODWARD COUNTY is in northwestern Oklahoma (fig. 1). It has a land area of 788,480 acres, or 1,232 square miles. In 1960, the population of the county was 13,902, about 67 percent of which was classified as urban, and 33 percent, as rural. The city of Woodward,

located at Woodward, gives important climatic data for the county.

There is a wide range in temperature, and changes in temperature may occur rapidly. In summer readings of 100 to 105° F. occur often, but, because of the low humidity, nights are usually cool. In winter the temperature occasionally drops to 15° below zero, but this seldom lasts for more than a few days. Temperature averages 38° during winter, 58° during spring, 80° during summer, and 60° during fall. The average date of the last killing frost in spring is April 7, and that of the first killing frost in fall is October 30. Frost has occurred as late as May 8, and as early as September 26, however.

Figure 2 shows the amount of precipitation in each year from 1885 through 1960. Approximately 78 percent of the annual precipitation occurs from April through Octo-

TABLE 1.—Temperature and precipitation at Woodward, Woodward County, Oklahoma

[Elevation, 1,908 feet]

Month	Temperature ¹			Precipitation ²			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1954)	Wettest year (1923)	Average snowfall
December	37.8	83	-12	0.94	0.04	0.95	3.0
January	36.1	89	-24	.75	.03	(³)	3.6
February	39.7	90	-13	1.05	.16	.11	4.3
March	48.5	96	-8	1.38	.09	2.12	2.6
April	58.9	98	11	2.47	1.34	2.20	.3
May	67.9	105	23	3.53	5.98	8.86	(³)
June	77.5	111	41	3.45	.80	5.96	(³)
July	82.4	113	45	2.62	.12	1.88	0
August	81.6	115	41	2.60	2.42	.38	(³)
September	73.3	110	29	2.55	.18	12.26	(³)
October	60.6	99	14	2.29	1.84	12.83	.2
November	47.9	89	3	1.44	(³)	1.19	1.0
Year	59.4	115	-24	25.07	13.00	48.74	15.0

¹ Average temperature based on a 64-year record, through 1955; highest temperature based on a 54-year record, and lowest temperature, on a 53-year record, through 1952.

² Average precipitation based on a 64-year record, through 1955; wettest and driest years based on a 61-year record, in the period 1891-1955; snowfall based on a 61-year record, through 1952.

³ Trace.

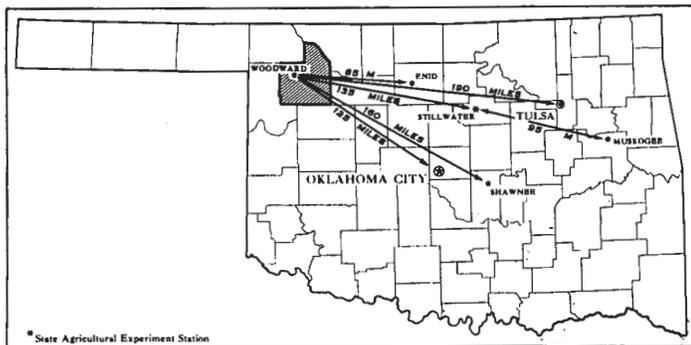


Figure 1.—Location of Woodward County in Oklahoma.

the county seat, had a population of 7,747 in 1960. The county and city of Woodward were named for a prominent official of the Santa Fe Railroad, which was extended through the area in 1887.

Woodward County is part of a rich agricultural area. Dairying and cattle raising are important. The principal crops are sorghums, wheat, hay, and vegetables.

Elevations range from 2,460 feet above sea level in the southwestern corner of the county to 1,450 feet in the northeastern corner. Physiographically, the county consists of two plains that are separated by a distinct escarpment, which extends southeastward across the county. The larger plain occupies three-fourths of the county, including the southwestern part, and has rolling dunelike relief. It slopes gradually to the North Canadian River, which crosses the county from northwest to southeast. The smaller plain is in the northeastern part of the county. It slopes northeastward toward the Cimarron River.

Climate

Woodward County has a continental climate. Table 1, compiled from records of the U.S. Weather Bureau sta-

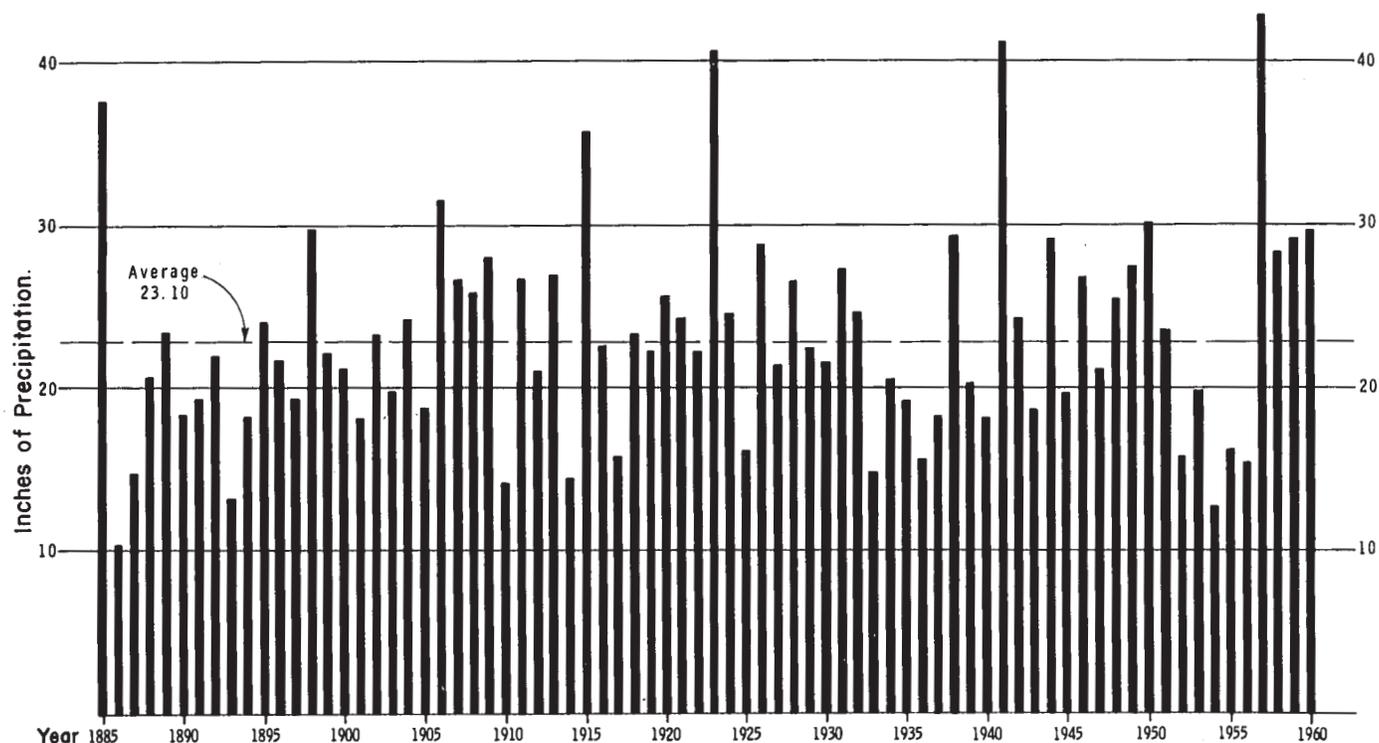


Figure 2.—Annual amounts of precipitation in Woodward County, according to records of the U.S. Weather Bureau. The figures for the years 1885 through 1914 are from the stations at Fort Supply and Woodward. Those for the years 1915 through 1960 are from the Southern Great Plains Field Station at Woodward.

ber. About 11 percent of it occurs in the winter (December, January, February); 29 percent, in the spring (March, April, May); 35 percent, in the summer (June, July, August); and 25 percent, in the fall (September, October, November). Approximately one-third of the precipitation occurs as light rains and adds little moisture to the subsoil. About one-fourth of it occurs as fast, dashing rains of 1 inch or more.

In 7 years out of 76, there have been 10 to 15 inches of annual precipitation. When this amount is distributed normally, the wheat crop is a near failure. In 20 years there have been 15 to 20 inches of precipitation; this amount of moisture results in below average yields of wheat. In 25 years there have been 20 to 25 inches of precipitation. In 18 years there have been 25 to 30 inches of precipitation, enough to result in yields that are above average. Three different years have had 30 to 40 inches of precipitation, and 3 years have had more than 40 inches.

During about 80 percent of the years of record, the county has received more than 1 inch of rainfall in both July and August. Periods of 3 to 5 years when precipitation has been below average have occurred four times during the period of record (1885-1960). During such periods drought and widespread failures of crops are common.

The critical windy season is spring. Many areas are bare at this time, as farmers then prepare to plant sorghums. At least one damaging wind of 40 miles per hour can be expected each spring. Prevailing winds are from the southwest, and there is enough wind to operate windmills on almost every day of the year. The weather is generally open (not inclement), except for a few days following rain or snow. It is possible to do some farmwork almost any time during the year.

Destructive hailstorms occur practically every summer. They generally affect local areas, and the probability of a particular farm being damaged is not great. In summer hot, dry winds, which evaporate soil moisture, are especially damaging.

Winter wheat, sown in fall, and sorghums, sown late in spring, are the principal crops suited to the climate of the county. Winter wheat is very important for grazing of livestock and for sale as grain. It makes use of moisture stored in the soil in summer and is semidormant during winter. Grain sorghum is generally able to use the summer moisture and to mature in spite of drought and hot, dry winds. The somewhat erratic pattern of rainfall makes the conservation of soil and water especially important.

Settlement and Development

In 1890, the Federal Government began negotiations with the Cheyenne and Arapaho Indians to open to white settlement the Cherokee Strip, which included the present Woodward County. The negotiations continued until 1893, when the Indians agreed to cede their claims to the area to the government. In September 1893, the Strip was opened at the firing of a signal gun. A great throng of settlers raced across the prairie until each pioneer found a suitable place to stake a claim for a homestead. The settlers were willing to face hardships in converting the prairie into pastures and cultivated fields and in building homes, schools, and churches. Early settlers built dugouts, box shacks, and soddies, but later replaced these with better dwellings (fig. 3).

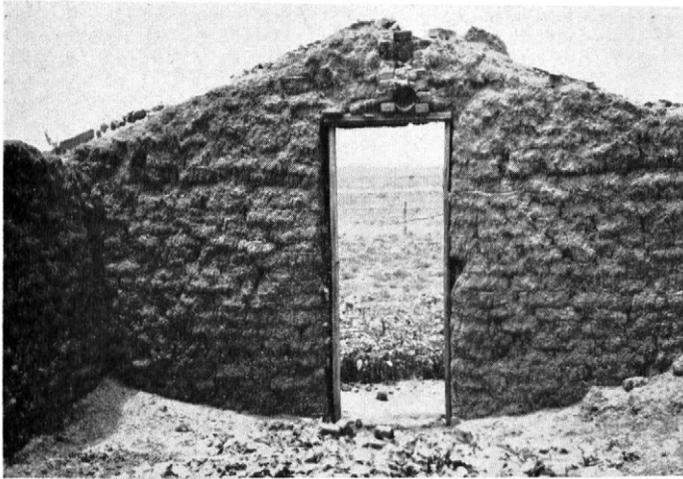


Figure 3.—Upper photograph shows the remains of a sod house, and the lower photograph, an early log house.

Within a few years, fields of grain and herds of beef cattle occupied areas that were formerly in native grass and sagebrush and grazed by herds of long-horned cattle. Also, profitable yields of vegetables were produced.

In the early days, prairie chickens were abundant and wild turkeys inhabited areas along streams. Although prairie chickens and wild turkeys are no longer abundant, the climate is ideal for the raising of domestic chickens and turkeys.

Community Facilities

Woodward County has eight consolidated schools, three of which are elementary schools. The last one-room school was closed in 1953. Approximately 2,800 pupils were enrolled in schools at the close of the school year in 1960. About half of them attended schools in the city of Woodward.

Recreational areas occur throughout the county. Boiling Springs State Park, 6 miles northeast of Woodward, is used for camping, hiking, swimming, boating, and fishing. Fort Supply Reservoir, occupying 1,800 acres, is 12 miles northwest of Woodward. Crystal Beach Park, in the city of Woodward, has many recreational facilities.

The Alabaster Caverns are northeast of Mooreland. They are the third largest caverns in the United States. The caverns are electrically lighted and can be walked through in 1½ hours. Walls of the caves consist of solid gypsum and evidently were formed by the force of subterranean streams.

Chimney Rock is another well-known place of interest (fig. 4). It is 40 to 50 feet high and stands as a reminder of the effect of geological erosion.

Transportation

Woodward County has good transportation facilities. The Sante Fe Railroad extends west to east, passing through Woodward, Mooreland, Quinlan, and Belva. The Missouri-Kansas-Texas Railroad crosses the county in a north-south direction and extends through Fort Supply, Woodward, and Sharon.

The airport at Woodward provides charter service and facilities for planes. There are no regularly scheduled flights from the county, but the Central Airlines at Enid, 87 miles east of the city of Woodward, provides connections to most major airlines.

Mid-Continent Trailways furnishes bus service in the county, and several large motor freight companies operate



Figure 4.—Chimney Rock, a landmark located 9 miles northwest of Belva.

in the city of Woodward. U.S. Highways 183 and 270 and State Highways 3, 15, and 34 cross the county.

Agriculture

Sorghums and wheat are the main crops grown in Woodward County. Acreages of these and other crops grown during stated years are given in table 2. Statistics are from the U.S. Census of Agriculture.

In 1959, farms of Woodward County reported 63,811 cattle and calves. Of this number, 3,342 were milk cows. There were 5,845 hogs and pigs and 1,088 sheep and lambs in 1959.

TABLE 2.—Acreage of principal crops in stated years

Crop	1929	1939	1949	1959
Alfalfa and alfalfa mixtures cut for hay-----	<i>Acres</i> 2, 983	<i>Acres</i> 2, 429	<i>Acres</i> 6, 508	<i>Acres</i> 4, 834
Broomcorn harvested-----	4, 919	880	1, 255	318
Corn for all purposes-----	29, 094	9, 824	3, 013	752
Cotton harvested-----	2, 701	431	51	221
Cowpeas grown for all pur- poses except processing----	334	433	1, 059	407
Small grains harvested:				
Barley-----	899	10, 335	644	15, 613
Oats-----	3, 137	3, 574	2, 300	1, 745
Rye-----	1, 049	11, 043	583	2, 919
Wheat-----	154, 703	116, 198	148, 690	87, 113
Sorghums:				
Harvested for grain or seed-----	26, 826	18, 592	17, 493	13, 924
Cut for silage, hogged or grazed, or cut for dry forage or hay-----	18, 723	20, 477	20, 248	22, 475



Figure 5.—This power tube, mounted on a pickup truck, permits quick examination of features of a soil profile.

istics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Carey and Pratt, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

Many soil series contain soils that are alike except for texture of their surface layer. According to this difference in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Pratt fine sandy loam and Pratt loamy fine sand are two soil types in the Pratt series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Carey silt loam, 1 to 3 percent slopes, is one of several phases of Carey silt loam, a soil type that ranges from nearly level to strongly sloping.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used photographs for their base map because they show woodlands, buildings, field borders, trees, and similar detail that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientist has a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map.

How Soils Are Named, Mapped, and Classified

Soil scientists made this survey to learn what kinds of soils are in Woodward County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rocks; and many facts about the soils. They dug or bored many holes to expose soil profiles (fig. 5). A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down to the rock material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. To use this report efficiently, one needs to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important character-

Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Woodward-Quinlan loams, 3 to 5 percent slopes. Also, in most mapping, there are areas to be shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as badland or Rough broken land, and are called miscellaneous land types rather than soils.

Only part of the soil survey was done when the soil scientists had named and described the soil series and mapping units and had shown the location of the mapping units on the soil map. The mass of detailed information they had recorded then needed to be presented in different ways for different groups of users, among them farmers, managers of woodlands and rangelands, and engineers.

To do this efficiently, the soil scientists had to consult with persons in other fields of work and jointly prepare with them groupings that would be of practical value to different users. Such groupings are the capability classes, subclasses, and units, designed primarily for those interested in producing the short-lived crops and tame pasture; range sites, for those using large tracts of native grasses; and the classifications used by engineers who build highways or structures to conserve soil and water.

General Soil Map

After study of the soils in a locality and the way they are arranged, it is possible to make a general map that shows several main patterns of soils, called soil associations. Such a map is the colored general soil map in the back of this report. Each association, as a rule, contains

a few major soils and several minor soils, in a pattern that is characteristic although not strictly uniform.

The soils within any one association are likely to differ from each other in some or in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map shows not the kind of soil at any particular place, but patterns of soils, in each of which there are several different kinds of soils.

Each soil association is named for the major soil series in it, but, as already noted, soils of other series may also be present. The major soils of one soil association may also be present in other associations, but in different patterns.

The general soil map, showing patterns of soils, is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Following are descriptions of the soil associations in Woodward County. In reading these it may be helpful to refer to figure 6, which shows the parent materials and some of the topographic features in relationship to the soils.

(A) St. Paul-Carey-Woodward Association: Gently Sloping Loamy Red Beds

This association is made up of deep loamy soils that have formed under grasses. It covers about 13 percent of the county and contains 100,900 acres.

The principal soils are the St. Paul, Carey, and Woodward (fig. 7). The St. Paul and Carey are deep, brown to reddish-brown loamy soils of the uplands. St. Paul soils have a blocky, reddish-brown clay loam subsoil, and Carey soils have a more friable silt loam subsoil. The Woodward are moderately deep, reddish-brown soils of the

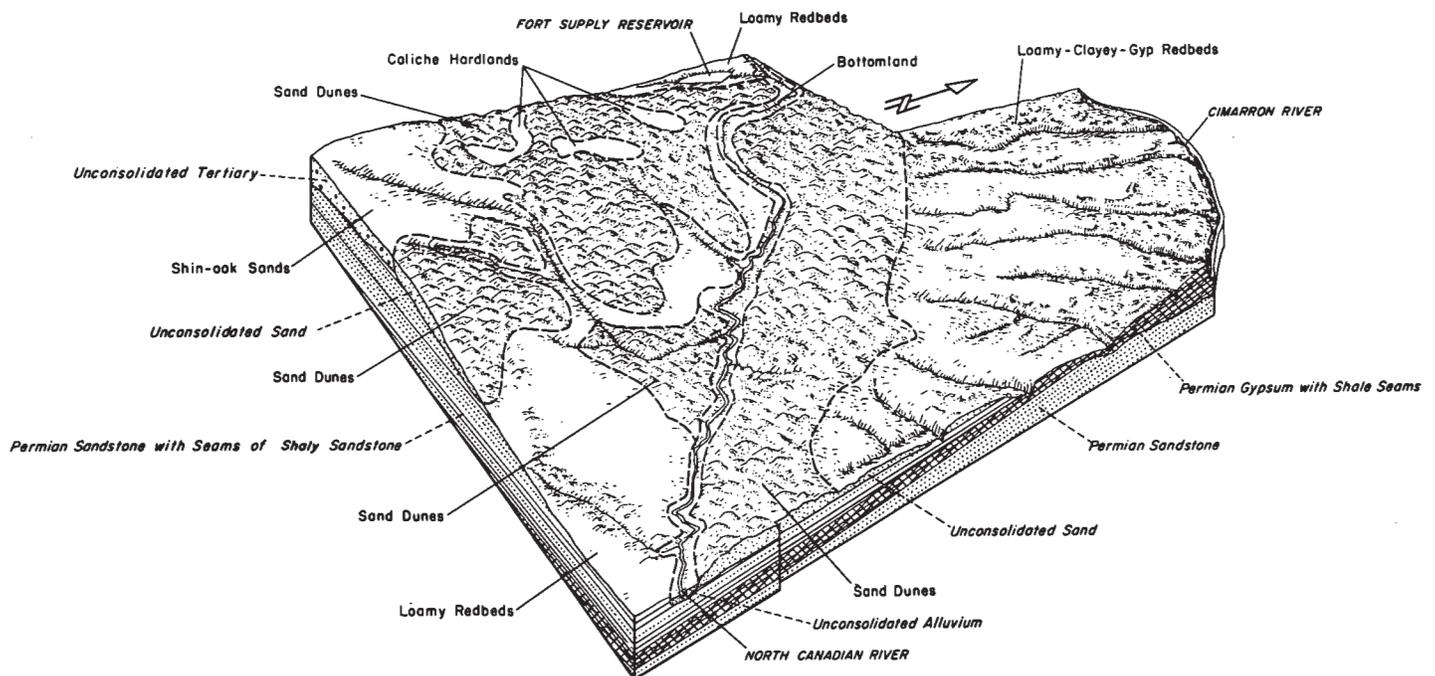


Figure 6.—Parent materials and some topographic features of the soils of Woodward County.

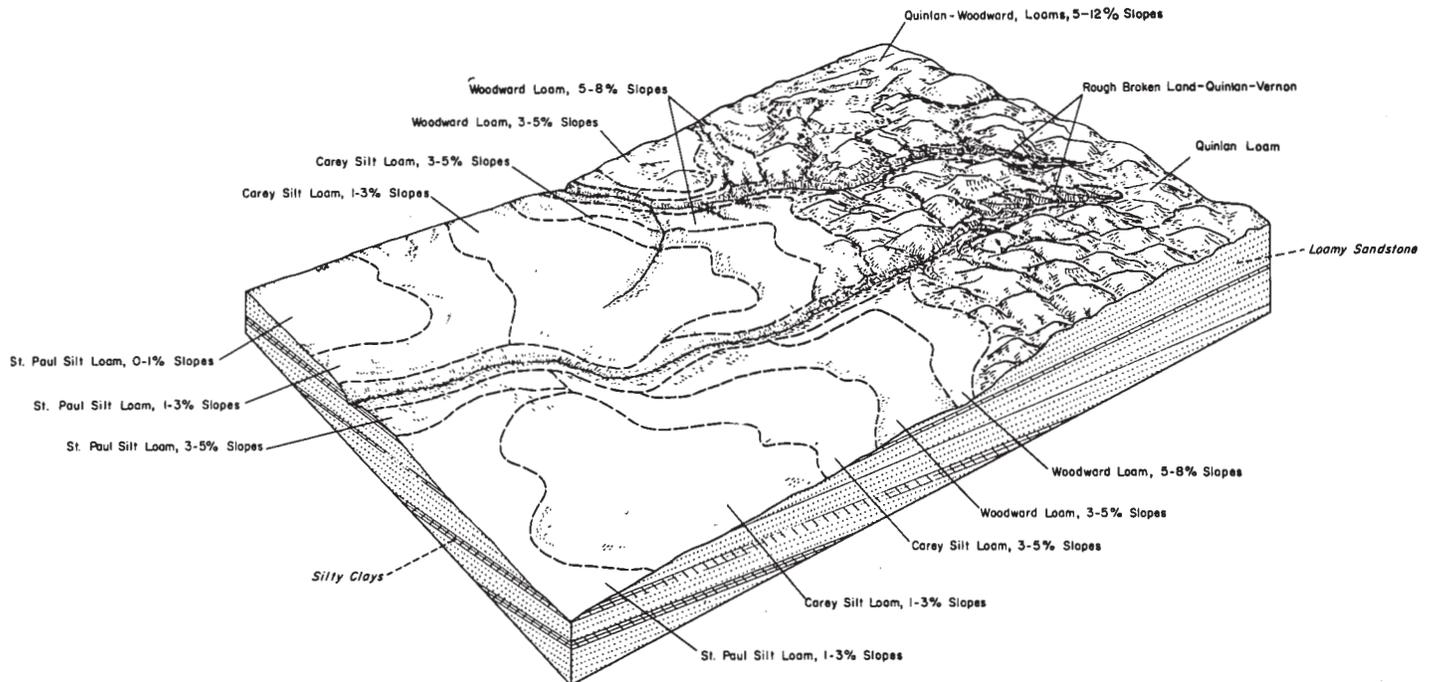


Figure 7.—Typical pattern of soils of the St. Paul-Carey-Woodward association.

uplands. They have a subsoil of reddish-brown loam that overlies sandstone, which is at a depth of 2 feet or more.

Small amounts of the shallow Quinlan and Vernon soils occur on some of the more sloping areas.

About 70 percent of this association is cropped and can be tilled safely if conservation practices are used. Wheat is the main crop, and sorghums are next in importance. The average yields per acre on these soils are among the best in the county. Nevertheless, there are crop failures during years of inadequate rainfall, particularly during prolonged droughts. Farmers generally grow wheat and other small grains and raise beef cattle, which are maintained throughout the winter on small-grain pasture.

In general, farms range from 300 to 600 acres in size. More than 80 percent of the farmers operate their own farms.

(B) Pratt Association: Sand Dunes

This association is made up of deep sandy soils that have formed under native grasses. Sand sagebrush is common, and a few trees occur in some areas. The Pratt association covers about 24 percent of the county and contains 192,000 acres. In general, the areas are not dissected by distant drainage patterns.

The principal soils are the Pratt and Tivoli (fig. 8). The deep, brown, sandy Pratt soils are on undulating to low dunelike topography in the uplands. They have a surface layer of brown fine sand or loamy fine sand and a subsoil of yellowish-brown loamy fine sand. Tivoli soils are made up of pale-brown, loose fine sand, and they occupy hummocky topography. The less extensive Carwile soils are in the narrow valleys. This association includes small acreages of Enterprise, Miles, and Holdrege soils.

About half the acreage of the Pratt and Tivoli soils is cultivated. Sorghums are the main crop, and wheat is next in importance. The soils absorb moisture well. They are subject to wind erosion but can be tilled safely if conservation practices are used.

Because the farms in this association have both arable and nonarable soils, a combination of crop farming and beef production is practiced. There are also a few small dairy farms. Average yields of crops range from low to medium; there are few total failures of crops. The size of farms varies greatly, but the average farm contains more than 640 acres.

(C) Mansker-Potter Association: Caliche Hardlands

This association is made up of moderately deep and shallow loamy soils of the sloping uplands. It covers about 2 percent of the county and contains about 14,380 acres.

Mansker and Potter, the principal soils, have formed under mixed native grasses. These soils occur in an irregular pattern. The moderately deep, grayish-brown, loamy Mansker soils have formed in weathered-limy sediments. The surface layer of grayish-brown loam is 4 to 8 inches thick and is underlain by a subsoil of dark-brown, friable light clay loam. At a depth of 17 to 24 inches, very pale, soft, calcareous, loamy caliche is generally present.

Potter soils are shallow, grayish brown, and loamy. They occupy rounded knobs and steeper slopes in close association with Mansker soils. Their subsoil is similar to that of Mansker soils but is generally within 8 inches of the surface. In eroded areas, this subsoil is exposed.

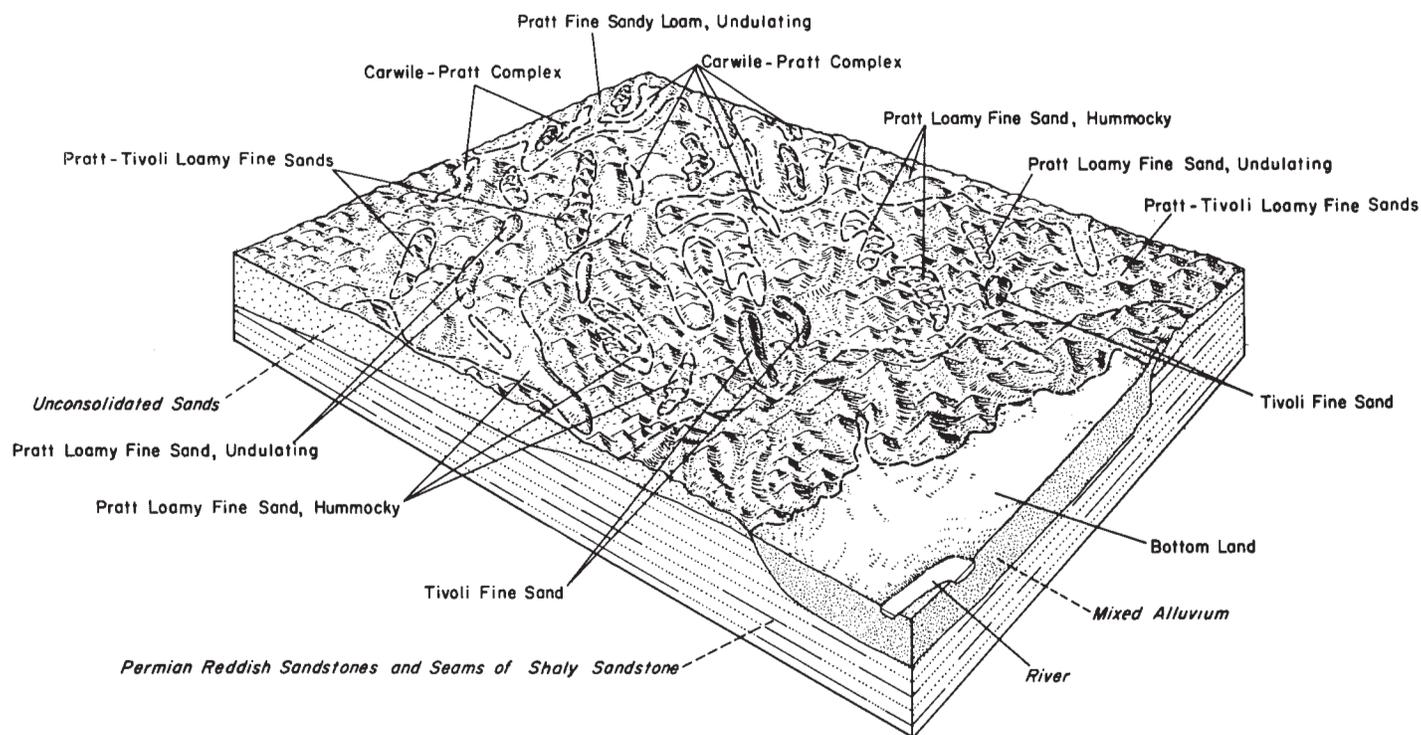


Figure 8.—Typical pattern of soils of the Pratt association.

Small acreages of Miles and Pratt soils occur in this association.

In gently sloping areas, the soils of this association are used primarily for cultivated crops, but, in the steeper areas, they are generally used as rangeland. Wheat and other small grains are the principal crops, but sorghums have been grown successfully. Conservation practices are necessary in cultivated areas. Farms generally range from 320 to 640 acres in size.

(D) Port Association: Nearly Level Loamy Bottom Lands

This association consists of soils on bottom lands. The soils are suited to cultivation (fig. 9). They have formed in water-deposited material under a cover of native grasses. The Port association covers about 3 percent of the county and contains about 22,800 acres of soils suited to cultivation.

The principal soils are the Port, Elsmere, Wann, Leshara, Yahola, and Lincoln loamy fine sand. Port and Elsmere soils occur parallel to streams on high terraces above areas that are overflowed. Wann soils are near the stream channels and receive occasional overflow. The Lincoln soil is on benches next to streams but above areas that are overflowed. Yahola fine sandy loam, high, is on bottom lands near the red beds.

The Port, Leshara, and Yahola soils are generally used for all crops suited to the climate. Because of a high water table, the Elsmere soils are used primarily for meadow. Wann soils and Lincoln loamy fine sand are used mainly as rangeland.

(E) Lincoln-Las Animas Association: Mainly Sandy and Loamy Bottom Lands

This association consists of soils that are mostly unsuited to cultivation. The soils have formed on water-deposited material that has a wide range in texture (fig. 10). The native vegetation was grasses. This association covers about 7 percent of the county and contains about 58,000 acres.

The principal soils, the Lincoln and Las Animas, occur primarily along the North Canadian River. The Lincoln soils are sandy and droughty; the Las Animas have a high water table.

Sweetwater soils, which also have a high water table, are mainly along Indian Creek and North and South Persimmon Creeks. Treadway soils are clayey and lie along the Cimarron River. Stream channels are included in this association.

This association also includes small acreages of Yahola, Elsmere, and Wann soils that are suitable for cultivation. Yahola soils occur along creeks that drain red beds in the uplands, and they are occasionally flooded. Elsmere and Wann soils are discussed under the Port association.

Lincoln soils are moderately productive as grassland, but are susceptible to wind erosion if cultivated. If necessary, the high water table in Las Animas soils can be lowered, and the soils used for cultivated crops.

Beef-cattle ranches vary in size from 200 to 2,000 acres. Most of the ranches contain a mixture of soils of the bottom lands and the uplands.

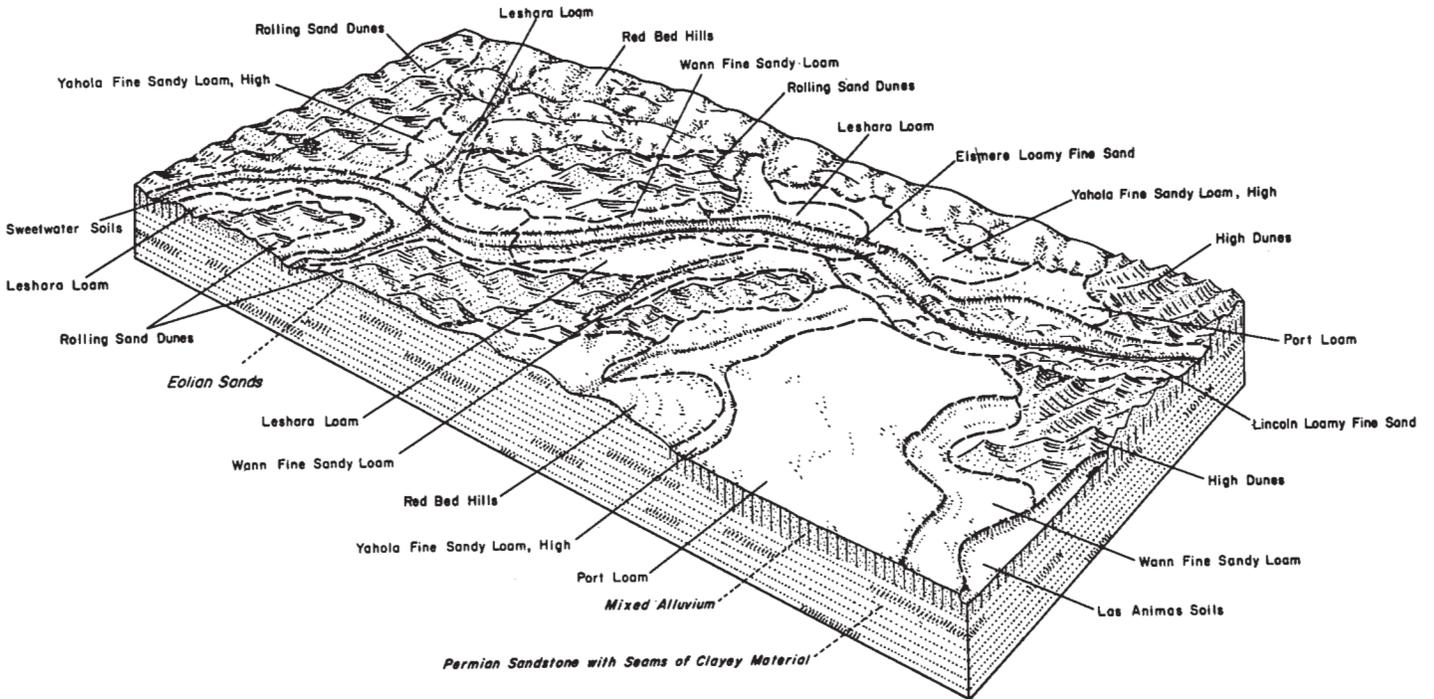


Figure 9.—Typical pattern of soils of the Port association.

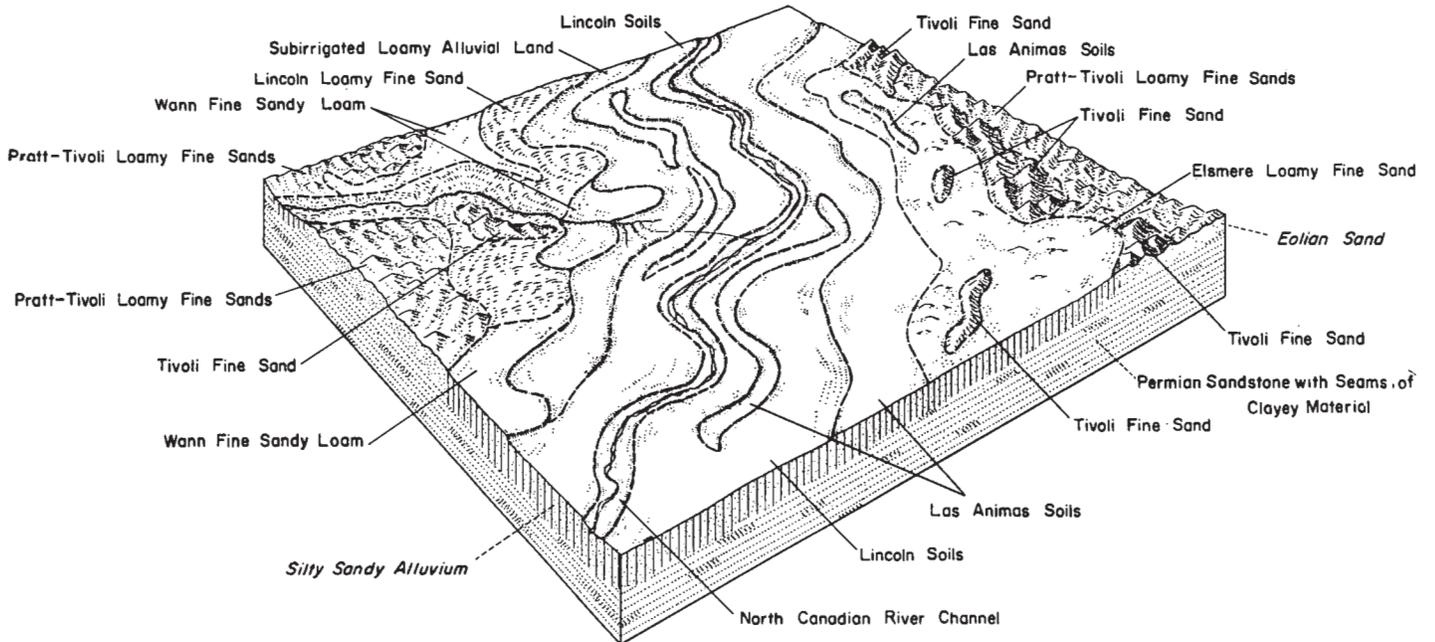


Figure 10.—Typical pattern of soils of the Lincoln-Las Animas association.

(F) Pratt-Tivoli Association: High Sand Dunes

This association consists of deep sandy soils that have formed on steep sand dunes under a cover of tall native grasses. Sand sagebrush is common, and a few scattered trees grow in some places. The Pratt-Tivoli association covers about 17 percent of the county and contains approximately 130,200 acres.

The principal soils are the Pratt and Tivoli. These soils do not have a dissected drainage pattern. Because they are sandy, however, they absorb most of the rain as it falls, and little water is ponded in the valleys between the dunes.

Minor soils in this association are the arable Pratt, which are on low dunes, the Enterprise, and the Carwile.

Most of the acreage of this association should not be cultivated, because of the susceptibility to wind erosion. In general, this is a beef-ranching area. The ranches range from 320 to several thousand acres in size. Many of them contain 640 acres or more.

(G) Nobscot-Brownfield Association: Shinnery-Oak Sands

This association is made up of sandy soils that have formed under forests (fig. 11). At present the vegetation is a mixture of scrubby shinnery oak and tall native grasses. The soils have a wide range in degree of slope.

The Nobscot-Brownfield association covers about 6 percent of the county and contains about 50,400 acres. The principal soils are the Nobscot, Brownfield, and Eufaula. Brownfield soils occur in the more nearly level areas, the Nobscot in sloping areas, and the Eufaula in steep, extremely sandy areas. The soils have an indistinct drainage pattern, and a small amount of water is ponded in valleys.

About 10 percent of the acreage is cultivated, and 90 percent is used as rangeland. In the early days, many

acres of Brownfield and Nobscot soils were farmed, but, because of low fertility and the extreme susceptibility to wind erosion, most of the cultivated land has been planted to grasses. Sorghums and rye are the principal cultivated crops still grown. If properly managed, rangeland is moderately productive. The subsoil of the Brownfield and Nobscot soils has enough clay to prevent water from draining out too quickly.

Beef-cattle ranches range from 160 to 2,500 acres in size. A few dairy farms also occur in this soil association.

(H) Quinlan-Woodward Association: Strongly Sloping Loamy Red Beds

This association is made up of loamy soils that have strong slopes. The soils have formed under mixed native grasses. The Quinlan-Woodward association covers about 13 percent of the county and contains about 100,100 acres.

The principal soils are the Quinlan and Woodward. The shallow, steep Quinlan soils occur in red beds. The moderately deep, loamy Woodward soils generally are on less sloping areas below the Quinlan soils. Nevertheless, mixtures of Woodward and Quinlan soils commonly occur in the same field or pasture.

Small acreages of Carey and Vernon soils are in this association.

Quinlan soils are used primarily as rangeland. Less sloping areas of Woodward soils and mixtures of Woodward and Quinlan soils are cultivated or used as rangeland. Wheat is the main crop grown, and sorghums are next in importance. Water erosion is a constant threat in cultivated fields. If properly managed, the soils produce fair yields of grasses.

Because the farms have a pattern of soils that are either suited or unsuited to cultivation, a combination of crop farming and beef production is practiced. Average yields of crops are low, but total crop failure seldom occurs. The size of farms and ranches varies a great deal, but the average holding is 640 acres.

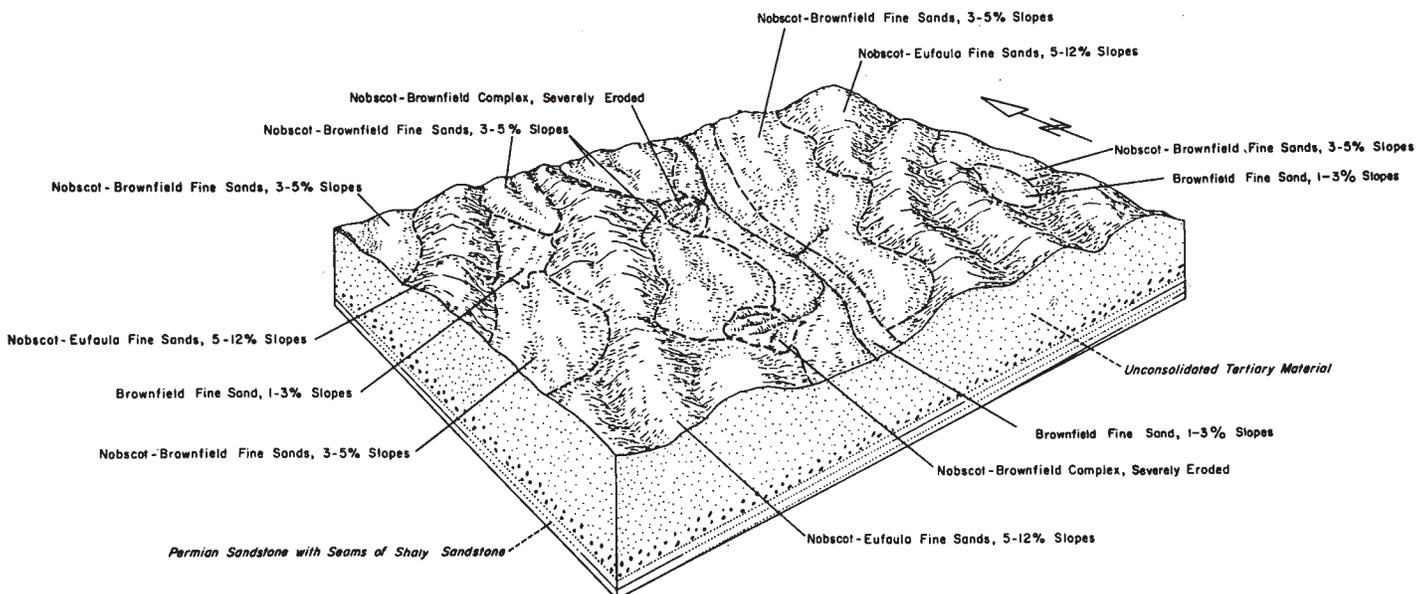


Figure 11.—Typical pattern of soils of the Nobscot-Brownfield association.

(I) Vernon-Cottonwood Association: Dissected Gypsum Plains

This association consists of shallow soils that have developed under native grasses. There is a wide range of slopes. The Vernon-Cottonwood association covers about 9 percent of the county and occurs on 74,900 acres (fig. 12).

In places the clayey Vernon soils are interspersed with the loamy Cottonwood soils, but in large acreages only the Vernon soils occur. The Vernon soils have developed in shaly clay and are in broken, dissected areas from which much of the gypsum has been removed. Cottonwood soils have developed in gypsum. Bare gypsum rock, exposed in many areas of Cottonwood soils, indicates the degree of erosion. Some areas of gypsum have been hollowed out, so as to leave exposures of shaly clay, sinkholes, small caves, or natural bridges. In large acreages of Vernon soils, all the gypsum has been removed and shaly clay is exposed.

Minor soils in this association are the St. Paul, Carey, Yahola, and Rough broken land.

The Cottonwood soils and the steeply sloping Vernon soils are used as rangeland. Proper management is needed to keep a good stand of desirable grasses. Small, less steeply sloping areas of Vernon, St. Paul, Carey, and Yahola soils are farmed. Wheat is the principal crop. In the less sloping areas, farmers combine the growing of crops with beef production. Ranches range from 320 to 5,000 acres in size, but most of them contain 1,000 or more acres.

(J) Vernon-Badland Association: Shaly Clay Red Beds

This association is made up of a highly erodible mixture of soils and miscellaneous land types. It covers about 3 percent of the county and contains about 21,300 acres.

The shallow Vernon soils are most extensive. The many acres of exposed shaly clay are called badland. Areas of this association are used primarily as rangeland, but there are few ranches.

Small acreages of gently sloping St. Paul, Carey, and Yahola soils occur in this association. In these places a combination of wheat farming and beef raising is practiced.

(K) Nobscot-Pratt Association: Mixed-Oak Sands

This association is made up of deep sandy soils that have formed on sand dunes under a cover of trees and grasses. Scrubby oak is very thick in some places. The Nobscot-Pratt association covers about 3 percent of the county and contains 23,500 acres.

The Nobscot soils have formed under forest, and the Pratt, under prairie. These soils are mixed together in an irregular pattern. No distinct drainage pattern has developed, and, because of trapped drainage, narrow wet-weather lakes occasionally form in the valleys.

Small acreages of Carwile and Miles soils occur in this association.

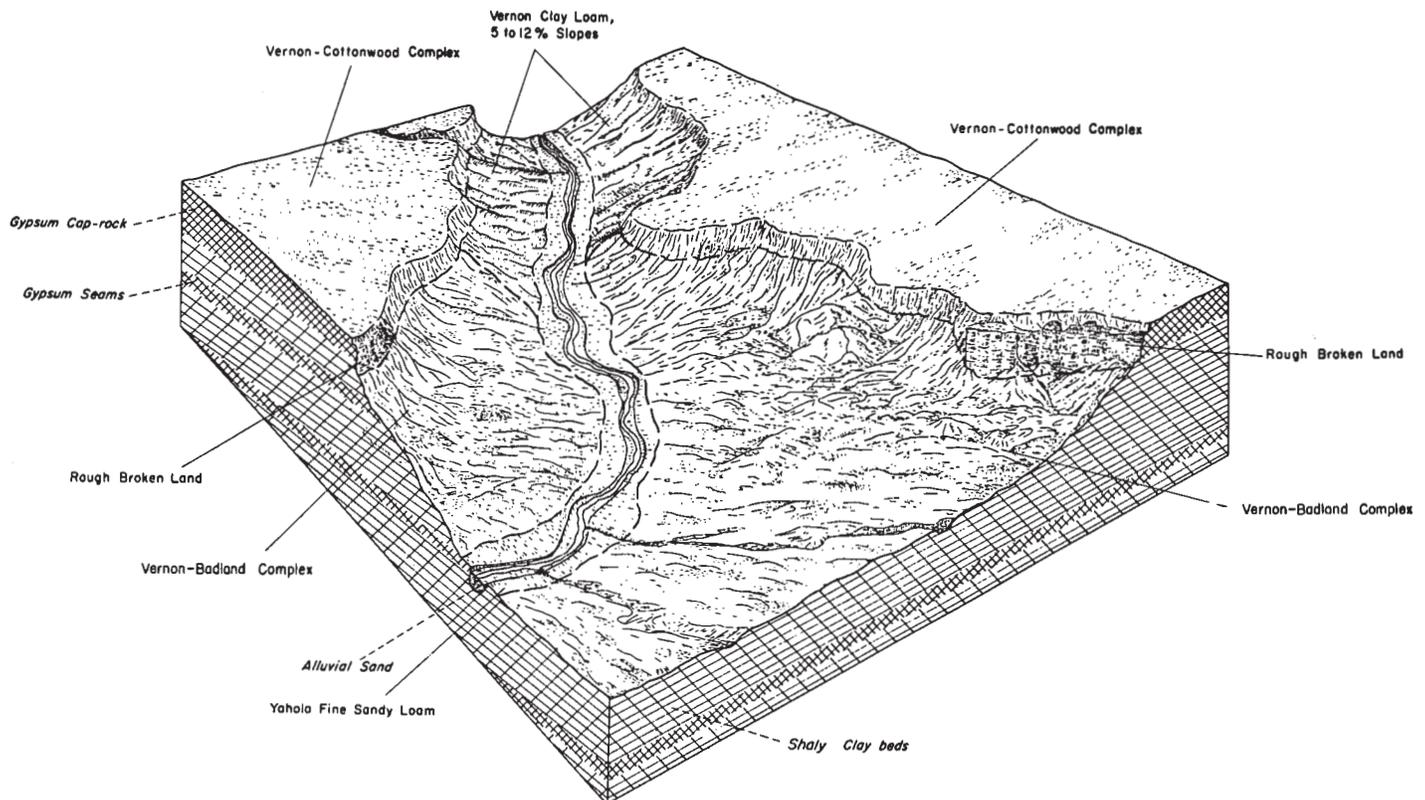


Figure 12.—Typical pattern of soils of the Vernon-Cottonwood association.

Most of the Nobscot-Pratt association is used as wooded rangeland. Ranches are small, and yields of grasses are low. Some less sloping areas are used for sorghums and small grains. Yields are low, but crop failures are rare.

Descriptions of the Soils

This section describes, in nontechnical language, the soil series (groups of soils) and single soils (mapping units) of Woodward County. The procedure is to first describe the soil series, and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How Soils are Named, Mapped, and Classified," not all mapping units are members of a soil series. Rough broken land and other miscellaneous land types do not belong to a soil series but, nevertheless, are listed in approximate alphabetic order along with the soil series.

Following the name of each mapping unit there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and the range site in which the mapping unit has been placed. The pages on which each capability unit and each range site are described can be found readily by referring to the "Guide to Mapping Units, Capability Units, and Range Sites" at the back of the report.

Soil scientists, engineers, students, and others who want detailed descriptions of soil series should turn to the section "Formation, Classification, and Morphology of Soils." The acreage and proportionate extent of each mapping unit are given in table 3.

Badland

This is a miscellaneous land type that consists of shale outcrops. More than 50 percent of the area lacks vegetation. Reddish shale and fragments of white, pink, red, and water-clear gypsum occur on the surface. Rapid geological erosion has left many unusual landforms. The irregular topography and lack of vegetation present a picture of a painted desert.

Badland occurs in the northeastern part of the county in association with Vernon clay. The two are mixed together in such a pattern that it was not practical to separate them in mapping; outcrops of raw shaly clay are interspersed with islands and valleys in which the soil has accumulated. The Vernon-badland complex is described under the Vernon series.

The profile of badland is made up of stratified shaly clay, throughout which deposits of gypsum of various thicknesses are scattered. Badland is seldom moistened below a depth of 10 inches. Permeability is very slow. As soil develops, it is removed through geologic erosion. The areas of badland are used as range.

Brownfield Series

The Brownfield series consists of deep, well-drained, grayish-brown fine sands and loamy fine sands of the uplands. The soils are on gentle to moderate slopes in the

TABLE 3.—Approximate acreage and proportionate extent of the soils

Soil	Area	Extent
	Acres	Percent
Brownfield fine sand, 1 to 3 percent slopes.....	7, 847	1. 0
Carey silt loam, 1 to 3 percent slopes.....	24, 340	3. 1
Carey silt loam, 3 to 5 percent slopes.....	16, 558	2. 1
Carey silt loam, 5 to 8 percent slopes.....	1, 275	. 2
Carey silt loam, 5 to 8 percent slopes, eroded.....	4, 437	. 6
Carwile-Pratt complex.....	11, 875	1. 5
Elsmere loamy fine sand.....	6, 078	. 8
Enterprise fine sandy loam, undulating.....	2, 763	. 4
Enterprise loam, 3 to 5 percent slopes.....	7, 750	1. 0
Enterprise-Pratt complex, 5 to 8 percent slopes.....	1, 131	. 1
Enterprise-Pratt complex, 8 to 20 percent slopes.....	5, 650	. 7
Holdrege loam, 1 to 3 percent slopes.....	3, 185	. 4
Las Animas soils.....	13, 014	1. 7
Leshara loam.....	2, 338	. 3
Lincoln loamy fine sand.....	4, 856	. 6
Lincoln soils.....	17, 771	2. 3
Mansker loam, 1 to 3 percent slopes.....	11, 277	1. 4
Mansker loam, 3 to 5 percent slopes.....	5, 154	. 7
Mansker-Potter loams, 5 to 12 percent slopes.....	1, 621	. 2
Miles fine sandy loam, 1 to 3 percent slopes.....	12, 187	1. 5
Miles fine sandy loam, 3 to 5 percent slopes.....	2, 462	. 3
Nobscot-Brownfield fine sands, 3 to 5 percent slopes.....	14, 158	1. 8
Nobscot-Brownfield complex, severely eroded.....	925	. 1
Nobscot-Eufaula fine sands, 5 to 12 percent slopes.....	24, 384	3. 1
Nobscot-Pratt complex, hummocky.....	4, 610	. 6
Nobscot-Pratt complex, duned.....	16, 954	2. 2
Otero loamy fine sand, undulating.....	904	. 1
Port loam.....	6, 908	. 9
Pratt fine sandy loam, hummocky.....	12, 217	1. 5
Pratt fine sandy loam, undulating.....	30, 590	3. 9
Pratt loamy fine sand, hummocky.....	76, 776	9. 7
Pratt loamy fine sand, undulating.....	22, 069	2. 8
Pratt-Tivoli loamy fine sands.....	96, 535	12. 2
Quinlan loam.....	31, 913	4. 0
Quinlan-Woodward loams, 3 to 5 percent slopes, eroded.....	8, 208	1. 0
Quinlan-Woodward loams, 5 to 12 percent slopes.....	43, 318	5. 5
Quinlan-Woodward loams, 5 to 12 percent slopes, eroded.....	7, 320	. 9
Rough broken land.....	7, 834	1. 0
St. Paul silt loam, 0 to 1 percent slopes.....	4, 911	. 6
St. Paul silt loam, 1 to 3 percent slopes.....	17, 110	2. 2
St. Paul silt loam, 3 to 5 percent slopes.....	11, 964	1. 5
Sweetwater soils.....	6, 145	. 8
Tivoli fine sand.....	32, 003	4. 1
Treadway clay.....	2, 358	. 3
Vernon clay loam, 0 to 3 percent slopes.....	1, 194	. 2
Vernon clay loam, 3 to 5 percent slopes.....	13, 532	1. 7
Vernon clay loam, 5 to 12 percent slopes.....	26, 856	3. 4
Vernon-badland complex.....	14, 274	1. 8
Vernon-Cottonwood complex.....	31, 823	4. 0
Wann fine sandy loam.....	4, 981	. 6
Woodward loam, 1 to 3 percent slopes.....	8, 752	1. 1
Woodward loam, 3 to 5 percent slopes.....	9, 037	1. 2
Woodward loam, 5 to 8 percent slopes.....	9, 323	1. 2
Woodward-Quinlan loams, 3 to 5 percent slopes.....	4, 036	. 5
Yahola fine sandy loam.....	4, 603	. 6
Yahola fine sandy loam, high.....	6, 386	. 8
River and creek channels.....	10, 000	1. 3
Total.....	788, 480	100. 0

southwestern part of the county. They have formed under shinnery oak and scattered tall grasses.

The grayish-brown surface layer is 3 to 5 inches thick, single grained, and loose when dry or moist. It is generally easy to work but, because of the susceptibility to wind erosion, is difficult to manage when cultivated.

Pale-brown fine sand is below the surface layer. It is 5 to 20 inches thick, single grained, and loose when dry or moist. It is acid and has been leached of plant nutrients.

The subsoil of yellowish-red sandy clay loam is about 30 inches thick. It has coarse, prismatic structure that breaks easily to granular. It is moderately permeable to water, and roots penetrate fairly easily. The subsoil is acid and is hard when dry and friable when moist.

The parent material consists of sandy sediments of Tertiary age.

Brownfield soils have more clay in their subsoil than Nobscot soils. They have formed under forests and have an acid solum (normally the surface layer and subsoil). The Pratt soils, in contrast, have formed under prairie grasses and have a neutral solum.

In many of the more level areas, the surface layer is grayish brown, and in the sloping areas, it is brown. In small areas, there are thin layers of silty clay in the subsoil. Under cultivation, the leached layer underlying the surface layer is darkened with organic matter.

Brownfield soils are best suited to native grasses but can be used for rye or sorghums. Native shinnery oak and grasses still grow on most of the acreage.

Brownfield fine sand, 1 to 3 percent slopes (BfB), is a sandy, billowy soil. It has a surface layer of fine sand over a subsoil of yellowish-red sandy clay loam that takes water well.

This soil is used primarily for pasture. Cultivated areas are generally used for sorghums or rye. The soil is extremely erodible, so it needs vegetation or crop residues on the surface at all times.

Management problems are the severe susceptibility to wind erosion, low fertility, maintenance of organic matter, and the difficulty in establishing stands of crops. (Capability unit IVE-2; Deep Sand Savannah range site.)

Carey Series

The Carey series consists of deep, well-drained, reddish-brown or brown loamy soils of the uplands. The soils occur on gentle to strong slopes throughout the red-bed areas of the county. They have formed under mid and tall native grasses.

The reddish-brown or brown silt loam surface layer has granular structure and is slightly hard when dry and friable when moist. It is easily worked, but, if it is pulverized through excessive tillage, the surface will crust after rains. A plowpan is likely to form if tillage is always at the same depth.

The subsoil of reddish-brown silt loam is about 30 inches thick. It has coarse, prismatic structure that breaks easily to granular. Permeability is moderate, and roots penetrate with little difficulty. The subsoil is generally noncalcareous and usually has no accumulation of lime.

The parent material is highly weathered, fine-grained, calcareous sandstone. In places, some lime has accumulated in the upper part of this material.

Carey soils are redder and less dark in the surface layer and upper part of the subsoil than St. Paul soils, and they have less clay in the subsoil. Their surface layer is not so red as that of the Woodward soils. The Carey soils have a more strongly developed subsoil than the Woodward soils.

The surface layer is 10 to 20 inches thick. In the southern part of the county, it approaches loam in texture. In some areas of the county where the parent material has been reworked by water, the Carey soils have a very deep profile. In many places they are 60 inches or more in depth.

The soils have moderate to rapid runoff. They are well suited to small grains, sorghums, and native grasses. Wheat is the principal cultivated crop.

Carey silt loam, 1 to 3 percent slopes (CaB), is gently sloping. The silt loam surface layer is about 14 inches thick. It is underlain by silt loam subsoil that takes water well.

Up to 10 percent of an individual area may consist of Woodward or St. Paul soils.

Carey silt loam, 1 to 3 percent slopes, is used mainly for wheat, but it is well suited to all small grains. Sorghums are also grown successfully, and, occasionally, alfalfa is planted during years of favorable rainfall. This soil is suited to irrigation.

Management problems are surface crusting, the breakdown of structure in the surface layer, a slight susceptibility to erosion, and the formation of a plowpan. (Capability unit IIe-1; Loamy Prairie range site.)

Carey silt loam, 3 to 5 percent slopes (CaC), is moderately sloping. It has a surface layer of reddish-brown or brown silt loam, about 12 inches thick, over a subsoil of silt loam that takes water well.

Up to 10 percent of the acreage in any individual area may consist of Woodward and St. Paul soils.

Carey silt loam, 3 to 5 percent slopes, is used mainly for wheat, but it is well suited to other small grains. Sorghums are grown with limited success.

Management problems are surface crusting, the breakdown of structure in the surface layer, a moderate susceptibility to water erosion, and the formation of a plowpan. (Capability unit IIIe-1; Loamy Prairie range site.)

Carey silt loam, 5 to 8 percent slopes (CaD), is strongly sloping. It has approximately 11 inches of brown to reddish-brown silt loam over a silt loam subsoil that takes water well. This soil is inextensive and is confined to a narrow band in the northern part of the county.

Up to 10 percent of the acreage in any individual area may consist of Woodward soils.

Carey silt loam, 5 to 8 percent slopes, is used primarily as rangeland. Management problems in cultivated areas are surface crusting, the breakdown of structure in the surface layer, a severe susceptibility to water erosion, and the formation of a plowpan. (Capability unit IVe-1; Loamy Prairie range site.)

Carey silt loam, 5 to 8 percent slopes, eroded (CaD2), is strongly sloping. It has approximately 8 inches of brown to reddish-brown silt loam over a subsoil of silt loam that takes water well. This inextensive soil is confined to a narrow band in the northern part of the county.

Up to 10 percent of the acreage in any individual area may consist of Woodward soils.

Wheat and other small grains are the main crops grown on Carey silt loam, 5 to 8 percent slopes, eroded. Sorghums are grown with limited success. Management problems in cultivated areas are surface crusting, the breakdown of structure in the surface layer, a severe sus-

ceptibility to water erosion, and the formation of a plowpan. (Capability unit IVE-1; Loamy Prairie range site.)

Carwile Series

The Carwile series consists of deep, imperfectly drained, gray or grayish-brown soils of the uplands. These soils occur in depressions between sand dunes. They have formed under mid and tall grasses.

The gray or grayish-brown surface layer is about 11 inches thick and ranges from loamy sand to clay loam. It has granular structure and is hard when dry and firm when moist. Its workability varies according to location and degree of wetness.

The subsoil of brown sandy clay is about 30 inches thick. It has prismatic and blocky structure and is very hard when dry and firm when moist. Roots have difficulty penetrating this blocky layer. There are many prominent mottles of yellowish red in the subsoil.

The parent material is highly weathered, sandy alluvium. Many soft concretions of lime are at a depth of 36 inches, but the soil material above is noncalcareous.

Carwile soils become sandy with increasing depth; loamy sand occurs 45 to 65 inches below the surface.

In Woodward County the Carwile soils are mapped in a complex with Pratt soils. Carwile soils are darker and more strongly developed than Pratt soils. They are used as rangeland and for growing small grains and sorghums.

Carwile-Pratt complex (Cp) is as an intricate mixture of soils in depressions between sand dunes. The Carwile soil, which is most extensive, occupies low areas and takes water very slowly; the Pratt soil is on low dunes and takes water fairly well.

Up to 10 percent of the acreage in any individual area may consist of Miles soils.

About three-fourths of the acreage of this mapping unit is cultivated, mainly to wheat and grain sorghum. Because of standing water, normal tillage is not always possible. In spring, crops are sometimes drowned out on small spots of Carwile soil. The Carwile and Pratt soils are fairly well suited to sprinkler irrigation.

Management problems are trapped drainage, the slow intake of water in low spots, the maintenance of organic matter, a moderate susceptibility to wind erosion, and the formation of a plowpan. (Capability unit IIIw-1; Sandy Prairie range site.)

Cottonwood Series

The Cottonwood series consists of very shallow, excessively drained, grayish-brown loamy soils of the uplands. The soils are on gentle to steep slopes throughout areas of gypsum-bearing red beds in the northeastern part of the county. The native vegetation is mid and tall grasses.

The grayish-brown surface layer is about 5 inches thick. It has granular structure and is soft when dry and very friable when moist. It is easily removed through erosion.

The subsoil of very pale brown loam is about 4 inches thick. It has granular structure and is soft when dry and very friable when moist. Permeability is moderate, and roots easily penetrate this layer. The subsoil is calcareous but has no accumulation of lime.

The parent material, which begins 9 inches below the surface, is consolidated gypsum that ranges from crystalline clear selenite to grayish-white satin spar. Mixtures of colors are most common.

Cottonwood soils occur in an irregular pattern with Vernon soils in places where weathering has dissolved some areas of gypsum and left clay exposed. The Cottonwood soils have formed in gypsum, and the Vernon soils, in clay. In many areas of Cottonwood soils, the thickness of the surface layer and the subsoil vary. In some places bare gypsum is exposed.

Cottonwood soils are used as rangeland and need careful management. In Woodward County they are mapped in a complex with the Vernon soils. This complex of soils is described under the Vernon series.

Elsmere Series

The Elsmere series consists of deep, grayish-brown loamy fine sands that have a high water table. The soils occur on nearly level bottom lands along the North Canadian River and the large creeks.

The grayish-brown surface layer is about 16 inches thick. It is single grained and is soft when dry and very friable when moist. The soil is easily worked but, when tilled, the sandy surface layer, which is slightly saline, is exposed to damaging winds.

The pale-brown subsoil is about 30 inches thick. It is stratified and averages a loamy fine sand in texture. It is single grained and is soft when dry and very friable when moist. The subsoil is generally calcareous and is faintly mottled. Roots easily penetrate this layer. Permeability is rapid down to the high water table.

The parent material consists of very pale brown, faintly mottled, stratified, calcareous sands. It is single grained and is loose when dry and moist.

Elsmere soils are less clayey than Las Animas soils and are darker than Lincoln soils.

In some areas of Elsmere soils, the surface layer is of gray color or of fine sandy loam texture. Mottling in the subsoil ranges from faint to distinct. The water table is 3 to 6 feet below the surface.

Elsmere loamy fine sand (Ee) is a nearly level sandy soil that is subirrigated by a water table that keeps the soil moist up to within 3 feet of the surface.

Up to 10 percent of the acreage of any individual area may consist of Las Animas, Lincoln, or Wann soils.

Elsmere loamy fine sand is used primarily for meadow and rangeland. Small areas are used for sorghums and small grains. The soil is slightly saline, and salt-tolerant vegetation, such as inland saltgrass and alkali sacaton, are the main grasses in many places. Nevertheless, bottom-land switchgrass does well under good management.

Management problems are a susceptibility to wind erosion, low fertility, and the maintenance of organic matter. (Capability unit IVw-1; Subirrigated range site.)

Enterprise Series

The Enterprise series consists of deep, well-drained, brown, calcareous loamy soils of the uplands. These soils are on gentle to steep slopes throughout the county. The native vegetation is mid and tall grasses.

The surface layer of brown loam is about 17 inches thick. It has a granular structure and is slightly hard when dry and very friable when moist. It is easily worked, but, if it is pulverized through excessive tillage, the surface will crust after rains. A plowman is likely to form if tillage is always at the same depth.

The subsoil of brown loam is about 25 inches thick. It has granular structure, has moderately rapid permeability, and is slightly hard when dry and very friable when moist. Roots penetrate this layer fairly easily. Lime generally does not accumulate in the subsoil.

The parent material is brown, calcareous, unconsolidated alluvium and loess of loam texture. Some lime has accumulated in this material. The content of sand increases with depth.

The surface layer of the Enterprise soils varies in depth from the crest of a hill to the bottom of the slope. Their texture ranges from loam to sandy loam. They are more loamy and less sandy than Pratt soils.

Less sloping Enterprise soils are used for small grains and sorghums, and steeply sloping soils are used as rangeland.

Enterprise fine sandy loam, undulating (E1B), has a surface layer consisting of about 18 inches of brown, calcareous fine sandy loam. Beneath this is a fine sandy loam subsoil that takes water well. The soil occurs primarily along the North Canadian River.

Up to 10 percent of the acreage in any individual area may be made up of Pratt or Wann soils.

This Enterprise soil is used for wheat and sorghums. Management problems are surface crusting, a moderate susceptibility to wind erosion, the breakdown of surface soil structure, and the formation of a plowman. (Capability unit IIIe-2; Sandy Prairie range site.)

Enterprise loam, 3 to 5 percent slopes (EmC), has a surface layer, 15 to 18 inches thick, of brown loamy material. Beneath this is a subsoil of granular loam that takes water well. This soil occurs primarily in the southwestern part of the county.

Up to 10 percent of the acreage in any individual area may be made up of Pratt or Holdrege soils.

All crops suited to this area are grown on Enterprise loam, 3 to 5 percent slopes. Wheat and sorghums are the principal crops. Management problems are surface crusting, a moderate susceptibility to erosion, the breakdown of surface soil structure, and the formation of a plowman. (Capability unit IIIe-1; Loamy Prairie range site.)

Enterprise-Pratt complex, 5 to 8 percent slopes (EpD), consists of a mixture of Enterprise loam and Pratt fine sandy loam. These soils occur together in an irregular pattern on strongly sloping uplands, primarily in the southwestern part of the county. They have a brown surface layer, approximately 15 inches thick, over a granular subsoil that takes water well.

These soils are used primarily for wheat and sorghums. Management problems are a severe susceptibility to erosion, surface crusting, the breakdown of structure in the surface layer, and the formation of a plowman. (Capability unit IVe-1; Sandy Prairie range site.)

Enterprise-Pratt complex, 8 to 20 percent slopes (EpE), consists of a mixture of Enterprise and Pratt soils. These soils occur together in an irregular pattern on steeply sloping uplands. They are primarily on the

north side of sandy areas. They take water well but, if cultivated, are susceptible to severe erosion.

The soils are well covered with mid and tall native grasses and sagebrush and are used as rangeland. (Capability unit VIe-5; Sandy Prairie range site.)

Eufaula Series

The Eufaula Series consists of deep, steep, excessively drained, pale-brown fine sands of the uplands. These soils have formed under forests consisting primarily of shinnery oaks.

The pale brown or very pale brown surface layer is about 24 inches thick. It is single grained and is loose when dry and moist. If cultivated, it is susceptible to severe wind damage.

The subsoil of very pale brown fine sand is about 30 inches thick. It is single grained and is loose when dry and moist. Roots of trees and grasses penetrate this layer fairly easily. The reaction is moderately acid to strongly acid. Irregular, horizontal, yellowish-red bands of loamy fine sand, one-fourth to one-sixteenth inch thick, occur in the subsoil. The bands are slightly hard when dry and very friable when moist. The subsoil has rapid permeability.

The parent material is very pale brown, moderately acid fine sand that is loose when dry and moist.

In Woodward County the Eufaula and Nobscot soils occur together in an irregular pattern. The Eufaula soils have been mapped only in a complex with the Nobscot soils. Eufaula soils have a very pale brown subsoil that contains less clay than the reddish-yellow subsoil of Nobscot soils. The Eufaula soils are used as rangeland.

Holdrege Series

The Holdrege series consists of deep, well-drained, brown loamy soils of the uplands. These soils occur on gentle slopes throughout the county. They have formed under mid and tall native grasses.

The surface layer of brown loam is about 19 inches thick. It has granular structure and is slightly hard when dry and friable when moist. It is easily worked, but, if this layer is pulverized through excessive tillage, its surface will crust after rains. A plowman is likely to form if tillage is always at the same depth.

The subsoil of brown loam is about 32 inches thick. It has granular structure and is slightly hard when dry and friable when moist. Permeability is moderate, and roots penetrate this layer fairly easily. The subsoil is generally noncalcareous, and neutral in reaction.

The parent material is dark yellowish-brown and brown unconsolidated loamy alluvium and loess. Generally, it is more sandy than the subsoil.

Holdrege soils are more strongly developed than Enterprise soils. They are more loamy and less sandy than Pratt soils. In many places buried soils are under the Holdrege soils.

Holdrege soils are used primarily for small grains and sorghums. Only one soil of this series has been mapped in Woodward County.

Holdrege loam, 1 to 3 percent slopes (HoB), has a surface layer of brown loam over a loam subsoil that takes

water well. This soil occurs around Mooreland and in the southern part of the county.

Up to 10 percent of the acreage of any individual area may be made up of Enterprise or Pratt soils.

Wheat and sorghums are the main crops grown on Holdrege loam, 1 to 3 percent slopes, but all small grains are well suited to the soil. Alfalfa is planted during some years when rainfall is more favorable. This soil is well suited to irrigation.

Management problems are surface crusting, a slight susceptibility to erosion, the breakdown of soil structure, and the formation of a plowpan. (Capability unit IIe-1; Loamy Prairie range site.)

Las Animas Series

The Las Animas series consists of deep, imperfectly drained loamy soils that have a high water table. These soils are on nearly level bottom lands along the rivers and large creeks.

The grayish-brown or brown, calcareous surface layer consists of stratified silty clay loam, fine sandy loam, and silty clay. It is about 17 inches thick and has an average texture of heavy loam. The fine sandy loam material has granular structure and is soft when dry and very friable when moist. The silty clay loam material has granular structure and is slightly hard when dry and friable when moist. The silty clay material has subangular blocky structure and is hard when dry and firm when moist. A few distinct mottles occur in the lower part of the surface layer.

The subsoil is stratified sandy clay loam, fine sandy loam, and medium and fine sands; its average texture is fine sandy loam. This layer is yellowish brown, pale brown, gray, light gray, and light brownish gray. Roots have some difficulty in penetrating the layers of silty clay. Prominent mottles are present. The water table ranges from 3 to 10 feet below the surface.

The parent material is calcareous, stratified sand that has seams of sandy loam, silty clay loam, and silty clay; its average texture is sand.

Profile characteristics of Las Animas soils vary from place to place because of the variations in the alluvial strata. The texture of the surface layer ranges from loamy sand to clay loam.

Only one mapping unit of the Las Animas series occurs in Woodward County.

Las Animas soils (Ia) occur on bottom lands, primarily near the channel of the North Canadian River. They are subirrigated by a high water table. The surface layer, 10 to 15 inches thick, is grayish-brown loamy sand to clay loam.

Up to 10 percent of the acreage of any individual area may consist of Elsmere, Lincoln, or Wann soils.

Most areas of Las Animas soils are used as rangeland and produce an abundance of salt-tolerant grasses. (Capability unit Vw-1; Subirrigated range site.)

Leshara Series

The Leshara series consists of deep, somewhat poorly drained, grayish-brown loamy soils. These soils are on nearly level and gently sloping bottom lands along the larger creeks in the southwestern part of the county.

The surface layer of grayish-brown loam is about 20 inches thick. It has granular structure and is slightly hard when dry and friable when moist. It is easily worked, but, if it is pulverized through excessive tillage, its surface will crust after rains. A plowpan is likely to form if tillage is always at the same depth.

The subsoil of grayish-brown and pale-brown clay loam has subangular blocky structure and is hard when dry and firm when moist. Permeability is slow, and roots have some difficulty in penetrating this layer. The subsoil is calcareous, and in many places it contains accumulations of lime. It has distinct mottles.

The parent material is stratified, calcareous, sandy alluvial sediments. Distinct mottles are less numerous with increasing depth.

In some areas the surface layer is made up of fine sandy loam. The color of the surface layer ranges from dark gray to grayish brown. Characteristics of the soil vary a great deal because of the deposition of fresh sediments from side drains in the uplands.

Only one soil of the Leshara series has been mapped in Woodward County.

Leshara loam (Ie) occurs above areas ordinarily overflowed by creeks, but it receives some water from drains in the uplands. The subsoil of stratified clay loam takes water slowly.

This soil is used for small grains, alfalfa, and sorghums. Management problems are the accumulation of water from side drains, the breakdown of structure in the surface layer, and the formation of a plowpan. (Capability unit IIw-1; Loamy Bottom-Land range site.)

Lincoln Series

The Lincoln series consists of excessively drained, pale-brown fine sands of the bottom lands. The soils occur on broad, irregular topography near major streams.

The pale-brown, calcareous surface layer is about 18 inches thick, single grained, and loose when dry and moist. There has been some damage through wind erosion.

The subsoil of very pale brown fine sand is single grained and is loose when dry and moist. Permeability is rapid, and roots have no difficulty in penetrating this layer. The subsoil is calcareous, and there are few accumulations of lime.

The parent material is calcareous sandy sediments that have been deposited recently and have been reworked somewhat by the wind.

Texture of the surface layer ranges from sand to clay loam, but the average texture is sand. Some of the soils in the northern part of the county consist of material washed from red beds; their texture is similar to that of the other Lincoln soils.

Lincoln soils are used primarily as rangeland. They are generally too sandy for cultivation.

Lincoln loamy fine sand (If) has a surface layer of about 17 inches of grayish-brown to pale-brown loamy sand. Beneath this is a subsoil of loamy sand.

Up to 10 percent of the acreage of any individual area may consist of Wann and other associated soils.

Lincoln loamy fine sand is used primarily for pasture, but small acreages are in sorghums and rye. Management problems are a severe susceptibility to wind erosion, low fertility, the maintenance of organic matter, and drought-

iness. (Capability unit IVE-2; Sandy Bottom-Land range site.)

Lincoln soils (ln) are very sandy and droughty, and they are subject to severe wind erosion. The topography is slightly uneven because of the movement of the sand by wind. Small blowouts are common.

Up to 10 percent of the acreage of any individual area may be made up of Wann, Elsmere, or Las Animas soils.

Lincoln soils are productive of grasses. They should be kept in grasses because of their susceptibility to wind erosion, droughtiness, and flooding by major streams. Overgrazing will result in loss of cover and will permit the soils to erode. (Capability unit VIe-7; Sandy Bottom-Land range site.)

Mansker Series

The Mansker series consists of moderately deep, well-drained, grayish-brown, loamy caliche soils of the uplands. The soils occur on gentle to strong slopes in the western part of the county. They have formed under native grasses.

The grayish-brown surface layer is about 8 inches thick. It has granular structure and is slightly hard when dry and friable when moist. It is easily worked, but, if the soil is pulverized through excessive tillage, the surface will crust after rains and there will be a severe hazard of wind erosion.

The brown subsoil is about 9 inches thick. It has granular structure and is slightly hard when dry and friable when moist. Permeability is moderate, and roots penetrate this layer fairly easily. The subsoil is calcareous, and about 5 percent of the volume consists of caliche concretions.

The parent material is very pale brown, calcareous loamy sediments mixed with 15 to 35 percent caliche (primarily calcium carbonate).

Mansker soils are more strongly developed to a greater depth over the caliche than Potter soils. They are not so sandy as the Pratt or Miles soils. In some areas near the Pratt and Miles soils, their surface layer is fine sandy loam.

Depth to the caliche horizon ranges from 12 to 22 inches. Scattered caliche concretions are on the surface and throughout the profile.

Mansker soils are used for small grains, sorghums, and native grasses.

Mansker loam, 1 to 3 percent slopes (MbB), is a gently sloping soil that has a very limy subsoil. The surface layer is made up of about 8 inches of grayish-brown loamy material. It is underlain by a subsoil of granular clay loam that contains chalky deposits of caliche.

On the low, light-colored knobs are spots of the shallow Potter soil, which makes up as much as 10 percent of an individual area.

Mansker loam, 1 to 3 percent slopes, is used mainly for wheat, but sorghums are also grown successfully. Management problems are a moderate susceptibility to wind erosion, the breakdown of structure in the surface layer, and the formation of a plowpan. (Capability unit IIIe-1; Loamy Plains range site.)

Mansker loam, 3 to 5 percent slopes (MbC), is a moderately sloping soil that has a very limy subsoil. It has a grayish-brown surface layer, about 7 inches thick, over a

granular clay loam subsoil that contains many chalky concretions of caliche. Light-colored spots of caliche are common on the surface.

Up to 10 percent of the acreage of any individual area may consist of Potter soil.

Mansker loam, 3 to 5 percent slopes, is used principally for wheat, but sorghums are also grown successfully. Management problems are a severe susceptibility to erosion, the breakdown of structure in the surface layer, and the formation of a plowpan. (Capability unit IVE-1; Loamy Plains range site.)

Mansker-Potter loams, 5 to 12 percent slopes (McD), consists of a mixture of Mansker and Potter soils. These loamy soils occur in an irregular pattern on steeply sloping uplands. The Mansker soil has approximately 8 inches of loam over a granular clay loam subsoil that takes water well. The Potter soil, which is more shallow over caliche, takes water fairly well.

These soils occur in such a pattern that they must be used in the same way. They are productive grassland and should be kept in grasses. (Capability unit VIe-1; Loamy Plains and Shallow range sites.)

Miles Series

The Miles series consists of deep, well-drained, brown fine sandy loams of the uplands. The soils are on gentle and moderate slopes, primarily in the western part of the county. They have formed under mid and tall native grasses.

The brown surface layer is about 9 inches thick. It has granular structure and is soft when dry and very friable when moist. This layer is easily worked, but excessive tillage will pulverize it and destroy the needed crop residues. A plowpan is likely to form if tillage is always at the same depth.

The subsoil of brown or reddish-brown sandy clay loam is about 30 inches thick. It has coarse, prismatic structure that breaks easily to granular. The subsoil is hard when dry but friable when moist. A few waterworn pebbles occur. Permeability is moderate, and roots penetrate this layer fairly easily. The subsoil is noncalcareous in the upper part and calcareous in the lower part. Generally, there is no accumulation of lime.

The parent material is mainly calcareous, stratified sandy and loamy sediments.

Miles soils are more sandy than Mansker soils. They have more clay in the subsoil than Pratt soils. The surface horizon ranges from brown to reddish brown. The subsoil ranges from heavy fine sandy loam to heavy sandy clay loam in texture and from brown to reddish brown in color.

The Miles soils are used for sorghums and small grains. They need a protective cover of growing crops or crop residues on the surface at all times.

Miles fine sandy loam, 1 to 3 percent slopes (MfB), is a gently sloping soil. It has a surface layer, approximately 10 inches thick, of dark-brown sandy loam. Beneath this is a subsoil of sandy clay loam that takes water well.

Up to 10 percent of the acreage of any individual area may be made up of Pratt or Mansker soils.

Miles fine sandy loam, 1 to 3 percent slopes, is used primarily for sorghums and wheat. During years of

favorable rainfall, alfalfa is often planted, but the stands die out during droughts. The soil is well suited to sprinkler irrigation.

Management problems are the maintenance of organic matter, a susceptibility to wind erosion, and the formation of a plowpan. (Capability unit IIIe-2; Sandy Prairie range site.)

Miles fine sandy loam, 3 to 5 percent slopes (MfC), is a moderately sloping soil. It has a surface layer, about 7 inches thick, of brown fine sandy loam, which is underlain by a subsoil of sandy clay loam that takes water well.

Up to 10 percent of the acreage of any individual area may be made up of Mansker or Pratt soils.

Most of Miles fine sandy loam, 3 to 5 percent slopes, is used for sorghums and wheat. Management problems are the maintenance of organic matter, a susceptibility to erosion, the formation of a plowpan, and in places, uneven topography. (Capability unit IVe-2; Sandy Prairie range site.)

Nobscot Series

The Nobscot series consists of deep, somewhat excessively drained sandy soils of the uplands. The soils occur in areas of shinnery oak and blackjack oak.

The upper layer consists of about 20 inches of fine sand. The top 5 inches is grayish brown, and the lower 15 inches is pale brown. The fine sand is loose when dry or moist. Excessive tillage exposes the soil to wind erosion. The surface layer is highly susceptible to blowing.

The subsoil of reddish-yellow fine sand is about 34 inches thick. It is single grained and is slightly hard when dry but very friable when moist. It is moderately to strongly acid. The subsoil has irregular, horizontal, yellowish-red bands, one-half to one-sixteenth inch thick. The bands are of loamy fine sand and fine sandy loam texture and are 2 to 8 inches apart. When the material in the bands and the fine sand between the bands are mixed together, the texture is heavy fine sand that approaches loamy fine sand. Permeability is rapid, and roots penetrate the subsoil fairly easily.

The parent material is slightly acid, stratified mixed sediments. It extends many feet deep over the contact with the red beds.

Nobscot soils have more clay in the subsoil than Eufaula soils. They have less clay in the subsoil than Brownfield soils. Nobscot soils have formed under forest and have an acid profile; Pratt soils, in contrast, have formed under prairie and have a neutral profile. In some areas the surface layer of Nobscot soils consists of loamy fine sand. In places it is brown. The lower part of the surface layer darkens if the soils are cultivated. Where slopes are steeper, the profiles of these soils are more variable.

Nobscot soils are used primarily for the grazing of livestock. Because of the risk of erosion, these soils need a cover crop or crop residue on the surface at all times.

Nobscot-Brownfield fine sands, 3 to 5 percent slopes (NbC), consists of two very sandy soils. These soils occur in an irregular pattern, so it was not practical to map them separately. They are on low, moderately sloping dunes in areas of shinnery oak in the southwestern part of the county. The Nobscot soil makes up approximately 60 percent of the mapping unit, and the Brownfield soil, approximately 40 percent. Both soils have a surface

layer of brown fine sand. The Brownfield soil has a sandy clay loam subsoil, the Nobscot soil, a loamy fine sand subsoil.

These soils are used primarily for woody pasture. Small acreages are used for sorghums and rye.

Management problems are a severe susceptibility to wind erosion, low fertility, the maintenance of organic matter, and the difficulty in establishing stands of crops. (Capability unit IVe-2; Deep Sand Savannah range site.)

Nobscot-Brownfield complex, severely eroded (Nc3), consists of two very sandy soils that occur in an irregular pattern. The soils are on moderate slopes in areas of shinnery oak in the southwestern part of the county. The Brownfield soil makes up approximately 40 percent of the mapping unit, and the Nobscot, approximately 60 percent. Uncrossable gullies, 2 to 6 feet deep, occur in most areas.

These severely eroded soils were once farmed. They are best suited for rangeland. (Capability unit VIe-3; Deep Sand Savannah range site.)

Nobscot-Eufaula fine sands, 5 to 12 percent slopes (NeD), consists of a mixture of two very sandy soils that lie in an irregular pattern. The soils are in strongly sloping to steep areas of shinnery oak, primarily in the southwestern part of the county. Nobscot soil makes up most of the acreage. Eufaula soil accounts for 5 to 50 percent of individual areas and from 15 to 20 percent of the total acreage. Both soils take water well but are extremely susceptible to wind erosion.

These soils are used as rangeland. (Capability unit VIe-3; Deep Sand Savannah range site.)

Nobscot-Pratt complex, hummocky (NpC), is made up of two deep sandy soils that lie in an irregular pattern in areas of blackjack oak. The soils are moderately sloping. These Nobscot and Pratt soils take water well, but, if cultivated, they are susceptible to severe wind erosion. Consequently, they are used mainly as woody rangeland. (Capability unit IVe-2; Deep Sand Savannah and Deep Sand range sites.)

Nobscot-Pratt complex, duned (NpE), consists of two deep sandy soils that lie in an irregular pattern in areas of blackjack oak. The soils have steep slopes. They are of loamy fine sand and fine sand texture, and they take water well. If cultivated, however, these soils are susceptible to severe wind erosion. They are used mostly as woody rangeland. (Capability unit VIe-3; Deep Sand Savannah and Deep Sand range sites.)

Otero Series

The Otero series consists of moderately deep, somewhat excessively drained, grayish-brown sandy soils of the upland. The soils are on gentle slopes in the western part of the county. They are forming under native grasses.

The surface layer of grayish-brown loamy fine sand is about 12 inches thick. It is single grained and is soft when dry and very friable when moist. It has scattered concretions of caliche, up to one-half inch in diameter. The soil is easily worked, but excessive tillage pulverizes it and may result in severe wind erosion.

The subsoil of pale-brown loamy fine sand is about 8 inches thick. It is single grained and is soft when dry and very friable when moist. The number of caliche concretions increases with depth, but caliche makes up less

than 5 percent of the subsoil. Permeability is rapid, and roots penetrate the subsoil fairly easily.

The parent material is mixed calcareous sands. Caliche makes up about 5 percent of the parent material. There are small amounts of small waterworn pebbles.

Otero soils are less developed and more calcareous than Pratt soils. In some areas the texture of the uppermost 5 inches is fine sandy loam.

Only one soil of the Otero series has been mapped in Woodward County.

Otero loamy fine sand, undulating (O₁B), is a sandy soil that contains an excessive amount of caliche. This soil is on low dunes in the western part of the county. It takes water rapidly, but, if cultivated, it is susceptible to severe wind erosion.

Up to 10 percent of the acreage of any individual area may consist of Pratt or Mansker soils.

Otero loamy fine sand, undulating, is used primarily as rangeland and for growing sorghums. A growing crop or crop residues must be kept on the surface at all times to provide protection against erosion. (Capability unit IVE-2; Limy Sandy Plains range site.)

Port Series

The Port series consists of deep, moderately well drained, brown loamy soils. The soils occur on nearly level bottom lands near the major streams.

The surface layer of brown or reddish-brown loam is about 20 inches thick. It has granular structure and is slightly hard when dry and friable when moist. This layer is very fertile and easily worked, but, if it is pulverized through excessive tillage, its surface will crust after rains. A plowpan is likely to form if tillage is always at the same depth.

The reddish-brown subsoil is stratified but averages light clay loam in texture and is about 26 inches thick. It has granular structure and is slightly hard when dry and friable when moist. Permeability is moderate to moderately slow. Roots penetrate this layer fairly easily. The subsoil is generally calcareous, but in only a few places are there accumulations of lime.

The parent material is calcareous, stratified, mixed sediments.

Port soils are more silty and clayey than Yahola soils. Sandy strata are generally below a depth of 4 feet. Buried soils are common but not present everywhere. In some areas the surface layer is of clay loam texture. The texture of the subsoil ranges from heavy loam to clay loam.

Only one soil of the Port series has been mapped in Woodward County.

Port loam (Pc) is a dark-colored soil that occurs mostly south of the North Canadian River. It lies above areas that are ordinarily overflowed. The surface layer of brown, granular loam is underlain by a clay loam subsoil that takes water fairly well.

Up to 10 percent of the acreage of any individual area may be made up of Yahola fine sandy loam, high.

Port loam is valuable for dryland farming and for irrigation farming. It is used for wheat, alfalfa, sorghums, and all other crops suited to the climate.

Management problems are surface crusting, the disposal of run-in water that comes from the uplands, the

breakdown of structure in the surface layer, and the formation of a plowpan. (Capability unit I-1; Loamy Bottom-Land range site.)

Potter Series

The Potter series consists of shallow, somewhat excessively drained, grayish-brown, loamy, caliche soils of the uplands. They occur primarily in the western part of the county. They are forming under mid and short native grasses.

The surface layer of grayish-brown loam is about 6 inches thick. It has granular structure and is slightly hard when dry and friable when moist. It is easily worked, but, if it is pulverized through excessive tillage, its surface will crust after rains and there will be a severe hazard of wind erosion.

The subsoil of brown light clay loam is about 4 inches thick. It has a granular structure and is slightly hard when dry and friable when moist. This layer is a mixture of light clay loam and subrounded caliche pebbles. Permeability is moderate.

The parent material is caliche that is either hard and consolidated or chalky and semi-indurated. Below a depth of 3 feet, the content of caliche decreases and there are various strata of mixed sediments.

Potter soils are less strongly developed than Mansker soils. In some areas near Pratt and Miles soils, the surface layer of the Potter soils consists of fine sandy loam. Many scattered caliche pebbles are on the surface.

The Potter soils are used primarily as rangeland. In less sloping areas, they are used to grow small grains or sorghums. Potter soils are mixed with Mansker soils, and, therefore, the fields have an uneven appearance. During some years, chlorosis (iron deficiency) can be expected in sorghums grown on Potter soils.

In Woodward County the Potter soils are mapped in a complex with the Mansker soils. This complex is described under the Mansker series.

Pratt Series

The Pratt series consists of somewhat excessively drained, brown sandy soils of the uplands. The soils occur in areas of undulating to duned topography. They have formed under tall native grasses.

The surface layer of brown loamy fine sand is about 12 inches thick. It is single grained and is slightly hard when dry and friable when moist. It is easily worked but can be damaged through excessive tillage. It is susceptible to severe wind erosion. A plowpan is likely to form if tillage is always at the same depth.

The subsoil of yellowish-brown loamy fine sand is about 30 inches thick. It has weak, granular structure and is slightly hard when dry and very friable when moist. Permeability is rapid, and roots have little difficulty in penetrating this layer. The subsoil is generally noncalcareous and neutral in reaction.

The parent material is wind-deposited sand that has been rolled and bounced from stream channels to the uplands.

Pratt soils are more strongly developed than Otero soils. They have less clay in the subsoil than Miles soils. Pratt soils, which have formed under prairie, have gradual

boundaries between soil layers, while the Nobscot soils, which have formed under forest, have abrupt boundaries.

The surface layer of the Pratt soils is loamy fine sand or fine sandy loam. The fine sandy loam texture occurs in the more nearly level areas. The surface layer ranges from 8 to 15 inches in thickness. In some places it is grayish brown. Near the red beds the Pratt soils are redder.

Small areas consisting of remnants of gravelly outwash are included with Pratt soils.

The Pratt soils on dunes are used primarily as rangeland. Less sloping Pratt soils are used as rangeland and for growing sorghums or small grains. All Pratt soils need a cover crop or crop residue on the surface at all times for protection against wind erosion.

In Woodward County the Pratt soils are mapped separately and also in complexes with the Carwile soils, the Enterprise soils, the Nobscot soils, and the Tivoli soils.

Pratt fine sandy loam, hummocky (PbC), occurs on low, moderately sloping dunes. The dark-brown or dark grayish-brown surface layer is underlain by a granular sandy loam subsoil that takes water well.

Up to 10 percent of the acreage in any individual area may be made up of associated soils.

Pratt fine sandy loam, hummocky, is used primarily for grain sorghum. Management problems are the maintenance of organic matter, a moderate susceptibility to wind erosion, and the formation of a plowpan. (Capability unit IVe-2; Sandy Prairie range site.)

Pratt fine sandy loam, undulating (PbB), is a gently sloping soil that has uneven relief. The dark-brown and dark grayish-brown surface layer, approximately 14 inches thick, is underlain by a granular sandy loam subsoil that takes water well.

Up to 10 percent of the acreage of any individual areas may be made up of associated soils.

Pratt fine sandy loam, undulating, is used primarily for grain sorghum and wheat. All small grains are suited to this soil. Alfalfa is occasionally planted during years of favorable rainfall.

Management problems are the maintenance of organic matter, a susceptibility to wind erosion, and the formation of a plowpan. (Capability unit IIIe-2; Sandy Prairie range site.)

Pratt loamy fine sand, hummocky (PfC), is on low sandy dunes and in narrow valleys between the dunes. It occurs throughout the sandy areas of the county. The brown or grayish-brown loamy fine sand surface layer is underlain by a loamy fine sand subsoil that takes water well.

Up to 10 percent of the acreage of any individual area may be made up of Carwile and other associated soils.

Pratt loamy fine sand, hummocky, produces low but dependable yields of crops. It is used primarily for sorghums and small grains. If improperly managed, the soil is susceptible to severe wind erosion. Other management problems are the maintenance of organic matter, low fertility, and the difficulty in establishing stands of crops. (Capability unit IVe-2; Deep Sand range site.)

Pratt loamy fine sand, undulating (PfB), lies between the larger sand dunes. It occurs throughout the sandy areas of the county. The surface layer of brown or grayish-brown loamy fine sand is underlain by a subsoil of loamy fine sand that takes water rapidly.

Up to 10 percent of the acreage of individual areas is made up of Carwile and other associated soils.

Pratt loamy fine sand, undulating, produces low but dependable yields of sorghums and wheat. Management problems are the severe susceptibility to wind erosion, low fertility, and the difficulty in establishing stands of crops. (Capability unit IIIe-2; Deep Sand range site.)

Pratt-Tivoli loamy fine sands (Pt) consists of a mixture of sandy soils that lie in an irregular pattern. The soils are on steep dunes and in narrow valleys between dunes. They occur throughout the sandy areas of the county. The surface layer of brown and grayish-brown loamy fine sand is underlain by a subsoil of loamy fine sand that takes water rapidly.

These soils produce high yields of grasses, but they are not suited to cultivation. (Capability unit VIe-2; Deep Sand and Dune range sites.)

Quinlan Series

The Quinlan series consists of shallow, somewhat excessively drained, red loamy soils of the uplands. The soils occur on sloping areas of the red beds. They are forming under native grasses.

The surface layer of red or reddish-brown loam is about 9 inches thick. It has a granular structure and is slightly hard when dry and friable when moist. This layer is easily worked.

The red subsoil is a mixture of loam and weathered sandstone. It is about 4 inches thick. Permeability is moderate, and roots penetrate this layer fairly easily. The subsoil is calcareous, but it has accumulations of lime in only a few places.

The parent material is reddish, weakly consolidated sandstone and sandy shale.

Quinlan soils have not developed to so great a depth as the Woodward soils.

The Quinlan soils are used primarily as rangeland. In less sloping areas, they are intermixed with Woodward soils. In these places they are used for small grains, sorghums, and grasses. Chlorosis (iron deficiency) can be expected if sorghums are grown.

Quinlan loam (Qm) is a shallow, steep soil. It has approximately 13 inches of reddish, calcareous loam that grades to highly weathered, fine-grained, calcareous sandstone.

Up to 10 percent of the acreage of any individual area may consist of Woodward or Vernon soils.

Quinlan loam is used primarily as rangeland. It takes water well if the range grasses are not overgrazed. (Capability unit VIe-4; Shallow Prairie range site.)

Quinlan-Woodward loams, 3 to 5 percent slopes, eroded (QwC2), consists of soils that lie in an irregular pattern on moderate slopes throughout the red beds. The shallow Quinlan soil occurs on low hills or knobs, and the moderately deep Woodward soil occurs in valleys and on footslopes. Both soils have a reddish-brown loamy surface layer and subsoil. They differ only in depth to weathered sandstone or sandy shale.

Small acreages of Carey soil are included in this mapping unit.

The soils of this mapping unit occur in such a pattern that they are used together, mainly for small grains and sorghums and as rangeland. Management problems are

a susceptibility to water erosion, surface crusting, the breakdown of structure in the surface layer, the formation of a plowpan, the danger of chlorosis in sorghums grown on the Quinlan soil, and the shallowness of the Quinlan soil. (Capability unit IVe-1; Shallow Prairie and Loamy Prairie range sites.)

Quinlan-Woodward loams, 5 to 12 percent slopes (QwD), consists of reddish, shallow and moderately deep, steep loamy soils that occur in an irregular pattern. The Quinlan soil makes up more than half of the acreage, and the Woodward soil, most of the rest.

Small amounts of Vernon or Carey soils occur in some areas.

Quinlan-Woodward loams, 5 to 12 percent slopes, is not suited to cultivation. Small acreages have been used for crops, but the areas are now used primarily as rangeland. (Capability unit VIe-4; Shallow Prairie and Loamy Prairie range sites.)

Quinlan-Woodward loams, 5 to 12 percent slopes, eroded (QwD2), occurs in an irregular pattern on steep slopes. The shallow Quinlan soil makes up most of the acreage, and the moderately deep Woodward soil, the rest.

This mixture of soils is too steep and generally too shallow to be suited to cultivation. The soils have been used as cropland but should be returned to grasses. (Capability unit VIe-4; Shallow Prairie and Loamy Prairie range sites.)

Rough Broken Land

Rough broken land (Rb) is a miscellaneous land type that consists of canyonlike drains or escarpments in areas of the red beds. The red or reddish-brown surface layer varies from place to place.

Areas in the Sandstone Canyon have steep, almost vertical sides, 30 to 60 feet high, on which there is no vegetation or only a very thin cover. On the bottom of the canyon there is a mixture of soil material that supports fair stands of grasses. This material, however, is shifted about from year to year, and some is eroded away. In areas of shale, the canyon walls are not so near vertical but support little vegetation.

Because much of the surface is barren, exposed, and affected by geological erosion, Rough broken land is difficult for livestock to graze. (Capability unit VIIe-2; Breaks range site.)

St. Paul Series

The St. Paul series consists of deep, moderately well drained, brown loamy soils of the uplands. The soils occur on the less sloping areas in the red beds.

The surface layer of brown silt loam is generally about 17 inches thick. It has granular structure and is slightly hard when dry and friable when moist. This layer is easily worked, but, if it is pulverized through excessive tillage, its surface will crust after rains. A plowpan is likely to form if tillage is always at the same depth.

The subsoil of reddish-brown clay loam is about 30 inches thick. It has subangular blocky structure and has clay films on the surfaces of the blocks. The subsoil is hard when dry and friable to firm when moist. Permeability is moderately slow, and roots have some difficulty

in penetrating this layer. Roots are abundant but are more numerous on the surfaces of the blocks than on the insides. The upper part of the subsoil is noncalcareous, and the lower part is calcareous. In many places soft lime concretions, threadlike or rounded, have accumulated in the lower part of the subsoil.

The St. Paul soils are darker in the surface layer and upper part of the subsoil than the Carey soils, and they contain more clay in the subsoil.

In some areas where the parent material has been reworked by water, the St. Paul soils have a very deep profile. Commonly, the effective soil depth is 60 inches or more. The surface layer is 10 to 20 inches thick.

St. Paul soils are used primarily for small grains. Some native grasses, sorghums, and alfalfa are also grown.

St. Paul silt loam, 0 to 1 percent slopes (ScA), has approximately 18 inches of brown, granular silt loam over a clay loam subsoil that takes water fairly well. The soil occurs throughout the more level areas of the red beds.

Up to 10 percent of the acreage of any individual area may consist of Carey soil.

St. Paul silt loam, 0 to 1 percent slopes, is productive. It is used mainly for cultivated crops; very little of it is in pasture. Wheat is the main crop, and yields are as high as those obtained on any of the soils of the uplands. Other small grains, sorghums, and, occasionally, alfalfa are also grown. The soil is well suited to all types of irrigation.

Management problems are surface crusting, the breakdown of structure in the surface layer, a slight susceptibility to wind erosion, the accumulation of water from sloping uplands, and the formation of a plowpan. (Capability unit IIc-1; Hardland range site.)

St. Paul silt loam, 1 to 3 percent slopes (ScB), is gently sloping. It has about 14 inches of brown, granular silt loam over a clay loam subsoil that takes water fairly well. The main area of this soil is in the northeastern part of the county. Small areas are scattered throughout the red beds.

Up to 10 percent of the acreage in any individual area may consist of Carey or Vernon soils.

St. Paul silt loam, 1 to 3 percent slopes, is used primarily for wheat, but other small grains are also grown. Sorghums are grown with limited success.

Management problems are surface crusting, the breakdown of structure in the surface layer, a slight susceptibility to wind and water erosion, and the formation of a plowpan. (Capability unit IIe-1; Hardland range site.)

St. Paul silt loam, 3 to 5 percent slopes (ScC), is moderately sloping. It has about 11 inches of brown, granular silt loam over a clay loam subsoil that takes water fairly well. The main area of this soil is in the northeastern part of the county. Smaller areas are scattered throughout the red beds.

Up to 10 percent of the acreage of any individual area may consist of Carey or Vernon soils.

St. Paul silt loam, 3 to 5 percent slopes, is used primarily for wheat, but other small grains are grown. Sorghums are grown with limited success.

Management problems are surface crusting, the breakdown of structure in the surface layer, a moderate susceptibility to water erosion, and the formation of a plowpan. (Capability unit IIIe-1; Hardland range site.)

Sweetwater Series

The Sweetwater series consists of imperfectly drained, gray, loamy soils of the bottom lands that have a high water table. The soils occur primarily along the major streams in the southwestern part of the county. They are forming under mid and tall native grasses.

The gray surface layer is made up of stratified silt loam, silty clay loam, and fine sandy loam. It has granular structure and is slightly hard when dry and friable when moist.

The gray or grayish-brown, mottled subsoil consists of stratified sandy loam, sandy clay loam, silt, and clay; it is more sandy with increasing depth. Permeability is slow, and roots are affected by the high water table.

The parent material is calcareous, stratified sediments of different textures but is typically sandy loam. It has distinct gray- and rust-colored mottles.

Sweetwater soils are more strongly developed than Las Animas soils. The surface layer of the Sweetwater soil ranges from dark gray to very dark grayish brown in color, and from sandy loam to silty clay loam in texture. In small areas the soils have a peatlike surface layer, 3 inches thick. The average texture of the uppermost 30 inches is calcareous heavy loam.

Sweetwater soils (Sw) are subirrigated by a water table that is close to the surface.

Up to 10 percent of the acreage in any individual area may be made up of Leshara soils.

Sweetwater soils are productive grassland, but they are slightly saline and are frequently flooded. Salt-tolerant grasses, such as inland saltgrass and alkali sacaton, are often dominant, but bottom-land switchgrass does well under good management. (Capability unit Vw-1; Subirrigated range site.)

Tivoli Series

The Tivoli series consists of excessively drained, pale-brown sandy soils. The soils occur as steeply sloping sand dunes on a broad, irregular plain. The native vegetation is tall grasses and scattered sand sagebrush.

The surface layer of fine sand is about 7 inches thick. It is single grained, loose when dry and moist, and very susceptible to wind erosion, particularly if cultivated.

The subsoil of yellow fine sand is many feet thick. It is single grained and is loose when dry and moist. Permeability is very rapid, and grass roots sometimes do not obtain enough moisture. The subsoil is generally noncalcareous and neutral in reaction.

The parent material is made up of weathered fine sand that have been rolled and bounced by wind from stream channels to the uplands.

Tivoli soils are not so dark in the surface layer and upper part of the subsoil as Pratt soils, and they contain less clay in the subsoil.

The surface layer of the Tivoli soils is brown, pale brown, or light yellowish brown. The parent material is yellow, pale brown, or reddish yellow. In some areas the surface layer is of loamy fine sand texture.

These soils are used primarily as rangeland.

Tivoli fine sand (Tv) has about 7 inches of pale-brown very sandy soil over loose fine sand that takes water very rapidly.

Up to 10 percent of the acreage in any individual area may be made up of Pratt or Carwile soils.

Tivoli fine sand has many small blowouts between bunches of tall native grasses and sagebrush and other woody plants. Overgrazing may quickly result in loss of cover and permit the soil to be blown. Careful grazing management is needed to maintain the productivity of rangeland. (Capability unit VIIe-3; Dune range site.)

Treadway Series

The Treadway series consists of youthful, poorly drained, reddish-brown soils on nearly level flood plains in the northeastern part of the county.

Highly weathered parent material, consisting of reddish-brown and red clay, extends from the surface to a depth of about 40 inches. It is massive and is very hard when dry and very firm when moist. Grass roots have difficulty in penetrating this slowly permeable material.

Gypsiferous, calcareous, stratified sand is beneath the clay. It ranges from 20 to 80 inches in thickness.

Only one soil of the Treadway series has been mapped in Woodward County.

Treadway clay (Tw) is a reddish clayey soil of the bottom lands. It is difficult to cultivate and is best suited to native grasses. The short and fairly tall native grasses do not completely cover the areas; bare areas are common between bunches of grass. (Capability unit VIc-1; Red Clay Flats range site.)

Vernon Series

The Vernon series consists of shallow, somewhat excessively drained, reddish-brown clay loams of the uplands. The soils are on gentle to strong slopes throughout the northeastern part of the county. They formed under native grasses.

The surface layer of reddish-brown clay loam is about 7 inches thick. It has a granular structure and is slightly hard when dry and friable to firm when moist. The soils are fairly easy to work, but tillage on the strong slopes causes extremely severe water erosion.

The subsoil of reddish-brown clay loam is about 8 inches thick. It has subangular blocky structure and is hard when dry and firm when moist. Permeability is moderately slow, and roots have some difficulty in penetrating this layer. The surface layer and subsoil are calcareous, but they generally contain no accumulation of lime.

The parent material is weathered, calcareous, gypsiferous clay that has thin seams of gypsum.

Vernon soils are redder and less dark in the surface layer and upper part of the subsoil than St. Paul soils. In some areas the surface layer is of clay texture.

Areas of Vernon soils on gentle to moderate slopes are used for small grains and as rangeland. The more sloping areas are used as rangeland.

Vernon clay loam, 0 to 3 percent slopes (VcB), is a gently sloping soil that occurs in red beds. This youthful, erodible soil is in the northeastern part of the county between the steep escarpments and the Cimarron River. The surface layer of dark reddish-brown clay loam is over a clay subsoil that takes water very slowly.

Up to 10 percent of the acreage in any individual area may be made up of St. Paul soils.

Vernon clay loam, 0 to 3 percent slopes, is used primarily for wheat and as rangeland. Management problems are susceptibility to water erosion, limited suitability to crops, droughtiness during summer, and difficulty in establishing stands of crops. (Capability unit IIIe-1; Red Clay Prairie range site.)

Vernon clay loam, 3 to 5 percent slopes (VcC), is a moderately sloping soil of the red beds. It is on high ridges in the northeastern part of the county. The surface layer of reddish-brown clay loam to loam is underlain by a clay loam subsoil that takes water slowly.

Up to 10 percent of the acreage of any individual area may be made up of St. Paul soils.

Vernon clay loam, 3 to 5 percent slopes, is used primarily as rangeland, but small areas are used for wheat and other small grains. Management problems are a susceptibility to water erosion, the limited suitability for crops, and droughtiness during summer. (Capability unit IVe-1; Red Clay Prairie range site.)

Vernon clay loam, 5 to 12 percent slopes (VcD), is a strongly sloping soil of the red beds. It occurs in the northeastern part of the county. The surface layer of the reddish-brown clay loam is underlain by a clay loam subsoil that takes water slowly.

Up to 10 percent of the acreage of any individual area may be made up of Cottonwood and other associated soils.

Vernon clay loam, 5 to 12 percent slopes, is used as rangeland. When properly managed, it supports a cover of short and fairly tall native grasses. Overgrazing causes some erosion and results in bare spots. (Capability unit VIe-6; Shallow Clay Prairie range site.)

Vernon-badland complex (Vm) consists of an irregular pattern of shallow clayey soil and badland. It occurs in the northeastern part of the county. Most areas have a very thin cover of mesquite, cactus, and short native grasses, but bare spots are common. Layers of various kinds and colors of gypsum are scattered throughout the clayey soil. Geological erosion is very rapid, and in many places there are remnants of soil material that resemble chimneys.

This complex of soils is used as rangeland. Very careful management is required to maintain even a thin cover of vegetation. (Capability unit VIIe-4; Shallow Clay Prairie and Eroded Red Clay range sites.)

Vernon-Cottonwood complex (Vp) consists mainly of a mixture of shallow clayey Vernon soil and shallow loamy Cottonwood soil. Vernon clay loam (on slopes of 5 to 12 percent) occupies about half the acreage. The rest is made up of Cottonwood soil interspersed with exposed gypsum rock, which shows the degree of erosion on this soil.

This complex of soils is used as rangeland. (Capability unit VIIe-1; Shallow Clay Prairie and Gyp range sites.)

Wann Series

The Wann series consists of sandy soils of the bottom lands. The soils are along the major streams in association with the Las Animas and Lincoln soils. They have formed under grasses and scattered trees.

Wann soils are occasionally flooded. They are highly stratified and calcareous, and their profile varies from

place to place. On the average, the uppermost 30 inches is heavy sandy loam. But in an individual area the soil material may be 12 inches of grayish-brown loam over 8 inches of stratified material that collectively is brown loam. The subsoil is a pale-brown, light fine sandy loam. At a depth of 48 inches, there is sand that has a few mottles. The parent material of these soils consists of mixed sediments.

Wann soils are deeper to the water table, are less mottled, and have fewer variations in their profile than Las Animas soils. They are not so sandy as Lincoln soils.

In Woodward County only the fine sandy loam type of the Wann series has been mapped. In small, irregular areas, however, the texture of the soil varies.

Wann fine sandy loam (Wf) is a deep, nearly level soil. It is stratified and ranges from loamy sand to clay loam.

Up to 10 percent of the acreage of any individual area may consist of Las Animas, Elsmere, Lincoln, or Leshara soils.

Wann fine sandy loam is used primarily as rangeland, but it produces good yields of cultivated crops. Management problems are occasional overflow, the maintenance of organic matter, the formation of a plowpan, and the difficulty that results from variation in texture of the surface layer. (Capability unit IIw-1; Loamy Bottom-Land range site.)

Woodward Series

The Woodward series consists of moderately deep, well-drained loamy soils of the uplands. The soils occur on gentle to strong slopes throughout the red beds. They have formed under native grasses.

The surface layer of reddish-brown loam is about 10 inches thick. It has granular structure and is slightly hard when dry and friable when moist. It is easily worked, but, if it is pulverized through excessive tillage, its surface will crust after rains. A plowpan is likely to form if tillage is always at the same depth.

The subsoil of reddish-brown loam is about 16 inches thick. It has granular structure and is slightly hard when dry and friable when moist. Permeability is moderate, and roots penetrate this layer fairly easily.

The subsoil, as well as the surface layer, is generally calcareous. In a few places, accumulations of lime occur in the subsoil.

The parent material is fine-grained, loosely cemented, calcareous sandstone. There are generally accumulations of lime in the upper part, or along the bedding planes.

Woodward soils are redder and less dark in the surface layer and in the upper part of the subsoil than Carey soils, and they contain less clay in the subsoil. Their surface layer is less red and their subsoil is more strongly developed than corresponding layers in the Quinlan soils.

In small areas the surface layer is silt loam or very fine sandy loam. The Woodward soils on foot slopes have a deep profile.

The Woodward soils are well suited to small grains, sorghums, and native grasses. Wheat is the principal cultivated crop.

Woodward loam, 1 to 3 percent slopes (WoB), is a gently sloping soil. It has about 10 inches of reddish-brown

loam over a subsoil of granular loam that takes water well. The subsoil grades to soft, highly weathered sandstone or sandy shale.

Spots of the more shallow Quinlan soils are common within areas of this soil. Up to 10 percent of the acreage of any individual area may consist of Quinlan or Carey soils.

Woodward loam, 1 to 3 percent slopes, is used primarily for wheat and sorghums. Yields are seldom high but are fairly dependable from year to year.

Management problems are surface crusting, a susceptibility to water erosion, the breakdown of structure in the surface layer, the formation of a plowpan, and, in the shallow spots, the danger of chlorosis (iron deficiency) in sorghums. (Capability unit IIe-1; Loamy Prairie range site.)

Woodward loam, 3 to 5 percent slopes (WoC), is a moderately sloping soil. It has about 10 inches of reddish-brown loam over a subsoil of granular loam that takes water well.

Spots of the more shallow Quinlan soils are common within this mapping unit. Up to 10 per cent of the acreage of any individual area may consist of Quinlan or Carey soils.

Woodward loam, 3 to 5 percent slopes, is used primarily for wheat and sorghums. Yields are seldom high but are fairly dependable from year to year.

Management problems are surface crusting, a susceptibility to water erosion, the breakdown of structure in the surface layer, the formation of a plowpan, and, in shallow spots, the danger of chlorosis in sorghums. (Capability unit IIIe-1; Loamy Prairie range site.)

Woodward loam, 5 to 8 percent slopes (WoD), is a strongly sloping soil that occurs in small areas throughout the red beds. It has about 10 inches of reddish-brown loam over a subsoil of granular loam that takes water well.

Spots of the more shallow Quinlan soils are common within this mapping unit.

Woodward loam, 5 to 8 percent slopes, is used primarily for wheat and as rangeland. Sorghums are also grown successfully.

Management problems are surface crusting, a severe susceptibility to water erosion, the breakdown of structure in the surface layer, the formation of a plowpan, and, in shallow spots, the danger of chlorosis in sorghums. (Capability unit IVe-1; Loamy Prairie range site.)

Woodward-Quinlan loams, 3 to 5 percent slopes (WwC), consists of soils that occur in an irregular pattern on moderately sloping areas. The moderately deep Woodward soil is in valleys and on foot slopes; the shallow Quinlan soil is on low hills and knobs. The Woodward and Quinlan soils have both a reddish-brown loamy surface layer and subsoil. They differ only in depth to weathered sandstone or sandy shale. Small spots of Carey or Vernon soils occur in some areas.

This mapping unit is used primarily as rangeland. Management problems are a susceptibility to water erosion, surface crusting, the breakdown of structure in the surface layer, the formation of a plowpan, and, in Quinlan soil, shallowness and the danger of chlorosis in sorghums. (Capability unit IVe-1; Loamy Prairie and Shallow Prairie range sites.)

Yahola Series

The Yahola series consists of well-drained sandy soils on bottom lands. The soils occur on flood plains along streams that drain the red beds.

The surface layer of reddish-yellow fine sandy loam is about 14 inches thick. It has granular structure and is slightly hard when dry and very friable when moist. It is easily worked but, if it is pulverized through excessive tillage, its surface will crust after hard rains. A plowpan is likely to form if tillage is always at the same depth.

The reddish-yellow subsoil is stratified loam, loamy sand, sandy loam, and silt that collectively form a fine sandy loam. This layer has granular structure and is slightly hard when dry and very friable when moist. Permeability is moderately rapid, and roots penetrate this layer fairly easily. The subsoil, as well as the surface layer, is generally calcareous but has no accumulations of lime.

The parent material is reddish, sandy and loamy calcareous sediments. Yahola soils are occasionally overflowed, and fresh sediments are then deposited. They are more sandy than Port soils.

The Yahola soils are well suited to small grains, sorghums, and native grasses. Wheat is the principal cultivated crop.

Yahola fine sandy loam (Ya) is a nearly level soil. It has a surface layer of reddish-yellow or reddish-brown fine sandy loam that is underlain by a moderately sandy subsoil that takes water well.

This soil is productive, but it generally occurs in narrow bands that are next to areas of soils that are not suited to cultivation. Consequently, it is used primarily for pasture, but some sorghums, wheat, and alfalfa are grown.

Management problems are the occasional overflow by streams, a slight susceptibility to wind erosion, the maintenance of organic matter, and the formation of a plowpan. (Capability unit IIw-1; Loamy Bottom-Land range site.)

Yahola fine sandy loam, high (Yh), occurs mainly in wide, nearly level areas that are above areas overflowed by streams. It receives some run-in water from red-bed areas in the uplands. The upper 40 inches of the profile consists of sandy stratified layers that collectively are brown fine sandy loam.

Up to 10 percent of the acreage of any individual area may consist of Port soils.

Yahola fine sandy loam, high, is used for wheat, sorghums, and alfalfa. Management problems are the run in of water from the uplands, a susceptibility to wind erosion, the maintenance of organic matter, and the formation of a plowpan. (Capability unit IIe-2; Loamy Bottom-Land range site.)

Management of the Soils

The first part of this section tells about the management of the soils for cultivated crops. The next part explains the capability grouping of soils and discusses management of soils by capability units. After this, the following are discussed, in order: Estimated yields of

crops, irrigation, range management, woodland, wildlife, and engineering uses of the soils.

Management of the Soils for Cultivated Crops

The successful farmer is conservation minded. He knows how much his soils will produce and the limitations of the different soils on his farm. He applies conservation methods suited to the climate and the soils so that he can obtain profitable long-term yields without depleting his soils.

In this county soil erosion is one of the most important problems. It will be discussed first because the management practices that promote good yields are those that also are appropriate for controlling erosion.

Soil erosion

In Woodward County soil erosion is caused by both water and wind. It is a continuing hazard.

Water erosion.—When a violent rainstorm strikes a field, two harmful agents—falling raindrops and flowing surface water—are at work. Raindrops cause splash erosion, which frequently causes more damage than that caused by flowing water. The raindrops move the soil downslope when they splash, and if the water from them cannot enter the soil, it flows and scours the land.

Besides scouring the land, flowing water tends to carve rills and gullies where it concentrates (fig. 13). Not as much soil is moved in rills and gullies as is moved by splash and scouring, but the result is more evident.

Water erosion is like a thief in the night. It robs fields of inches of surface soil over a period of years but goes unnoticed unless it leaves gullies as evidence. The stronger the slope of the land, the greater the danger of water erosion, and the greater the need for conservation farming.

Wind erosion.—High winds in spring and hot winds in summer cause considerable erosion in Woodward County. The threat of wind erosion is always present, and each spring a wind of 40 miles per hour can be expected during the greater part of at least 1 day. Such a wind damages unprotected land.

In summer hot, dry winds remove moisture from the upper 3 inches of the surface soil and make the soil susceptible to blowing. A cover of vegetation is essential for protecting the soils, especially the sandy ones.

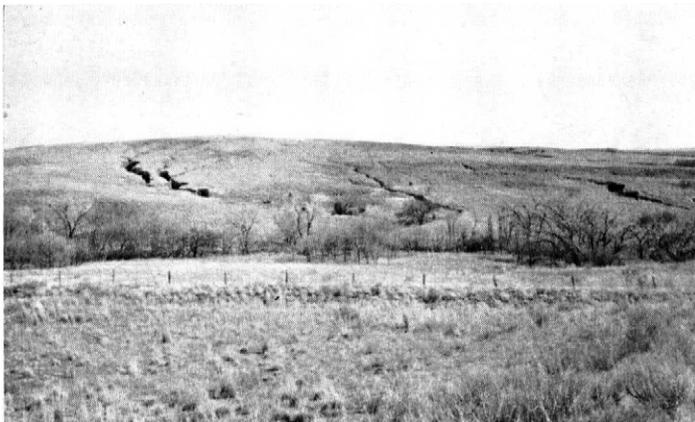


Figure 13.—Erosion has formed gullies in this area that was formerly cultivated.



Figure 14.—Fields, roads, and fences damaged by wind erosion.

Damage from wind erosion varies according to soil types. If crop residues are used properly, hardland soils can be kept from blowing. It is more difficult to keep sandy soils from blowing. Caliche (high-lime) soils are also susceptible to severe wind damage if they are left bare during critical periods.

During windstorms, the most fertile part, including the organic matter is blown from sandy, silty, and clayey soils, and the less fertile sand is left in the fields, along fences, and in roads (fig. 14).

Management practices

Controlling erosion and conserving water in cultivated fields requires a combination of conservation practices and the participation of the community as a whole. Following are discussions of practices used in Woodward County to protect the soils from erosion and to conserve water, as well as to increase soil productivity. Permanent structures used for these purposes are described in the section "Engineering Uses of the Soils."

Conservation cropping.—This involves growing suitable crops to control soil erosion, conserve soil moisture, and maintain or improve soil productivity. In addition, conservation cropping helps to control weeds, insects, and diseases.

The irregular distribution of rainfall in Woodward County limits the kinds of crops that can be grown. Wheat is the most important cash crop. It also provides grazing during at least half of the years. Also suited to the soils and the climate are oats, rye, barley, sorghums, and sudangrass (fig. 15). Other crops, including cotton, can be grown with some success. Alfalfa is suited to soils of the bottom lands and, during years of favorable rainfall, to the more nearly level soils of the uplands.

All crops grown should produce enough residues to maintain soil tilth. Because of the limitations of climate, legumes usually cannot be depended upon to provide cover; consequently, the proper use of crop residues is very important. Where suitable, however, alfalfa is generally a beneficial soil-building legume. It is essential to return at least 12 inches of aftergrowth of alfalfa to the soil at the end of the rotation. Forage grasses are also important as soil-maintaining crops.

Stubble mulching.—This is a year-round system of farming designed to keep a protective cover of crop resi-

dues on the surface until the next crop is seeded. This practice requires the use of sweeps, rod weeders, and blades that undercut the soil and leave residues on the surface. The seeding equipment must be capable of drilling through the trashy cover.

Stubble mulching protects the surface soil from wind erosion, reduces water erosion, improves soil tilth, reduces surface crusting, and limits extremes in temperature in the surface soil.

Use of crop residues.—Crop residues can be used to improve the soils and to protect them against erosion by water and wind. Proper management of crop residues is essential in Woodward County. Grazing and other uses of crop residues should be restricted so that enough residues are left on the surface during critical erosion periods (fig. 16). When a lot of crop residue remains after the harvest of a good crop, the addition of nitrogen fertilizer will help to decay it.

Contour farming.—In contour farming all tillage, planting, and other operations are done across the slope and as nearly on the contour as possible. This is a normal practice on terraced land (fig. 17). Contour farming helps to reduce erosion, to restrict runoff, and to provide better stands of crops.

Minimum tillage.—This practice is needed on all soils. Excessive tillage pulverizes the soils, destroys favorable structure, and removes protective residues. It also causes more compaction, surface crusting, and erosion.

Emergency tillage.—This practice is used to make the surface soil rough and cloddy so that it can resist the wind.

Emergency tillage should be applied only when there is not enough vegetation to protect the soils. Even though it helps to control wind erosion for a limited time, it has a detrimental effect on the tilth of the soils and reduces the supply of soil moisture.

In Woodward County most of the emergency tillage is done with chisels. The effectiveness of emergency tillage depends on the speed of the equipment, the depth of tillage, the spacing between chisels, and the size of the chisel points.

The following factors should be considered when planning emergency tillage: (1) Chiseling is rarely successful on sandy soils; (2) the effectiveness of chiseling soils that



Figure 15.—Grain sorghums growing on a contoured, terraced field. The stubble from this crop will help prevent wind erosion.



Figure 16.—Wheat residue helps to control wind erosion and to reduce water erosion on this field.

are low in organic matter is short lived because the soils rapidly fuse, or run together, when wet; (3) when soil moisture is low, emergency tillage further depletes the supply; (4) equipment that tends to pulverize the soils should not be used; (5) because it is an extra operation, emergency tillage should be delayed as long as possible; and (6) emergency tillage should be done over entire areas, rather than in strips.

Stripcropping.—This practice consists of growing crops in a systematic arrangement of alternate strips to provide a barrier against erosion.

In stripcropping, various combinations of crops are grown; one crop is used to break the force of the wind and to protect the other crop. The width of the strips is determined by the erodibility of the surface soil. Sandy soils need narrow strips.

On sandy soils erosion-resistant crops, such as sorghums, are sown in a strip that runs at a right angle to the prevailing wind. The next strip may consist of wheat stubble that will soon be tilled in preparation for planting a new crop.

Use of fertilizer.—Commercial fertilizers are not used extensively in Woodward County. If the supply of moisture is adequate, however, the use of fertilizers can result in maximum yields of crops. During years when rainfall is below normal, the application of fertilizers may not pay.

When applying fertilizers, the farmer needs to consider the particular soil and its potential fertility. He



Figure 17.—Terraced field in which contour farming is practiced.

must also consider the history of crops on a field, the history of fertilizer applications, the amount of available plant nutrients in the soil as indicated by analysis, and the yields to be expected after fertilizers have been added. Special problems on different soils should also be evaluated.

The cultivated soils of Woodward County have lost much of their original supply of nitrogen. When rainfall is adequate, yields of crops are influenced more by the supply of soil nitrogen than by the supply of any other element. A deficiency of soil phosphorous limits yields of crops in the county. Soil potassium and minor, or trace, elements are present in sufficient amounts for normal yields under dryland farming.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable they are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes, there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony, and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no erosion hazard but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change

the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system, and the subclasses and units in this county, are described in the list that follows.

Class I. Soils that have few limitations that restrict their use.

(No subclasses)

Capability unit I-1.—Nearly level loamy soil of the bottom lands.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIc. Soils that have moderate climatic limitations.

Capability unit IIc-1.—Nearly level loamy soil of the uplands.

Subclass IIe. Soils subject to moderate erosion if they are not protected.

Capability unit IIe-1.—Gently sloping loamy soils of the uplands.

Capability unit IIe-2.—Nearly level to slightly uneven fine sandy loam of the uplands.

Subclass IIw. Soils that have moderate limitations because of excess water.

Capability unit IIw-1.—Nearly level fine sandy loams and loams of the bottom lands.

Class III. Soils that have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.

Capability unit IIIe-1.—Mainly moderately sloping loamy soils of the uplands.

Capability unit IIIe-2.—Gently sloping and undulating sandy soils of the uplands.

Subclass IIIw. Soils that have severe limitations because of excess water.

Capability unit IIIw-1.—Sandy soils that are nearly level or slightly depressed.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-1.—Sloping loamy soils of the uplands.

Capability unit IVe-2.—Gently sloping to hummocky sandy soils of the uplands.

Subclass IVw. Soils that have very severe limitations for cultivation because of excess water.

Capability unit IVw-1.—Nearly level to slightly depressed sandy soil that has a perched water table.

Class V. Soils that are not likely to erode but have other limitations, impractical to remove, that limit their use largely to grazing, woodland, or wildlife.

Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.

Capability unit Vw-1.—Soils that are along rivers and creeks and have a high water table.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, chiefly by risk of erosion, if protective cover is not maintained.

Capability unit VIe-1.—Strongly sloping, shallow loamy soils of the uplands; the soils contain caliche.

Capability unit VIe-2.—Steep, dune loamy fine sands that support a mixture of sagebrush and tall grasses.

Capability unit VIe-3.—Steep fine sands that support a mixture of shinnery oak and grasses.

Capability unit VIe-4.—Steep, shallow loamy soils of the red beds.

Capability unit VIe-5.—Steep soils, consisting of a mixture of sand, in drainageways.

Capability unit VIe-6.—Strongly sloping, shallow clayey soil of the uplands.

Capability unit VIe-7.—Sandy soils on bottom lands along rivers and creeks.

Subclass VIi. Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Capability unit VIi-1.—Nearly level soil in slightly weathered, gypsiferous clay.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation and that restrict their use largely to grazing, woodland, or wildlife.

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion, if protective cover is not maintained.

Capability unit VIIe-1.—Very shallow gypsum soil and shallow clayey soil on strong slopes.

Capability unit VIIe-2.—Rough broken land.

Capability unit VIIe-3.—Extremely sandy soil on steep dune topography.

Capability unit VIIe-4.—Shallow clayey soil and badland.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply or to esthetic purposes.

(No class VIII soils in Woodward County.)

Management by capability units

In this section each capability unit in Woodward County is described and the soils in each are listed. Suggestions are given on how to use and manage the soils in each unit.

CAPABILITY UNIT I-1

This capability unit consists of a deep, nearly level, fertile soil of the bottom lands. The soil takes water fairly well, and there is only a slight hazard of runoff and erosion. The conservation of moisture is the principal management problem. The soil in this unit is—

Port loam.

This is one of the most desirable soils in the county because it produces consistently high yields of wheat and sorghums, the main crops grown. Wheat is usually more successful than sorghums, since it grows during the time

when the supply of moisture is most favorable. Yields of alfalfa are fair in years when there is enough moisture. If old stands of alfalfa are to be plowed out, do this early in spring and plant grain sorghum the first year.

To conserve water and get good yields, do not grow row crops for more than 3 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soil, and apply nitrogen fertilizer to decay them. Maintain enough small-grain stubble on the surface to provide protection during seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up the heads and leaves. When sorghum is cut for forage, maintain stubble 6 inches high in fields that are to be used for sown or close-rowed crops and stubble 10 inches high in fields intended for row crops.

Construct diversion terraces, where necessary, to protect the soil from runoff from higher areas. Reduce tillage to a minimum.

If enough water is available, the soil is suitable for irrigation. It is also suitable for the planting of shelterbelts.

CAPABILITY UNIT IIc-1

This capability unit consists of a deep, nearly level, fertile soil of the uplands. The soil takes water fairly well, and there is only a slight hazard of runoff and erosion. Conservation of moisture is the principal problem. The soil in this unit is—

St. Paul silt loam, 0 to 1 percent slopes.

Wheat and sorghums are the main crops grown. Wheat is usually more successful than sorghums because it grows during the time when the supply of moisture is most favorable. Alfalfa can be grown with some success.

To conserve water and get good yields, do not grow row crops for more than 3 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soil, and apply nitrogen fertilizer to decay them. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up heads and leaves. When sorghum is cut for forage, maintain stubble 6 inches high in fields that are to be used for sown or close-rowed crops and stubble 10 inches high in fields intended for row crops.

Conserve moisture through the use of water-impounding terraces and contour farming. Construct diversion terraces, where necessary, to protect the soil against runoff from higher areas. Reduce tillage to a minimum.

If enough water is available, the soil is suitable for irrigation.

CAPABILITY UNIT IIe-1

This capability unit consists of deep, gently sloping loamy soils of the uplands. The soils take water fairly well. Loss of moisture through runoff and a slight susceptibility to erosion are the main problems. The soils in this unit are—

Carey silt loam, 1 to 3 percent slopes.

Holdrege loam, 1 to 3 percent slopes.

St. Paul silt loam, 1 to 3 percent slopes.

Woodward loam, 1 to 3 percent slopes.

Wheat and sorghums are the main crops grown. Wheat is usually more successful than sorghums because it grows during the time when the supply of moisture is most favorable.

To conserve water and get good yields, do not grow row crops for more than 3 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soils. Include a soil-building crop in the rotation. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up heads and leaves. When sorghum is cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Conserve moisture and reduce erosion through terracing and contour farming. Construct diversion terraces, where needed and practical, to protect the soils against water from higher areas or to break up long slopes. Reduce tillage to a minimum.

CAPABILITY UNIT IIe-2

This capability unit consists of a deep fine sandy loam that is on nearly level to slightly uneven topography. The soil takes water well and makes most of the moisture available to crops. It is moderately susceptible to wind erosion. The conservation of soil and moisture is the main problem. The soil in this unit is—

Yahola fine sandy loam, high.

Sorghums and wheat are the main crops grown. The soil produces dependable yields of sorghums.

To conserve water and get good yields, do not grow row crops for more than 4 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soil. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up heads and leaves. When sorghum is cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Construct diversion terraces, where needed and practical, to protect the soil against water from higher areas. In unterraced fields, plant crops across the direction of the prevailing wind. Reduce tillage to a minimum. Alternate strips of sorghums and small grains to help control wind erosion.

The soil is suitable for irrigation and for shelterbelt plantings.

CAPABILITY UNIT IIw-1

This capability unit consists of deep, nearly level fine sandy loams and loams on bottom lands along rivers and large creeks. The soils are above areas that are frequently overflowed, but they are occasionally flooded. Conservation of soil and moisture is the principal problem. The soils in this unit are—

Leshara loam.
Wann fine sandy loam.
Yahola fine sandy loam.

These soils are well suited to wheat, sorghums, and alfalfa. If old stands of alfalfa are to be plowed out, do this early in spring and plant grain sorghum the first year.

To conserve water and get good yields, do not grow row crops for more than 4 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soils. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up heads and leaves. When sorghum is cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Construct diversion terraces, where needed and practical, to protect the soils against water from higher areas. In sandy areas, plant crops across the direction of the prevailing wind. Reduce tillage to a minimum. Alternate strips of sorghums and small grains to help control wind erosion.

The soils are suitable for irrigation and for shelterbelt plantings.

CAPABILITY UNIT IIIe-1

This capability unit consists of deep and moderately deep, mainly moderately sloping soils of the uplands. The soils lose a considerable amount of moisture through runoff. Conservation of soil and moisture is the principal problem. The soils in this unit are—

Carey silt loam, 3 to 5 percent slopes.
Enterprise loam, 3 to 5 percent slopes.
Mansker loam, 1 to 3 percent slopes.
St. Paul silt loam, 3 to 5 percent slopes.
Vernon clay loam, 0 to 3 percent slopes.
Woodward loam, 3 to 5 percent slopes.

These soils are best suited to wheat and other small grains. Sorghums are fairly successful on the loamy soils.

To conserve water and get good yields, do not grow row crops for more than 2 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soils. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up the heads and leaves. When sorghum is cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Construct diversion terraces, where needed and practical, to protect the soils against water from higher areas. Terrace slopes of 3 percent or more. On slopes of less than 3 percent, sown or close-rowed crops, planted on the contour, can take the place of terraces. Use contour farming on all terraced fields. Reduce tillage to a minimum.

CAPABILITY UNIT IIIe-2

This capability unit consists of deep, gently sloping and undulating sandy soils of the uplands. These soils take water well and make even the moisture from light rainfall available to growing crops. They have a moderate tendency to be blown, so control of erosion is important. The soils in this unit are—

Enterprise fine sandy loam, undulating.
 Miles fine sandy loam, 1 to 3 percent slopes.
 Pratt fine sandy loam, undulating.
 Pratt loamy fine sand, undulating.

Sorghums are the main crops, but wheat and other small grains are also grown.

To conserve water and get good yields, do not grow row crops for more than 3 consecutive years. Plant only crops that produce large amounts of residues. Manage residues so that they will build up the soils. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up the heads and leaves. When sorghums are cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Construct diversion terraces, where needed and practical, to protect the soils against runoff from higher areas. Where possible, construct field terraces on the Miles soil and farm the areas on the contour. Sown or close-rowed crops can be planted on unterraced fields; plant crops crosswise to the prevailing wind. Reduce tillage to a minimum. Alternate strips of sorghums and small grains to help control wind erosion.

The soils are suitable for sprinkler irrigation and for shelterbelt plantings.

CAPABILITY UNIT IIIw-1

This capability unit consists of soils of the deep sandy lands. The soils are nearly level or in slight depressions. Poor surface drainage or a perched water table may cause them to remain wet, especially during years of high rainfall. When dry, the surface soil in cultivated fields is susceptible to wind movement. This unit consists of—

Carwile-Pratt complex.

Sorghums and wheat are the main crops. Some alfalfa is also grown.

To conserve moisture and get good yields, plant only crops that produce large amounts of residues. Manage residues so that they will build up the soils and provide protection against the climate. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. When sorghum is cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Plant crops crosswise to the prevailing wind. Reduce tillage to a minimum. Alternate strips of small grains and sorghums to help control wind erosion. Construct simple drainage systems where necessary and practical.

These soils are suitable for shelterbelt plantings.

CAPABILITY UNIT IVe-1

This capability unit consists of deep and moderately deep, sloping soils of the uplands. The soils lose much moisture through runoff. If they are cultivated, careful management is needed to conserve soil and moisture. The soils in this unit are—

Carey silt loam, 5 to 8 percent slopes.
 Carey silt loam, 5 to 8 percent slopes, eroded.

Enterprise-Pratt complex, 5 to 8 percent slopes.
 Mansker loam, 3 to 5 percent slopes.
 Quinlan-Woodward loams, 3 to 5 percent slopes, eroded.
 Vernon clay loam, 3 to 5 percent slopes.
 Woodward loam, 5 to 8 percent slopes.
 Woodward-Quinlan loams, 3 to 5 percent slopes.

These soils are used as rangeland and cropland. The main crops are wheat and sorghums. It is best to plant native grasses in areas now being cultivated. The soils can be cultivated, however, if they are carefully managed.

To conserve water and get good yields, grow only sown or close-rowed crops that produce large amounts of residues. Manage residues so that they will protect and build up the soils. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up the heads and leaves. When sorghum is cut for forage, maintain at least 6 inches of stubble.

Construct diversion terraces, where needed and practical, to divert water from higher areas. Construct field terraces and farm on the contour. Reduce tillage to a minimum.

CAPABILITY UNIT IVe-2

This capability unit consists of deep sandy soils that are gently sloping to hummocky. The soils take water well and make even the moisture from light rainfall available to growing crops. They are easily blown, unless well protected by a growing crop or stubble. The soils in this unit are—

Brownfield fine sand, 1 to 3 percent slopes.
 Lincoln loamy fine sand.
 Miles fine sandy loam, 3 to 5 percent slopes.
 Nobscot-Brownfield fine sands, 3 to 5 percent slopes.
 Nobscot-Pratt complex, hummocky.
 Otero loamy fine sand, undulating.
 Pratt fine sandy loam, hummocky.
 Pratt loamy fine sand, hummocky.

These soils are used as rangeland and cropland. The main crops are sorghums and small grains. It is best to plant native grasses in areas now being cultivated. The soils can be cultivated, however, if they are carefully managed.

To conserve water and get good yields, plant only crops that produce large amounts of residues. Manage residues so that they will protect and improve the soils. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. Graze sorghum stubble no longer than it will take livestock to pick up the heads and leaves. When sorghums are cut for forage, maintain 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Plant crops across the direction of the prevailing wind. Reduce tillage to a minimum. To decrease the hazard of wind erosion, alternate strips of sorghums and small grains instead of growing small grains alone.

The soils are suitable for shelterbelt plantings.

CAPABILITY UNIT IVw-1

This capability unit consists of a deep, nearly level to slightly depressed soil of the sandy lands. A perched water table may cause the soil to remain wet, especially

during years of heavy rainfall. When dry, the surface layer in cultivated fields is susceptible to wind movement. The soil in this unit is—

Elsmere loamy fine sand.

This soil is used primarily as meadow or rangeland, but a smaller acreage is used for sorghum and small grains.

To conserve moisture and get good yields, plant only crops that produce large amounts of residues. Manage residues so that they will build up the soil and protect it against the climate. Maintain enough small-grain stubble on the surface to provide protection at seeding time. Let sorghum stalks remain standing during winter, and delay tillage as long as possible in spring. When sorghum is cut for forage, leave 6 inches of stubble in fields that are to be used for sown or close-rowed crops and 10 inches of stubble in fields intended for row crops.

Plant crops crosswise to the prevailing wind. Reduce tillage to a minimum. To help control wind erosion, alternate strips of small grain and sorghum instead of growing small grains alone. Construct simple drainage systems where needed and practical.

The soil is suitable for shelterbelt plantings.

CAPABILITY UNIT Vw-1

This capability unit consists of soils that are along rivers and creeks and have a high water table. The water table is on or near the surface at some times, and at a depth of 30 inches at others. Because of the high water table, the soils are difficult to cultivate, but they are valuable as grasslands. The soils in this unit are—

Las Animas soils.
Sweetwater soils.

Unless drainage can be established, these soils are generally unsuitable for cultivation. Undrained areas that are now being cultivated can be seeded to water-tolerant native grasses. If properly managed, the soils produce large amounts of grasses. Legumes can be added to the seeding mixtures to increase the carrying capacity of pasture or the production of hay.

To obtain increased yields of plants, consult one of the people working with the Woodward Soil Conservation District for information on the management of meadow and pasture, including the use of fertilizers. The soils of this unit are in the Subirrigated range site.

CAPABILITY UNIT VIe-1

This capability unit consists of strongly sloping, shallow loamy soils of the uplands. The soils contain caliche. They are erodible and droughty. This unit consists of—

Mansker-Potter loams, 5 to 12 percent slopes.

Some areas of these soils are being cultivated, but, in general, the areas are unsuited to cultivation. Yields are low, and the hazard of erosion is severe. Native grasses can be seeded in cultivated areas and in pastures where the grasses have been killed. Where these soils are in native range, fair yields of forage can be obtained if good management is practiced. The Mansker soil is in the Loamy Plains range site, and the Potter soil is in the Shallow range site.

CAPABILITY UNIT VIe-2

This capability unit consists of steep, dune loamy fine sands that have a mixture of sagebrush and tall native grasses. Areas where grasses are thin or have been killed are subject to severe wind erosion. Water erosion is not a problem; the loose sandy soils take water well and release it readily to plants. During dry periods the soils are droughty because of the coarse texture of the entire profile. This unit consists of—

Pratt-Tivoli loamy fine sands.

These soils are well suited to sand lovegrass and switchgrass. If properly managed, they produce high yields. A good cover of grasses will help to control wind erosion. Avoid overgrazing and trampling by livestock. Pratt soil is in the Deep Sand range site, and the Tivoli soil is in the Dune range site.

CAPABILITY UNIT VIe-3

This capability unit consists of steep fine sands that support a mixture of shinnery oak and grasses. The soils are erodible and droughty. The principal management problems are controlling wind erosion and keeping the cover of shinnery oak to a minimum. The soils in this unit are—

Nobscot-Brownfield complex, severely eroded.
Nobscot-Eufaula fine sands, 5 to 12 percent slopes.
Nobscot-Pratt complex, duned.

Areas of these soils that are now cultivated or have been abandoned can be profitably reseeded to native grasses for range or hay. Move salting and bedding grounds frequently to prevent overgrazing and the killing of grasses. Overgrazing will kill the better grasses and permit shinnery oak and weeds to increase. For help in the control of brush and weeds, consult one of the people working with the Woodward Soil Conservation District. Some of the new brush sprays may be used profitably in killing shinnery oak and increasing yields of grasses. The Nobscot, Eufaula, and Brownfield soils are in the Deep Sand Savannah range site, and the Pratt soil is in the Deep Sand range site.

CAPABILITY UNIT VIe-4

This capability unit consists of steep, shallow loamy soils of the red beds. The soils are too erodible and droughty to be cultivated. The principal management problems are the moderately low moisture-holding capacity, loss of water through runoff, a moderate to severe hazard of erosion, and the effects of erosion in areas previously cultivated. The soils in this unit are—

Quinlan loam.
Quinlan-Woodward loams, 5 to 12 percent slopes.
Quinlan-Woodward loams, 5 to 12 percent slopes, eroded.

To improve rangeland, regulate grazing so as to permit vigorous growth of the tops and roots of plants. Reseed grazed-out areas, old cropland, and abandoned cropland to suitable native grasses. Leave enough residues each year to provide a surface mulch and to increase the water intake of the soils. Consult one of the people working with the Woodward Soil Conservation District for information on reseeding, erosion control, and other range management practices. The Quinlan soils are in the Shallow Prairie range site, and the Woodward soils are in the Loamy Prairie range site.

CAPABILITY UNIT VIe-5

This capability unit is made up of steep soils that consist of a mixture of sand and occur along drainageways. The soils are too steep, erodible, and droughty for cultivation. The principal management problems are the low moisture-holding capacity, the severe hazard of wind erosion, and the deficiency of organic matter. Erosion is severe if a good cover of grass is not maintained. This unit consists of—

Enterprise-Pratt complex, 8 to 20 percent slopes.

To improve these soils, reseed grazed out areas to a suitable mixture of native grasses. Maintain a surface mulch of hay or straw to control erosion in blowout spots and in the areas reseeded to grasses. The mulch will also help increase the supply of organic matter. These soils are in the Sandy Prairie range site.

CAPABILITY UNIT VIe-6

This capability unit consists of a strongly sloping, shallow clayey soil of the uplands. The soil is not suited to cultivation. The principal management problems are the low moisture-holding capacity, the loss of water through runoff, and the severe hazard of water erosion. If overgrazed and trampled when wet, the soil tends to compact. The soil in this unit is—

Vernon clay loam, 5 to 12 percent slopes.

To increase the supply of organic matter and the intake of water, leave enough residues each year to provide a surface mulch. This will also help to maintain or increase yields of grasses. Reseed grasses in areas that have been overgrazed and in places where the native grasses have been killed. Adjust stocking rates on these areas to prevent the overgrazing and killing of grasses. This soil is in the Shallow Clay Prairie range site.

CAPABILITY UNIT VIe-7

This capability unit consists of sandy soils on bottom lands along rivers and creeks. The soils are subject to frequent overflow, silting, and streambank cutting. They are too droughty and erodible for cultivation. They are subject to wind erosion unless protected by grasses and trees. This unit consists of—

Lincoln soils.

Stands of trees have been established in some areas. The soils are generally suitable for postlot and woodlot plantings. The county agent or one of the people working with the Woodward Soil Conservation District will help you select the proper species of trees. Lincoln soils are in the Sandy Bottom-Land range site.

CAPABILITY UNIT VIe-1

This capability unit consists of a nearly level soil that is forming in slightly weathered, gypsiferous clay. The soil is too droughty and erodible for cultivation. Principal problems in managing this soil for grasses are a low rate of water intake, droughtiness, a high content of gypsum, and a susceptibility to erosion. The soil in this unit is—

Treadway clay.

Areas that have been cultivated or have been overgrazed can be restored as fair rangeland through the reseeded of suitable native grasses and careful range man-

agement. Regulate grazing so as to permit good growth of tops and roots of grasses. Leave enough residues each year to provide a surface mulch that will increase the rate of water intake and help control erosion. Treadway clay is in the Red Clay Flats range site.

CAPABILITY UNIT VIIe-1

This capability unit consists of a mixture of a very shallow gypsum soil and a shallow clayey soil. Relief is strongly sloping. The soils are too erodible and droughty for cultivation. They are subject to both wind and water erosion unless protected by a cover of grasses. This unit consists of—

Vernon-Cottonwood complex.

If well managed, these soils furnish some forage for grazing. Yields fluctuate greatly according to the amount of rainfall and the location of the areas. Mechanical reseeded may not be profitable on these soils. Natural reseeded of grasses, along with careful range management, is suggested.

Regulate grazing so that enough mulch is left on the surface to protect against erosion and to increase the rate of water intake. Other practical methods of increasing the water intake of the soils will result in higher yields of grasses. Consult one of the people working with the Woodward Soil Conservation District for help in managing grassland. The Vernon soil is in the Shallow Clay Prairie range site, and the Cottonwood soil is in the Gyp range site.

CAPABILITY UNIT VIIe-2

This capability unit consists of a miscellaneous land type that is not suited to cultivation. The areas are subject to severe erosion. The water-holding capacity of the soil material is low, and much water is lost through runoff on steep slopes and in canyons. This unit consists of—

Rough broken land.

Even under the best management, Rough broken land produces only a small amount of forage. Reseeding and mechanical treatment are impractical. Manage native rangeland carefully and leave some grass cover on the surface to help control erosion and to increase the water intake of the soil material. Rough broken land is in the Breaks range site.

CAPABILITY UNIT VIIe-3

This capability unit consists of an extremely sandy soil on steep dune topography. The soil is not suited to cultivation. Principal management problems are an extreme hazard of wind erosion, low moisture-holding capacity, and low yields of grasses. The soil in this unit is—

Tivoli fine sand.

Some blowouts occur in overgrazed pastures or near trails, watering places, and salting places. If the blowouts are not too large, stabilize them with a covering of straw or hay that has mature seed. If necessary, reseed small blowouts to prevent blown sand from covering nearby areas. Move salt often to prevent overgrazing, trampling, and killing of grasses. Tivoli fine sand is in the Dune range site.

CAPABILITY UNIT VIII-4

This capability unit consists of a mixture of a shallow clayey soil and badland. The soils are shallow, droughty, and highly erodible and are not suited to cultivation. They have a low rate of water intake and low moisture-holding capacity. This unit consists of—

Vernon-badland complex.

Even under good management, these soils produce only a small amount of grass. Regulate grazing to permit good growth of tops and roots of grasses. Leave enough residues each year to mulch the surface and to provide cover for wildlife. The Vernon soil is in the Shallow Clay Prairie range site, and badland is in the Eroded Red Clay range site.

Estimated Yields

Estimated average acre yields of wheat and grain sorghum, the principal crops grown on the arable soils of Woodward County, are listed in table 4. These figures, based on a 20-year record, apply only to yields obtained on acreage planted to wheat and grain sorghum under dryland farming.

Yields in columns A are those obtained under common management in which a few conservation practices are applied. Yields in columns B are those obtained under improved management in which all of the needed conservation practices, such as proper use of crop residues, fertilizing, terracing, and contour farming, are applied.

Management practices vary from farm to farm, and the climate fluctuates from year to year. Therefore, the estimated yields may not apply to specific tracts of land or indicate the yields in a particular year.

Irrigation

Approximately 7,500 acres of cropland are being irrigated in Woodward County. It is expected that a total of 12,000 acres will be under irrigation by 1975. Most of the irrigation is being done around Mooreland and in the Moscow Flats.

Interest in irrigation increases during extended droughts and decreases during periods when precipitation is normal or above normal. Generally, irrigation is used only to supply supplemental moisture to crops. Several farmers, however, irrigate their crops with the amount of water needed for maximum yields.

In Woodward County most irrigation is done by sprinkler systems, but flood irrigation is practiced on a small acreage. Sprinkler systems will probably be used on most additional land brought under irrigation, because the water that can be pumped for irrigation underlies sloping sandy soils.

Supply of water

Two broad areas in the county contain enough water for irrigation. One is along the North Canadian River, primarily on the north side, and the other is in the west-central and southwestern part of the county. Wells will not produce an abundant supply of water in all places within these areas, however. Test holes must be drilled to locate a dependable supply of water.

Along the North Canadian River, there is a band of sandy soils in the bottom lands and the adjacent uplands.

TABLE 4.—Estimated average acre yields of principal crops on soils suited to cultivation

[Yields in columns A are those obtained under common management; those in columns B are obtained under improved management. Absence of a yield figure indicates the crop is not commonly grown on the soil at the level of management specified]

Soil	Wheat		Grain sorghum	
	A	B	A	B
Brownfield fine sand, 1 to 3 percent slopes	Bu. 7	Bu. 8	Bu. 12	Bu. 14
Carey silt loam, 1 to 3 percent slopes	13	15	17	20
Carey silt loam, 3 to 5 percent slopes	11	13	14	16
Carey silt loam, 5 to 8 percent slopes	8	10	12	14
Carey silt loam, 5 to 8 percent slopes, eroded	8	10	12	14
Carwile-Pratt complex	12	13	15	16
Enterprise fine sandy loam, undulating	12	14	19	22
Enterprise loam, 3 to 5 percent slopes	11	13	14	16
Enterprise-Pratt complex, 5 to 8 percent slopes	8	10	12	14
Holdrege loam, 1 to 3 percent slopes	13	15	19	22
Leshara loam	13	15	16	19
Lincoln loamy fine sand	7	9	12	14
Mansker loam, 1 to 3 percent slopes	11	13	15	17
Mansker loam, 3 to 5 percent slopes	8	10	12	14
Miles fine sandy loam, 1 to 3 percent slopes	11	13	20	24
Miles fine sandy loam, 3 to 5 percent slopes	9	11	17	19
Nobscot-Brownfield fine sands, 3 to 5 percent slopes	6	7	9	12
Nobscot-Pratt complex, hummocky	8	10	13	17
Otero loamy fine sand, undulating	7	8	12	14
Port loam	18	22	26	32
Pratt fine sandy loam, undulating	12	14	19	22
Pratt fine sandy loam, hummocky	9	11	15	17
Pratt loamy fine sand, undulating	8	9	14	16
Pratt loamy fine sand, hummocky	7	8	12	14
Quinlan-Woodward loams, 3 to 5 percent slopes, eroded	7	8	10	12
St. Paul silt loam, 0 to 1 percent slopes	15	18	---	---
St. Paul silt loam, 1 to 3 percent slopes	13	15	---	---
St. Paul silt loam, 3 to 5 percent slopes	11	13	---	---
Vernon clay loam, 0 to 3 percent slopes	9	11	---	---
Vernon clay loam, 3 to 5 percent slopes	7	9	---	---
Wann fine sandy loam	12	14	17	20
Woodward loam, 1 to 3 percent slopes	12	14	16	19
Woodward loam, 3 to 5 percent slopes	10	12	14	17
Woodward loam, 5 to 8 percent slopes	8	10	12	14
Woodward-Quinlan loams, 3 to 5 percent slopes	7	8	10	12
Yahola fine sandy loam	12	14	17	20
Yahola fine sandy loam, high	12	14	17	20

Water-bearing material underlies these soils, but the water does not occur in a continuous sheet. Depth to water ranges from 25 to 75 feet. Where water is available, wells produce from 50 to 500 gallons per minute. In some of the valleys, it may be possible to drill additional wells that provide 500 gallons of water per minute.

In the west-central and southwestern parts of the county, the depth to water is 50 to 100 feet. In general, wells yield from 50 to 500 gallons of water per minute, but, in some places in the southwestern corner, it may be possible to develop wells that yield 500 to 1,000 gallons.

As yet, no artificial lakes, or reservoirs, have been constructed in the county for the storage of runoff water to be used for irrigation. In planning a lake, a farmer needs to know that 5 to 6 feet of the water in a lake evaporates each year and that a storage capacity of 3-acre feet of

water is needed for each acre of cropland to be irrigated. For additional details in planning an irrigation reservoir, he can contact a local representative of the Soil Conservation Service.

Planning an irrigation system

A farmer who plans to irrigate his land needs to (1) obtain water rights, (2) determine the suitability of his soils for irrigation, (3) obtain an adequate supply of water, (4) have the salt content of the water determined, (5) obtain a proper design of the irrigation system, (6) analyze the cost of the system, (7) select suitable crops to be grown, and (8) follow a soil-building and fertilizing program.

A farmer does not obtain water rights merely by owning land. To establish water rights, he must file an application with the Oklahoma Planning and Resource Board, Oklahoma City. The application will date his priority in the use of available water.

After filing his application for water rights, the farmer should contact the Woodward County Soil Conservation District and ask that a soil scientist help him determine the suitability of the soils on his farm for irrigation.

Before an irrigation well is drilled, a test hole should be made to determine the depth to and thickness of the layers of water-bearing sand and gravel. The test hole also will indicate the expected yield of water and provide information needed in the design of the gravel filter and well screen. As a general guide, about 10 gallons of water per minute must be produced for each acre of irrigated land. If 50 acres are to be irrigated, a well that yields 500 gallons per minute is needed.

Harmful or excessive amounts of salts in irrigation water can cause the failure of crops. If as much as 5 tons of salts are contained in each 12 inches of water applied per acre, the soils will become unsuitable for crops within a few years. A farmer can have his irrigation water checked for salts by a testing laboratory of the Federal or State government.

The design of an efficient irrigation system is complicated and requires the help of experts. Irrigation specialists of the Extension Service, the Soil Conservation Service, and State agencies can help lay out a system to fit the soils and the needs and time schedule of the farmer.

In addition, irrigation specialists can give reliable estimates on the cost of the irrigation system and the expected return to the farmer. After a well has been drilled and is ready for service, the drilling contractor should run a test of 24 to 48 hours to determine the amount of drawdown, the pumping lift, and the capacity of the well. Information gained through this test is essential in determining the kind of pump and other equipment that is needed.

A conservation cropping system needs to be followed along with the use of irrigation. If a definite cropping system is followed, the soil-building crops will offset the effects of the soil-depleting crops. Only crops that provide high yields under irrigation should be grown. Records of irrigation farmers indicate that it is a common practice to spread water thinly over too many acres. It is more profitable to select suitable crops and then to irrigate a smaller acreage and thereby obtain maximum yields.

Available water-holding capacity and water-intake rate of irrigable soils

The available water-holding capacity and water-intake rate are given for each of the irrigable soils of Woodward County in table 5.

Available water-holding capacity, as given in table 5, refers to the water in the soil that is available to growing plants. It is the difference between the water held at the wilting point and at field capacity. Terms used to describe the amount of available water that each foot of soil can store are as follows: *High*—1.6 to 2.1 inches; *medium*, 1.1 to 1.6 inches; and *low*—0.6 to 1.1 inches.

The water-intake rate of a given soil varies. The rates, as given in table 5, are based on the assumption that the soil is in good physical condition and that it is moist. Terms used to describe water-intake rate in inches per hour are as follows: *Very slow*—less than 0.2 inch; *slow*—0.2 to 1.0 inch; *moderate*—1.0 to 2.5 inches; *moderately rapid*—2.5 to 5.0 inches; and *rapid*—more than 5.0 inches.

Loamy soils are ideal for irrigation. They take water well and store large amounts for plant use. In loamy soils there is a good balance between soil, water, and air.

TABLE 5.—Available water-holding capacity and water-intake rate for deep and moderately deep cultivated soils

Soil type	Available water-holding capacity	Water-intake rate
Carey silt loam.....	Medium.....	Moderate.
Carwile clay loam.....	High.....	Very slow to slow.
Elsmere loamy fine sand..	Low.....	Rapid.
Enterprise fine sandy loam.	Medium.....	Moderate to moderately rapid.
Enterprise loam.....	Medium.....	Moderate to moderately rapid.
Holdrege loam.....	Medium.....	Moderate.
Leshara loam.....	High to medium.	Slow.
Lincoln loamy fine sand..	Low.....	Rapid.
Mansker loam.....	Medium.....	Slow to moderate.
Miles fine sandy loam...	High to medium.	Moderate.
Port loam.....	High.....	Slow.
Pratt fine sandy loam...	Medium.....	Moderately rapid.
Pratt loamy fine sand...	Low.....	Rapid.
St. Paul silt loam.....	High.....	Slow to moderate.
Wann fine sandy loam...	Medium.....	Moderate.
Woodward loam.....	Medium.....	Moderate.
Yahola fine sandy loam..	Medium.....	Moderately rapid.

Range Management ¹

Nearly 65 percent of the farmland of Woodward County is best suited to the growing of a permanent cover of grass. In the last 20 years, about 90,000 acres have been retired from cultivation and seeded to native grasses. A large acreage, however, has not yet been seeded for range use.

On the whole, range management has been such that high-quality grasses are maintained on the seeded areas (fig. 18). In general, the term "high-quality grasses" refers to the most palatable grasses of the native prairie.

¹ This section was prepared by JACK ENGLEMAN, range conservationist, Soil Conservation Service.



Figure 18.—Nonarable area that has been seeded to native grasses.

These grasses keep undesirable plants under control, control erosion, and provide large amounts of forage for livestock.

The original grassland was a mixture of warm- and cool-season grasses and palatable legumes. Forage production was as high as the climate would permit, because practically all of the rainfall soaked into the soil. Over the years, the rangeland has lost much of its original cover as the result of heavy grazing (fig. 19). There is still some native rangeland, however, that contains a large percentage of tall grasses, such as bluestems, which were once abundant throughout the county. Also, many of the seeded areas and some pastures have a large percentage of tall native grasses.

This section is divided into two parts. The first consists of a discussion of range sites and range condition classes, and the second, of a discussion of range management practices.

Range sites and condition classes

Different kinds of soils vary in their capacity to produce grasses and other plants for grazing. The soils that will produce about the same kind and amount of forage, if the ranges are in similar condition, make up what is called a range site.

Range sites are kinds of rangeland that differ from each other in their ability to produce vegetation. The soils of

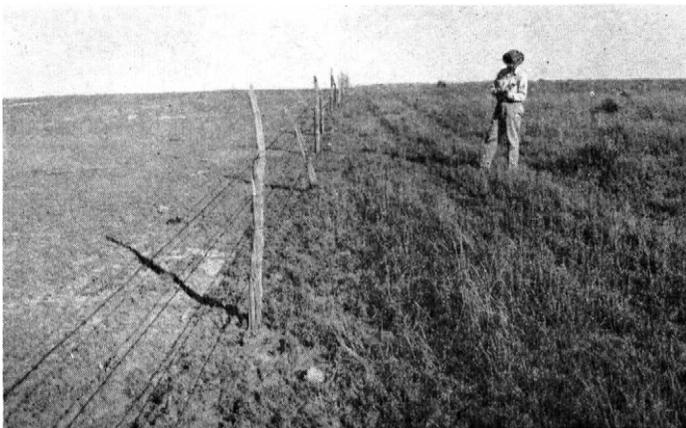


Figure 19.—Pasture to the left of fence has been heavily grazed and has a cover consisting mainly of buffalograss and blue grama. Pasture to the right of fence has been grazed intermittently, and side-oats grama is the dominant grass.

any one range site produce about the same kind of climax vegetation. *Climax vegetation* is the stabilized plant community on a particular site; it reproduces itself and does not change as long as the environment remains unchanged. Throughout most of the prairie and the plains, the climax vegetation is the combination of plants that was growing there when the region was first settled. If cultivated crops are not to be grown, the most productive combination of forage plants on a range site is generally the climax type of vegetation.

Decreasers are species in the climax vegetation that tend to decrease in relative amounts under close grazing. They generally are the tallest and most productive perennial grasses and forbs and the most palatable to livestock.

Increasesers are species in the climax vegetation that increase in relative amounts as the more desirable plants are reduced by close grazing. They are commonly shorter and some are less palatable to livestock than decreaseers.

Invaders are plants that cannot withstand the competition for moisture, nutrients, and light in the climax vegetation. Hence, they come in and grow along with the increaseers after the climax vegetation has been reduced by grazing. Many invaders are annual weeds; some are shrubs that have some grazing value, but others have little value for grazing.

Four range condition classes are used to indicate the degree of departure from the native, or climax, vegetation brought about by grazing or other use. The condition classes show the present condition of the native vegetation on a range site in relation to the native vegetation that could grow there.

A range is in *excellent condition* if 76 to 100 percent of the vegetation is of the same kind as in the original stand. It is in *good condition* if the percentage is between 51 and 75, in *fair condition* if the percentage is between 26 and 50, and in *poor condition* if the percentage is less than 25.

The condition of a range site may be lowered one class for reasons other than the kinds of vegetation. For example, an area of the Sandy Plains range site that was formerly cultivated can be reseeded to the extent that 50 to 75 percent of the vegetation is of the same kind as the original. This would normally indicate good range condition. If there are many bare areas and erosion is still active, however, the condition of the range would be fair instead of good. Careful stocking would be needed on such a site.

Range sites in Woodward County

In this section the range sites of the county are described in order of their estimated value as forage producers. Soils in each site are listed. The estimated forage production for each site is given in air-dry weight and applies to range that is in excellent condition. These estimates are based on year-end forage clippings at a number of locations.

Some sites, such as the Dune and Breaks, are not extensive in Woodward County, but they are the source of silt and sand that is deposited in adjacent areas and thereby cause management problems. Because of this hazard, grazing of these sites needs to be restricted. The Subirrigated and Sandy Bottom-Land range sites produce large amounts of forage, but soils of these sites may cover only a small part of a ranch.

Farmers and ranchers need to become familiar with the range sites in the county and to know the kinds and amounts of grasses and other native plants that the different sites will support. They can do this by studying areas that have been damaged by heavy grazing, wind erosion, or other disturbances. These places, sometimes called relict areas, can be compared with areas of the same range sites that are in different range condition.

SUBIRRIGATED RANGE SITE

This site is made up of soils on bottom lands along rivers. Depth to the water table varies from place to place and from season to season, but the water table is always within reach of the best meadow grasses. The texture of the surface layer of the soils varies but is generally sandy. Beneath the surface layer are layers of silt and clay that, in places, are separated by sand. Soils in this site are—

Elsmere loamy fine sand.
Las Animas soils.
Sweetwater soils.

Switchgrass is the predominant grass when the range is in excellent condition. Indiangrass, common reed, cordgrass, and Eastern grama are other good grasses that are decreaseers. Alkali sacaton, saltgrass, western wheatgrass, and American bulrush are common increaseers.

The Subirrigated site consists of soils that make up about 4 percent of the rangeland of the county. Annual forage production is about 9,000 pounds per acre when the climate is favorable and about 4,000 pounds when it is unfavorable.

SANDY BOTTOM-LAND RANGE SITE

This site is made up of soils forming in stabilized alluvium along creeks and rivers. Much of it is overflowed at times, and in many places there is a small percentage of subirrigated soil. Soils in this site are—

Lincoln loamy fine sand.
Lincoln soils.

Little bluestem and sand bluestem are the predominant grasses when the range is in excellent condition. Big sandreed is a common increaseer. Saltcedar, baccharis, willow, and cottonwood often invade this site.

The Sandy Bottom-Land site consists of soils that make up about 4 percent of the rangeland of the county. Annual forage production is about 5,300 pounds per acre when the climate is favorable and about 2,400 pounds when it is unfavorable.

LOAMY BOTTOM-LAND RANGE SITE

This site is made up of loamy soils on bottom lands that are occasionally overflowed or receive runoff from adjacent uplands. The soils of this site are—

Leshara loam.
Port loam.
Wann fine sandy loam.
Yahola fine sandy loam.
Yahola fine sandy loam, high.

Sand bluestem, little bluestem, switchgrass, western wheatgrass, and vine-mesquite are the principal decreaseers on this site. Side-oats grama, buffalograss, and blue grama increase under heavy grazing. Heavy grazing by cattle packs the soils, destroys the surface litter, and makes the site droughty.

This site consists of soils that make up about 1 percent of the rangeland of the county. Because of the deep, fertile soils and the addition of runoff from the higher areas, this site produces a fairly large amount of forage. Annual forage production is about 5,000 pounds per acre when the climate is favorable and about 2,200 pounds when it is unfavorable.

DEEP SAND RANGE SITE

This site consists of deep sands of the uplands (fig. 20). The soils contain little silt and clay. They are nearly level to rolling and steep. They are open and take water rapidly. There are few drainageways, because little water runs off. The soils of this site are—

Pratt soil in Nobscot-Pratt complex, hummocky.
Pratt soil in Nobscot-Pratt complex, duned.
Pratt loamy fine sand, undulating.
Pratt loamy fine sand, hummocky.
Pratt soil in Pratt-Tivoli loamy fine sands.

When in excellent condition, this site is made up mainly of little bluestem and sand bluestem. Sand lovegrass and switchgrass are fairly common decreaseers. Sand paspalum, sand dropseed, sand sagebrush, skunkbush, blue grama, and big sandreed are common increaseers.

Soils of this site make up about 22 percent of the rangeland of the county. Annual forage production is about 4,500 pounds per acre when the climate is favorable and about 2,000 pounds when it is unfavorable.

DEEP SAND SAVANNAH RANGE SITE

This site consists of deep sands of the uplands. The soils are gently to steeply sloping. Generally, their surface layer is underlain by a layer of sandy clay that tends to keep moisture from percolating downward. The soils in this site are—

Brownfield fine sand, 1 to 3 percent slopes.
Nobscot-Brownfield fine sands, 3 to 5 percent slopes.
Nobscot-Brownfield complex, severely eroded.
Nobscot-Eufaula fine sands, 5 to 12 percent slopes.
Nobscot soil in Nobscot-Pratt complex, hummocky.
Nobscot soil in Nobscot-Pratt complex, duned.

Under heavy grazing, shinnery and blackjack oaks increase at the expense of the better forage. Since oak is very persistent, it must be controlled artificially if the range is to produce large amounts of forage. A vigorous



Figure 20.—Deep Sand range site in excellent condition as the result of brush control and proper management of grazing.

stand of bluestem and the suppression of oak are signs of improvement on the range.

Soils of this site make up about 8 percent of the rangeland of the county. Annual forage production is about 4,500 pounds per acre when the climate is favorable and about 2,000 pounds when it is unfavorable.

SANDY PRAIRIE RANGE SITE

This site consists of gently sloping to rolling and steep soils that have a deep zone for plant roots. It is mainly under cultivation and is generally associated with the Deep Sand and Deep Sand Savannah range sites. The soils in the Sandy Prairie site are—

Carwile-Pratt complex.
Enterprise fine sandy loam, undulating.
Enterprise-Pratt complex, 5 to 8 percent slopes.
Enterprise-Pratt complex, 8 to 20 percent slopes.
Miles fine sandy loam, 1 to 3 percent slopes.
Miles fine sandy loam, 3 to 5 percent slopes.
Pratt fine sandy loam, undulating.
Pratt fine sandy loam, hummocky.

Bluestem is the dominant climax grass on this site. Normally, tall and mid grasses are prevalent, but, under continuous heavy grazing, short grasses and sand sagebrush take over.

Soils of this site make up about 3 percent of the rangeland of the county. Annual forage production is about 4,500 pounds per acre when the climate is favorable and about 1,800 pounds when it is unfavorable.

LOAMY PRAIRIE RANGE SITE

This site consists of deep loams and silt loams on level to rolling and steep topography. It contains some of the most productive soils of the uplands, so much of it is cultivated. Soils in this site are—

Carey silt loam, 1 to 3 percent slopes.
Carey silt loam, 3 to 5 percent slopes.
Carey silt loam, 5 to 8 percent slopes.
Carey silt loam, 5 to 8 percent slopes, eroded.
Enterprise loam, 3 to 5 percent slopes.
Holdrege loam, 1 to 3 percent slopes.
Woodward soil in Quinlan-Woodward loams, 3 to 5 percent slopes, eroded.
Woodward soil in Quinlan-Woodward loams, 5 to 12 percent slopes.
Woodward soil in Quinlan-Woodward loams, 5 to 12 percent slopes, eroded.
Woodward loam, 1 to 3 percent slopes.
Woodward loam, 3 to 5 percent slopes.
Woodward loam, 5 to 8 percent slopes.
Woodward soil in Woodward-Quinlan loams, 3 to 5 percent slopes.

In excellent condition, this site has a mixture of mid, tall, and short grasses; blue grama comprises about one-fourth of the cover. Heavy grazing leads to an increase of blue grama and side-oats grama and the invasion of buffalograss, sand dropseed, and weeds.

Soils of this site make up about 8.7 percent of the rangeland of the county. Annual forage production is about 4,200 pounds per acre when the climate is favorable and about 1,800 pounds per acre when it is unfavorable.

LOAMY PLAINS RANGE SITE

This site consists of gently sloping to unevenly sloping soils of the uplands and soils on limy knobs. The soils are moderately deep. They are—

Mansker loam, 1 to 3 percent slopes.
Mansker loam, 3 to 5 percent slopes.
Mansker soil in Mansker-Potter loams, 5 to 12 percent slopes.

This site is made up of medium and short grasses and of some tall grasses in drainageways and other areas that receive extra runoff water. The principal grasses are little bluestem, side-oats grama, and blue grama. Side-oats grama and blue grama are increasers that gradually replace little bluestem when the condition of the range becomes poorer. A general invasion of broom snakeweed, red three-awn, and hairy tridens is evidence of a serious decline in the productivity of the range.

Soils of this site make up about 2.5 percent of the rangeland of the county. Annual forage production is about 3,000 pounds per acre when the climate is favorable and about 1,500 pounds when it is unfavorable.

HARDLAND RANGE SITE

This site consists of deep, medium-textured soils that have a subsoil of clay loam. Relief is gently to moderately sloping. Soils in this site are—

St. Paul silt loam, 0 to 1 percent slopes.
St. Paul silt loam, 1 to 3 percent slopes.
St. Paul silt loam, 3 to 5 percent slopes.

When packed by continuous heavy grazing, soils of this site tend to be droughty, and, as a result, the site usually consists of short grasses of which buffalograss and blue grama are dominant. In excellent condition the range has a cover that includes a small amount of tall grasses and a considerable amount of little bluestem, side-oats grama, vine-mesquite, and western wheatgrass.

Soils of this site make up about 1 percent of the rangeland of the county. Annual forage production is about 3,500 pounds per acre when the climate is favorable and about 1,200 pounds when it is unfavorable.

SHALLOW CLAY PRAIRIE RANGE SITE

This site consists of shallow to moderately deep soils that are moderately sloping to steep. Because they have been influenced somewhat by gypsum and dolomitic limestone, these clayey soils are friable and take water more readily than most fine-textured soils. Soils of this site are—

Vernon clay loam, 5 to 12 percent slopes.
Vernon soil in Vernon-badland complex.
Vernon soil in Vernon-Cottonwood complex.

In excellent condition this site supports a good cover of mid and tall grasses and legumes and other palatable forbs.

Soils of this site make up about 9 percent of the rangeland of the county. Annual forage production is about 3,500 pounds per acre when the climate is favorable and about 1,200 pounds when it is unfavorable.

RED CLAY PRAIRIE RANGE SITE

This site consists of friable, fine-textured soils that are shallow to moderately deep. Soils in this site are—

Vernon clay loam, 0 to 3 percent slopes.
Vernon clay loam, 3 to 5 percent slopes.

In excellent condition the range supports a mixed stand of grasses; buffalograss and blue grama make up much of the cover. Continuous heavy grazing leads to a cover of buffalograss and weeds.

Soils of this site make up about 2 percent of the rangeland of the county. Annual forage production is about 3,500 pounds per acre when the climate is favorable and about 1,200 pounds when it is unfavorable.

SHALLOW PRAIRIE RANGE SITE

This site is made up of shallow, moderately sloping to steep soils (fig. 21). There are some bare areas along the sides of ravines and on the tops of ridges. Soils in this site are—

Quinlan loam.

Quinlan soil in Quinlan-Woodward loams, 3 to 5 percent slopes, eroded.

Quinlan soil in Quinlan-Woodward loams, 5 to 12 percent slopes.

Quinlan soil in Quinlan-Woodward loams, 5 to 12 percent slopes, eroded.

Quinlan soil in Woodward-Quinlan loams, 3 to 5 percent slopes.

Little bluestem is the predominant grass when the range is in excellent condition. Side-oats grama is an increaser. Sand dropseed and weeds come in after continuous heavy grazing.

Soils of this site make up about 16 percent of the rangeland of the county. Annual forage production is about 3,100 pounds per acre when the climate is favorable and about 1,000 pounds when it is unfavorable.

LIMY SANDY PLAINS RANGE SITE

This site consists of an open sandy soil. Caliche underlies the soil at various depths. The only soil in this range site is—

Otero loamy fine sand, undulating.

Tall and mid grasses make up nearly all the cover when the range is in excellent condition. Side-oats grama, little bluestem, and sand bluestem are the principal decreaseers. Sand dropseed, hairy grama, and weeds take over after continuous heavy grazing.

The soil of this site makes up 0.1 percent of the rangeland of the county. Annual forage production is about 3,000 pounds per acre when the climate is favorable and about 1,000 pounds when it is unfavorable.

RED CLAY FLATS RANGE SITE

This site consists of a deep, nearly level clayey soil that occurs mainly on flood plains. The only soil in the Red Clay Flats range site is—

Treadway clay.



Figure 21.—Shallow Prairie range site. This upland site is fairly productive.



Figure 22.—View of the Breaks range site. The steep-walled canyons restrict the movement of livestock.

Mesquite trees and alkali sacaton are typical of this site. Switchgrass, western wheatgrass, vine-mesquite, and meadow dropseed are important grasses when the range is in excellent condition. Mesquite trees are invaders, and buffalograss is an increaser. Continuous heavy grazing will result in barren areas of compacted clay.

Soils of this site make up 0.3 percent of the rangeland of the county. Annual forage production is about 2,500 pounds per acre when the climate is favorable and 1,000 pounds when it is unfavorable.

SHALLOW RANGE SITE

This site consists of a shallow, friable, medium-textured soil that has caliche pebbles at or near the surface. Relief is gently sloping to steep. In this site is—

Potter soil in Mansker-Potter loams, 5 to 12 percent slopes.

Side-oats grama, little bluestem, and hairy grama are the principal grasses when the range is in excellent condition. This site also supports many kinds of legumes and other palatable broad-leaved plants.

Soils of this site make up 0.2 percent of the rangeland of the county. Annual forage production is about 2,000 pounds per acre when the climate is favorable and about 700 pounds when it is unfavorable.

BREAKS RANGE SITE

This site consists of steep, barren areas, pockets of productive soil, and narrow strips in valleys (fig. 22). In this site is—

Rough broken land.

Tall and mid grasses are predominant when the range is in excellent condition, but many legumes and other palatable broad-leaved plants are native to the site. Grazing is restricted by the steep slopes, and some areas are inaccessible to livestock because of gullying. Heavy grazing quickly leads to additional gullying in the bottoms of narrow valleys and to slouging of soil material on steep slopes.

Rough broken land makes up about 1.2 percent of the rangeland of the county. Annual forage production is about 1,800 pounds per acre when the climate is favorable and about 500 pounds when it is unfavorable.

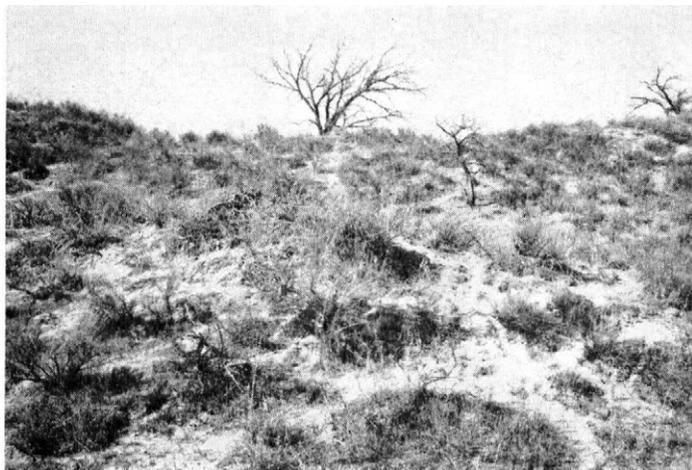


Figure 23.—Dune range site in the uplands. This site provides little forage for livestock.

DUNE RANGE SITE

This site consists of steep sandy soils that have little clay and silt (fig. 23). On the steeper slopes, trampling by livestock has caused appreciable damage to the desirable plants. The soils in this site are—

Tivoli soil in Pratt-Tivoli loamy fine sands.
Tivoli fine sand.

Normally, woody plants cover up to about 30 percent of the acreage of the soils, but it is best not to remove all the brush. Sand bluestem, little bluestem, and sand lovegrass are prominent when the range is in excellent condition. Weeds and brush increase after heavy grazing.

Soils of this site make up 12 percent of the rangeland of the county. Annual forage production is about 1,800 pounds per acre when the climate is favorable and about 500 pounds when it is unfavorable.

GYP RANGE SITE

This site consists of moderately sloping to steep soils that have outcrops of gypsum (fig. 24). In this site is—

Cottonwood soil in the Vernon-Cottonwood complex.

Little bluestem and side-oats grama are the principal grasses when the range is in excellent condition. Sand

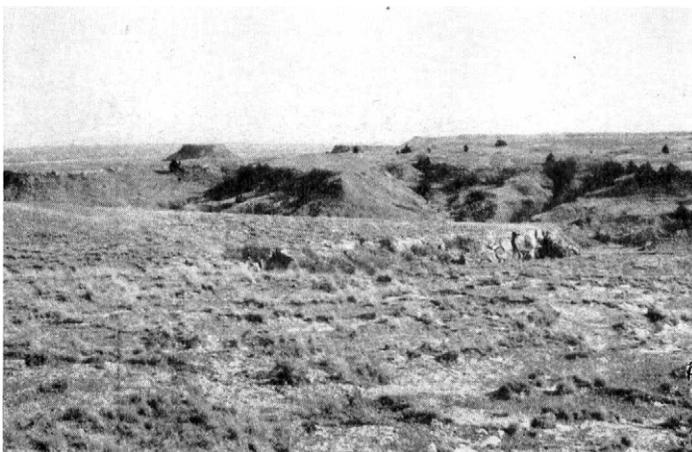


Figure 24.—View of the Gyp range site. When grazed, this site needs special care.

dropseed and gypweed make up the cover after many years of heavy grazing.

Soils of this site make up about 4 percent of the rangeland of the county. Because of the high percentage of barren gypsum, the Gyp site produces little forage. Annual forage production is about 1,000 pounds per acre when the climate is favorable and about 300 pounds when it is unfavorable.

ERODED RED CLAY RANGE SITE

This site consists of flats and dissected areas (fig. 25). Recent geologic erosion has removed the surface soil and exposed the parent material over most of the area. This site is made up mainly of—

Badland in the Vernon-badland complex.

Included in this site are small areas of Vernon soils. The Eroded Red Clay site makes up about 1 percent of the rangeland of the county. Annual forage production is about 500 pounds per acre when the climate is favorable and about 100 pounds when it is unfavorable. Because of runoff from adjacent slopes and the lack of surface soil, this site can be improved only if it is grazed lightly and if grazing is restricted to the winter.

Principles of range management

The basic purpose of good range management is to increase the number of the best forage plants and to encourage their growth. Following is a discussion of the main practices needed to achieve this purpose.

Proper grazing use.—The number of livestock that can be grazed is a basic consideration in grazing management. A rule of thumb is that about half of the yearly growth of range plants should be left ungrazed. Because of the irregularity of rainfall in Woodward County, the number of livestock to be grazed must be based on the expected supply of forage. If areas are grazed too intensively for extended periods, the productivity of the range will decrease and after rainfall the range will recover more slowly than if it had been only moderately grazed.

The number of breeding cattle should be based on the amount of forage produced during dryer years. If this is done, the operator will not have to reduce his herd during dry periods and there may be no serious reduction in the calf crop or in calf weights. If surplus grass is available, stockers can be added during fall. The herd can be reduced the following spring if moisture is lacking.

Using pastures during the proper season is an important method of improving rangeland. If a good supply of moisture in winter and early spring results in an abundant stand of winter grasses and weeds on range that was previously in poor condition, livestock can be concentrated on the pastures when annuals are growing rapidly. When closely grazed, this feed, which is temporarily abundant, will provide less competition for the warm-season grasses that start to grow later in spring. Ordinarily, the deferred range can be grazed once the warm-season grasses green up. If badly depleted, however, the range should be deferred from grazing until the latter part of June.

Another example of proper seasonal use is the intensive grazing of coarse, normally unpalatable forage when it is growing rapidly; at this time livestock will eat this kind of forage more readily. When it has a high percentage

of inland saltgrass, the Subirrigated range site can be improved if these coarse plants are grazed heavily during spring and the site is then rested so that the more desirable switchgrass and other palatable plants can develop fully.

Deferred grazing.—By periodically deferring his different pastures from grazing, the rancher can, in time, rest all his rangeland during the growing season and thereby improve the vigor of his best grasses. If the rancher has a deferred pasture in reserve and keeps his other pastures only moderately stocked, he has "money in the bank" that he can draw on when rainfall is below normal.

Proper distribution of grazing.—Getting even distribution of grazing is a problem on some pastures, particularly those that contain soils of different range sites. Fencing the different kinds of pastures is often the only way to distribute grazing evenly. It is especially desirable to fence subirrigated range separately. Proper spacing of livestock water is also important. In addition, salt can be placed on ungrazed parts of a pasture to attract cattle and change their pattern of grazing.

Control of weeds and brush.—As a rule, it is best to allow the natural succession of native plants to crowd out weeds, instead of mowing or spraying. Unpalatable weeds help to protect soils from trampling and packing by livestock, help control erosion, and furnish food and cover for wildlife.

On rangeland that has a cover of sand sagebrush, skunkbush, and other woody plants (fig. 26), the brush can be controlled by spraying with herbicides, by beating, or by mowing. Because of the danger of erosion, it is generally not safe to destroy woody plants on steep, choppy sand dunes.

After brush-control practices have been applied, the range should be rested during the growing season to permit depleted stands of grasses to grow vigorously and to produce seed. Ordinarily, the range should be grazed moderately the following winter so that livestock will help distribute seed and mulch.

Seeding native grasses.—During the last 17 years, much of the acreage in the county best suited to grasses has been seeded to perennial native grasses through the efforts of the Woodward Soil Conservation District. A large acreage still needs to be seeded, however.

To reseed a field, the rancher needs to select kinds of grasses best suited to the particular sites that compose the field. Hardlands should be seeded to a mixture that consists principally of side-oats grama, blue grama, and switchgrass. Western wheatgrass also is desirable especially in draws and swales. Loamy and sandy sites should be seeded to a mixture made up largely of little bluestem, side-oats grama, sand bluestem, switchgrass, and blue grama. Deep sands should be seeded to a mixture of such taller grasses as sand bluestem, switchgrass, Indiangrass, little bluestem, sand lovegrass, and Canada wildrye.

Cattle tend to concentrate on the reseeded area for at least several years after the new stand has been established. Consequently, it is best to leave the fence around the field until the seeded area and the adjacent native range have similar cover.

Stocking rates.—No specific rates for stocking livestock are given in this report. The rancher's pastures are likely to contain different range sites, and parts of any one site

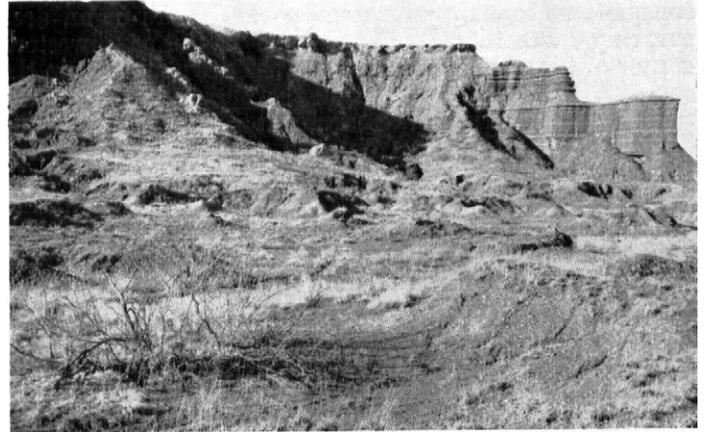


Figure 25.—Eroded Red Clay range site in foreground, and gypsum breaks in the background.

may be in different range condition. As a result, each pasture must be evaluated and managed separately.

Because the production of forage varies according to the amount of yearly rainfall, a stocking rate that is too high will result in financial losses during droughts. If a rancher uses a flexible rate of stocking, he can increase his herd when grasses are abundant and vigorous, and decrease it during droughts.

Woodland ²

In Woodward County, native trees occur along the streams and, to some extent, in the sandy uplands. The main trees along the streams are cottonwood, elm, willow, and hackberry; there are also some walnut trees. These trees attain fair height and diameter. Trees in the uplands are scrubby, except in a minor intrusion, in the southeastern part of the county, where there is the post oak-blackjack oak forest type that is common in central Oklahoma. Elm, hackberry, and stunted oak are characteristic of the uplands.

More or less common along streams and in the uplands are soapberry, chittamwood, persimmon, and plum. A



Figure 26.—Deep Sand range site that is heavily infested with sand sagebrush and is in poor condition.

² HERBERT R. WELLS, woodland and biology conservationist, Soil Conservation Service, prepared this section and the following section "Wildlife."

considerable amount of shinnery oak occurs in an area covering more than two townships in the southwestern corner of the county. Redcedar was once abundant in the county. It is still common on the Quinlan and similar soils along the rough escarpment that separates the drainage areas of the Cimarron and North Canadian Rivers.

The timber of Woodward County, though not present in commercial quantities, supplies posts and some rough lumber for local use and provides windbreaks for farms and fields. Suitability of soils of the county for windbreaks and post lots is given in table 6. Ratings in table 6 are defined as follows: *Suitable*—soils that have good soil-water-plant relationships and occur in favorable locations; *suitable with limitations*—soils of limited suitability for windbreaks and post lots because of unfavorable location, texture, or soil layers; such soils require extra water, additional tillage, and very wide spacing of trees; *not suitable*—soils not generally suitable for growing trees for windbreaks or post lots. A discussion of the use of trees for field and farmstead windbreaks and for post lots follows.

TABLE 6.—*Suitability of soils for field and farmstead windbreaks and post-lot plantings*
[S=suitable; SL=suitable with limitations; NS=not suitable]

Soil	Suitability for—		
	Field windbreaks	Farmstead windbreaks	Post lots
Brownfield fine sand, 1 to 3 percent slopes	S	S	SL
Carey silt loam, 1 to 3 percent slopes	SL	S	NS
Carey silt loam, 3 to 5 percent slopes	NS	SL	NS
Carey silt loam, 5 to 8 percent slopes	NS	SL	NS
Carey silt loam, 5 to 8 percent slopes, eroded	NS	SL	NS
Carwile-Pratt complex	SL	SL	SL
Elsmere loamy fine sand	SL	S	S
Enterprise fine sandy loam, undulating	SL	S	S
Enterprise loam, 3 to 5 percent slopes	NS	SL	NS
Enterprise-Pratt complex, 5 to 8 percent slopes	NS	SL	NS
Enterprise-Pratt complex, 8 to 20 percent slopes	NS	SL	NS
Holdrege loam, 1 to 3 percent slopes	SL	S	S
Las Animas soils	SL	S	S
Leshara loam	NS	S	SL
Lincoln loamy fine sand	S	S	S
Lincoln soils	S	S	S
Mansker loam, 1 to 3 percent slopes	SL	S	NS
Mansker loam, 3 to 5 percent slopes	NS	SL	NS
Mansker-Potter loams, 5 to 12 percent slopes	NS	SL	NS
Miles fine sandy loam, 1 to 3 percent slopes	SL	S	S
Miles fine sandy loam, 3 to 5 percent slopes	SL	S	S
Nobscoot-Brownfield fine sands, 3 to 5 percent slopes	SL	SL	NS
Nobscoot-Brownfield complex, severely eroded	SL	SL	NS
Nobscoot-Eufaula fine sands, 5 to 12 percent slopes	SL	SL	NS
Nobscoot-Pratt complex, hummocky	SL	S	SL
Nobscoot-Pratt complex, duned	SL	S	SL
Otero loamy fine sand, undulating	SL	S	NS
Port loam	SL	SL	SL
Pratt fine sandy loam, hummocky	SL	S	S
Pratt fine sandy loam, undulating	SL	S	S
Pratt loamy fine sand, hummocky	NS	SL	SL

TABLE 6.—*Suitability of soil for field and farmstead windbreaks and post-lot planting*—Continued
[S=suitable; SL=suitable with limitations; NS=not suitable]

Soil	Suitability for—		
	Field windbreaks	Farmstead windbreaks	Post lots
Pratt loamy fine sand, undulating	SL	S	SL
Pratt-Tivoli loamy fine sands	NS	SL	NS
Quinlan loam	NS	NS	NS
Quinlan-Woodward loams, 3 to 5 percent slopes, eroded	NS	SL	NS
Quinlan-Woodward loams, 5 to 12 percent slopes	NS	NS	NS
Quinlan-Woodward loams, 5 to 12 percent slopes, eroded	NS	NS	NS
Rough broken land	NS	NS	NS
St. Paul silt loam, 0 to 1 percent slopes	NS	SL	NS
St. Paul silt loam, 1 to 3 percent slopes	NS	SL	NS
St. Paul silt loam, 3 to 5 percent	NS	SL	NS
Sweetwater soils	NS	NS	NS
Tivoli fine sand	NS	NS	NS
Treadway clay	NS	SL	NS
Vernon clay loam, 0 to 3 percent slopes	NS	SL	NS
Vernon clay loam, 3 to 5 percent slopes	NS	SL	NS
Vernon clay loam, 5 to 12 percent slopes	NS	NS	NS
Vernon-badland complex	NS	NS	NS
Vernon-Cottonwood complex	NS	NS	NS
Wann fine sandy loam	S	S	S
Woodward loam, 1 to 3 percent slopes	NS	SL	NS
Woodward loam, 3 to 5 percent slopes	NS	SL	NS
Woodward loam, 5 to 8 percent slopes	NS	SL	NS
Woodward-Quinlan loams, 3 to 5 percent slopes	NS	SL	NS
Yahola fine sandy loam	S	S	S
Yahola fine sandy loam, high	S	S	S

Windbreaks

If located on proper soils, field windbreaks help to protect crops and to control wind erosion. In the past they have been planted extensively in Woodward County, but some located on unsuitable soils or improperly managed have not been successful.

The trees in a windbreak should be spaced fairly wide apart. On a dryland field that has no reliable source of underground water, or to which no additional moisture is diverted, the distance between rows should range from 14 to 20 feet, depending on the depth to which the soil is permeable and on how much moisture the soil will hold. The distance between trees in the row is usually 8 feet. On very favorable sites, rows may be as little as 12 feet apart, and the trees in the row as close as 6 feet. On most sites, shrubs are usually planted 4 feet apart in the row; the soil should be permeable enough to store moisture to a depth of 6 feet. A very coarse textured soil needs an impermeable layer at the bottom of the root zone for the holding of moisture. Windbreaks should be restricted to slopes of less than 5 percent, unless they can be laid out on the contour.

In Woodward County, field windbreaks are most effective when planted in patterns that will protect the southern, western, and northern boundaries of a field. Supporting belts must be planted at intervals that do not exceed 20 times the height tall trees will reach, at ma-

turity. Belts of three rows, consisting of two rows of tall trees and one row of shrubs, are effective and are popular because they occupy less land than the 10-row belts commonly planted in the thirties.

Because of the swing to narrower fieldbelts, however, the number of suitable trees and shrubs has been limited. Essential plants in three-row belts are (1) suitable tall trees that give maximum protection and (2) shrubs or small trees that have a dense understory. The second row of tall trees protects against losses during the period when gaps occur in the first row. Suitable tall trees that can be readily obtained from public agencies are cottonwood, Siberian elm, honeylocust, and sycamore. Redcedar and ponderosa pine are very suitable for windward-side rows. Russian mulberry, planted at 4-foot spacing in the rows, will make a dense, shrublike barrier.

The average farmstead windbreak does not require trees of great height to protect soils and crops. Because of this and the possibility that the farmstead windbreak will be managed better and receive more water than field windbreaks, trees can be planted on shallower, finer textured soils. Trees and shrubs used in fieldbelts serve well in farmstead plantings. Also suitable are catalpa and similar plants that can be readily obtained at low cost, as well as trees and shrubs recommended by local nurseries.

Up to seven rows are frequently used in farmstead windbreaks. The rows can be made up of all hardwoods or all conifers. Commonly, they consist of a combination of the two to furnish both shade and a dense barrier against the wind. Conifers are especially desirable because of their year-round foliage. In general, spacing between rows and between trees should conform to those previously suggested for field windbreaks, but, if the farmstead windbreak is irrigated, minimum spacing can be used.

Post lots

Post lots can be established on some soils of the county, as indicated in table 6. Black locust, catalpa, and Osage-orange are commonly planted for posts, and Russian mulberry is grown to a limited extent. The spacing is usually 6 by 12 feet. This provides enough growing space because, under proper management, the trees are cut before they fully mature. The sprouts that result are managed for successive harvests.

In post lots, as well as other plantings, cultivation is essential. If minimum spacing is used, cultivation can be halted after the crowns of the trees mesh together and shade out competing vegetation. This may occur within 3 to 5 years. If the spacing between trees is especially wide, the post lot usually needs to be cultivated for the life of the planting.

Wildlife

Woodward County lies within an area that has the highest normal density of bobwhite quail and doves in the State. Although the number of these birds varies from year to year, more hunting is generally done in this area than in other parts of Oklahoma.

Approximately two-thirds of the county is underlain by sandy geological material. The soils that have formed from this material provide excellent natural habitats consisting of tall grasses, sand sagebrush, and skunkbush.

The extensive Pratt soils have a few post oak, blackjack oak, elm, hackberry, soapberry, chittamwood, persimmon, and plum trees. In the extreme southwestern corner of the county, an area of more than two townships made up of Nobscot soils has an extensive stand of shinnery oak. The lesser prairie chicken, which is decreasing in number, is in this area. Almost all of the sandy part of the county attracts wildlife because of the use of a cropping system that includes small grains, grain sorghum, and sudangrass.

About a third of Woodward County is underlain by red beds. This area is mostly in the northeastern part. The soils are generally finer textured and shallower than those elsewhere in the county, and they have a cover made up mainly of short and mid grasses. There are some good habitats for birds in the uplands, but, in general, the most stable bird population occurs along the complex drainage system of the North Canadian River.

Areas along the North Canadian and Cimarron Rivers, the main streams in the county, have a cover of coarse grasses and some stands of cottonwood, willow, and saltcedar, as well as small trees and shrubs common to the sandy area. Persimmon and Indian Creeks, spring-fed streams in the sandy area, are of particular value as wildlife habitats. These streams begin in the southwestern part of the county and flow northeastward into the North Canadian River. Many small, short streams drain northeastward into the Cimarron River.

Fox, squirrel, raccoon, opossum, and a few families of mink frequent stream courses, particularly those near the rough broken escarpment that separates the two physiographic areas in the county. A few beaver colonies still persist under the protection of small spring-fed creeks. Upland species, such as skunk, badger, cottontail, jackrabbit, and coyote, also make use of stream areas to some extent. There are many coyotes and a few bobcats in the rougher areas along streams. Deer inhabit the areas along the North Canadian and Cimarron Rivers. They are not abundant, but in recent years there has generally been a short hunting season.

To increase the wildlife population on a farm or ranch, an operator needs to establish suitable plants for food and cover. By and large, however, good-sized populations can be maintained if areas are properly grazed and protected against burning. Areas of special value to wildlife can be fenced to exclude livestock.

Fishing is permitted seasonally in parts of some streams, in small farm ponds, in the Fort Supply Reservoir, and in 8 or 10 other reservoirs, each of which impounds from 10 to 30 acres of water. The Fort Supply Reservoir is fairly shallow, but it covers an area of 1,820 acres. It contains mainly carp, white bass, catfish, and crappie and some largemouthed bass and other sunfish. The rivers support about the same kind of fish but in much more limited numbers. Most farm ponds have been stocked with largemouthed black bass, bluegill, and channel catfish. In general, fishing in ponds is not especially good, because of the turbidity of the water and the lack of systematic management.

In some years migrating waterfowl provide fair hunting for short periods in areas near streams and in fields of small grains and grain sorghum. Pheasants have increased in number and in range of habitat, but they are not numerous enough to justify an extended open season

for hunting. Wild turkeys have been introduced in the county in the past few years and have persisted and increased in some places.

Engineering Uses of the Soils ³

This soil survey report contains information that can be used by engineers to—

- (1) Make soil and land-use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.
- (2) Make estimates of runoff characteristics for use in designing drainage structures and planning dams and other structures for water and soil conservation.
- (3) Make reconnaissance surveys of soil and ground conditions that will aid in selecting locations for highways and airports and in planning detailed investigations of the selected locations.
- (4) Locate probable sources of sand, gravel, caliche, and other construction materials.

- (5) Correlate performance of engineering structures with soil mapping units and thus develop information that will be useful in designing and maintaining the structures.
- (6) Determine the suitability of soil mapping units for cross-country movements of vehicles and construction equipment.
- (7) Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making maps and reports that can be readily used by engineers.
- (8) Develop other preliminary estimates for construction purposes pertinent to the particular area.

The mapping and the descriptive report are somewhat generalized and should be used only for planning more detailed field surveys to determine the characteristics of

³This section was prepared by ROBERT L. BARTHOLIC, engineer, Soil Conservation Service.

TABLE 7.—Brief description of the soils

Symbol on map	Soil name	Description of soil and site	Depth from surface (typical profile)	Classification
				USDA texture
BfB	Brownfield fine sand, 1 to 3 percent slopes.	Deep fine sand underlain by subsoil of sandy clay loam; formed in sandy sediments of the Tertiary age that have been reworked by wind; gently sloping relief; soil is forested.	Inches 0 to 10 10 to 40	Loamy fine sand..... Silty clay loam.....
CaB	Carey silt loam, 1 to 3 percent slopes.....	Deep, gently sloping loamy soils of the uplands; formed from permeable, calcareous, weakly consolidated sandy and loamy sediments of the Permian red beds; native vegetation was grasses.	0 to 14 14 to 30 30 to 44	Silt loam.....
CaC	Carey silt loam, 3 to 5 percent slopes.....			Silt loam.....
CaD	Carey silt loam, 5 to 8 percent slopes.....			Silty clay.....
CaD2	Carey silt loam, 5 to 8 percent slopes, eroded.			
Cp	Carwile-Pratt complex.....	Carwile: Deep soil in valleys between sand dunes and in depressions. Pratt: See Pratt fine sandy loams.....	0 to 9 9 to 34 45 to 60	Clay loam..... Sandy clay..... Loamy fine sand.....
Fe	Elsmere loamy fine sand.....	Deep, nearly level sandy soil of the bottom lands; formed from windblown sand; high water table.	0 to 16 16 to 48	Loamy fine sand..... Loamy sand.....
EfB	Enterprise fine sandy loam, undulating..	Deep, gently sloping fine sandy loam of the uplands; occurs along the major streams; formed from wind-deposited calcareous sand.	0 to 6 6 to 49	Fine sandy loam..... Very fine sandy loam.
EmC	Enterprise loam, 3 to 5 percent slopes..	Deep, sloping loamy soil; formed in unconsolidated, slightly reddish, calcareous sand, silt, and clay of the Tertiary age and in windblown deposits.	0 to 6 6 to 42	Fine sandy loam..... Loam.....
EpD	Enterprise-Pratt complex, 5 to 8 percent slopes.	Enterprise: See Enterprise loam, 3 to 5 percent slopes; Pratt: See Pratt fine sandy loams.		
EpE	Enterprise-Pratt complex, 8 to 20 percent slopes.			
HoB	Holdredge loam, 1 to 3 percent slopes..	Deep, gently sloping loamy soil formed in alluvium of the Pleistocene age that is mantled with windblown deposits.	0 to 19 19 to 75	Loam..... Loam.....
La	Las Animas soils (silty clay loam).....	Deep, calcareous loamy and sandy soils of the bottom lands; soils are forming in mixed alluvium of the Tertiary age; high water table.	0 to 22 22 to 72	Silty clay..... Loamy fine sand.....

the in-place soil at the site of any proposed engineering construction.

Thus, the information in this section of the report will not eliminate the need for sampling and testing for design and construction of specific engineering works, but it will serve as a guide and allow more efficient sampling and testing.

Engineering soil classifications, interpretations, and soil test data

Tables 7, 8, and 9 summarize the physical properties and the suitability of the soils of Woodward County for engineering construction.

Table 7 provides a brief description of each of the soils mapped and estimates of their physical properties. These estimates are for typical, or modal, soil profiles, divided into layers significant in soil engineering. For some of the soils, the properties were estimated on the basis of soil tests made on these soils in Woodward County (see table 9). For other soils, tests were not made in the county, but soil properties were estimated by (a) using data on the

same soils that were tested in other counties, (b) by comparing them with similar soils that were tested in this county, and (c) by using past experience in engineering construction. Since the estimates in table 7 are based on typical, or modal, profiles, considerable variation from these estimates should be anticipated. More information on the range in soil properties to be expected on the various soils can be obtained in other sections of this report.

In table 7 soil texture is described according to (1) the classification of the U.S. Department of Agriculture (USDA), (2) the Unified classification⁴ developed by the Corps of Engineers, U.S. Army, and (3) the system used by the American Association of State Highway Officials (AASHO).⁵

⁴ WATERWAYS EXPERIMENT STATION. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3-357, 48 pp., illus. Prepared for Off. of Engin., Vicksburg, Miss. 1953.

⁵ AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 parts, illus. Washington, D.C. 1961.

and their estimated physical properties

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Dispersion	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200					
SM	A-2	100	100	14	Inches per hour 1.0 to 2.5	Inches per inch of soil 0.067	Noncalcareous	High	Low.
SC	A-6	100	100	40					
ML	A-4	100	100	51	1.0 to 2.5	.117	Noncalcareous	Medium	Low.
ML-CL	A-4	100	100	60	1.0 to 2.5	.117	Calcareous	Low	Medium.
CL	A-4	100	100	76	1.0 to 2.5	.125	Calcareous	Low	Medium.
CL	A-4	100	100	59	0.05 to 0.20	.142	Noncalcareous	Low	Low.
SC	A-2 or A-6	100	100	35	0.10 to 0.80	.142	Noncalcareous	Low	Low to medium.
SM	A-2	100	100	10	1.0 to 2.5	.067	Calcareous	High	Low.
SM	A-2	100	100	15	5.0 to 10.0	.067	Calcareous	High	Low.
SP-SM	A-2	100	100	8	5.0 to 10.0	.042	Calcareous	High	Low.
ML-CL	A-4	100	100	59	3.0 to 8.0	.142	Calcareous	High	Low.
SM	A-2	100	100	32	2.5 to 5.0	.142	Calcareous	High	Low.
SM or SM-SC	A-4	100	100	62	1.0 to 3.0	.142	Calcareous	High	Low.
ML or CL	A-4 or A-6	100	100	58	0.8 to 2.5	.142	Calcareous	High	Medium.
ML	A-4	100	100	80	0.8 to 2.5	.117	Noncalcareous	Medium	Low.
CL	A-6	100	100	78	0.5 to 1.7	.142	Noncalcareous	Medium	Medium.
ML or CL	A-4 to A-7	100	100	65	0.05 to 0.1	.167	Calcareous	Low	Medium to high.
SM	A-4	100	95	35	2.5 to 5.0	(¹)	Calcareous	High	Low.

See footnote at end of table.

TABLE 7.—*Brief description of the soils and*

Symbol on map	Soil name	Description of soil and site	Depth from surface (typical profile)	Classification
				USDA texture
Le	Leshara loam	{ Deep, nearly level to gently sloping loamy soil of the bottom lands; slopes of 0 to 2 percent.	<i>Inches</i> 0 to 28 28 to 45	Loam Clay loam
Ln	Lincoln soils (loamy fine sand grading to fine sand).	{ Deep, very sandy soils of the bottom lands; occur near stream channels; topography consists of low, irregular dunes and valleys between dunes.	0 to 18 18 to 60	Loamy fine sand Fine sand
Lf	Lincoln loamy fine sand	{ Deep, very sandy soil of the bottom lands; similar to Lincoln soils.		
MbB MbC	Mansker loam, 1 to 3 percent slopes Mansker loam, 3 to 5 percent slopes	{ Moderately deep, gently sloping caliche soils; formed from fine- and medium-textured sediments of the Tertiary age.	0 to 8 8 to 16 16 to 40	Loam Clay loam Loam or clay loam
McD	Mansker-Potter loams, 5 to 12 percent slopes.	{ Mansker: See description of Mansker loams. Potter: Shallow, sloping, loamy caliche soil forming in fine- and medium-textured sediments of the Tertiary age.	0 to 10 10+	Loam or clay loam Consolidated caliche
MfB MfC	Miles fine sandy loam, 1 to 3 percent slopes Miles fine sandy loam, 3 to 5 percent slopes.	{ Deep, nearly level to gently sloping fine sandy loams that have a sandy clay loam subsoil; formed from sandy and loamy sediments of the Tertiary age.	0 to 8 8 to 36 36 to 40 40 to 53	Sandy loam Sandy clay loam Clay Loamy sand
NbC Nc3	Nobscot-Brownfield fine sands, 3 to 5 percent slopes. Nobscot-Brownfield complex, severely eroded.	{ Nobscot: Sloping sandy soils that are forested; formed in calcareous sand of the Tertiary age. Brownfield: See description of Brownfield fine sand, 1 to 3 percent slopes.	0 to 20 20 to 84	Fine sand Loamy sand
NpC NpE	Nobscot-Pratt complex, hummocky Nobscot-Pratt complex, duned	{ Nobscot: See description of Nobscot soil of Nobscot-Brownfield complexes; Pratt: See description of Pratt loamy fine sands.		
NeD	Nobscot-Eufaula fine sands, 5 to 12 percent slopes.	{ Nobscot: See description of Nobscot soil of Nobscot-Brownfield complexes. Eufaula: Sloping, forested soil formed in sand of the Tertiary age.	0 to 24 24 to 55	Fine sand Fine sand
OtB	Otero loamy fine sand, undulating	{ Deep, calcareous sandy soil on gently undulating slopes of 3 percent; forming in calcareous sand of the Tertiary age.	0 to 20 20 to 60	Loamy fine sand Loamy sand
Pa	Port loam	Deep, nearly level loamy soil of the bottom lands.	0 to 20 20 to 46 46 to 61	Loam Clay loam Sandy clay
PbC PbB	Pratt fine sandy loam, hummocky Pratt fine sandy loam, undulating	{ Deep fine sandy loams on slightly uneven topography with slopes of 1 to 5 percent; formed in windblown sand.	0 to 39 39 to 60	Fine sandy loam Loamy fine sand
PfC PfB	Pratt loamy fine sand, hummocky Pratt loamy fine sand, undulating	{ Deep sandy soils on dune topography with slopes of 1 to 12 percent; formed in windblown sand.	0 to 65	Loamy fine sand
Pt	Pratt-Tivoli loamy fine sands	{ Pratt: See description of Pratt loamy fine sands; Tivoli: Similar to Tivoli fine sand.		
Qm	Quinlan loam	{ Shallow, steep loamy soil on slopes of 10 percent; forming in weakly consolidated, open-grained, reddish sandstone and sandy shale of the Permian age.	0 to 13 13 to 65	Loam Weakly consolidated sandstone.
QwC2 QwD QwD2	Quinlan-Woodward loams, 3 to 5 percent slopes, eroded. Quinlan-Woodward loams, 5 to 12 percent slopes. Quinlan-Woodward loams, 5 to 12 percent slopes, eroded.	{ Quinlan: See description of Quinlan loam; Woodward: See description of Woodward loams.		

their estimated physical properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Dispersion	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200					
ML or CL	A-4 or A-6	100	100	92	Inches per hour 0.1 to 0.5 0.05 to 0.2	Inches per inch of soil .142 .167	Calcareous	Medium	Medium.
CL or CH	A-7-6	100	100	95			Calcareous	Low	High.
SM	A-2	95	70	15	10.0 to 20.0	.042	Calcareous	High	Low.
SP or SM	A-2	85	60	10	10.0 to 20.0	.042	Calcareous	High	Low.
ML or CL	A-4 or A-6	100	100	60	1.0 to 1.5	.117	Calcareous	Medium	Low to medium.
CL	A-6 or A-7-6	100	100	90	0.5 to 1.0	.142	Calcareous	Medium	Medium to high.
ML or CL	A-4 or A-6	95	95	70	0.2 to 1.0	.117	Calcareous	Low	Medium.
ML or CL	A-4, A-6, or A-7-6.	95	90	60	0.8 to 1.5	.067	Calcareous	Medium	Medium.
SM	A-2	100	100	31	0.8 to 2.5	.142	Noncalcareous	High	Low.
SC or CL	A-6	100	90	48	0.5 to 2.0	.142	Noncalcareous	Medium	Medium.
CH or MH	A-7-5	100	100	100	0.05 to 0.1	.167	Noncalcareous	Low	High.
SM	A-2	100	82	13	5.0 to 0.1	.10	Noncalcareous	High	Low.
SM	A-2-4	100	100	15	5.0 to 10.0	.083	Noncalcareous	High	Low.
SM-SC	A-2-4	100	100	20	2.5 to 5.0	.067	Noncalcareous	High	Low.
SM	A-2-4	100	100	15	5.0 to 10.0	.083	Noncalcareous	High	Low.
SM	A-2-4	100	100	17	5.0 to 7.5	.067	Noncalcareous	High	Low.
SM	A-2	100	90	20	3.0 to 5.0	.083	Calcareous	High	Low.
SM	A-2	98	95	15	5.0 to 10.0	.067	Calcareous	High	Low.
ML or CL	A-4 or A-6	100	100	100	0.3 to 0.9	.167	Calcareous	Low	Medium.
CL or CH	A-6 or A-7-6	100	100	100	0.2 to 0.8	.167	Calcareous	Low	High.
CL or CH	A-7-6	100	100	90	0.8 to 1.5	.15	Calcareous	Medium	High.
SM-SC	A-2	100	100	20	3.5 to 9.0	1.42	Noncalcareous	High	Low.
SM	A-2	100	100	10	5.0 to 10.0	.083	Noncalcareous	High	Low.
SP-SM	A-3	100	100	8	5.0 to 10.0	.067	Noncalcareous	High	Low.
ML or CL	A-4 or A-6	100	100	60	0.8 to 2.5	.142	Calcareous	Medium	Medium.

See footnote at end of table.

TABLE 7.—*Brief description of the soils and*

Symbol on map	Soil name	Description of soil and site	Depth from surface (typical profile)	Classification
				USDA texture
Rb	Rough broken land.....	{ An extremely steep miscellaneous land type that consists of a mixture of loamy sediments of the Permian age. Areas underlain by sandstone: similar to Quinlan loam; areas underlain by shale: similar to Vernon clay loams.	Inches	-----
SaA SaB SaC	St. Paul silt loam, 0 to 1 percent slopes. St. Paul silt loam, 1 to 3 percent slopes. St. Paul silt loam, 3 to 5 percent slopes.	{ Deep, nearly level to sloping loamy soils of the uplands; formed from weakly consolidated, fine-grained sandstone and sandy shale of the Permian age.	0 to 10 10 to 20 20 to 60	Silt loam..... Silty clay..... Clay loam.....
Sw	Sweetwater soils (silt loam).....	{ Deep, nearly level soils that have a high water table; formed in mixed alluvial sediments of the Tertiary age.	0 to 3 3 to 10 10 to 24 24 to 55	Silt loam..... Silty clay..... Sandy loam..... Sandy loam.....
Tv	Tivoli fine sand.....	{ Deep, steep very sandy soil in sand dunes; forming in recent windblown deposits from stream channels.	0 to 60	Fine sand.....
Tw	Treadway clay.....	{ Weathered, clayey alluvial sediments in which soil is forming; consists of youthful, gypsiferous shaly clay over sand similar to that of the Lincoln soils.	0 to 40 40 to 75	Clay..... Sand.....
VcB VcC VcD	Vernon clay loam, 0 to 3 percent slopes. Vernon clay loam, 3 to 5 percent slopes. Vernon clay loam, 5 to 12 percent slopes.	{ Shallow, nearly level to sloping clay loams; forming in calcareous shaly clay of the Permian age.	0 to 18 18 to 60	Clay loam..... Clay.....
Vm	Vernon-badland complex.....	{ Vernon: See description of Vernon clay loams. Badland: A miscellaneous land type consisting of eroded gypsiferous shale of the Permian age; slopes of 1 to 12 percent.	0 to 12 12 to 60	Clay..... Clay.....
Vp	Vernon-Cottonwood complex.....	{ Vernon: See description of Vernon clay loams. Cottonwood: Shallow, sloping soil that is forming in gypsum of the Permian age; slopes of 3 to 8 percent.	0 to 9 9+	Loam..... Consolidated gypsum.
Wl	Wann fine sandy loam.....	{ Deep, nearly level loamy soil of the bottom lands; forming from mixed alluvial sediments; slopes of 0 to 1 percent.	0 to 12 12 to 30 30 to 72	Fine sandy loam..... Sandy loam..... Sand.....
WoB WoC WoD	Woodward loam, 1 to 3 percent slopes. Woodward loam, 3 to 5 percent slopes. Woodward loam, 5 to 8 percent slopes.	{ Moderately deep, nearly level to sloping loamy soils of the uplands; formed in slightly consolidated, open-grained sandstone and sandy shale of the Permian age.	0 to 10 10 to 20 20 to 50	Loam..... Loam..... Loam over sandstone
WwC	Woodward-Quinlan loams, 3 to 5 percent slopes.	{ Woodward: See description of Woodward loams; Quinlan: See description of Quinlan loam.	-----	-----
Ya Yh	Yahola fine sandy loam..... Yahola fine sandy loam, high.....	{ Deep, nearly level fine sandy loams of the bottom lands; forming in a mixture of sandy alluvial sediments of the Permian age.	0 to 14 14 to 55	Fine sandy loam..... Fine sandy loam.....

¹ Unlimited.

In the Unified system, soils are identified on the basis of texture and plasticity and their performance as engineering construction materials. They are classified as coarse grained (8 classes), fine grained (6 classes), or highly organic (1 class). Under the Unified system, the symbols GW, GP, GM, GC, SW, SP, SM, and SC are used to identify coarse-grained soils; symbols ML, CL, OL, MH, CH, and OH, fine-grained soils; and symbol Pt., highly organic soils.

The AASHO classification is used by highway engineers in classifying soils according to their engineering properties as determined by the performance of the soils in highways. In this system soil materials are classified in seven principal groups. The groups range from A-1, made up of gravelly soils of high bearing capacity, to A-7, made up of clay soils having low strength when wet.

In table 7 columns under "Percent passing sieve" show the separation between the coarse- and fine-grained soils

their estimated physical properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Dispersion	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200					
					<i>Inches per hour</i>	<i>Inches per inch of soil</i>			
ML or CL	A-4	100	100	80	0.35 to 1.0	.117	Noncalcareous	Medium	Low.
CL	A-4 or A-6	100	100	85	0.2 to 0.8	.142	Noncalcareous	Medium	Low.
CL	A-6	100	100	82	0.1 to 0.6	.167	Calcareous	Low	Medium.
ML	A-4	100	100	68	0.05 to 0.2	.142	Calcareous	Medium	Low.
CL	A-6	100	100	66	0.05 to 0.2	.167	Calcareous	Low	Medium.
SM or SC	A-2 or A-4	100	100	35	1.0 to 5.0	.083	Calcareous	Medium	Low.
SM	A-2 or A-4	100	100	35	(²)		Calcareous	High	Low.
SP	A-3	100	100	5	10.0 to 30.0	.042	Noncalcareous	High	Low.
CH or MH	A-7-5	100	100	98	0.01 to 0.05		Calcareous	Low	High.
SP	A-3	100	95	5	5.0 to 20.0		Calcareous	High	Low.
CL	A-6 or A-7	100	100	93	0.2 to 0.8	.142	Calcareous	Low	Medium to high.
CL	A-7	100	100	80	0.1 to 0.5	.167	Calcareous	Low	Medium to high.
CL	A-6 or A-7	100	100	93	0.2 to 0.8		Calcareous	Low	Medium to high.
ML or MH	A-7-6	100	100	90	0.05 to 0.2		Calcareous	Medium	High.
ML or CL	A-6 or A-7-6	100	100	85	1.0 to 2.5	.142	Calcareous	High	Medium.
ML	A-4	100	100	60	0.8 to 2.5	.142	Calcareous	Medium	Low.
SM	A-2	100	100	30	0.8 to 2.5	.117	Calcareous	Medium	Low.
SP-SM	A-3	100	90	8	5.0 to 10.0	.042	Calcareous	High	Low.
ML	A-4	100	100	66	0.8 to 2.5	.117	Calcareous	Medium	Low.
ML-CL	A-4	100	100	58	0.8 to 2.5	.117	Calcareous	Medium	Low.
ML-CL	A-4	100	100	81	0.5 to 1.5	.142	Calcareous	Medium	Low.
Quinlan loam									
ML	A-4	100	100	60	2.5 to 5.0	.117	Calcareous	Medium	Low.
SM-SC	A-2	100	100	30	2.5 to 5.0	.142	Calcareous	Medium	Low.

² Water table.

and list the percentage of soil material that is smaller in diameter than the openings of the given screen.

The column headed "Permeability" refers to estimated rate of percolation, in inches per hour, of water in the soil.

The *available water capacity* represents the maximum amount of moisture available to plants. It differs from the water-holding capacity, which is approximately twice as great.

Dispersion refers to the degree and rapidity with which soil structure breaks down or slakes in water. A soil that has a high content of silt and no sand has high dispersion. A sandy soil that contains clay has low dispersion. Soils affected by dispersion are highly erodible, have low shear strength, and have high piping potential.

The *shrink-swell potential* refers to the change in volume of the soil that results from a change in water con-

TABLE 8.—Engineering

[Dashes indicate that the soil is not used for the specified engineering use. Miscellaneous land

Soil series and map symbols	Suitability of soil materials for—		Suitability as source of—		Suitability for engineering work	
	Road subgrade	Road fill	Topsoil	Sand	Farm ponds	
					Reservoir	Embankment
Brownfield ¹ (BfB, NbC, Nc3).	Fair	Fair	Fair	Poor	Fair	Fair
Carey (CaB, CaC, CaD, CaD2).	Fair	Fair	Good	Unsuitable	Good	Good
Carwile ¹ (Cp).	Fair to ½ or 1 foot; good below.	Good	Poor	Good below 10 feet.	Fair	Good
Cottonwood ¹ (Vp).	Poor	Poor	Poor	Unsuitable	Poor	Poor
Elsmere (Ee).	Fair	Fair; lacks binder.	Fair	Poor; high water table.	Poor	Poor
Enterprise ¹ (EfB, EmC, EpD, EpE).	Fair	Fair	Good	Unsuitable	Good	Fair
Eufaula (NeD).	Poor	Poor	Poor	Good	Poor	Poor
Holdrege (HoB).	Fair	Fair	Good	Unsuitable	Good	Good
Las Animas (La).	Poor to 2 feet; fair to good below.	Poor to 2 feet; good below.	Good	Good below 6 feet.	Good	Poor
Leshara (Le).	Good if confined.	Good; lacks binder.	Good	Unsuitable	Good	Fair
Lincoln (Lf, Ln).	Poor; good if confined.	Poor; lacks binder.	Poor	Good	Poor	Poor
Mansker ¹ (MbB, MbC, McD).	Fair	Fair	Fair	Unsuitable	Good	Good
Miles (MfB, MfC).	Fair	Fair	Good	Fair below 4 feet.	Good	Poor; seepage.
Nobscot ¹ (NbC, Nc3, NeD, NpC, NpE).	Good	Good	Poor	Fair	Fair	Good
Otero (OtB).	Good	Good	Poor	Fair	Fair	Good
Port (Pa).	Fair to 1½ or 2½ feet; poor below.	Fair to 1½ or 2½ feet; poor to fair below.	Good	Unsuitable	Good	Good
Potter (McD).	Fair; shallow to caliche.	Fair	Poor	Unsuitable ²	Good	Poor; seepage.
Pratt ¹ (PbB, PbC, PfB, PfC, Pt, Cp, EpD, EpE, NpC, NpE).	Poor to fair; good if confined.	Poor to fair; lacks binder.	Fair	Good	Fair	Poor
Quinlan ¹ (Qm, QwC2, QwD, QwD2, WwC).	Good	Good	Poor	Unsuitable	Good	Good
St. Paul (SaA, SaB, SaC).	Fair	Fair	Good	Unsuitable	Good	Good
Sweetwater (Sw).	Poor to fair	Poor to fair	Poor	Unsuitable	Good	Poor
Tivoli ¹ (Tv, Pt).	Poor; good if confined.	Poor; lacks binder.	Poor	Good	Poor	Poor
Treadway (Tw).	Poor to 3 or 4 feet; at lower depth, good if confined.	Fair to 3 or 4 feet; poor below, lacks binder.	Poor	Unsuitable to 3 or 4 feet; good below.	Poor	Poor
Vernon ¹ (VcB, VcC, VcD, Vm, Vp).	Poor	Fair	Poor	Unsuitable	Good	Good
Wann (Wf).	Fair	Fair	Good	Fair	Poor	Fair
Woodward ¹ (WoB, WoC, WoD, WwC, QwC2, QwD, QwD2).	Fair	Fair	Good	Unsuitable	Good	Good
Yahola (Ya, Yh).	Fair	Fair	Good	Unsuitable	Good	Good

¹ Soils of this series are mapped in complexes and the symbols for such mapping units are given in more than one place. For example, the symbol Cp, which identifies the Carwile-Pratt complex, is given under both the Carwile and Pratt series.

interpretations of the soils

types are not rated in this table; see table 7 for characteristics of miscellaneous land types]

Suitability for engineering work—Continued							Remarks
Agricultural drainage	Irrigation				Field terraces and diversions	Waterways	
	Land leveling	Irrigation ditches	Borders	Holdover reservoirs			
Good.....	Poor.....	Poor.....	Poor.....	Poor.....	Poor.....	Fair.....	Subject to wind erosion.
Good.....	Poor.....	Fair.....	Good.....	Good.....	Good.....	Fair.....	Subject to water erosion.
Good.....	Poor.....	Poor.....	Poor.....	Fair.....	Good.....	Good.....	
Good.....							Contains gypsum.
Good.....						Good.....	Has medium water table.
Good.....	Poor.....	Fair.....	Fair.....	Good.....	Good.....	Good.....	
					Poor.....	Poor.....	Subject to wind erosion.
Fair.....	Fair.....	Good.....	Good.....	Good.....	Good.....	Good.....	
Good.....						Good.....	Has high water table.
Poor.....	Fair.....	Good.....	Good.....	Poor.....	Fair.....	Good.....	
Good.....						Fair.....	Has medium water table.
Fair.....					Good.....	Good.....	Contains caliche.
Fair.....	Fair.....	Fair.....	Fair.....	Poor; seepage.	Fair.....	Fair.....	Subject to wind erosion.
Good.....					Poor.....	Poor.....	Subject to wind erosion.
Good.....					Poor.....	Poor.....	Subject to wind erosion.
Fair.....	Good.....	Good.....	Good.....	Good.....	Good for diver- sions.	Good.....	
Fair.....					Good.....	Fair.....	Contains caliche.
Good.....					Poor.....	Fair.....	Subject to wind erosion.
					Good.....	Poor.....	
Fair.....	Fair.....	Good.....	Good.....	Good.....	Good.....	Good.....	
						Good.....	Has high water table.
							Subject to wind erosion.
					Good for diversions.	Fair.....	
Poor.....					Good.....	Poor.....	
Good.....						Good.....	Has medium water table.
Fair.....	Fair.....	Good.....	Good.....	Good.....	Good.....	Good.....	
Fair.....	Fair.....	Good.....	Good.....	Good.....	Fair.....	Good.....	

¹ The Potter soils are shallow over caliche, which is a possible source of construction material.

tent. It is expressed as *high*, *medium*, and *low* in table 7. Clay soils, such as those classified as CH or A-7, have a high shrink-swell potential, and sandy soils, such as those classified as SP or A-3, have a low shrink-swell potential. Sandy soils that have small amounts of nonplastic to slightly plastic fines, as well as most other soil materials that are nonplastic to slightly plastic, also have a low shrink-swell potential.

In table 8 ratings on the suitability of the soils for engineering work are given. Also listed are some specific features that affect the use of soils for engineering. The interpretations in table 8 were made after the evaluation of the estimated data in table 7 and actual test data in table 9 and after considering the performance of the soils in the field.

The suitability of the soil materials for road subgrade

TABLE 9.—Engineering test data¹ for

Soil name and location	Parent material	Oklahoma report number	Depth	Horizon	Shrinkage	
					Limit	Ratio
Carey silt loam: 1,690 feet S. and 465 feet W. of N¼ cor. of sec. 6, T. 20 N., R. 18 W. (modal profile).	Permian sandstone and sandy shale.	SO-500	Inches 4-10	A ₁ -----	19	1.74
		SO-501	14-24	B ₂ -----	19	1.73
		SO-502	30-40	B ₃ -----	20	1.74
Carwile complex: 70 feet S. and 1,148 feet E. of the W¼ cor. of sec. 27, T. 24 N., R. 19 W. (modal profile).	Alluvial sand and sandy clay---	SO-523	2-8	A ₁ -----	14	1.89
		SO-524	10-18	B ₂ -----	12	1.94
		SO-525	27-34	B ₃ -----	15	1.84
Las Animas soils: 620 feet E. and 1,056 feet S. of the center of sec. 19, T. 23 N., R. 20 W. (modal profile).	Alluvium (flood plain)-----	SO-520	5-10	A ₁₂ -----	22	1.64
		SO-521	12.5-17	C ₁ -----	14	1.83
		SO-522	26-30	C ₃ -----	(⁵)	(⁵)
Miles fine sandy loam: 250 feet E. and 38 feet N. of the SW. cor. of sec. 26, T. 22 N., R. 22 W. (modal profile).	Tertiary outwash-----	SO-504	1-7	A ₁ -----	(⁵)	(⁵)
		SO-505	9-16	B ₂₁ -----	16	1.86
		SO-506	45-53	C-----	18	1.76
Pratt loamy fine sand: 1,452 feet N. and 1,637 feet W. of SE. cor. of sec. 7, T. 23 N., R. 19 W. (modal profile).	Eolian sandy material-----	SO-507	2-8	A ₁ -----	(⁵)	(⁵)
		SO-508	11-18	B ₂ -----	(⁵)	(⁵)
		SO-509	26-38	BC-----	(⁵)	(⁵)
1,993 feet S. and 620 feet W. of NE. cor. of sec. 7, T. 23 N., R. 19 W. (nonmodal profile).	Eolian sandy material-----	SO-510	2-12	A ₁ and A ₁₂	(⁵)	(⁵)
		SO-511	15-24	B ₂ -----	(⁵)	(⁵)
		SO-512	32-40	BC-----	(⁵)	(⁵)
St. Paul silt loam: 726 feet N. and 264 feet W. of SE. cor. of sec. 36, T. 26 N., R. 19 W. (modal profile).	Permian red bed material-----	SO-517	2-7	A ₁₁ -----	20	1.70
		SO-518	21-29	B ₂₁ -----	16	1.79
		SO-519	31-38	B ₂₂ -----	14	1.86
990 feet N. and 100 feet E. of SW. cor. of sec. 5, T. 24 N., R. 18 W. (nonmodal profile).	Colluvial-alluvial Permian material.	SO-513	2-9	A ₁₁ -----	21	1.67
		SO-514	12-18	A ₁₂ -----	18	1.77
		SO-515	20-29	B ₂₁ -----	17	1.81
		SO-516	44-53	B _{3ca} -----	16	1.83
Tivoli fine sand: 2,012 feet N. and 3,366 feet W. of SE. cor. of sec. 9, T. 23 N., R. 20 W. (modal profile).	Eolian sand-----	SO-529	12-53	C-----	(⁵)	(⁵)
Vernon-badland complex: 370 feet S. and 237 feet W. of the NE. cor. of sec. 28, T. 25 N., R. 17 W. (modal profile).	Gypsiferous, red shale-----	SO-503	24-48	C ₂ -----	23	1.67
Woodward loam: 150 feet N. and 885 feet E. of S¼ cor. of sec. 35, T. 23 N., R. 20 W. (modal profile).	Sandstone or sandy shale-----	SO-526	2-9	A ₁ -----	19	1.69
		SO-527	11-19	AC-----	20	1.69
		SO-528	27-34	C-----	20	1.72

¹ Tests performed by Oklahoma Department of Highways in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

² Mechanical analyses according to the American Association of State Highway Officials Designation: T 88. Results by this procedure frequently may differ somewhat from results that would

have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the

and road fill depends mainly on the texture of the soil materials and on the natural water content. Highly plastic soil materials are rated "poor" for road subgrade and "poor" or "fair" for road fill, depending on the natural water content of the soil materials and the ease with which one can handle, dry, and compact them. Highly erodible soils, such as those composed primarily of fine sands or silts, require moderately gentle slopes, close moisture con-

trol during compaction, and live vegetation on side slopes to prevent erosion. These soils are rated "fair" for road subgrade and "fair" for road fill.

In table 9 are data from tests made on soil materials taken from 11 profiles in the county. The profiles are designated as modal or nonmodal. A modal profile is typical of the soil as it occurs in the county, and a nonmodal profile varies significantly from the modal. Laboratory

samples taken from 11 soil profiles

Volume change from field moisture equivalent	Mechanical analysis ²							Liquid limit	Plasticity index	Classification	
	Percentage passing sieve—				Percentage smaller than—					AASHO ³	Unified ⁴
	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.				
<i>Percent</i>											
4	100	100	95	51	42	15	13	22	3	A-4(3)-----	ML.
9	100	99	97	60	47	20	17	27	7	A-4(5)-----	ML-CL.
12	100	100	98	76	62	21	17	28	8	A-4(8)-----	CL.
22	100	97	92	59	54	25	21	28	10	A-4(5)-----	CL.
29	100	96	84	48	45	27	25	32	14	A-6(4)-----	SC.
16	100	94	78	33	28	21	19	28	11	A-2-6(0)---	SC.
1	100	100	99	68	60	18	15	25	2	A-4(7)-----	ML.
56	100	94	82	66	64	40	33	49	24	A-7-6(13)---	CL.
(⁵)	100	69	30	3	3	3	2	(⁵)	(⁵)	A-3(0)-----	SP.
(⁵)	100	86	62	31	24	10	9	(⁵)	(⁵)	A-2-4(0)---	SM.
19	100	90	71	48	42	25	22	31	13	A-6(4)-----	SC.
3	100	82	49	13	12	9	9	20	1	A-2-4(0)---	SM.
(⁵)	100	92	73	10	8	4	2	(⁵)	(⁵)	A-3(0)-----	SP-SM.
(⁵)	100	90	72	6	5	3	2	(⁵)	(⁵)	A-3(0)-----	SP-SM.
(⁵)	100	97	81	6	5	4	3	(⁵)	(⁵)	A-3(0)-----	SP-SM.
(⁵)	100	98	85	10	8	3	2	(⁵)	(⁵)	A-3(0)-----	SP-SM.
(⁵)	100	98	86	9	7	4	2	(⁵)	(⁵)	A-3(0)-----	SP-SM.
(⁵)	100	99	88	8	7	6	5	(⁵)	(⁵)	A-3(0)-----	SP-SM.
9	100	99	99	77	68	18	13	28	6	A-4(8)-----	ML-CL.
22	100	100	99	78	70	26	23	33	12	A-6(9)-----	CL.
29	100	99	97	74	66	30	27	34	14	A-6(9)-----	CL.
8	100	100	99	88	80	21	17	30	8	A-4(8)-----	ML-CL.
17	100	100	99	87	82	26	21	30	9	A-4(8)-----	ML-CL.
16	100	100	99	90	82	26	21	29	9	A-4(8)-----	CL.
18	100	100	99	79	75	28	25	29	10	A-4(8)-----	CL.
(⁵)	100	98	71	5	3	2	1	(⁵)	(⁵)	A-3(0)-----	SP.
27	100	97	96	92	90	72	57	48	18	A-7-6(13)---	ML.
4	100	97	94	66	55	12	8	24	1	A-4(6)-----	ML.
7	100	94	92	58	44	14	10	26	4	A-4(5)-----	ML-CL.
12	100	98	96	81	75	18	11	33	10	A-4(8)-----	ML-CL.

pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

³ Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 7): The Classification

of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145-49.

⁴ Based on the Unified Soil Classification System, Technical Memorandum No. 3-357, Vol. 1, Waterways Experiment Station, Corps of Engineers, March 1953.

⁵ Nonplastic.

tests reported in table 9 were made by the Oklahoma Department of Highways, Materials and Research Department, in accordance with standard procedures of the American Association of State Highway Officials, (AASHO).

The engineering soil classifications in table 9 were based on data obtained by mechanical analysis and by tests to determine liquid limits and plastic limits. Mechanical analysis was made by the combined sieve and hydrometer methods. The percentage of clay obtained in this test by the hydrometer is not used in determining soil textural classes.

The tests for *liquid limit* measure the effect of water on the consistence of the soil material. As the moisture content of clayey soil increases from a dry state, the material changes from semisolid to plastic. If the moisture content is increased further, the material changes from plastic to liquid condition. The plastic limit is the moisture content at which the soil material passes from solid to plastic. The liquid limit is the moisture content at which the material passes from plastic to liquid. The *plasticity index* is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which a soil material is plastic.

As moisture leaves a soil, the soil decreases in volume in direct proportion to the loss in moisture, until a point is reached where shrinkage stops although additional moisture is removed. The moisture content where shrinkage stops is called the *shrinkage limit*.

The shrinkage limit of a soil is a general index of clay content and will generally decrease as the clay content increases. The shrinkage limit of sands that contain no clay gives a test result that is close to the liquid limit and is therefore considered insignificant. Sands containing some silt and clay have a shrinkage limit of approximately 14 to 25, and the shrinkage limit of clays ranges from approximately 6 to 14. As a rule, the load-carrying capacity of a soil is at a maximum when its moisture is at or below the shrinkage limit. Sands do not follow this rule because, if confined, they have a uniform load-carrying capacity within a considerable range in moisture content.

The *shrinkage ratio* is the volume change resulting from the drying of a soil material, divided by the loss of moisture caused by drying. The ratio is expressed numerically.

Volume change is the change in volume that takes place in a soil when it dries from a given moisture content to a point where no further shrinkage takes place. *Field moisture equivalent* (FME) is the minimum moisture content at which a smooth surface of soil will absorb no more water in 30 seconds when the water is added in individual drops. It is the moisture content required to fill all the pores in sands and to approach saturation in cohesive soils.

Engineering structures for the control of water and erosion

This subsection consists of two parts. In the first the structures used in Woodward County to control water and erosion are described. In the second part, soil associations, or general soil areas, and conservation structures are discussed.

PERMANENT CONSERVATION STRUCTURES

The main structures used to conserve water and to control erosion in Woodward County are field terraces, diversion terraces, waterways, erosion-control dams, pipe drops, and stock-watering ponds.

Field terraces.—In Woodward County field terraces are used (1) to reduce water erosion; (2) to spread, conserve, and control runoff water; (3) to serve as guidelines for contour farming; (4) to divert and spread water on cultivated land that has a slope of 2 percent or less; and (5) to increase yields of crops by protecting the surface soil and increasing the intake of water.

Field terraces are used on all cultivated soils in the county, except those that are subject to wind erosion and those that are nearly level and not subject to appreciable water erosion.

Diversion terraces.—Diversions are used (1) to divert runoff from higher areas off cultivated land and to discharge it on a protected area; (2) to divert the discharged water from erosion-control dams to a protected area; (3) to divert the discharge water from stock-watering ponds to an area away from the back toe of the dam or to another spill area; (4) to divert water from active gullies and head cuts; (5) to collect water for water-spreading systems; and (6) to break up concentrations of water on large, nearly level cultivated fields and in water-spreading systems. Diversion terraces are suited to all areas in Woodward County, except those where the wind might blow soil and fill the channels.

Grassed waterways.—Waterways are necessary for the removal of runoff from cultivated fields that are terraced. They are needed (1) in places that lack a suitable spill area for water discharged from field terraces, diversion terraces, or both; (2) in fields that receive runoff from higher areas; and (3) in irrigated fields where excess rainfall accumulates.

Waterways need a dense cover of vegetation to protect the soil against moving water (fig. 27). Native grasses are most suitable. Suitable species vary, depending on the kind of soil in a waterway.

Generally, terraces are constructed after grassed waterways have been established.



Figure 27.—Grassed waterway such as this provides excellent spill areas for runoff from terraces.

The effectiveness of a waterway depends on how well it is maintained. Maintenance is often a continuous job, especially if a large amount of water is carried through a waterway. Waterways should be pastured to maintain a vigorous, uniform cover. But they should not be grazed too closely, grazed when wet, or used for roadways or livestock runways.

Erosion-control dams.—These dams are of the impounding type. They store runoff water and release it (1) through a pipe or pipes into a principal spillway where the water is discharged at a safe rate or (2) through a diversion spillway to an area where the water can be released without causing erosion.

Pipe drops.—These structures are used in places where the capacity of the pipe is large enough to carry all expected runoff to a safe elevation (usually base grade) for discharge. The lower ends of small waterways, field terraces, and diversion terraces can be protected by the use of pipe drops.

Stock-watering ponds.—If these ponds are located properly, grazing by livestock will be evenly distributed and the best use will be made of grassland. Ponds should be spaced close together so that livestock will be within about $\frac{1}{2}$ to 1 mile of water at all times.

Pit ponds, or reservoirs, are extremely susceptible to filling by silt or other sediments, and, if not protected, they will become useless in a season or two. On larger drains, they should be constructed as a by-pass structure so that when the reservoir is full the stream does not run through the structure.

Ponds and reservoirs should be designed in accordance with the size of the drainage area, the vegetation, the kinds of soils, the condition of the spillway area, the condition of the range, and the number of livestock to be grazed.

To provide a year-round source of water, make sure that ponds in Woodward County are at least 11 feet deep before excavation and have a drainage area of approximately 40 to 48 acres for each acre-foot of permanent storage in the ponds. For help in planning stock-watering ponds, consult a representative of the Woodward Soil Conservation District.

SOIL ASSOCIATIONS AND CONSERVATION STRUCTURES

The suitability of soils in the different soil associations, or general soil areas, in Woodward County for the conservation structures just described is discussed in this section. Some of the associations, for example associations A and H, have similar suitability and are therefore discussed together. There is a colored map of the soil associations in the back part of the report. For a detailed description of each soil association, turn to the section "General Soil Map" in the front part of the report.

Associations A and H.—These associations are made up mainly of the St. Paul, Carey, Woodward, and Quinlan soils, which occur on long, variable slopes. Large areas are cultivated. Crop yields are good, but the soils are subject to wind erosion.

Generally, terraces function well. The vertical interval between terraces is critical because of excessive water erosion. If the terraces are too far apart, erosion is likely to be severe. Large gullies are eating back into many

fields. Erosion-control dams work well if pipe spillways are used to transport excess water to a lower grade.

A number of terraces spill onto grassland. Many waterways are needed and they should be kept in grasses, except for those in nearly level areas. Erosion-control dams may be needed at the lower ends of waterways to safely lower excess water to a stable grade.

Generally, the ends of terraces are partly blocked, and, in a few places, they are completely blocked. Impounding-type terraces work very well on slopes of 2 to 2.5 percent.

If improperly grazed, grassland is subject to considerable sheet erosion and in many places gullies form in paths made by livestock. Diversion terraces, pipe drops, and, in a few places, erosion-control dams are used to prevent erosion.

Water for livestock is generally stored by impounding-type dams. The drainage area should consist almost entirely of grassland.

Associations B and F.—These associations are made up mainly of Pratt and Tivoli soils. The soils occur in sandy areas of dune-type topography. Because the soils are subject to wind erosion, it is impractical to construct field terraces or diversion terraces. Runoff from higher areas moves through shallow channels in cultivated fields. Waterways covered with alfalfa or grasses will control this runoff.

In areas of grassland, water for livestock is usually supplied by wells or by excavated reservoirs that occur in low depressions.

Association C.—This association consists mainly of the Mansker and Potter soils. The soils are on rolling topography and have concentrations of caliche on or near the surface. Most of the acreage is cultivated. Terraces generally work very well; however, in localized spots that contain large concentrations of caliche, a weak place may develop in the terrace ridge. Consequently, the terraces require more maintenance than those in fields made up of soils of most other associations. In general, channel-type terraces are more satisfactory than the impounding type.

Spillways for terraces are subject to severe erosion, and many waterways are required. In a number of cultivated fields, diversion terraces are needed to control runoff that comes from the steeper slopes.

In areas of grassland, water for livestock is provided by wells or by impounding-type ponds. An impounding-type pond usually loses some water through seepage, but this is not a hazard to the dam. There are a few satisfactory sites for reservoirs on soils of association C.

Association D.—This association is made up mainly of the Port soil, which occurs mostly in nearly level areas. Most of the acreage is cultivated, and yields of crops are good.

Diversion terraces are needed along the outer edges of fields, away from the stream, to control runoff that comes from higher areas. Waterways are needed to transport runoff across the fields to streams. Because the areas are nearly level, waterways are easy to maintain if the high vegetation is clipped so that silt is not trapped in the channel. Impounding-type terraces conserve water very well but are generally crooked and hard to farm.

Water spreaders, spaced 300 to 500 feet apart, work very well. Livestock water is usually obtained from wells.

Association E.—This association is made up mainly of the Lincoln and Las Animas soils. The soils have a high water table and are subject to overflow. Conservation structures have little or no value on soils of this association. The areas are in rangeland, and livestock obtain water from streams.

Associations G and K.—These associations consist mainly of the Nobscot, Brownfield, and Pratt soils. The soils are very sandy and have very irregular topography. Only a small acreage is cultivated.

Because of the hazard of wind erosion and the very irregular topography, field terraces and diversion terraces do not function satisfactorily.

In most places, water for livestock is obtained from wells. A few reservoirs have been constructed, but, because the soils are sandy, water must be piped into the reservoirs.

Associations I and J.—These associations consist mainly of the Vernon and Cottonwood soils and badland. The topography is irregular, and the areas have a considerable amount of gypsum caprock underlain by underground caverns and channels. Areas in the red beds are subject to water erosion. Diversion terraces, erosion-control dams, and pipe drops are used to control erosion, but the low value of the land restricts the extent to which these structures are used. The removal of excess water onto spillways is a problem because it is difficult to establish vegetation in channels that extend into fields of Vernon soil.

Storage of water for livestock is a serious problem in gypsum or in soil overlying gypsum. A pond will hold water from 1 to 5 years before large openings develop in the bottom; the holes lead to underground channels or caverns. Ponds and reservoirs that extend below gypsum function excellently. Only small drainage areas are required, and very little seepage occurs. Reservoirs should not be constructed close to the foot of rough broken areas because silt will wash in from steep slopes.

Some cultivated areas of St. Paul and Yahola soils occur within associations I and J. In these places diversion terraces are needed to control runoff from higher areas and, in general, field terraces are also needed.

Formation, Classification, and Morphology of the Soils

The purpose of this section is to present the outstanding characteristics of the soils of Woodward County and to relate these characteristics to the factors of soil formation. This section consists of two main parts. The first part deals with the factors of soil formation; the second, with the classification and morphology of the soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical compo-

sition of the parent material; (2) the climate under which the soil material has accumulated; (3) the plant and animal life on and in the soil; (4) the relief, or the lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil formation. They act on the parent material accumulated through the weathering of rocks and slowly change it into a natural body with generally related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and in extreme cases determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but generally a long time is required for the development of distinct horizons.

The individual factors of soil formation are discussed separately in the paragraphs that follow. It is the interaction of all of these factors, however, that determines the nature of the soil profile. The interrelationship among the five factors is complex; the effects of any one factor are difficult to isolate. In some areas the effects of four of the factors are constant, or nearly so, and the effects of the fifth factor can be partly evaluated. Even in these areas, the appraisal of the effects is only an approximation.

Parent materials

The soils of Woodward County have formed mainly from materials of three geological ages—the Permian, the Quaternary, and the Tertiary; in addition some soils are forming mainly in alluvium along streams (fig. 28).

Permian red beds.—From one-third to two-fifths of the surface area of Woodward County is underlain by red-bed material of the Permian age. A part of this material consists of weakly consolidated, soft sandstone made up of very fine sand and soft silty rocks. The sandstone belongs to the Rush Springs and Marlow formations, which occur mainly in a band parallel to, and south of, the North Canadian River. A few small remnants of Upper Day Creek dolomite occur as basal members of the Cloud Chief formation. These remnants are in a narrow band north of Mooreland at the edge of sands of the Quaternary age.

The Dog Creek formation consists of a band of red clay and shale that is exposed parallel to outcrops of Blaine gypsum across the northeastern part of the county. This formation is generally 40 to 100 feet thick and contains one or more ledges of dolomite. It occurs below the Rush Springs formation and above the Blaine formation.

Blaine gypsum, an important rock in the northern part of the country, is made up of two massive beds of gypsum that are separated by red shaly clay and thin layers of dolomite and anhydrite.

The Flowerpot formation consists of soft, gypsiferous, red shale. In many areas the surface is strewn with white, pink, red, or waterclear, satin-spar crystals of selenitic gypsum. The seams of gypsum range from paper thin to several inches in thickness. In northeastern Woodward County, the Flowerpot formation is undergoing rapid geological erosion and there are many unusual relief forms.

Soils in Woodward County that have formed from red-bed material are the Carey, Cottonwood, Quinlan, St. Paul, Treadway, Vernon, and Woodward.

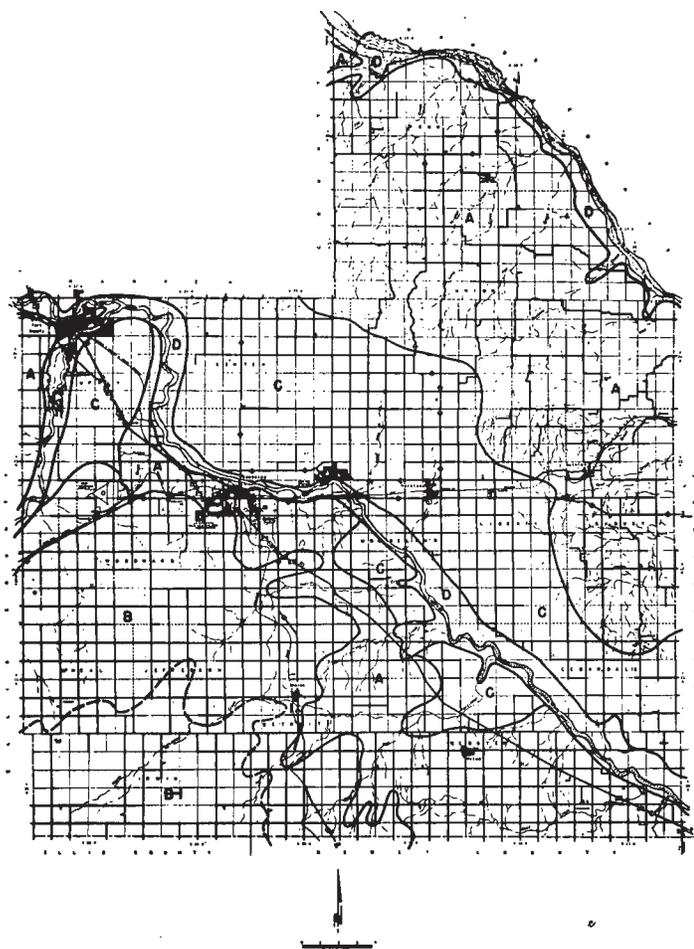


Figure 28.—Generalized geology map of Woodward County.

- (A) Permian red beds.
- (B) High Plains outwash of the Tertiary age.
- (B-1) Tertiary sands.
- (C) Quaternary sands.
- (D) Alluvium.

Quaternary sands.—About one-third of the county is made up of Quaternary sands. During Pleistocene time the wind greatly altered these alluvial sands. Some of the sands are very siliceous and low in weatherable minerals. The sands have dunelike topography and occur in a band parallel to the North Canadian River. Soils that have formed from Quaternary sands are the Carwile, Pratt, and Tivoli. The more coarse-textured Tivoli soils are generally nearest streams.

High Plains outwash of the Tertiary age and Tertiary sands.—About one-fifth of the county, in the western and southwestern parts, is made up of material of the Tertiary age.

The unconsolidated or weakly cemented outwash of the High Plains consists of limy loam, sand, or clay loam. Locally, the outwash has been modified by loess that has been reworked from the same material. Generally, the deposits are high in lime and feldspathic minerals. In places the outwash contains beds of caliche. Soils formed from High Plains outwash are the Enterprise, Holdrege, Mansker, Miles, Otero, and Potter.

Tertiary sands form an almost continuous, but thin, cover over red beds. Soils formed from this material are the Brownfield, Eufaula, Nobscot, and Pratt.

Alluvium.—A small part of the county, primarily along major streams and their tributaries, is covered by alluvium. Soils forming primarily in alluvium are the Elsmere, Las Animas, Leshara, Lincoln, Port, Sweetwater, Wann, and Yahola.

Climate

The climate of Woodward County is continental. Rainfall is greatest in spring. Summers are hot and generally are dry; only a little rain comes in fall and winter. One result of the climate, of interest in relation to soil formation, has been the spotted and rather shallow leaching of the soils. Because of the wind and hot weather, much soil moisture evaporates, and water moves through the profile only occasionally. Thus, basic elements are not depleted by leaching. The presence of a lime zone in many soils suggests the average depth to which water moves. The depth to a lime zone ranges from a few inches in sloping clayey soils to several feet in nearly level, permeable soils. The very sandy soils do not have a distinct lime zone. In some places the soils that formed in extremely limy material are calcareous at the surface.

Living matter

Plant and animal life, both on and in the soil, is active in soil-forming processes. As plants decay and die, they add organic matter to the soil. This darkens the upper part of the soil profile. Soils that originally supported deep-rooted tall grasses contained more organic matter and generally were darkened to a greater depth than soils formed mainly under a cover of buffalograss and grama grasses. Most of the nearly level and gently sloping soils absorbed a large amount of water and supported thick stands of grasses, and so they became darkened to a considerable depth. In contrast, the steep soils, which had less vegetation and consequently contained less organic matter, were darkened to only a shallow depth. If cultivated, steep soils tend to lose the darkened layer through erosion.

Many kinds of micro-organisms are needed to transform organic remains into stable humus from which plants can obtain nutrients. Small burrowing animals and earthworms influence soil formation by mixing the organic and mineral parts of the soil and by deepening the zone in which organic matter accumulates. They also tend to keep the soil supplied with minerals by bringing unleached parent material to the surface.

Since soil life thrives in a moist, moderately warm environment, it is most active late in spring and early in fall. Plant remains decompose slowly during the hot, dry summer. For this reason, wheat farmers try to work the land immediately after harvest so that at least part of the stubble will decompose before planting time in fall.

Relief

The soils of Woodward County range from nearly level to steep. The degree and type of slope determines, in part, how much water runs off, how much water infiltrates the soil, and how much soil is likely to be lost through erosion, especially in cultivated areas.

Slopes of the terrain usually determine the proportion of moisture and air in the soil. Normally, on slopes of more than 3 percent, more water runs off than infiltrates the soil. The amount of water that runs off, however, also depends to a great extent on the thickness of the vegetation and soil mulch.

In Woodward County the profiles of the strongly sloping soils are not well developed, because there is an excessive amount of runoff and not enough movement of clay downward from the A horizon to the B horizon. Also, the colors of the soils are similar to those of the parent materials because the soil materials are relatively dry and contain only small amounts of organic matter. Consequently, the degree of profile development that takes place, within a given time on a particular kind of parent material and under a cover of similar plants, depends mostly on the amount of water passing through the soil.

Soil series that have formed on similar parent material and under a similar cover of plants but that differ in relief or drainage can be grouped in soil-relief sequences known as catenas. In Woodward County the St. Paul, Carey, Woodward, and Quinlan soils form a catena. The soils are arranged in progressive order as to degree of slope; the St. Paul is most nearly level, and the Quinlan is most strongly sloping.

Time

Considerable time is required for the development of a soil from the parent material. The amount of time needed varies greatly according to the kind of parent material. For example, limestone is dissolved slowly as rains come and go, and most of it is carried away, leaving only a small amount of weathered material to form a regolith. Millions of years may pass before parent material has accumulated and a soil profile has formed. On the other hand, a profile may form in fresh alluvial sands in a few hundred years.

After the parent material has been deposited or has accumulated in place through weathering, the surface layer becomes darkened by the accumulation of organic matter. Calcium carbonate and other soluble minerals may be leached downward from the surface layer. The movement of clay downward from the surface layer proceeds more slowly. Generally, when clay is leached from the A horizon, there is a corresponding increase of clay in the B horizon. The rate of this process depends, in part, on how rapidly the soil material in the upper soil layers is weathered.

Because of the presence of buried soils that were formed thousands of years ago, it is assumed that many of the soils of Woodward County are at least 20,000 years old. The age of the parent material does not parallel the age of the soils of the county, however. Generally, the Permian red beds make up the oldest parent material, but soils formed in red beds appear to be more youthful than those formed in outwash of the Tertiary age. The Tertiary sediments were once spread over much, or possibly all, of the county, but over a long period of time, much of this material was stripped away by the headward cutting of streams. Thus, red-bed material was exposed.

In general the profiles of the soils of Woodward County are not strongly developed. The lack of strong development has been caused only partly by the factor of time. The red-bed sandstone is relatively high in quartz min-

erals that weather slowly, and parent material from this rock does not develop rapidly into soils with well-differentiated profiles that have clayey B horizons. The loam of the Tertiary age contains a much higher content of feldspar than the sandstone of the Permian red beds, and, therefore, soils with distinct horizons form more quickly in the loamy material than in red beds having similar relief and vegetation.

Classification and Morphology of the Soils

Soils are placed in narrow classes for the organization and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparisons of large areas, such as continents. In the comprehensive system of soil classification followed in the United States, the soils are placed in six categories, one above the other. Beginning at the top, the six categories are order, suborder, great soil group, family, series, and type.

In the highest category, the soils of the whole country are grouped in three orders, whereas thousands of soil types are recognized in the lowest category. The suborder and family categories have never been fully developed and thus have been used but little. Attention has been given largely to the classification of soils into soil series and types within counties or comparable areas and to the subsequent grouping of series into great soil groups and orders. The subdivision of soil types into phases provides finer distinctions significant to soil use and management. Soil series, types, and phases are discussed briefly in the section "How Soils Are Named, Mapped, and Classified" and are defined in the Glossary in the back of this report.

In the highest category of the classification scheme are the zonal, intrazonal, and azonal orders. The zonal order comprises soils with evident, genetically related horizons that reflect the predominant influence of climate and living organisms in their formation. In the intrazonal order are soils with evident, genetically related horizons that reflect the dominant influence of a local factor of topography or parent material over the effects of climate and living organisms. In the azonal order are soils that lack distinct, genetically related horizons, commonly because of youth, resistant parent material, or steep topography.

A great soil group is made up of soils that have certain internal characteristics in common. The soil series of Woodward County have been classified in the following great soil groups: Alluvial, Calcisol, Chestnut, Lithosol, Planosol, Reddish Brown, Reddish Chestnut, Red-Yellow Podzolic, Regosol, and Regosol intergrading to Reddish Chestnut.

In table 10 the soil series are classified according to soil orders and great soil groups, and important characteristics of each series are given.

Following is a detailed discussion, including a representative profile, of each soil series in Woodward County. In the profile descriptions, the symbols that follow the names of colors are Munsell color notations; ⁶ unless otherwise specified, the notations refer to dry soil. The range in depth given at the beginning of the description of each horizon applies only to that specific horizon. At the end of the descriptions of some horizons there is a range in

⁶ UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handb. 18, 503 pp., illus. 1951.

depth, as determined by the examination of profiles at a number of locations. Technical terms used in the series descriptions are defined in the Glossary in the back part of the report.

BROWNFIELD SERIES

The soils of the Brownfield series have formed under shinnery oak and scattered tall grasses on gentle slopes. Their parent material is sandy sediments of the Tertiary age. These well-drained, deep soils have an A₁ horizon of fine sand, an A₂ horizon of leached fine sand, and a B horizon of sandy clay loam.

Brownfield soils are associated with Nobscot soils. The two kinds of soils occur in a complex pattern in many woody pastures that contain a mixture of scrubby shinnery oak and tall native grasses. The Brownfield soils have more clay in the B horizon than the Nobscot soils. They are members of the Reddish-Brown great soil group.

Representative profile: Brownfield fine sand, 1 to 3 percent slopes, about 1,580 feet west and 530 feet south of the half-mile point on the east side of sec. 20, T. 20 N., R. 22 W.:

- A₀₀ ¼ inch to 0, partly decayed leaves.
- A₁ 0 to 3 inches, dark grayish-brown (10YR 4/2) fine sand that grades to loamy fine sand, very dark grayish brown (10YR 3/2) when moist; single grain (structureless); loose when dry and moist; many coarse and fibrous roots; noncalcareous; pH 7.0; clear lower boundary. 3 to 5 inches thick.
- A₂ 3 to 10 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) when moist; single grain (structureless); loose when dry and moist; few fibrous roots; noncalcareous; pH 6.5; clear lower boundary. 5 to 20 inches thick.
- B₂ 10 to 24 inches, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; weak, coarse, prismatic structure that breaks to granular; hard when dry, friable when moist; many fine roots; many fine pores; pH 6.0; gradual lower boundary. 10 to 16 inches thick.
- B₃ 24 to 40 inches, reddish-yellow (5YR 6/6) light sandy clay loam that grades to sandy loam, yellowish red (5YR 5/6) when moist; weak, medium, granular structure; slightly hard when dry, very friable when moist; few fine and coarse roots; pH 6.0; gradual lower boundary. 10 to 16 inches thick.
- C 40 to 55 inches, reddish-yellow (5YR 6/6) loamy fine sand that grades at lower depth to fine sand, yellowish red (5YR 5/6) when moist; weak, granular structure to single grain (structureless); soft when dry, very friable to loose when moist; few fine roots; pH 6.0.

In some sloping areas, the A₂ horizon is thicker and the B₂ horizon is less clayey. The A₁ horizon ranges from very dark grayish brown to brown, and the A₂ horizon, from brown to very pale brown. The B₃ horizon is strong brown to reddish yellow.

CAREY SERIES

The Carey series consists of well-drained, brown and reddish-brown prairie soils that have formed in calcareous loamy red beds. The soils are on eroded, convex slopes in the uplands. Their native vegetation was grasses.

Carey soils have a less strongly developed profile and are redder than the St. Paul soils. They have a B horizon, whereas the Woodward soils do not. Carey soils are members of the Reddish Chestnut great soil group.

Representative profile: Carey silt loam, 1 to 3 percent slopes, about 1,690 feet south and 465 feet west of the

half-mile point on the north side of sec. 6, T. 20 N., R. 18 W.

- A_{1D} 0 to 4 inches, brown (7.5YR 5/3) silt loam, dark brown (7.5YR 3/3) when moist; weak, granular structure largely destroyed by tillage; slightly hard when dry, friable when moist; material at surface tends to crust and run together; this layer has less pore space than the layer below; noncalcareous.
- A₁₂ 4 to 14 inches, reddish-brown (5YR 5/3) silt loam, dark reddish brown (5YR 3/3) when moist; very weak, coarse, prismatic structure that breaks to moderate, medium, granular; slightly hard when dry, friable when moist; many fine and fibrous roots; many pores; abundant earthworm castings; noncalcareous; pH 6.5 to 7.0; gradual lower boundary. 12 to 15 inches thick.
- B₂ 14 to 30 inches, reddish-brown (5YR 4/4) heavy silt loam, dark reddish brown (5YR 3/4) when moist; weak, coarse, prismatic structure that breaks to moderate, medium, granular; slightly hard when dry, friable when moist; many fine and fibrous roots; many fine pores; abundant earthworm castings; noncalcareous; pH 7.0; diffuse lower boundary. 10 to 18 inches thick.
- B₃ 30 to 44 inches, reddish-brown (5YR 4/5) silt loam, dark reddish brown (5YR 3/5) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many fine roots; many fine pores; few scattered bits of weathered sandstone in lower part; pH 7.5 to 8.0; clear lower boundary. 10 to 15 inches thick.
- C₁ 44 to 51 inches, stratified mixture of red (2.5YR 4/6), highly weathered, fine-grained sandstone and sandy shale, dark red (2.5YR 3/6) when moist; calcium carbonate and plant roots occur along the bedding planes; this horizon could be called a weak C_{ea} horizon.
- C₂ 51 to 61 inches, red (2.5YR 4/7), very fine grained, highly weathered, stratified sandstone; massive (structureless); hard when dry, firm when moist; pH 8.0.

Many areas of Carey soils have an erratic, discontinuous mantle of loess. The A₁ horizon is more silty in the northern part of the county. The thickness of the A horizons range from 10 to 20 inches. The texture of the B₂ horizon ranges from loam to light clay loam, and the structure ranges from coarse, prismatic to medium, subangular blocky. In many places the upper part of the C horizon is the zone of maximum lime accumulation. In areas where the parent material has been reworked by water, the profile is 60 inches or more in depth. In many places the layer between 51 and 61 inches is more highly weathered than that described in the detailed profile.

CARWILE SERIES

The Carwile series consists of imperfectly drained soils that have formed from sandy sediments in depressed areas between sand dunes. The native vegetation consisted of grasses.

These soils have a wide range in texture of the surface layer and have a mottled sandy clay B₂ horizon. Their profile is more strongly developed than that of Pratt soils.

Carwile soils are members of the Planosol great soil group.

Representative profile: Carwile clay loam about 70 feet south and 1,148 feet east of the half-mile point on the west side of sec. 27, T. 24 N., R. 19 W.:

- A₁ 0 to 9 inches, dark-gray (10YR 4/1) heavy clay loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure below a depth of 2 inches; the structure in the upper 2 inches has been destroyed by tillage

TABLE 10.—Important characteristics of the soil series, and the

Soil series	Range of slope	Drainage class	Important profile characteristics ¹		
			Surface layer (A horizon)		
			Color	Structure	Texture
Brownfield	Percent 1 to 5	Well drained	Grayish brown and brown	Single grain	Fine sand
Carey	1 to 8	Well drained	Brown and reddish brown	Granular	Silt loam
Carwile	0 to 1	Imperfectly drained	Gray and grayish brown	Granular	Clay loam and sandy loam
Cottonwood	3 to 8	Excessively drained	Grayish brown to light brown	Granular	Loam
Elsmere	0 to 1	Imperfectly drained (high water table)	Grayish brown	Single grain	Loamy fine sand
Enterprise	0 to 20	Well drained	Brown	Granular	Loam and sandy loam
Eufaula	5 to 12	Excessively drained	Pale brown	Single grain	Fine sand
Holdrege	1 to 3	Well drained	Brown	Granular	Loam
Las Animas	0 to 1	Imperfectly drained (high water table)	Grayish brown	Granular	Loam
Leshara	0 to 1	Somewhat poorly drained	Grayish brown	Granular	Loam
Lincoln	0 to 5	Excessively drained	Pale brown	Single grain	Sand
Mansker	1 to 8	Well drained	Grayish brown	Granular	Loam
Miles	1 to 5	Well drained	Brown	Granular	Fine sandy loam
Nobscot	3 to 12	Somewhat excessively drained	Grayish brown and brown	Single grain	Fine sand
Otero	1 to 5	Somewhat excessively drained	Grayish brown	Single grain	Loamy fine sand
Port	0 to 1	Moderately well drained	Brown	Granular	Loam
Potter	5 to 12	Somewhat excessively drained	Grayish brown	Granular	Loam
Pratt	1 to 12	Somewhat excessively drained	Brown	Single grain	Loamy fine sand
Quinlan	4 to 12	Somewhat excessively drained	Red	Granular	Loam
St. Paul	0 to 5	Moderately well drained	Brown	Granular	Silt loam
Sweetwater	0 to 1	Imperfectly drained (high water table)	Gray and grayish brown	Granular	Heavy loam
Tivoli	8 to 20	Excessively drained	Pale brown	Single grain	Fine sand
Treadway	0 to 1	Poorly drained	Red and reddish brown (C horizon)	Massive (C horizon)	Clay (C horizon)
Vernon	0 to 12	Somewhat excessively drained	Reddish brown	Granular	Clay loam
Wann	0 to 1	Moderately well drained	Brown and grayish brown	Granular	Fine sandy loam
Woodward	1 to 8	Well drained	Reddish brown	Granular	Loam
Yahola	0 to 1	Well drained	Reddish yellow	Granular	Fine sandy loam

¹ The principal colors, structure, and texture are described for the surface layer and subsoil of profiles of each series. The colors,

which were determined through use of Munsell color charts, are for dry soils.

and by salts; hard when dry, firm when moist; many fine and fibrous roots; only slightly porous near the surface but more porous with increasing depth; noncalcareous; pH 6.0 to 6.5; clear lower boundary. 7 to 14 inches thick but averages 11 inches.

B₂ 9 to 25 inches, brown (10YR 4/3) sandy clay, dark brown (10YR 3/3) when moist; faces of peds are dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2) when moist; weak, very coarse, prismatic structure that breaks to moderate to strong, coarse, angular blocks and a few subangular blocks; very hard when dry, firm to very firm when moist; many fine roots on faces of peds but few roots inside of peds; 20 percent of mass has many, coarse, prominent mottles of yellowish red (5YR 5/6), yellowish red (5YR 4/6) when moist; few, coarse, distinct yellowish-brown mottles; noncalcareous; pH 6.5 to 7.0; gradual lower boundary. 15 to 18 inches thick.

B₃ 25 to 40 inches, pale-brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) when moist; faces of the peds are grayish brown (10YR 5/2), dark grayish-brown (10YR 4/2) when moist; weak, prismatic structure that breaks to moderate, coarse, subangular blocky

(many angular blocks are also present); hard to very hard when dry, firm when moist; many, coarse, prominent mottles of yellowish brown to yellowish red; faces of peds are noncalcareous; insides of peds are slightly calcareous; fine roots are more common on faces of peds than inside the peds; many fine pores; 6 to 12 manganese concretions, 2 to 5 millimeters in size, occur in a 12- by 12-inch area; the soil mass becomes calcareous at a depth of 36 inches; many soft, coarse concretions of calcium carbonate are below 36 inches; diffuse lower boundary. 10 to 16 inches thick.

C 40 to 60 inches, uppermost few inches are pale-brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) when moist; mottles similar to those in the B₂ horizon; soil material is more sandy and more yellow with increasing depth; at 60 inches the texture is loamy fine sand.

The upper part of the B₂ horizon of the profile just described might possibly have been designated as a B₁ horizon.

great soil group and soil order to which each series belongs

Important profile characteristics ¹ —Continued				Great soil group	Soil order
Subsoil (B or AC horizon)			Depth to C horizon		
Color	Structure	Texture			
Yellowish red.....	Prismatic.....	Sandy clay loam.....	<i>Inches</i> 40 to 60	Reddish Brown.....	Zonal.
Reddish brown.....	Granular.....	Heavy silt loam.....	32 to 48	Reddish Chestnut.....	Zonal.
Grayish brown to brown.....	Blocky.....	Sandy clay.....	32 to 48	Planosol.....	Intrazonal.
Pale brown.....	Granular.....	Loam.....	2 to 16	Lithosol.....	Azonal.
Pale brown.....	Single grain.....	Loamy fine sand.....	30 to 50	Chestnut.....	Zonal.
Brown.....	Granular.....	Loam and sandy loam.....	30 to 50	Regosol.....	Azonal.
Very pale brown.....	Single grain.....	Fine sand.....	55 to 65	Red-Yellow Podzolic.....	Zonal.
Brown.....	Granular.....	Loam.....	25 to 55	Chestnut.....	Zonal.
Gray, grayish brown, yellowish brown, pale brown.	Variable.....	Heavy sandy loam.....	25 to 35	Alluvial.....	Azonal.
Pale brown.....	Subangular blocky.....	Clay loam.....	20 to 40	Alluvial.....	Azonal.
Pale brown.....	Single grain.....	Fine sand.....	10 to 20	Alluvial.....	Azonal.
Brown.....	Granular.....	Clay loam.....	13 to 22	Calcisol.....	Intrazonal.
Brown and reddish brown.....	Prismatic and granular.	Sandy clay loam.....	30 to 50	Reddish Chestnut.....	Zonal.
Reddish yellow.....	Single grain.....	Fine sand.....	30 to 60	Red-Yellow Podzolic.....	Zonal.
Pale brown.....	Single grain.....	Loamy fine sand.....	16 to 24	Regosol.....	Azonal.
Reddish brown.....	Granular.....	Clay loam.....	32 to 50	Alluvial.....	Azonal.
Grayish brown.....	Granular.....	Clay loam.....	7 to 13	Lithosol.....	Azonal.
Yellowish brown.....	Single grain.....	Loamy fine sand.....	32 to 50	Reddish Chestnut.....	Zonal.
Red.....	Granular.....	Loam.....	11 to 16	Regosol.....	Azonal.
Reddish brown.....	Subangular blocky.....	Clay loam.....	38 to 53	Reddish Chestnut.....	Zonal.
Gray and grayish brown.....	Variable.....	Loam.....	22 to 33	Alluvial.....	Azonal.
Yellow (C horizon).....	Single grain (C horizon).	Fine sand (C horizon).....	6 to 12	Regosol.....	Azonal.
Pale brown (C horizon).....	Single grain (C horizon).	Sand (C horizon).....	(?)	Alluvial.....	Azonal.
Reddish brown.....	Subangular blocky.....	Clay loam.....	12 to 20	Lithosol.....	Azonal.
Brown.....	Granular.....	Loam.....	16 to 30	Alluvial.....	Azonal.
Reddish brown.....	Granular.....	Loam.....	15 to 24	Regosol intergrading to Reddish Chestnut.	Azonal-Zonal.
Reddish yellow.....	Granular.....	Fine sandy loam.....	10 to 18	Alluvial.....	Azonal.

² C horizon begins at the surface.

The texture of the A₁ horizon ranges from loamy sand to clay loam. The B₂ horizon is grayish brown to brown, and the degree of mottling ranges from faint to prominent. The B₃ horizon consists of sandy loam to sandy clay loam, and the mottling is generally more prominent than in the B₂ horizon. The C horizon is generally fine sandy loam but is loamy sand at a depth of 45 to 65 inches. In any given area, the profiles of Carwile soils may vary greatly because these soils are intermingled with Pratt soils.

COTTONWOOD SERIES

The Cottonwood series consists of excessively drained, very shallow soils on eroded, convex slopes in the uplands. The soils have formed from gypsum. The native vegetation was grasses.

Cottonwood soils are loamy, very erodible, and thin over gypsum; the associated Vernon soils are more clayey. The

Cottonwood soils are members of the Lithosol great soil group.

Representative profile: Cottonwood loam, about 0.35 mile north and 0.2 mile west of the southeast corner of sec. 11, T. 25 N., R. 18 W.:

- A₁ 0 to 5 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate to weak, medium, granular structure; soft to slightly hard when dry, very friable when moist; many roots and pores; gypsum crystals are mixed with the loam; calcareous; gradual lower boundary. 2 to 10 inches thick.
- C 5 to 9 inches, very pale brown (10YR 7/4) loam mixed with gypsum, light yellowish brown (10YR 6/4) when moist; weak, granular structure; soft to slightly hard when dry, very friable when moist; few roots; many pores; calcareous; abrupt lower boundary. 4 to 6 inches thick.
- D_r 9 inches +, consolidated gypsum that is noncalcareous; the gypsum ranges from crystalline clear to grayish-white selenite, which results from the presence of

sodium, to satin spar, which receives its color from potassium; impure mixtures of gypsum are most common.

In Woodward County the areas of Cottonwood soils contain a considerable amount of exposed gypsum rock. Through weathering, some of the gypsum has been hollowed out. This has exposed shaly clay, in which the Vernon soils have formed, and also resulted in the formation of small caves in the gypsum. Consequently, the areas in which Cottonwood soils occur have uneven relief. Geological erosion removes the soil nearly as fast as it is formed.

ELSMERE SERIES

The Elsmere series is made up of deep sandy soils of the bottom lands. The soils have a high water table and are used primarily as meadow. They are not so clayey as the Las Animas soils nor so sandy as the Lincoln soils. Elsmere soils belong to the Chestnut great soil group.

Representative profile: Elsmere loamy fine sand, about 200 feet west and 300 feet south of the northeast corner of sec. 31, T. 23 N., R. 19 W.:

- A₁ 0 to 16 inches, grayish-brown (10YR 5/2) heavy loamy fine sand, very dark grayish brown (10YR 3/2) when moist; texture is more sandy with increasing depth; single grain (structureless) to weak, granular structure; soft when dry, very friable when moist; many roots; neutral to slightly calcareous; clear lower boundary. 10 to 20 inches thick.
- AC 16 to 45 inches, pale-brown (10YR 6/3), stratified material that commonly is loamy fine sand, brown (10YR 5/3) when moist; single grain (structureless); soft when dry, very friable when moist; few, medium and coarse, faint mottles of yellowish brown (10YR 5/6) when moist; few roots; calcareous; stratified lower boundary 20 to 30 inches thick.
- C 45 to 65 inches, very pale brown (10YR 7/3) sand, pale brown (10YR 6/3) when moist; single grain (structureless); loose when dry and moist; calcareous; faintly mottled.

In small areas the A₁ horizon is of gray color or of fine sandy loam texture. Mottling in the AC horizon ranges from faint to distinct. The water table is 3 to 6 feet below the surface.

ENTERPRISE SERIES

The Enterprise series consists of well-drained, deep, calcareous soils that are forming in unconsolidated, slightly reddish loess. The soils have a monotextured profile that gradually becomes more sandy with increasing depth. Loam and fine sandy loam soil types have been mapped in Woodward County.

Enterprise soils are generally less sandy, more reddish, and more calcareous than Pratt soils. They belong to the Regosol great soil group.

Representative profile: Enterprise loam, 3 to 5 percent slopes, about 1,000 feet south and 325 feet west of the northeast corner of sec. 8, T. 20 N., R. 20 W.:

- A_{1p} 0 to 6 inches, brown (7.5YR 4/2) loam that grades to fine sandy loam, dark brown (7.5YR 3/2) when moist; structure has been destroyed by tillage; slightly hard when dry, very friable when moist; neutral to slightly calcareous; pH 7.0 to 7.5.
- A₁₂ 6 to 17 inches, brown (7.5YR 4/2) loam, dark brown (7.5YR 3/2) when moist; weak, very coarse, prismatic structure that breaks to weak, medium, granular; slightly hard when dry, very friable when moist; numerous pores, roots, and castings of earthworms; slightly calcareous; pH 7.0 to 7.5; gradual lower boundary.

AC 17 to 42 inches, brown (7.5YR 4/3) loam, dark brown (7.5YR 3/3) when moist; very coarse, prismatic structure that breaks to weak, medium, granular; slightly hard when dry, very friable when moist; numerous pores, roots, and castings of earthworms; pH 7.0 to 7.5; gradual lower boundary. 20 to 26 inches thick.

C 42 to 75 inches, brown (7.5YR 4/3) loam, dark brown (7.5YR 3/3) when moist, in the upper 10 inches but more sandy with increasing depth; texture at lower depth is loamy fine sand; weak, granular structure; slightly hard to soft when dry, very friable when moist; has about 1 percent or less of calcium carbonate concretions, which are the size of sand grains, and numerous threads of calcium carbonate; many pores and earthworm castings; pH 7.5.

The A₁ horizons are progressively thicker from the crest of a hill to the bottom of the slope. They are 11 to 22 inches thick, but the average thickness is 16 inches. The C horizon is generally more sandy with increasing depth. Buried soils occur in a few places.

EUFULA SERIES

The Eufaula series is made up of excessively drained soils that have formed under forest on steep, sandy uplands. These soils are acid in reaction. They are mixed with Nobscot soils. The Eufaula soils occur on crests and on east-facing slopes and have formed mainly from fine sand that has been removed from west-facing slopes consisting of Nobscot soils. The Eufaula soils have less clay in their B horizon than the Nobscot soils. Eufaula soils belong to the Red-Yellow Podzolic great soil group.

Representative profile: Eufaula fine sand (5 to 12 percent slopes) in a shinnery-oak pasture about 500 feet west and 75 feet south of the half-mile point on the north side of sec. 26, T. 20 N., R. 22 W.:

- A₀₀ For a fraction of an inch, generally a mixture of decaying leaves from the previous year.
- A₁ 0 to 4 inches, pale-brown (10YR 6/3) fine sand, grayish brown (10YR 5/2) when moist; single grain (structureless); loose when moist and dry; many tree roots and a few grass roots; pH 6.0; clear lower boundary.
- A₂ 4 to 24 inches, very pale brown (10YR 7/3) fine sand, pale brown (10YR 6/3) when moist; single grain (structureless); loose when moist and dry; many tree roots; pH 5.5; clear lower boundary.
- B 24 to 55 inches, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) when moist; there are about 12 distinct, irregular, broken, horizontal bands of yellowish-red or reddish-brown loamy sand; these bands are from 1/8 to 1/4 inch wide, but they do not alter the average texture of this horizon; pH is 5.5 grading to 5.0 at a depth of 48 inches; diffuse lower boundary.
- C 55 to 65 inches, very pale brown (10YR 8/4) fine sand, very pale brown (10YR 7/4) when moist; contains horizontal bands like those in B horizon; loose when dry and moist; single grain (structureless); many tree roots; pH 5.5.

Because the sand deposit varies in depth, many profiles of Eufaula soils grade toward those of Nobscot soils.

HOLDREGE SERIES

The Holdrege series is made up of well-drained grassland soils that have formed in slightly reddish loamy and sandy sediments on low, convex areas. These soils have a weakly developed B horizon, whereas the Enterprise soils have no B horizon. They are more loamy than the Pratt soils. Holdrege soils are members of the Chestnut great soil group.

Representative profile: Holdrege loam, 1 to 3 percent slopes, about 850 feet south and 50 feet east of the northwest corner of sec. 3, T. 20 N., R. 20 W.:

- A_{1p} 0 to 5 inches, brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) when moist; structure has been mostly destroyed by tillage; slightly hard when dry, very friable when moist; many roots and pores; pH 6.5.
- A₁₂ 5 to 19 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, medium, granular structure; slightly hard when dry, very friable when moist; many fine roots and pores; pH 6.5; gradual lower boundary.
- B₂ 19 to 37 inches, brown (10YR 4/3) loam, very dark grayish brown (10YR 3/2) when moist; contains about 5 percent more clay than the A₁ horizon; moderate, medium, granular structure; slightly hard when dry, friable when moist; many roots and pores; pH 7.0; gradual lower boundary.
- B₃ 37 to 52 inches, brown (10YR 4/3) loam, dark brown (10YR 3/3) when moist; weak to moderate, medium, granular structure; slightly hard when dry, very friable when moist; many roots, pores, and castings of earthworms; pH 7.0; gradual lower boundary.
- C 52 to 75 inches, dark yellowish-brown (10YR 4/4) light loam, dark yellowish brown (10YR 3/4) when moist; weak, granular structure; slightly hard when dry, very friable when moist; few roots; many pores; pH 7.0.

The A₁ horizons are brown, dark brown, dark grayish brown, and very dark grayish brown. They are 16 to 20 inches thick. The content of clay gradually increases from the A₁ horizons to the B₂ horizon, but the content decreases from the B₂ to the C horizon. In many places there are buried soils.

LAS ANIMAS SERIES

The Las Animas series consists of loamy soils on bottom lands that have a high water table. The soils are subject to infrequent overflow and the deposition of fresh alluvial sediments. They are forming in mixed calcareous sediments under native grasses.

Las Animas soils contain more clay than Lincoln and Elsmere soils. They have a higher water table, more mottling, and more variation in the profile than the Wann soils. The Las Animas soils belong to the Alluvial great soil group.

Representative profile: Las Animas soils, about 620 feet east and 1,056 feet south of the center of sec. 19, T. 23 N., R. 20 W.:

- A₁₁ 0 to 4 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; many fine roots; pH 7.5; stratified lower boundary.
- A₁₂ 4 to 10 inches, stratified layers that average brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) when moist; bands of silty clay and silty clay loam, ¼ to 1 inch thick, are dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2) when moist; massive (structureless) to weak, granular structure; soft when dry, very friable when moist; many fine roots; few, fine, distinct mottles of iron that are strong brown (7.5YR 5/6), strong brown (7.5YR 4/6) when moist; calcareous; stratified lower boundary.
- A₁₃ 10 to 13 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; clay flow on faces of peds; hard when dry, firm when moist; few earthworm castings the size of pencil lead; few, medium, distinct mottles of iron that are brown to

yellowish brown (10YR 5/3 to 5/4); calcareous; stratified lower boundary.

- A₁₄ 13 to 17 inches, grayish-brown (10YR 5/2), highly stratified silty clay, silty clay loam, silt and sandy loam that average heavy silty clay loam, dark grayish brown (10YR 4/2) when moist; massive (structureless) to weak, medium, subangular blocky structure; many, coarse, prominent mottles that are very dark gray (10YR 3/1) when moist or brown (7.5YR 4/4) when moist; few mottles of calcium carbonate; few fine roots; few fine pores; few earthworm castings; calcareous; stratified lower boundary.
- C₁ 17 to 22 inches, yellowish-brown (10YR 5/4) sandy clay loam, dark yellowish brown (10YR 4/4) when moist; massive (structureless) to weak, coarse, subangular blocky structure; hard when dry, friable when moist; few fine pores and roots; many, coarse, prominent mottles of dark gray (black when moist) and brown; few mottles of calcium carbonate; calcareous; pH 7.5; stratified lower boundary.
- C₂ 22 to 72 inches, stratified material that averages fine sandy loam to a depth of 36 inches; medium and fine sands below 36 inches; horizon contains small bands of silt; light gray (10YR 7/2), light brownish gray (10YR 6/2) when moist, at 26 inches; material is very pale brown (10YR 7/3), pale brown (10YR 6/3) when moist, at increasing depth; single grain; loose when dry and moist; few fine roots extend to water table; a few round, dark-gray balls of mud; few, coarse, prominent, dark-gray and brown mottles (probably consisting of manganese and iron); water table occurs at depth of 4 feet; pH 6.5 at water table.

The profile varies from place to place because of variations in the alluvial strata. The texture of the surface layer ranges from loamy sand to clay loam but averages loam. The material between a depth of 10 and 30 inches averages light loam and grades to heavy fine sandy loam. Sand occurs below 30 inches. The water table is 3 to 10 inches below the surface.

LESHARA SERIES

The Leshara series is made up of somewhat poorly drained loamy soils of the bottom lands. These soils are forming in calcareous mixed sediments under native grasses. Leshara soils are better drained, less mottled, less gray, deeper to the water table, and higher lying than Sweetwater soils. They are members of the Alluvial great soil group.

Representative profile: Leshara loam, about 1,650 feet south and 300 feet east of the northwest corner of sec. 30, T. 21 N., R. 20 W.:

- A_{1p} 0 to 5 inches, grayish-brown (10YR 5/2) light loam, very dark grayish brown (10YR 3/2) when moist; structure has been destroyed by tillage; slightly hard when dry, friable when moist; calcareous.
- A₁₂ 5 to 20 inches, dark-gray to dark grayish-brown (10YR 4/2) heavy loam, very dark grayish brown (10YR 3/2) when moist; granular structure; slightly hard when dry, friable when moist; many pores and roots; calcareous; clear lower boundary.
- AC 20 to 28 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, granular structure to massive (structureless); slightly hard when dry, friable when moist; few, distinct, dark yellowish-brown mottles; numerous roots and pores; calcareous; few, small, soft concretions of calcium carbonate; gradual lower boundary.
- C₁ 28 to 45 inches, pale-brown (10YR 6/3) clay loam that grades toward sandy clay loam, brown (10YR 5/3) when moist; weak, subangular blocky structure to massive (structureless); hard when dry, firm when moist; many, distinct, brownish-yellow mottles; calcareous; few roots; at least 5 percent of the mass is made up of soft concretions of calcium carbonate;

clay loam or sandy clay loam strata is 15 to 40 inches thick; clear lower boundary.

- C₂ 45 to 72 inches, light brownish-gray (10YR 6/2) loamy sand that grades to sand at a depth of 50 inches, grayish brown (10YR 5/2) when moist; single grain (structureless); when dry, soil material is soft in upper part of layer and loose with increasing depth, and when wet, soil material is very friable to loose; distinct mottles of yellowish brown are less numerous with increasing depth; calcareous.

In some areas the surface layer consists of fine sandy loam mixed with loam. The A₁ horizons range from very dark gray to very dark grayish brown, the predominant color. They are from 12 to 24 inches thick. The soils are generally mottled within 35 inches of the surface. The texture of the AC and C horizons is variable because different kinds of sediments were deposited by the side drains of the uplands. Buried soils are common.

LINCOLN SERIES

The Lincoln series is made up of excessively drained sandy soils of the bottom lands. The soils are forming in calcareous sand under native grasses and scattered trees. They are subject to occasional flooding and the deposition of fresh soil material. The parent material has been altered little by weathering.

Lincoln soils are more sandy and are deeper to the water table than Las Animas and Elsmere soils. Because of variations in profile characteristics within short distances, no single profile is representative of the Lincoln series. Lincoln soils belong to the Alluvial great soil group.

Profile: Lincoln soils, about 1,300 feet north of the southeast corner of sec. 25, T. 23 N., R. 20 W.:

- A₁ 0 to 18 inches, pale-brown (10YR 6/3) loamy fine sand that grades to fine sand, brown (10YR 5/3) when moist; single grain (structureless); loose when dry, very friable to loose when moist; many roots; pH 7.5 to 8.0; stratified; strata have abrupt boundaries; cross bedding shows evidence of movement by wind. 10 to 20 inches thick.
- C 18 to 60 inches, very pale brown (10YR 7/4) fine sand, yellowish brown (10YR 5/4) when moist; single grain (structureless); loose when dry and when moist; few roots; stratified with water-deposited material; some cross bedding of soil material by wind; pH 7.5.

To get a complete picture of soils of the Lincoln series, one can observe profiles parallel to the North Canadian River for a distance of three-fourths of a mile northwest of the profile just described.

Texture of the surface layer ranges from sand to clay loam but averages sand. Because of the movement of sand by wind, the topography is broadly irregular.

Included with the Lincoln series, as mapped in Woodward County, are soils forming in sediments from Permian red beds. The sediments are yellowish red to reddish brown and in texture are similar to those in which typical Lincoln soils are forming. They are deposited in frequently flooded areas along the larger creeks that drain the red beds. The soils that are forming are redder than the typical Lincoln soils.

MANSKER SERIES

The Mansker series is made up of well-drained, loamy caliche soils that have formed in medium- and fine-textured calcareous sediments under native grasses. The soils are on eroded, convex slopes in the uplands.

Mansker soils are thicker over caliche than Potter soils. They belong to the Calcisol great soil group.

Representative profile: Mansker loam, 1 to 3 percent slopes, about 1,585 feet east and 100 feet north of the northwest corner of sec. 27, T. 22 N., R. 22 W.:

- A_{1D} 0 to 4 inches, grayish-brown (10YR 5/2) heavy loam, very dark grayish brown (10YR 3/2) when moist; structure has been largely destroyed by tillage; slightly hard when dry, friable when moist; many pores; strongly calcareous.
- A₁ 4 to 8 inches, grayish-brown (10YR 5/2) heavy loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; numerous pores and roots; strongly calcareous; gradual lower boundary.
- AC 8 to 17 inches, brown (10YR 5/3) light clay loam, dark brown (10YR 3/3) when moist; strong, medium, granular structure; slightly hard when dry, friable when moist; about 5 percent of the volume is soft caliche concretions; numerous pores; gradual lower boundary. Generally 6 to 12 inches thick but as much as 18 inches thick in a few places.
- C_{ca} 17 to 41 inches, very pale brown (10YR 7/3), calcareous heavy loamy material, pale brown (10YR 6/3) when moist; soil material is mixed with caliche (primarily calcium carbonate); structureless; loamy material is slightly hard when dry, friable when moist; caliche, in the form of slightly indurated concretions, occupies 15 to 35 percent of the mass; strongly calcareous; few fine roots; many pores; diffuse lower boundary. 20 to 30 inches thick.
- C 41 to 52 inches, very pale brown (10YR 8/3) heavy sandy loam to loam, very pale brown (10YR 7/3) when moist; massive (structureless); slightly hard when dry, friable when moist; strongly calcareous.

Near areas of the sandy Pratt and Miles soils, the Mansker soils have a surface layer that grades toward sandy loam. Total thickness of the A horizons is from 6 to 10 inches. The amount of calcium carbonate in the C_{ca} horizon ranges from 10 to 40 percent. Depth to the C_{ca} horizon ranges from 12 to 22 inches. Scattered caliche pebbles are on the surface.

MILES SERIES

The Miles series consists of well-drained moderately sandy soils of the uplands. The soils have formed in loamy and sandy outwash sediments under a cover of native grasses. They have an A horizon of windblown fine sandy loam and a B horizon of sandy clay loam.

Miles soils have more clay in the subsoil than Pratt soils. They are members of the Reddish Chestnut great soil group.

Representative profile: Miles fine sandy loam, 1 to 3 percent slopes, about 250 feet east and 40 feet north of the southwest corner of sec. 26, T. 22 N., R. 22 W.:

- A₁ 0 to 8 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) when moist, that has been worked by the wind; massive (structureless) to weak, fine, granular structure; soft when dry, very friable when moist; many fine fibrous roots; few water-deposited pebbles, 5 to 10 millimeters in diameter; noncalcareous; pH 7.0; clear lower boundary. 4 to 12 inches thick but averages 9 inches.
- B₂₁ 8 to 17 inches, sandy clay loam (layer of maximum clay accumulation) that differs in color with increasing depth; brown (10YR 4/3), dark brown (10YR 3/3) when moist, at 9 inches; brown (7.5YR 4/2), dark brown (7.5YR 3/2) when moist, at 13 inches; reddish brown (5YR 4/3), dark reddish brown (5YR 3/3) when moist, at 16 inches; coarse, prismatic structure that breaks to moderate, medium, granular; hard when dry, friable when moist; many fine roots;

- patchy clay films on faces of prisms; many fine pores; few castings of earthworms; noncalcareous; pH 7.0; a layer of gravel, less than 1 inch thick made up of pebbles 5 to 15 millimeters in diameter, is near the bottom of this horizon; gradual lower boundary.
- B₂₂ 17 to 27 inches, reddish-brown (5YR 5/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; this horizon contains less clay than the horizon above; weak, coarse, prismatic structure that breaks to moderate, medium, granular; slightly hard to hard when dry, friable when moist; many fine roots; many fine pores; few pebbles, 2 to 20 millimeters in diameter; few castings of earthworms; pH 7.0; clear lower boundary.
- B₃ 27 to 38 inches, reddish-brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) when moist; weak, granular structure; slightly hard when dry, friable when moist; many pebbles, 5 to 15 millimeters in diameter; few fine roots; few, distinct, brownish-yellow mottles of iron; calcareous; pH 7.5; abrupt lower boundary. 11 to 20 inches thick.
- C₁ 38 to 53 inches, stratified loamy sand and fine sandy loam that averages loamy sand; average base color is yellowish red (5YR 5/6); structureless; soft when dry, very friable when moist; few pebbles, 2 to 15 millimeters in diameter; calcareous; pH 7.5.

The A horizon is brown, dark brown, and reddish brown. In some places the texture of the B₂ horizon is heavy fine sandy loam; the color ranges from brown to reddish brown. The total thickness of the B₂ horizons ranges from 15 to 25 inches. The C horizon is generally a stratified mixture of sandy and loamy sediments.

NOBSCOT SERIES

The Nobscot series is made up of somewhat excessively drained, deep sandy soils that have formed under trees. The soils are on convex, eroded slopes in the uplands. They occur in an irregular pattern with the Brownfield, Pratt, or Eufaula soils.

Nobscot soils have less development in the B horizon than Pratt soils. They have formed under forest, unlike Pratt soils, which have formed under prairie. The Nobscot soils belong to the Red-Yellow Podzolic great soil group.

Representative profile: Nobscot fine sand, about 1,630 feet west and 210 feet north of the half-mile point on the east side of sec. 8, T. 20 N., R. 22 W.:

- A₀₀ A fraction of an inch of partly decomposed leaf mold that is dark gray when dry and black when moist.
- A₁ 0 to 5 inches, grayish-brown (10YR 5/2) fine sand (90 percent sand, 8 percent silt, 2 percent clay), very dark grayish brown (10YR 3/2) when moist; single grain (structureless); loose when dry, very friable when moist; noncalcareous; pH 6.6; 0.86 percent organic carbon; clear, wavy and irregular lower boundary. 3 to 7 inches thick.
- A₂₁ 5 to 13 inches, pale-brown (10YR 6/3) fine sand (93 percent sand, 5 percent silt, 2 percent clay), brown (10YR 5/3) when moist; loose when dry, very friable when moist; pH 6.1; 0.18 percent organic carbon; other characteristics of this horizon are the same as those given for the A₂₂ horizon; gradual lower boundary.
- A₂₂ 13 to 20 inches, pale-brown (10YR 6/3) fine sand (95 percent sand, 3 percent silt, 2 percent clay), brown (10YR 5/3) when moist; single grain (structureless); soft when dry, very friable when moist; very small amounts of reddish specks the size of sand grains; pH 5.7; 0.13 percent organic carbon; clear, very irregular lower boundary.
- B₂₁ 20 to 32 inches, reddish-yellow (5YR 6/8) fine sand, yellowish red (5YR 5/8) when moist; soil mass has distinct, very irregular, horizontal, broken bands of yellowish-red (5YR 5/6) loamy sand to sandy loam, yellowish red (5YR 4/6) when moist; when

soil material in the bands is mixed with the fine sand, the texture approaches loamy fine sand (87 percent sand, 4 percent silt, 9 percent clay); the bands are ¼ to 1½ inches thick and 2 to 4 inches apart; bands are hard when dry, friable when moist; the soil mass is single grain (structureless) and is slightly hard when dry, very friable when moist; many feeder oak roots; many pores; pH 5.3; 0.24 percent organic carbon; clear, irregular lower boundary.

- B₂₂ 32 to 44 inches, reddish-yellow (5YR 6/6) fine sand (91 percent sand, 2 percent silt, 7 percent clay), yellowish red (5YR 5/6) when moist; structure and consistence are the same as for the B₂₁ horizon; contains bands of yellowish-red (5YR 5/6) loamy sand, yellowish red (5YR 4/6) when moist; the bands are ⅛ to ½ inch thick and 3 to 6 inches apart; pH 5.2; 0.09 percent organic carbon; other characteristics are similar to those of the B₂₁ horizon; diffuse lower boundary.
- B₃ 44 to 54 inches, reddish-yellow (5YR 6/6) fine sand (92 percent sand, 2 percent silt, 6 percent clay), yellowish red (5YR 5/6) when moist; has broken, irregular bands of yellowish-red (5YR 5/6) loamy sand, yellowish red (5YR 4/6) when moist; the bands are ⅛ to ½ inch thick and 4 to 8 inches apart; the structure and consistence of the bands and soil mass are similar to those of the B₂₁ horizon; pH 5.9; 0.06 percent organic carbon; diffuse, irregular lower boundary. 10 to 20 inches thick.
- C 54 to 70 inches, fine sand (92 percent sand, 3 percent silt, and 5 percent clay); color, structure, and consistence are similar to those of the B₃ horizon; the bands are less thick and about 8 inches apart; pH 6.3; 0.04 percent organic carbon.

In some areas the A₁ horizon consists of brown loamy fine sand. Total thickness of the A₂ horizons ranges from 8 to 35 inches, but the average thickness is 20 inches. Texture of the B₂ horizons varies greatly, but, on the average, it is loamy sand in which occur narrow bands of yellowish-red fine sandy loam. The B₂ horizons are 10 to 25 inches in total thickness.

OTERO SERIES

The Otero series consists of somewhat excessively drained, calcareous loamy sands. These undulating soils are forming under grasses. When cultivated, they are extremely susceptible to wind erosion. The removal and accumulation of soil is common in cultivated fields.

Otero soils are calcareous and have a less developed profile than the noncalcareous Pratt soils. They belong to the Regosol great soil group.

Representative profile: Otero loamy fine sand, undulating, in a cultivated field in the E½ of the SW¼ of sec. 24, T. 23 N., R. 22 W.:

- A₁ 0 to 12 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; content of medium sand increases with depth; single grain (structureless); soft when dry, very friable when moist; scattered caliche concretions of up to one-half inch in diameter; many roots; strongly calcareous; diffuse lower boundary. 10 to 14 inches thick.
- AC 12 to 20 inches, pale-brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) when moist; horizon becomes more sandy with increasing depth; single grain (structureless); soft when dry, very friable when moist; caliche concretions increase with depth but make up less than 5 percent of the volume; strongly calcareous; few roots; diffuse lower boundary. 6 to 10 inches thick.
- C 20 to 60 inches, very pale brown (10YR 7/4) loamy sand, light yellowish brown (10YR 6/4) when moist; single grain (structureless); loose when dry, very

friable when moist; few roots; caliche concretions make up less than 5 percent of the volume; strongly calcareous.

In many virgin areas the uppermost 5 inches of the profile consists of light fine sandy loam. After a few years of cultivation, this part of the profile becomes loamy fine sand. Small amounts of waterworn pebbles, 1 inch or less in diameter, are scattered throughout the profile.

PORT SERIES

The Port series is made up of moderately well drained loamy soils of the bottom lands. The soils are forming in mixed calcareous sediments under grasses.

Port soils are more silty and clayey than Yahola soils. Buried soils are common but not always present. The Port soils are members of the Alluvial great soil group.

Representative profile: Port loam, about 0.35 mile west and 100 feet south of the northeast corner of sec. 11, T. 21 N., R. 19 W.:

- A₁₀ 0 to 5 inches, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak, granular structure, most of which has been destroyed by tillage; slightly hard when dry, friable when moist; many roots, pores, and castings of earthworms; noncalcareous; pH 7.0; gradual lower boundary.
- A₁₂ 5 to 20 inches, reddish-brown (5YR 4/3) heavy loam, dark reddish brown (5YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many roots, pores, and castings of earthworms; noncalcareous; pH 7.0; gradual lower boundary.
- AC 20 to 46 inches, reddish-brown (5YR 5/3) light clay loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many roots and pores; few earthworm castings; few concretions of calcium carbonate in the lower part; calcareous; pH 7.5; stratified lower boundary.
- C 46 to 55 inches, brown (7.5YR 5/4) sandy loam that appears to be a buried horizon; many roots; slightly hard when dry, very friable when moist; calcareous, stratified boundary.
- C₂ 55 to 61 inches, light-brown (7.5YR 6/4), stratified loamy sand, brown (7.5YR 5/4) when moist; calcareous; slightly hard to soft when dry, very friable when moist; few roots.
- C₃ 61 to 73 inches, mottled sandy clay that grades to clay; base color is brown (7.5YR 5/2), brown (7.5YR 4/2) when moist; mottles are dark gray and brown; soil material is hard to very hard when dry, firm to very firm when moist; very few roots; about 3 percent of volume consists of calcium carbonate concretions, and less than 1 percent of manganese concretions.

The total thickness of the A₁ horizons ranges from 10 to 20 inches but averages 14 inches.

POTTER SERIES

The Potter series is made up of somewhat excessively drained, shallow caliche soils that are forming from medium- and fine-sized sediments. The soils occupy convex, eroded slopes in the uplands.

In Woodward County the Potter soils occur in an irregular pattern with the Mansker soils on slopes of 1 to 8 percent. They are not so thick over caliche as Mansker soils. Potter soils are members of the Lithosol great soil group.

Representative profile: Potter loam, about 275 feet south and 250 feet east of the northwest corner of sec. 27, T. 22 N., R. 22 W.:

- A₁ 0 to 6 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; strongly calcareous; porous and permeable; gradual lower boundary. 4 to 8 inches thick.
- AC 6 to 10 inches, light clay loam mixed with subrounded caliche pebbles; colors are the same as those of the A₁ horizon; moderate, medium, granular structure; porous and permeable; slightly hard when dry, friable when moist; gradual boundary to caliche. 3 to 5 inches thick.
- C_{ca} or D_r 10 inches +, white (10YR 8/2) caliche that is hard and consolidated; below a depth of 3 feet, the content of caliche decreases and there are various strata of High Plains sediments of fine, medium, and coarse size.

In some places the C_{ca} or D_r horizon may consist of 2 feet of solid and semi-indurated or soft and chalky caliche.

PRATT SERIES

The Pratt series is made up of somewhat excessively drained sandy soils that are forming in wind-deposited material under a cover of grasses. The soils are on a broadly irregular, wavy plain.

In Woodward County, there are two soil types of the Pratt series. These are loamy fine sand, which makes up 80 per cent of the acreage, and fine sandy loam, which makes up 20 percent. Some Pratt soils occur in irregular patterns with Tivoli, Carwile, and Nobscot soils and are mapped in complexes with these soils. The Pratt soils are members of the Reddish Chestnut great soil group.

Representative profile: Pratt loamy fine sand, hummocky, near the northwest corner of sec. 25, T. 24 N., R. 22 W.:

- A₁ 0 to 12 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) when moist; weak, granular structure to single grain (structureless); slightly hard when dry, very friable when moist; many roots and pores; noncalcareous and neutral; gradual lower boundary. 8 to 15 inches thick.
- B₂ 12 to 28 inches, light yellowish-brown (10YR 6/4) loamy fine sand, dark yellowish brown (10YR 4/4) when moist; weak, granular structure that grades to single grain (structureless) and weak, very coarse, prismatic; slightly hard when dry, very friable when moist; many roots and pores; noncalcareous and neutral; gradual lower boundary. 12 to 18 inches thick.
- B₃ 28 to 42 inches, light yellowish-brown (10YR 6/4) loamy fine sand, dark yellowish brown (10YR 4/4) when moist; has about 4 percent less clay than the B₂ horizon; weak, granular structure to single grain (structureless); slightly hard when dry, very friable when moist; few roots; many pores; noncalcareous and neutral; gradual lower boundary. 12 to 16 inches thick.
- C 42 to 65 inches, brownish-yellow (10YR 6/6) loamy fine sand, yellowish brown (10YR 5/6) when moist; heavy fine sand occurs at a depth of 60 inches; single grain (structureless); slightly hard to soft when dry, very friable when moist; noncalcareous and neutral.

To get more complete concept of the Pratt soils, examine the soil and topography southeast of the profile just described for a distance of one-half mile.

Grayish-brown soil, which is darker than that of the profile just described, occurs in valleys between dunes. Pratt soils are neutral, and the A, B, and C horizons have a pH ranging from 6.5 to 7.0. In some areas where there is competition between trees and grasses, the lower part of the A₁ horizon is similar to an A₂ horizon.

QUINLAN SERIES

The Quinlan series is made up of somewhat excessively drained, shallow loamy soils that are forming in weakly consolidated calcareous red beds under a cover of grasses. The soils have mainly steep, convex slopes.

Quinlan soils are the most steeply sloping member of the red-bed catena that includes, in order of increasing slope and loss of moisture through runoff, the St. Paul, Carey, Woodward, and Quinlan soils. The Quinlan soils have not developed to so great a depth as the Woodward soils. They are members of the Regosol great soil group.

Quinlan soils are used primarily as rangeland. Quinlan soils are mixed with Woodward soils in the less sloping cultivated fields. In these places the Quinlan and Woodward soils have been mapped as complexes. There are two eroded phases of these complexes.

Representative profile: Quinlan loam, in the west $\frac{1}{4}$ of sec. 33, T. 25 N., R. 19 W.:

- A₁ 0 to 9 inches, red (2.5YR 4/6) loam, dark red (2.5YR 3/6) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; many roots and pores; calcareous; gradual lower boundary 7 to 10 inches thick.
- AC 9 to 13 inches, a mixture of loam and weathered sandstone; similar in color to the A₁ horizon; calcareous; gradual lower boundary. 4 to 6 inches thick.
- C 13 to 65 inches, weakly consolidated, open-grained, highly weathered sandstone that is red (2.5YR 5/6) at a depth of 60 inches; bedded structure; calcareous; seams of calcium carbonate are at various angles in cracks caused by dry weather; when moistened to capacity, the sandstone is friable, but, when dry, it is hard; massive (structureless); many roots at a depth of 20 inches but few at 45 inches.

When dry, the A₁ and C horizons are red and reddish brown, hues 5YR and 2.5YR.

ST. PAUL SERIES

The St. Paul series is made up of moderately well drained, brown soils that are nearly level to gently sloping. These prairie soils have formed in calcareous loamy red beds under native grasses.

St. Paul soils are not so red as Carey soils. They are darker in the A horizon and the upper part of the B horizon, and more clay has accumulated in their B horizon. The St. Paul soils are members of the Reddish Chestnut great soil group.

Representative profile: St. Paul silt loam, 1 to 3 percent slopes, about 100 feet north and 100 feet west of the southeast corner of sec. 27, T. 24 N., R. 17 W.:

- A_{1p} 0 to 4 inches, brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) when moist; granular structure that has been largely destroyed by tillage; slightly hard when dry, friable when moist; many roots; pH 6.4.
- A₁₂ 4 to 9 inches, brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; weak to moderate, medium and fine, granular structure; slightly hard when dry, friable when moist; many roots and pores; pH 6.5; gradual lower boundary.
- AB 9 to 17 inches, reddish-brown (5YR 4/3) heavy loam that grades to heavy silt loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many roots and pores; pH 7.0; gradual lower boundary. 6 to 9 inches thick.
- B₂ 17 to 33 inches, reddish-brown (5YR 4/3) medium clay loam that grades to medium silty clay loam, dark reddish brown (5YR 3/3) when moist; moderate, coarse, subangular blocky structure with oriented clay films almost continuous; hard when dry, friable

to firm when moist; many fine roots and pores; pH 7.2; gradual lower boundary. 12 to 18 inches thick.

- B₃ 33 to 47 inches, reddish-brown (5YR 4/4) light clay loam, dark reddish brown (5YR 3/4) when moist; weak to moderate, coarse, subangular blocky structure; oriented clay films are not continuous on faces of peds; hard when dry, friable to firm when moist; few fine roots; many fine pores; pH 7.3; gradual lower boundary. 10 to 15 inches thick.
- C 47 to 58 inches, reddish-brown (5YR 4/4) light clay loam that grades to heavy loam, dark reddish brown (5YR 3/4) when moist; weak, coarse, subangular blocky structure; slightly hard when dry, friable to firm when moist; many fine pores; few roots; pH 7.5.

In small areas the texture of the surface layer is loam. Total thickness of the A₁ horizons is 9 to 14 inches; the average thickness is 11 inches. The B₂ horizon is of reddish-brown, dark reddish-brown, and brown color and of medium clay loam or finer texture. The C horizon ranges from heavy loam to light clay loam and is reddish brown, dark reddish brown, and yellowish red, hues 5YR and 2.5YR.

SWEETWATER SERIES

The Sweetwater series is made up of imperfectly drained soils of the bottom lands. The soils are forming in mixed alluvial sediments that are calcareous. The native vegetation is grasses.

Sweetwater soils are more mottled, have a higher water table, and are flooded more frequently than Leshara soils. They belong to the Alluvial great soil group.

Representative profile: Sweetwater soils, about 325 feet north and 325 feet west of the southeast corner of sec. 12, T. 20 N., R. 22 W.:

- A₁₁ 0 to 3 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) when moist; weak, medium, granular structure; slightly hard to soft when dry, very friable when moist; slightly calcareous; numerous roots and pores; clear lower boundary.
- A₁₂ 3 to 10 inches, gray (10YR 5/1) silty clay loam, very dark gray (10YR 3/1) when moist; weak, granular structure; hard when dry, friable to firm when moist; many roots and pores; pH 7.2; clear lower boundary.
- AC 10 to 24 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard to soft when dry, very friable when moist; few, medium, distinct, gray and rust-colored mottles; pH 8.0; clear lower boundary.
- C 24 to 55 inches, gray (10YR 5/1), stratified heavy fine sandy loam and light sandy clay loam, dark gray (10YR 4/1) when moist; contains thin seams of silt and clay; soil material is more sandy with increasing depth; average texture of horizon is sandy loam; many, medium, distinct, light-gray, and brown mottles; calcareous.

The profile just described is about average for the series. But, because of variations in the alluvial deposits, the profile of these soils varies from place to place. The surface layer ranges from dark gray to very dark grayish brown in color and from sandy loam to silty clay loam in texture. In small areas there is a peatlike surface layer, 3 inches thick. The upper 30 inches of the profile averages heavy loam in texture, but the soil is more sandy with increasing depth.

TIVOLI SERIES

The Tivoli series consists of excessively drained soils that are forming in wind-deposited sand under grasses. The soils are on a broadly irregular plain made up of

sand dunes. Two soil types, fine sand and loamy fine sand, have been mapped in Woodward County.

Tivoli soils have a less strongly developed profile than Pratt soils. They belong to the Regosol great soil group.

Representative profile: Tivoli fine sand, about 2,000 feet north and 3,350 feet west of the southeast corner of sec. 9, T. 23 N., R. 20 W.:

- A₁ 0 to 7 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 4/3) when moist; single grain (structureless); loose when dry, loose to very friable when moist; many roots; noncalcareous and neutral; gradual lower boundary. 6 to 10 inches thick.
- C 7 to 60 inches, yellow (10YR 7/6) fine sand, brownish yellow (10YR 6/6) when moist; single grain (structureless); loose when dry and when moist; roots less numerous with increasing depth; noncalcareous and neutral; soil material continues for a depth of at least 40 feet.

In the profile just described, the soil material between a depth of 5 and 9 inches is transitional between the A₁ and C horizons. When dry, the A₁ horizon is brown, pale brown, and light yellowish brown, hue 10YR. When dry, the C horizon is yellow, pale brown, and reddish yellow, hues 10YR and 7.5YR.

TREADWAY SERIES

The Treadway series consists of poorly drained, youthful grassland soils. The soils are forming in gypsiferous shaly clay that has been deposited recently.

Treadway soils differ from Vernon soils in that they are less strongly developed, occur on alluvial flood plains, and have calcareous sand under the shaly clay. They belong to the Alluvial great soil group.

Profile description: Treadway clay, 800 feet south and 800 feet west of the center of sec. 22, T. 25 N., R. 17 W.:

- C₁ 0 to 40 inches, reddish-brown (5YR 4/4) clay, reddish brown (2.5YR 4/4) when moist; massive (structureless); very hard when dry, very firm when moist; when dry, soil mass crumbles at the edges; layer has a high content of gypsum that makes the texture feel less clayey; few roots in upper 20 inches, except for those that penetrate to sand in the lower part of the profile; gypsum crystals are present; calcareous. 20 to 80 inches thick but averages 40 inches.
- C₂ 40 to 75 inches, stratified mixture of calcareous sand that is generally redder than material in horizon above, but is less red with increasing depth; in the upper part of the layer, near where the sand contacts the clay of the horizon above, the soil material, when dry, has hues of 5YR and 7.5YR, values of 5, 6, and 7, and chromas of 4 to 6; at a lower depth the material, when dry, is pale brown to yellow, hue 10YR.

The profile just described is about average for the Treadway soils in Woodward County. To get more information on the Treadway series, look at profiles, 6 feet deep, in the following places: About 1,200 feet east and 250 feet north of the southwest corner of sec. 15, T. 25 N., R. 17 W.; about 275 feet south and 600 feet west of the center of sec. 22, T. 25 N., R. 17 W.

In small areas the C horizon is red (2.5YR 4/6). The thickness of the layer of clay is influenced by the location of side drains and the distance from the Cimarron River. Depth to the water table varies greatly according to the distance from the river and the thickness of the clay over sand.

VERNON SERIES

The Vernon series consists of somewhat excessively drained grassland soils that are forming from weathered, reddish, calcareous shale and gypsiferous shale. The soils occupy convex, eroded slopes in the uplands. Relief is nearly level to strongly sloping.

Vernon soils have a less strongly developed, redder, and more clayey surface layer than St. Paul soils. They belong to the Lithosol great soil group.

Representative profile: Vernon clay loam, 5 to 12 percent slopes, 850 feet north and 200 feet west of the half-mile point on the south side of sec. 17, T. 25 N., R. 17 W.:

- A₁ 0 to 7 inches, reddish-brown (5YR 4/3) clay loam; moderate, medium, granular structure; slightly hard when dry, friable to firm when moist; many roots and pores; calcareous; gradual lower boundary. 6 to 10 inches thick.
- AC 7 to 15 inches, reddish-brown (2.5YR 4/4) clay loam that has more clay than the soil material in the A₁ horizon; moderate, coarse, subangular blocky structure with clay films on the faces of the peds; hard when dry, firm when moist; roots are more abundant on faces of peds than on insides of peds; contains gypsum crystals; calcareous; gradual lower boundary. 6 to 10 inches thick.
- C 15 to 60 inches, reddish-brown and red (hues 5YR and 2.5YR), stratified, weathered gypsiferous clay; thin seams of gypsum; massive (structureless); breaks along bedding planes and cracks caused by dry weather; few roots below a depth of 25 inches; calcareous.

In Woodward County, Vernon soils are primarily of clay loam texture, but they are of clay texture where mapped as part of the Vernon-badland complex. When dry, the C horizon ranges from reddish brown to brown, hues 5YR and 2.5YR.

WANN SERIES

The Wann series consists of moderately well drained soils on bottom lands. The soils are forming in calcareous loamy and sandy sediments under native grasses and scattered trees.

Wann soils are deeper to the water table, are less mottled, and have a more uniform profile than the Las Animas soils. They are more loamy than Lincoln soils. Their profile is stratified, and it varies in texture. On the average, the upper 30 inches consists of fine sandy loam. The Wann soils belong to the Alluvial great soil group.

Representative profile: Wann fine sandy loam, about 1,050 feet north and 1,575 feet east of the southwest corner of sec. 30, T. 23 N., R. 19 W.:

- A₁ 0 to 12 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, granular structure; soft to slightly hard when dry, very friable when moist; numerous roots and pores; calcareous; stratified lower boundary. 8 to 15 inches thick.
- AC 12 to 20 inches, brown (10YR 5/3) stratified material that averages loam, dark brown (10YR 3/3) when moist; granular structure; slightly hard when dry, friable when moist; many fine and coarse roots; many pores; few, faint, gray mottles in lower part; calcareous; stratified lower boundary.
- C 20 to 46 inches, pale-brown (10YR 6/3), stratified material that averages light sandy loam, brown (10YR 5/3) when moist; contains light-brown (hue 7.5YR) strata; weak, granular structure; soft to slightly hard

when dry, very friable when moist; few fine roots; few, medium, faint, gray mottles; calcareous; stratified lower boundary.

- C₂ 46 to 72 inches, very pale brown (10YR 7/3) sand, pale brown (10YR 6/3) when moist; single grain (structureless); soft when dry, very friable to loose when moist; calcareous; few, distinct, gray mottles.

The A₁ horizon ranges from gray to brown. It is loamy sand to clay loam, but fine sandy loam is the principal texture. The thickness of the AC horizon varies according to the kinds of sediments that have been deposited.

WOODWARD SERIES

The Woodward series is made up of well-drained, moderately deep, reddish soils of the uplands. The soils have formed in weakly consolidated red-bed sediments under native grasses. They have convex slopes that are nearly level to strongly sloping.

Woodward soils have developed to a greater depth than Quinlan soils. Unlike the Carey soils, they lack a B horizon. The Woodward soils are Regosols that intergrade to Reddish Chestnut soils.

Representative profile: Woodward loam, 5 to 8 percent slopes, about 1,400 feet west and 1,350 feet north of the southeast corner of sec. 3, T. 23 N., R. 18 W.:

- A_{1p} 0 to 4 inches, reddish-brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) when moist; structure has been mostly destroyed by tillage; slightly hard when dry, friable when moist; neutral.
- A₁₂ 4 to 10 inches, reddish-brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; slightly calcareous; pH 7.0; many roots and pores and castings of earthworms; gradual lower boundary.
- AC 10 to 20 inches, reddish-brown (5YR 5/4) loam, reddish brown (5YR 4/4) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many roots, pores, and castings of earthworms; this horizon has about 5 percent more clay than the horizon above; calcareous; pH 7.5; gradual lower boundary. 8 to 12 inches thick.
- C₁ 20 to 26 inches, transitional layer of loam that grades to weathered sandstone below.
- C₂ 26 to 50 inches, red (2.5YR 4/6), highly weathered, loosely cemented, open-grained sandstone; at a depth of 45 inches material is red (2.5YR 5/8); massive (structureless); accumulations of calcium carbonate along bedding planes; very hard when dry, friable when moist; few roots; calcareous; pH 8.0.

Total thickness of the A₁ horizons ranges from 7 to 12 inches. These horizons are thinner at the crest of a slope and thicker at the bottom. Soil on colluvial foot slopes has a deeper profile than the soil just described. In some places the profile has a C_{ca} horizon.

YAHOLA SERIES

The Yahola series consists of well-drained soils of the bottom lands. The soils are forming in mixed red-bed sediments under native grasses. They occasionally are overflown and receive deposits of fresh sediments from creeks. The higher lying areas receive runoff from small drains in red beds of the uplands.

Yahola soils are more sandy than Port soils; the average texture in the upper 36 inches is fine sandy loam. The Yahola soils are members of the Alluvial great soil group.

Representative profile: Yahola fine sandy loam, about 150 feet east of the bridge on Chimney Creek and 100 feet

south of the road that goes through the center of sec. 28, T. 25 N., R. 17 W.:

- A₁ 0 to 14 inches, reddish-yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 4/6) when moist; weak, granular structure; slightly hard when dry, very friable when moist; many roots and pores; calcareous; clear, stratified lower boundary. 10 to 18 inches thick.
- C 14 to 55 inches, stratified loam, loamy sand, and sandy loam and seams of silt that average reddish-yellow (5YR 6/6) fine sandy loam, yellowish red (5YR 5/6) when moist; weak, granular structure; slightly hard when dry, very friable when moist; calcareous; numerous earthworm castings.

The A₁ horizon ranges from reddish brown to reddish yellow, hues 7.5YR and 5YR. In small areas the texture of the surface layer is loam or very fine sandy loam. The different strata of the profile vary greatly—from loamy sand to clay loam—according to the location; the average texture is fine sandy loam. In general, the profile is more sandy with increasing depth.

Glossary

- AC soil.** A soil that has an A and a C horizon but no B horizon. Commonly such soils are immature, like those developing from alluvium or those on steep, rocky slopes.
- Aggregate, soil.** A single mass or cluster of many soil particles held together in the form of a granule, clod, block, or prism.
- Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.
- Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.
- Caliche.** A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, such as in the Southwestern States. The material may consist of soft, thin layers in the soil or hard, thick beds that are just beneath the solum or are exposed at the surface by erosion.
- Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter (0.000079 inch) in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.
- Colluvium.** Soil material, rock fragments, or both, moved by creep, slide or local wash and deposited at the base of steep slopes.
- Concave slopes.** Slopes that are curved like the interior of a circle or hollow sphere. Concave spots in nearly level fields may be swalelike or may resemble a saucer.
- Concretions.** Hard grains, pellets, or nodules of various sizes, shapes, and colors resulting from concentrations of compounds that cement the soil grains together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.
- Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—
- Loose.*—Noncoherent; will not hold together in a mass.
- Friable.*—When moist, crushes easily under pressure between thumb and forefinger and can be pressed together into a lump.
- Firm.*—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.
- Plastic.*—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.
- Sticky.*—When wet, adheres to other materials; tends to stretch somewhat and pull apart, rather than pull free from other material.
- Hard.*—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.
- Soft.*—When dry, breaks into powder or individual grains under very slight pressure.
- Cemented.*—Hard and brittle; little affected by moistening.

Convex, relief. Land surface that is curved or rounded and resembles the outer surface of a sphere.

Depth, soil. In this report, terms used to indicate soil depth refer to the combined thickness of the surface soil and subsoil:

Deep—more than 36 inches; *moderately deep*—20 to 36 inches; *shallow*—10 to 20 inches; and *very shallow*—less than 10 inches.

Gravel (engineering definition, Unified soil classification system). A coarse-grained soil of which more than 50 percent is retained on a no. 4 screen.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. The relative positions and nomenclature of the horizons in a typical soil profile are:

A₀₀ Loose leaves and organic debris, largely undecomposed.

A₀ Organic debris, partly decomposed or matted.

A₁ A dark-colored horizon having a fairly high content of organic matter mixed with mineral matter.

A_{1p} Plow layer.

A₂ A light-colored horizon, often representing the zone of maximum leaching where podzolized; absent in wet, dark-colored soils.

A₃ Transitional to B horizon but more like A than B; sometimes absent.

B₁ Transitional to B horizon but more like B than A; sometimes absent.

B₂ A usually deeper colored horizon, which often represents the zone of maximum illuviation where podzolized.

B₃ Transitional to C horizon.

C Slightly weathered parent material; absent in some soils.

D Underlying substratum.

The A horizons make up a zone of eluviation, which is a leached zone. The B horizons make up a zone of illuviation, in which clay and other materials have accumulated. The A and B horizons, together, are called the solum, or true soil.

Loess. A fine-grained eolian (windblown) deposit, dominantly of silt-sized particles.

Morphology, soil. The constitution of the soil including the texture, structure, consistence, color, and other physical, chemical, and biological properties of the various soil horizons that make up the soil profile.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are: *Very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Phase, soil. A subdivision of a soil type or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects management.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction, because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed as:

	pH
Extremely acid.....	Below 4.5
Very strongly acid.....	4.5 to 5.0
Strongly acid.....	5.1 to 5.5
Medium acid.....	5.6 to 6.0

	pH
Slightly acid.....	6.1 to 6.5
Neutral.....	6.6 to 7.3
Mildly alkaline.....	7.4 to 7.8
Moderately alkaline.....	7.9 to 8.4
Strongly alkaline.....	8.5 to 9.0
Very strongly alkaline.....	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock. Only the upper part of this, modified by organisms and other soil-building forces, is regarded by soil scientists as soil. Most American engineers speak of the whole regolith, even to great depths, as "soil."

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles of soil that range in diameter between the upper size of clay, 0.002 millimeter, and the lower size of very fine sand, 0.05 millimeter. Soil of the textural class silt contains 80 percent or more of silt and less than 12 percent of clay. Silt also refers to sediments deposited from water in which the individual grains are approximately of the size of silt, although the term is sometimes applied loosely to sediments containing considerable sand and clay.

Slope, soil. The number of feet of fall (expressed in percent) per 100 feet of horizontal distance. Slope terms and their numerical equivalents used in this report are as follows: *Nearly level*—0 to 1 percent slopes; *gently sloping*—1 to 3 percent slopes; *moderately sloping*—3 to 5 percent slopes; *strongly sloping*—5 to 8 percent slopes; *steep*—8 to 12 percent slopes; *very steep*—more than 12 percent slopes.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are (1) single grain—each grain by itself, as in dune sand, or (2) massive—the particles adhering together without any regular cleavage as in many claypans and hardpans.

Subsoiling. The tillage of the soil below the normal plow depth, usually to shatter a hardpan or claypan.

Substratum. Any layer lying beneath the solum, or true soil; the C or D horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically, texture refers to the proportions of sand, silt, and clay.

Topsoil. Presumably fertile soil used to topdress roadbanks, parks, gardens, and lawns.

Type, soil. A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

GUIDE TO MAPPING UNITS, CAPABILITY UNITS, AND RANGE SITES

[See table 3, p. 11, for approximate acreage and proportionate extent of the soils; table 4, p. 32, for estimated average acre yields of principal crops on soils suited to cultivation. For information on irrigation farming, see the section "Irrigation," beginning on p. 32, and for a discussion of the engineering properties of the soils, turn to the section "Engineering Uses of the Soils," beginning on p. 42. A detailed profile of each soil series is described in the section "Formation, Classification, and Morphology of the Soils"]

Map symbol	Mapping unit	Capability unit		Range site		
		Page	Symbol	Page	Name	Page
BfB	Brownfield fine sand, 1 to 3 percent slopes.....	12	IVe-2	29	Deep Sand Savannah	35
CaB	Carey silt loam, 1 to 3 percent slopes.....	12	IIE-1	27	Loamy Prairie	36
CaC	Carey silt loam, 3 to 5 percent slopes.....	12	IIIE-1	28	Loamy Prairie	36
CaD	Carey silt loam, 5 to 8 percent slopes.....	12	IVe-1	29	Loamy Prairie	36
CaD2	Carey silt loam, 5 to 8 percent slopes, eroded.....	12	IVe-1	29	Loamy Prairie	36
Cp	Carwile-Pratt complex.....	13	IIIW-1	29	Sandy Prairie	36
Ee	Elsmere loamy fine sand.....	13	IVw-1	29	Subirrigated	35
EfB	Enterprise fine sandy loam, undulating.....	14	IIIE-2	28	Sandy Prairie	36
EmC	Enterprise loam, 3 to 5 percent slopes.....	14	IIIE-1	28	Loamy Prairie	36
EpD	Enterprise-Pratt complex, 5 to 8 percent slopes.....	14	IVe-1	29	Sandy Prairie	36
EpE	Enterprise-Pratt complex, 8 to 20 percent slopes.....	14	VIe-5	31	Sandy Prairie	36
HoB	Holdrege loam, 1 to 3 percent slopes.....	14	IIE-1	27	Loamy Prairie	36
La	Las Animas soils.....	15	Vw-1	30	Subirrigated	35
Le	Leshara loam.....	15	IIw-1	28	Loamy Bottom Land	35
Lf	Lincoln loamy fine sand.....	15	IVe-2	29	Sandy Bottom Land	35
Ln	Lincoln soils.....	16	VIe-7	31	Sandy Bottom Land	35
MbB	Mansker loam, 1 to 3 percent slopes.....	16	IIIE-1	28	Loamy Plains	36
MbC	Mansker loam, 3 to 5 percent slopes.....	16	IVe-1	29	Loamy Plains	36
McD	Mansker-Potter loams, 5 to 12 percent slopes.....	16	VIe-1	30	Loamy Plains and Shallow	36, 37
MfB	Miles fine sandy loam, 1 to 3 percent slopes.....	16	IIIE-2	28	Sandy Prairie	36
MfC	Miles fine sandy loam, 3 to 5 percent slopes.....	17	IVe-2	29	Sandy Prairie	36
NbC	Nobscot-Brownfield fine sands, 3 to 5 percent slopes.....	17	IVe-2	29	Deep Sand Savannah	35
Nc3	Nobscot-Brownfield complex, severely eroded.....	17	VIe-3	30	Deep Sand Savannah	35
NeD	Nobscot-Eufaula fine sands, 5 to 12 percent slopes.....	17	VIe-3	30	Deep Sand Savannah	35
NpC	Nobscot-Pratt complex, hummocky.....	17	IVe-2	29	Deep Sand Savannah and	
NpE	Nobscot-Pratt complex, duned.....	17	VIe-3	30	Deep Sand Savannah and	35
OtB	Otero loamy fine sand, undulating.....	18	IVe-2	29	Limy Sandy Plains	37
Pa	Port loam.....	18	I-1	27	Loamy Bottom Land	35
PbB	Pratt fine sandy loam, undulating.....	19	IIIE-2	28	Sandy Prairie	36
PbC	Pratt fine sandy loam, hummocky.....	19	IVe-2	29	Sandy Prairie	36
PfB	Pratt loamy fine sand, undulating.....	19	IIIE-2	28	Deep Sand	35
PfC	Pratt loamy fine sand, hummocky.....	19	IVe-2	29	Deep Sand	35
Pt	Pratt-Tivoli loamy fine sands.....	19	VIe-2	30	Deep Sand and Dune	35, 38
Qm	Quinlan loam.....	19	VIe-4	30	Shallow Prairie	37
QwC2	Quinlan-Woodward loams, 3 to 5 percent slopes, eroded.....	19	IVe-1	29	Shallow Prairie and	
QwD	Quinlan-Woodward loams, 5 to 12 percent slopes.....	20	VIe-4	30	Loamy Prairie.	37, 36
QwD2	Quinlan-Woodward loams, 5 to 12 percent slopes, eroded.....	20	VIe-4	30	Shallow Prairie and	37, 36
Rb	Rough broken land.....	20	VIIe-2	31	Loamy Prairie.	37, 36
SaA	St. Paul silt loam, 0 to 1 percent slopes.....	20	IIc-1	27	Breaks	37
SaB	St. Paul silt loam, 1 to 3 percent slopes.....	20	IIE-1	27	Hardland	36
SaC	St. Paul silt loam, 3 to 5 percent slopes.....	20	IIIE-1	28	Hardland	36
Sw	Sweetwater soils.....	21	Vw-1	30	Hardland	36
Tv	Tivoli fine sand.....	21	Vw-1	30	Subirrigated	35
Tw	Treadway clay.....	21	VIIe-3	31	Dune	38
VcB	Vernon clay loam, 0 to 3 percent slopes.....	21	VIe-1	31	Red Clay Flats	37
VcC	Vernon clay loam, 3 to 5 percent slopes.....	21	IIIE-1	28	Red Clay Prairie	36
VcD	Vernon clay loam, 5 to 12 percent slopes.....	22	IVe-1	29	Red Clay Prairie	36
Vm	Vernon-badland complex.....	22	VIe-6	31	Shallow Clay Prairie	36
Vp	Vernon-Cottonwood complex.....	22	VIIe-4	32	Shallow Clay Prairie and	
Wf	Wann fine sandy loam.....	22	VIIe-1	31	Eroded Red Clay.	36, 38
WoB	Woodward loam, 1 to 3 percent slopes.....	22	IIw-1	28	Shallow Clay Prairie and	
WoC	Woodward loam, 3 to 5 percent slopes.....	23	IIe-1	27	Gyp.	36, 38
WoD	Woodward loam, 5 to 8 percent slopes.....	23	IIIE-1	28	Loamy Bottom Land	35
WwC	Woodward-Quinlan loams, 3 to 5 percent slopes.....	23	IVe-1	29	Loamy Prairie	36
Ya	Yahola fine sandy loam.....	23	IVe-1	29	Loamy Prairie	36
Yh	Yahola fine sandy loam, high.....	23	IVe-1	29	Loamy Prairie and Shallow	
					Prairie.	36, 37
					Loamy Bottom Land	35
					Loamy Bottom Land	35

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