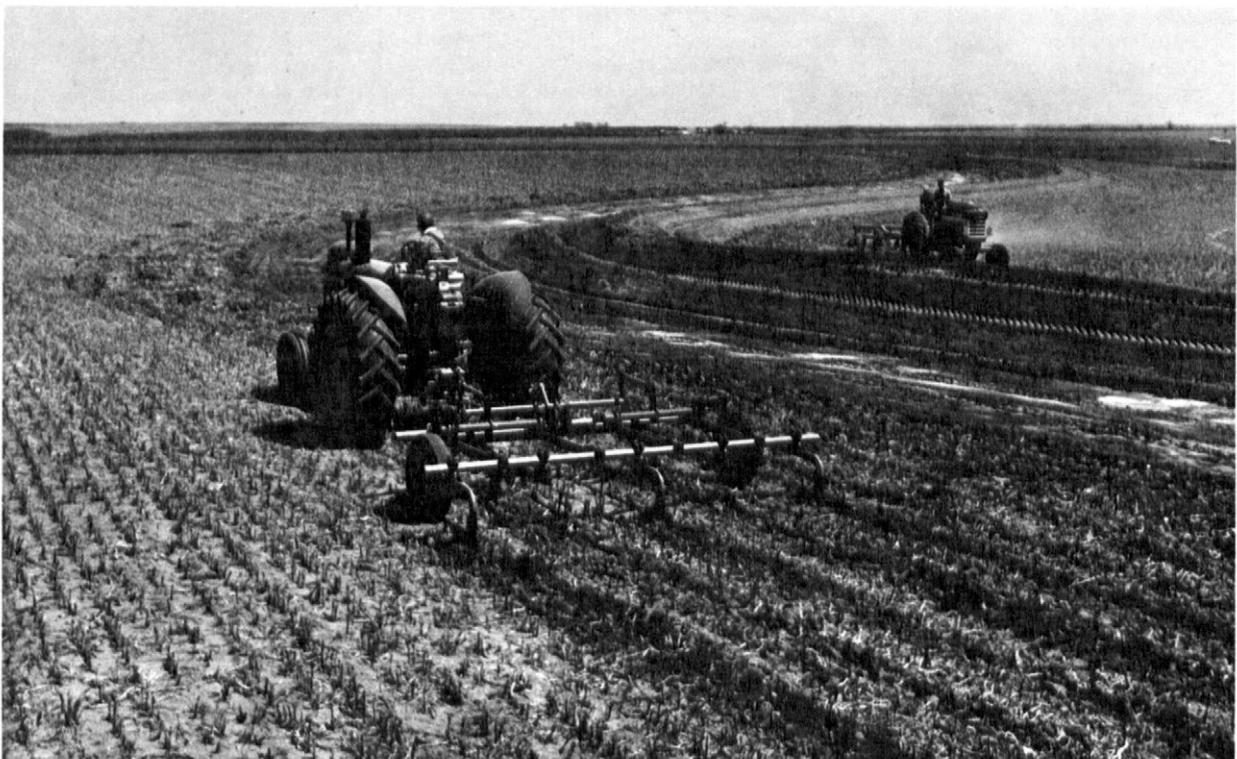


SOIL SURVEY

Ellis County Oklahoma



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

HOW TO USE THIS SOIL SURVEY REPORT

THIS SOIL SURVEY of Ellis County will serve several groups of readers. It will help farmers and ranchers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid managers of forest and woodland; add to the soil scientists' knowledge of soils; and help prospective buyers and others in appraising a farm or other tract.

Locating the soils

At the back of this report is an index map and a soil map consisting of many sheets. On the index map are rectangles numbered to correspond to the sheets of the soil map, so that the sheet showing any area can be located easily. On each map sheet, the soil boundaries are outlined and there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where it belongs. For example, an area on the map has the symbol McC. The legend for the detailed map shows that this symbol identifies Mansic clay loam, 3 to 5 percent slopes. This soil and all others mapped in the county are described in the section "Descriptions of the Soils."

Finding information

In the "Guide to Mapping Units" at the back of this report, the soils are listed in the alphabetic order of their map symbols. This guide shows where to find a description of each soil and where to find a discussion of its capability unit and range site. It also shows where to find the acreage of each soil, the yields that can be expected, and information about engineering uses of the soils.

Farmers and those who work with farmers can learn about the soils on a farm by reading the description of each soil and of its capability

unit and other groupings. A convenient way of doing this is to turn to the soil map and list the soil symbols on a farm and then to use the "Guide to Mapping Units" in finding the pages where each soil and its groupings are described.

Ranchers and others interested in range will find the subsection "Range Management" helpful. In that subsection the soils of the county are placed in groups according to their suitability as rangeland, and the management of each group is discussed.

Engineers and builders will find in the subsection "Engineering Uses of the Soils," tables that (1) give engineering descriptions of the soils in the county; (2) name soil features that affect engineering practices and structures; and (3) rate the soils according to their suitability for several kinds of engineering work.

Scientists and others who are interested can read about how the soils formed and how they are classified in the section "Genesis, Classification, and Morphology of the Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interests.

Newcomers in Ellis County will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

* * * * *

This soil survey was made as part of the technical assistance furnished by the Soil Conservation Service to the Ellis County Soil Conservation District, which was organized through the efforts of local farmers in 1941. Through this district the farmers and ranchers receive technical help from the Soil Conservation Service in planning for the use and conservation of the soils on their farms and ranches.

Fieldwork for this survey was completed in 1961. Unless otherwise indicated, all statements in the report refer to conditions in the county at the time the survey was in progress.

Cover Picture: Stubble mulching on the contour in a terraced field. This practice helps to control wind erosion, to increase water intake, and to build up the organic-matter content of the soils.

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SOIL SURVEY OF ELLIS COUNTY, OKLAHOMA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN
COOPERATION WITH THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION

ELLIS COUNTY is located in the northwestern part of Oklahoma (fig. 1). The county consists of about 782,080 acres, or 1,222 square miles.

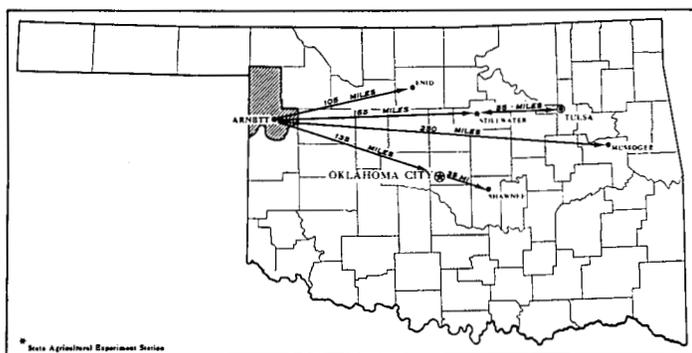


Figure 1.—Location of Ellis County in Oklahoma.

Ellis County was named for Albert H. Ellis, vice president of the Oklahoma Constitutional Convention, which met in 1906 at Guthrie. Early settlement was under the Homestead Act, which allowed settlers 160 acres of land.

The county is primarily agricultural and has only a few small industries. Income is derived mainly from wheat, sorghum, beef, and dairy products. About one-third of the acreage is cropland, and about two-thirds is rangeland. Several hundred acres is under irrigation. Wells are the main sources of water. About one-half of the county has underground water that could be used for agriculture and industry.

How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Ellis 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 rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent 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 nationwide, uniform procedures. To use this report efficiently, it is necessary 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, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. 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. Mansic and Pratt, for example, are the names of two soil series. All the soils in the United States having the same series names are essentially alike in those characteristics that affect their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences 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 phases. The name of a soil phase indicates a feature that affects management. For example, Mansic clay loam, 3 to 5 percent slopes, is one of several phases of Mansic clay loam, a soil type in this county that has a slope range of 1 to 8 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that 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 scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and occur in individual areas of such small size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soils in it, for example, Otero-Mansker complex. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on the soil map like other mapping units, but they are given descriptive names, such as Gravelly broken land or Riverwash, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. On the basis of the yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

By drawing lines around the different patterns of soils on a small map, one obtains a general map of the soil areas, or soil associations. Such a map is useful to those who want a general idea of the soils, who want to compare different parts of a county, or who want to locate large areas suitable for a particular kind of farming or other broad land use. It is not detailed enough, however, for use in planning the management of a single farm or ranch.

The 11 soil associations of Ellis County, shown on the colored map at the back of this report, are described in the paragraphs that follow. Each association is named for the major soils in it. The soils that occur in one association may occur in another, but in a different proportion and pattern. Each association has a distinct pattern of

soils, and the differences are important to the farms in the association.

1. Woodward-Carey association

Dark-colored, loamy, nearly level to moderately sloping soils

This association is in the northeastern part of Ellis County. The total area is about 27,370 acres, or 3.5 percent of the county. About 70 percent of this acreage consists of gently or moderately sloping Woodward soils, about 17 percent consists of gently sloping Carey soils, and most of the rest consists of nearly level and gently sloping St. Paul soils. Figure 2 shows the topographic position of the major soils in this association.

The Woodward soils are reddish-brown, calcareous, well-drained loams. The Carey soils have a surface layer of dark-brown silt loam and a subsoil of clay loam. The St. Paul soils have a surface layer of dark grayish-brown silt loam and a subsoil of blocky silty clay loam. All of these soils formed in Permian red beds.

About 85 percent of this association is cultivated. Small grain and sorghum are the main crops. The soils are productive, but they are susceptible to wind and water erosion, and conservation measures are needed to maintain productivity. Little bluestem, sideoats grama, buffalograss, and blue grama are the main pasture grasses.

2. Quinlan-Woodward association

Reddish, loamy, rolling soils

This association is mostly in the southeastern part of the county. It is characterized by strong slopes, knobs, and steep breaks. The total area is 52,390 acres, or nearly 7 percent of the county. About 36 percent of this acreage consists of Woodward soils, about 34 percent consists of Quinlan soils, and the rest consists of Rough broken land and minor areas of Loamy alluvial land and rolling Vernon soils. Figure 2 shows the topographic position of the major soils in this association.

The Woodward soils are reddish-brown, calcareous, well-drained loams. They occur below ridge crests, on the smoother slopes. The Quinlan soils are red, calcareous loams that are shallow over partly weathered red-bed material. They occur on the steeper slopes in drainage ways. Rough broken land includes ridges, canyon walls, and steep cliffs that impede movement of livestock.

Almost all of this association is used as range. If well managed it provides moderate to good grazing for beef cattle. Little bluestem, buffalograss, and grama are the principal grasses. Cultivation is not practical, because of the steep slopes and the resulting hazard of water erosion. A few areas have been cultivated but are now reseeded to native grasses.

3. Broken land-Berthoud-Enterprise association

Moderately sandy, hilly soils

This association extends in a narrow band along the north side of the Canadian River and northward along some of the tributaries in the southwestern part of the county. The total area is 61,770 acres, or almost 8 percent of the county. About 60 percent consists of Broken land, about 28 percent consists of Berthoud soils, and about 12 percent consists of Enterprise soils. Figure 2

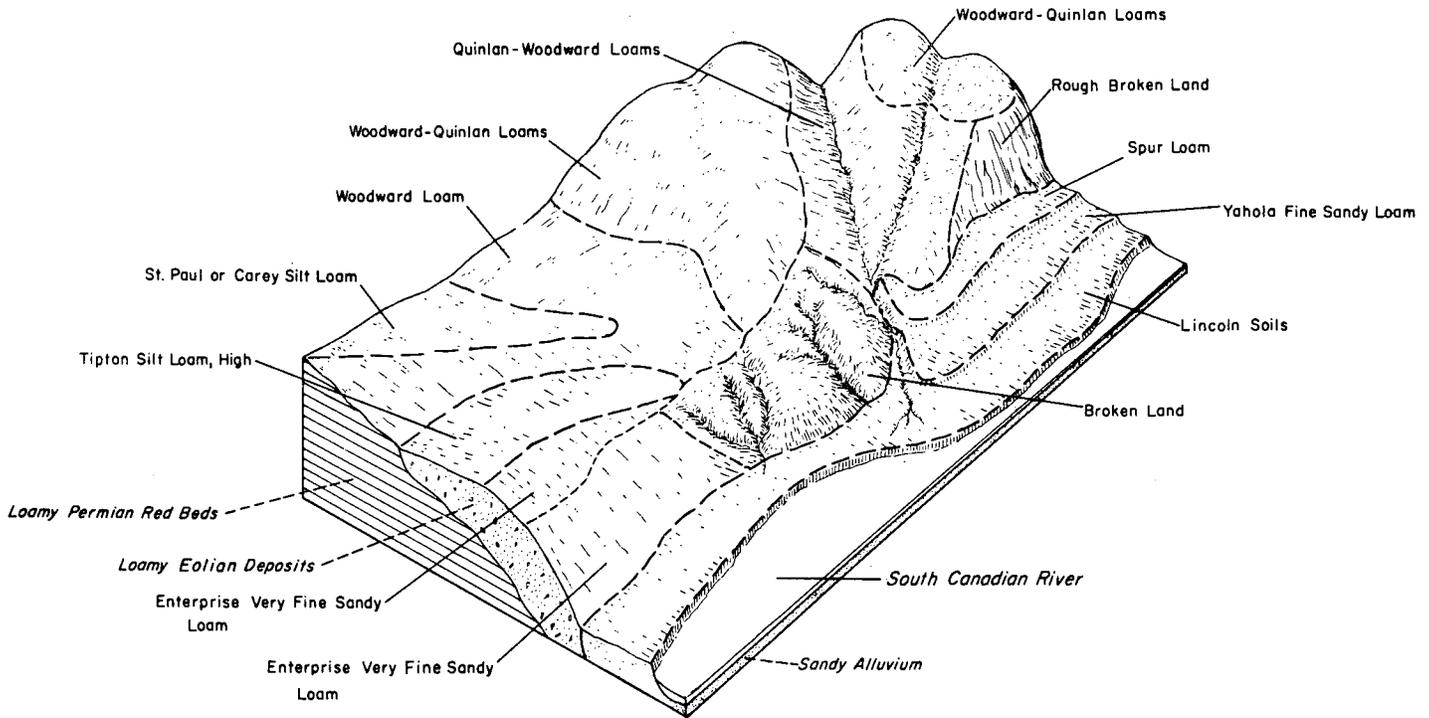


Figure 2.—Major soils of associations 1, 2, 3, and 11.

shows the topographic position of the major soils in this association.

Broken land occurs as steep and hilly areas along the South Canadian River and its larger tributaries. It consists of calcareous soil material and generally has a surface layer of fine sandy loam and a subsoil of sandy loam or loamy sand. The Berthoud soils are on the slopes below the caliche caprock. They have a surface layer and subsoil of grayish-brown, calcareous fine sandy loam. Minor areas of moderately sloping Berthoud soils are included. The Enterprise soils are gently sloping or moderately sloping and consist of brown very fine sandy loam. All of these soils formed in alluvial and eolian deposits of calcareous very fine sandy loam to loamy fine sand.

This association is best suited to native grass, and about 85 percent of the acreage is used as range. The range vegetation consists mainly of little bluestem, grama grasses, and sand sagebrush. Beef cattle are the main source of income. Most of the cultivated areas are on the gently sloping or moderately sloping Enterprise soils. Wheat is the main cultivated crop, but some grain sorghum and some forage sorghum are grown. Controlling water erosion is the major problem if cultivated crops are grown. Good management of crop residues is one means of erosion control.

4. Nobscot-Brownfield association

Sandy, hummocky soils with a reddish subsoil

This association occupies an extensive area in the southeastern part of the county. The total area is about 151,740 acres, or about 19 percent of the county. About 58 percent of this acreage consists of Nobscot soils, and about 42 percent consists of Brownfield soils. Figure 3 shows the topographic position of the major soils in this association.

The Nobscot soils occur in hummocky and duned areas. The surface layer consists of a thin layer of dark grayish-brown material over about 25 inches of light-colored fine sand, and the subsoil is reddish fine sandy loam. The Brownfield soils occupy smooth, gentle slopes. Their surface layer consists of a thin layer of dark grayish-brown material over about 15 inches of light-colored fine sand, and the subsoil is reddish sandy clay loam. All of these soils formed in sandy deposits under a cover of shinnery oak.

Minor areas of Pratt and Miles soils are included in this association. The Pratt soils are in the hummocky areas, and the Miles soils are mostly in the gently sloping areas.

Beef cattle are the main source of income, and about 90 percent of the association is used as range. Most of the ranches are several thousand acres in size. The vegetation consists mainly of little bluestem, sand lovegrass, and shinnery oak.

Because the soils that make up this association are low in fertility and are susceptible to wind erosion, most of the areas once cultivated have been reseeded to grass. Small areas are used for the production of forage sorghum and grain sorghum.

5. Pratt-Tivoli association

Sandy, duned soils

This association is in steep, duned areas along the larger streams in the county. The total area is 37,530 acres, or nearly 5 percent of the county. About 55 percent of this acreage consists of Tivoli soils, and about 45 percent consists of Pratt soils.

The Pratt soils occur in the smoother, less sloping areas. They have a surface layer of grayish-brown loamy fine sand and a subsoil of loamy fine sand. The Tivoli soils

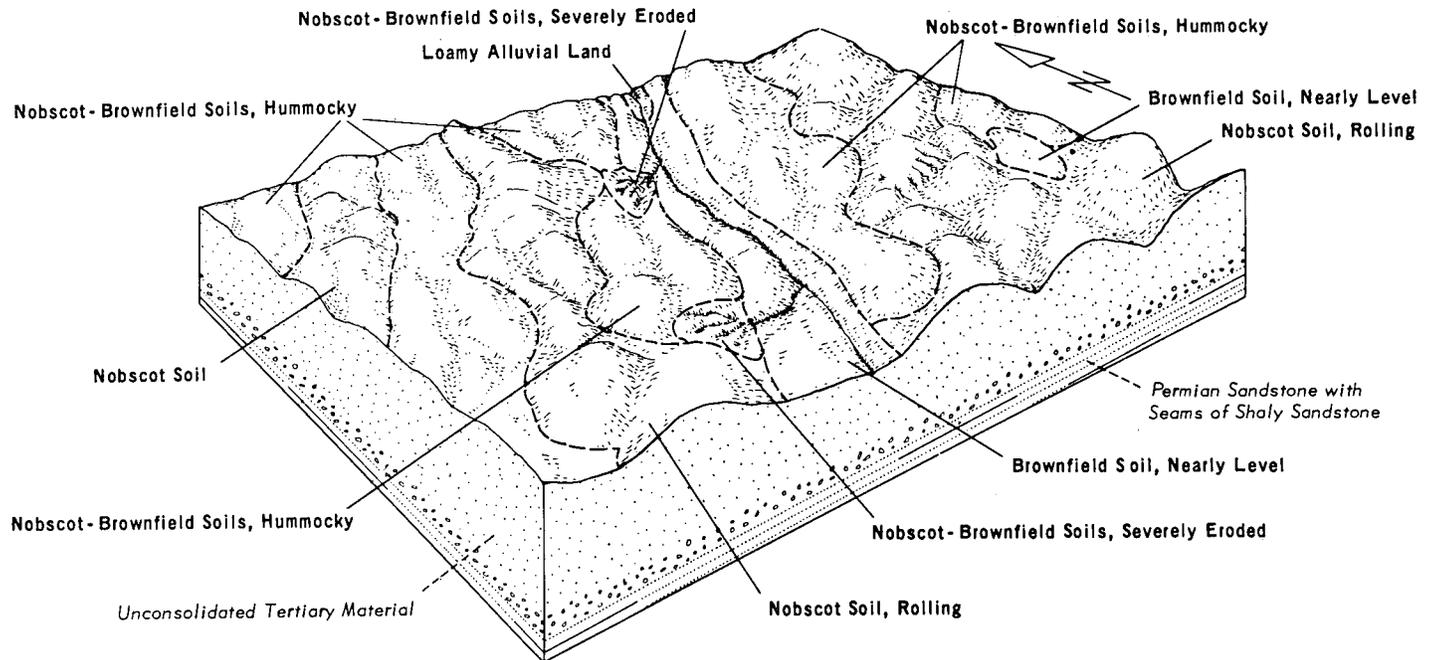


Figure 3.—Major soils of association 4.

occur in the duned areas and have a surface layer of grayish-brown fine sand and a subsoil of fine sand. All of these soils formed in eolian deposits of noncalcareous sands.

Almost all of this association is used as range. If well managed it is moderately productive. Beef cattle are the main source of income. The range vegetation consists mainly of sand bluestem, little bluestem, and sand sagebrush. Because of the severe hazard of wind erosion, cultivation is not practical.

6. Pratt-Carwile association

Moderately sandy, hummocky soils

This association is mostly in the southern and eastern parts of the county. The largest area is east of Arnett. The total area is 28,150 acres, or nearly 4 percent of the county. About 89 percent of this acreage consists of Pratt soils, and about 11 percent consists of Carwile soils.

The Pratt soils occur in the undulating and hummocky areas. They have a surface layer and a subsoil of loamy fine sand or fine sandy loam. The surface layer is grayish brown, and the subsoil is noncalcareous. The Carwile soils are dark grayish-brown, imperfectly drained sandy clay loams. They occur in level areas and in depressions. The Pratt soils formed in eolian deposits of sands, and the Carwile soils formed in eolian and alluvial deposits.

About 60 percent of the acreage is cultivated. The farms average 800 acres in size. Wheat and grain sorghum are the main crops. When the moisture supply is favorable, yields are fair. The major problems are controlling wind erosion, conserving moisture, and preventing the ponding of water in the depressions. Good management of crop residues is the best means of erosion control.

The range vegetation consists mainly of grama grasses, little bluestem, and sand sagebrush. Overgrazing results in an increase in the amount of sand sagebrush.

7. Mansker-Potter association

Limy, loamy, rolling soils

This association is in the northern and western parts of the county and along the Oklahoma-Texas boundary. The total area is about 85,230 acres, or almost 11 percent of the county. About 84 percent of this acreage consists of very shallow Potter soils and moderately shallow Mansker soils, and most of the rest consists of Berthoud soils. Also in this association are minor areas of Mansic soils, which occur in the strongly sloping areas below the caprock. Figure 4 shows the topographic position of the major soils in this association.

The Potter and Mansker soils are grayish-brown, calcareous, well-drained loams underlain by caliche. The Potter soils occupy the ridgetops, and the Mansker soils are mostly on the side slopes. The Berthoud soils are adjacent to the caprock on the colluvial-alluvial foot slopes below the Potter and Mansker soils. They are grayish-brown, calcareous fine sandy loams.

About 95 percent of this association is used as range. If the range is well managed it is highly productive of little bluestem and grama grasses. Beef cattle are the main source of income. The soils are not arable, because they are steep, very shallow, and droughty.

8. Mansic-Richfield association

Loamy, moderately sloping soils

This association occupies uplands that are dissected by drainageways. Of the two largest areas, one is north of Wolf Creek and above the caprock, and one is south of Wolf Creek. The total area is 133,720 acres, or about 17 percent of the county. About 55 percent of this acreage consists of gently sloping to strongly sloping Mansic soils,

about 29 percent consists of gently sloping and moderately sloping Potter and Mansker soils, and the rest consists of gently sloping and moderately sloping Richfield soils. Figure 4 shows the topographic position of the major soils in this association.

The Mansic soils are dark grayish-brown, calcareous, well-drained clay loams underlain by caliche. The Potter soils, which are very shallow, and the Mansker soils, which are moderately shallow, occur along the ridgetops. They are grayish-brown, calcareous, well-drained loams underlain by caliche. The Richfield soils are deep, dark grayish-brown, well-drained clay loams. Their subsoil is compact. All of these soils formed in deposits of calcareous loam and clay loam.

About 80 percent of this association is cultivated, chiefly to grain sorghum and to wheat and other small grain. The farms average about 960 acres in size. The soils are fertile, and yields are good if the moisture supply is favorable. Controlling water erosion and conserving moisture are the major problems. Farming on the contour, terracing, and managing crop residues help to solve these problems. The steep slopes and drainageways are used for pasture. Buffalograss, little bluestem, and grama grasses are the principal native grasses.

9. Likes-Otero association

Limay, sandy, hummocky soils

This association is distributed over the county along the major streams and their tributaries. The total area is about 61,770 acres, or almost 8 percent of the county. About 60 percent of this acreage consists of the Likes soils, and about 40 percent consists of the Otero soils.

The Likes soils have a surface layer of grayish-brown loamy fine sand and a subsoil of fine sand. They occur as undulating and hummocky deposits along the major streams. The Otero soils are somewhat excessively drained, grayish-brown, calcareous, stratified loamy sands and fine sandy loams. They occur in hummocky and undulating areas on the uplands. All of these soils formed in eolian and alluvial deposits of calcareous fine sandy loam to sand.

Small areas of the Mansker, Mansic, and Potter soils are included. They occur with the Otero soils.

About 95 percent of this association is used as range. If well managed the range is moderately productive. The vegetation consists mainly of sand bluestem, grama grasses, and sand sagebrush. Cultivation is inadvisable because of the severe hazard of wind erosion. Most of the areas once cultivated have been reseeded to grass.

10. St. Paul-Manter-Dalhart association

Loamy, gently sloping soils

This association occurs as an irregular band on the south side of Wolf Creek and as scattered areas in the northwestern and southwestern parts of the county. The total area is about 89,240 acres, or a little more than 11 percent of the county. About 53 percent of this acreage consists of gently sloping or moderately sloping Manter and Otero soils, about 27 percent of nearly level or gently sloping St. Paul soils, and about 20 percent of gently sloping or moderately sloping Dalhart soils. Figure 4 shows the topographic position of the major soils in this association.

The Manter soils are deep, dark grayish-brown, well-drained fine sandy loams. They occur in a complex with

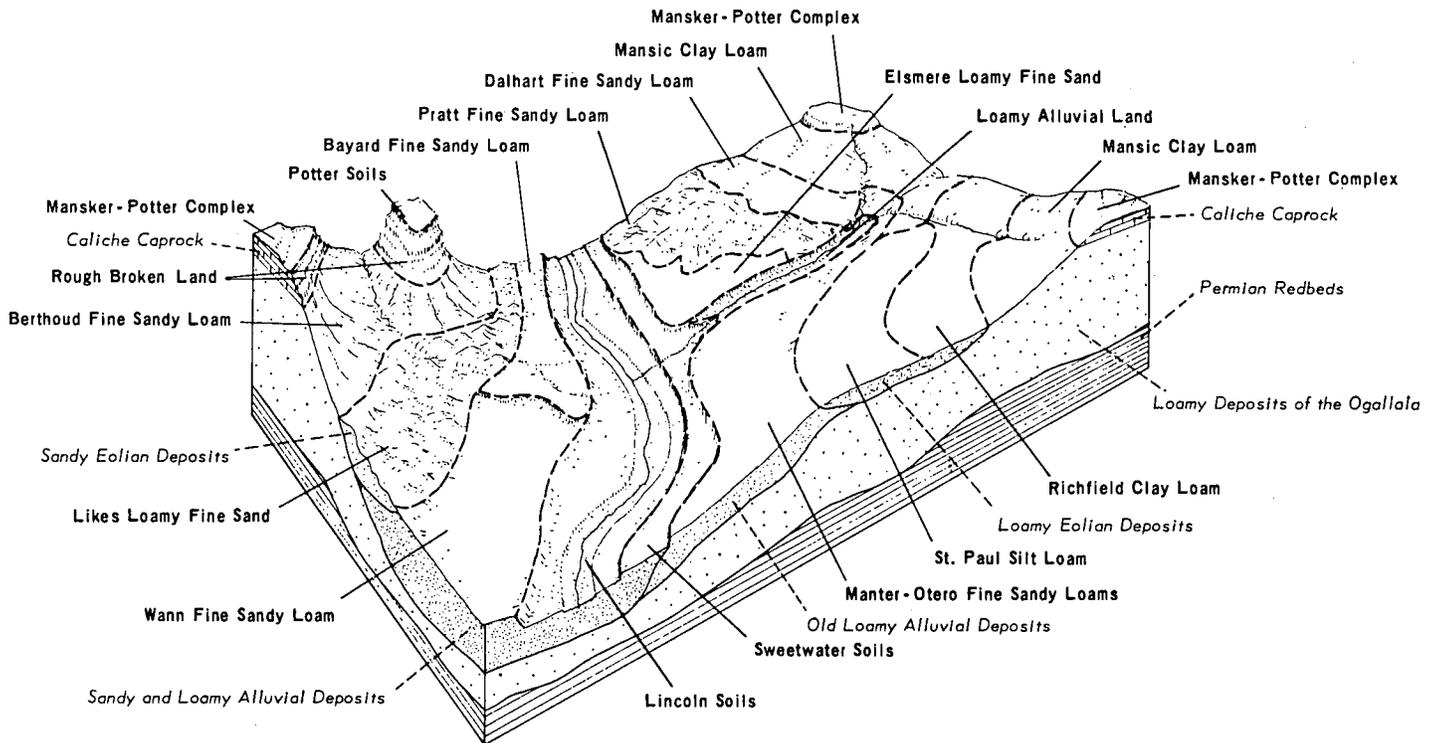


Figure 4.—Major soils of associations 7, 8, and 10.

the Otero soils, which are lighter colored, calcareous fine sandy loams. The St. Paul soils are deep, dark grayish-brown, well-drained silt loams. The Dalhart soils are deep, well-drained, dark-brown fine sandy loams. Their subsoil consists of sandy clay loam. All of these soils formed in deposits of calcareous sandy loam to clay loam.

About 90 percent of the acreage is cultivated. The farms average about 800 acres in size. Wheat is the principal crop, but other small grains and grain sorghum are also grown. The soils are fertile, and yields are fair when the moisture supply is favorable. Stubble mulching, terracing, and contour farming are effective means of controlling wind and water erosion. The range vegetation consists mostly of buffalograss, little bluestem, grama grasses, and a scattering of sand sagebrush in the sandier areas.

11. Lincoln-Spur association

Sandy and loamy soils on bottom lands

This association is on the flood plains and terraces of Wolf Creek, the Canadian River, the North Canadian (Beaver) River, and their tributaries. The total area is 53,170 acres, or nearly 7 percent of the county. Lincoln and Spur soils are dominant. Minor areas of Bayard, Elsmere, Sweetwater, Wann, Yahola, and Zavala soils and Loamy alluvial land are included. Figure 2 shows the topographic position of the major soils in this association.

The Lincoln soils are calcareous, unmottled sands. They occur at the lowest elevations on the flood plains. The Sweetwater soils occur above the Lincoln soils at elevations of 2 to 6 feet. They have a gray surface layer and a subsoil of mottled, wet sand. Loamy alluvial land consists of fine sandy loam. It occurs along the tributaries of Wolf Creek. All of these soils formed in alluvium derived from the Ogallala formation. They are frequently flooded.

The Wann soils have a dark grayish-brown surface layer and a subsoil of mottled, wet fine sandy loam. They are on the terraces above the Sweetwater soils. The Elsmere soils are mottled, wet loamy fine sands. They occur on the nearly level areas between sand dunes. The Bayard soils generally occur along the lower tributaries of Wolf Creek. They are fine sandy loams. The Zavala soils occupy a small acreage in the southeastern part of the county. All of these soils formed in alluvium. They are rarely flooded.

The Spur and Yahola soils formed in alluvium derived from the Permian red beds. They occur mostly along the lower tributaries of the Canadian River and are subject to flooding. The Spur soils have a surface layer of reddish loam and a subsoil of clay loam. The Yahola soils are reddish fine sandy loams.

About 30 percent of this association is cultivated. Most of the cultivated areas consist of the Bayard, Elsmere, Spur, Wann, and Yahola soils. The Bayard, Spur, and Yahola soils produce good yields, but saline areas of the Elsmere and Wann soils are less productive. Wind erosion is a hazard, but it can be controlled by good management of crop residues.

The range vegetation consists mostly of indiagrass, switchgrass, little bluestem, and sand bluestem. Wet areas that have been heavily grazed have been invaded by undesirable grasses, such as saltgrass and alkali sacaton.

Descriptions of the Soils

In this section the soil series represented in Ellis County and the single soils mapped in the county are described.

The soils of each series are first described as a group. Important features common to all the soils of the series are described, and the position of the soils on the landscape is given. Comparisons are made with other soils that either are located nearby or are generally similar to the soils of the series being described. The series description ends with a general statement of how the soils of the series are used.

Following the description of each series are descriptions of the single soils, or mapping units, in the series. These are the areas delineated on the map and identified by soil symbols. Generally these descriptions tell how the profile of each soil differs from the profile described as representative of the series. They also tell about the use and suitability of the soil described and something about the management it needs.

General information about the broad patterns of soils in the county is given in the section "General Soil Map." A profile of a representative soil of each series is described in detail in the section "Genesis, Classification, and Morphology of the Soils." The "Guide to Mapping Units" at the back of the report lists the soils mapped in the county and the capability unit and range site in which each has been placed. The location and distribution of the individual soils are shown on the detailed map at the back of this report. The approximate acreage and proportionate extent of the soils are given in table 1. Technical terms used in the soil descriptions are defined in the Glossary.

Bayard Series

The Bayard series consists of dark-colored soils of the bottom lands. They occur in rarely flooded areas along the major streams in Ellis County.

The surface layer is dark grayish brown, friable, and about 12 inches thick. It commonly consists of fine sandy loam and has fine and medium, granular structure.

The subsoil consists of brown, weakly stratified fine sandy loam that has granular structure. It is calcareous and friable. Generally, the lower part is sandier than the upper part.

The substratum consists of pinkish-gray, calcareous alluvial material that is structureless and has the texture of loamy fine sand.

The surface layer ranges from 5 to 14 inches in thickness and is dark grayish brown or brown in color. Locally, it is loamy fine sand in texture. The subsoil ranges from a typical sandy loam to loam in texture and from grayish brown to light brown in color. The depth to the loamy fine sand is more than 20 inches and commonly more than 30 inches. The depth to lime ranges from 0 to 10 inches.

These soils are well drained, have moderately rapid permeability, are high in fertility, and have fair moisture-storage capacity. There is a slight hazard of wind erosion. The reaction is moderately alkaline.

The Bayard soils have a more sandy subsoil than the Spur soils and a more clayey subsoil than the Elsmere

TABLE 1.—Approximate acreage and proportionate extent of the soils

Map symbol	Soil	Acre	Per-cent	Map symbol	Soil	Acre	Per-cent
Ba	Bayard fine sandy loam.....	6, 878	0. 9	MfC	Miles fine sandy loam, 3 to 5 percent slopes.....	2, 260	0. 3
BeC	Berthoud fine sandy loam, 3 to 5 percent slopes.....	3, 609	. 5	NbC	Nobscot-Brownfield fine sands, hummocky.....	66, 613	8. 5
BeD	Berthoud fine sandy loam, 5 to 12 percent slopes.....	13, 038	1. 7	Nc3	Nobscot-Brownfield complex, severely eroded.....	2, 399	. 3
Bg	Blown-out land.....	524	. 1	NoE	Nobscot fine sand, rolling.....	41, 412	5. 2
Bk	Breaks-alluvial land complex.....	24, 032	3. 1	Om	Otero-Mansker complex.....	6, 784	. 9
Bn	Broken land.....	37, 666	4. 8	OtB	Otero soils, undulating.....	3, 032	. 4
BfB	Brownfield fine sand, 1 to 3 percent slopes.....	19, 160	2. 4	OtC	Otero soils, hummocky.....	5, 223	. 7
CaB	Carey silt loam, 1 to 3 percent slopes.....	2, 654	. 3	Pa	Potter soils.....	7, 063	. 9
Cp	Carwile-Pratt complex.....	6, 111	. 8	Pd	Potter-Berthoud complex.....	9, 695	1. 2
DaB	Dalhart fine sandy loam, 1 to 3 percent slopes.....	8, 556	1. 1	Pm3	Potter-Mansker complex, severely eroded.....	1, 024	. 1
DaC	Dalhart fine sandy loam, 3 to 5 percent slopes.....	4, 936	. 6	PbB	Pratt fine sandy loam, undulating.....	12, 316	1. 6
Ee	Elsmere loamy fine sand.....	3, 155	. 4	PbC	Pratt fine sandy loam, hummocky.....	6, 788	. 9
EnB	Enterprise very fine sandy loam, 1 to 3 percent slopes.....	4, 742	. 6	PfB	Pratt loamy fine sand, undulating.....	13, 512	1. 7
EnC	Enterprise very fine sandy loam, 3 to 5 percent slopes.....	4, 609	. 6	PfC	Pratt loamy fine sand, hummocky.....	30, 467	3. 9
EnD	Enterprise very fine sandy loam, 5 to 8 percent slopes.....	1, 917	. 2	Pt	Pratt-Tivoli loamy fine sands.....	30, 050	3. 8
EnE	Enterprise very fine sandy loam, 8 to 20 percent slopes.....	5, 866	. 8	QwE	Quinlan-Woodward loams, 8 to 20 percent slopes.....	19, 026	2. 4
Er	Eroded sandy land.....	4, 168	. 5	RcB	Richfield clay loam, 1 to 3 percent slopes.....	11, 719	1. 5
Gb	Gravelly broken land.....	2, 674	. 3	RcC	Richfield clay loam, 3 to 5 percent slopes.....	9, 434	1. 2
Lf	Likes loamy fine sand.....	27, 531	3. 5	Rb	Rough broken land.....	6, 892	. 9
Ln	Lincoln soils.....	14, 926	1. 9	SaA	St. Paul silt loam, 0 to 1 percent slopes.....	2, 717	. 4
La	Loamy alluvial land.....	11, 909	1. 5	SaB	St. Paul silt loam, 1 to 3 percent slopes.....	29, 426	3. 8
McB	Mansic clay loam, 1 to 3 percent slopes.....	14, 219	1. 8	Sp	Spur loam.....	4, 817	. 6
McC	Mansic clay loam, 3 to 5 percent slopes.....	39, 019	5. 0	Sw	Sweetwater soils.....	10, 269	1. 3
McD	Mansic clay loam, 5 to 8 percent slopes.....	7, 068	. 9	Th	Tipton silt loam, high.....	700	. 1
McD2	Mansic clay loam, 3 to 8 percent slopes, eroded.....	13, 210	1. 7	Tv	Tivoli fine sand.....	3, 238	. 4
MaB	Mansker loam, 1 to 3 percent slopes.....	6, 702	. 9	Vx	Vernon complex.....	5, 972	. 8
MaC	Mansker loam, 3 to 5 percent slopes.....	11, 218	1. 4	Wf	Wann fine sandy loam.....	2, 576	. 3
MpC	Mansker-Potter complex, 3 to 5 percent slopes.....	25, 003	3. 2	WoB	Woodward loam, 1 to 3 percent slopes.....	2, 285	. 3
MpE	Mansker-Potter complex, 5 to 20 percent slopes.....	43, 983	5. 6	WoC	Woodward loam, 3 to 5 percent slopes.....	7, 035	. 9
MrB	Manter-Otero fine sandy loams, 1 to 3 percent slopes.....	13, 239	1. 7	WwD2	Woodward-Quinlan loams, 3 to 8 percent slopes, eroded.....	3, 930	. 5
MrC	Manter-Otero fine sandy loams, 3 to 5 percent slopes.....	11, 426	1. 5	WwE	Woodward-Quinlan loams, 5 to 12 percent slopes.....	13, 778	1. 8
MfB	Miles fine sandy loam, 1 to 3 percent slopes.....	3, 885	. 5	Ya	Yahola fine sandy loam.....	1, 218	. 2
				Za	Zavala fine sandy loam.....	622	. 1
					Rivers and streams ¹	10, 155	1. 3
					Total.....	782, 080	100. 0

¹ Including Riverwash (Rw).

soils. They are better drained than the Wann soils. Both the Elsmere and the Wann soils are mottled in the subsoil.

Most of the acreage of Bayard soils is cultivated. Good yields of alfalfa, wheat, and sorghum are produced. The main native plants are tall and mid grasses.

Bayard fine sandy loam (Ba).—This soil occurs on nearly level, rarely flooded bottom lands. The slope range is 0 to 1 percent. The profile is like the one described for the series. Included in the areas mapped are areas of Wann fine sandy loam and of Spur loam. The inclusions total less than 10 percent of the acreage.

This soil has fair moisture-storage capacity and produces good yields. It is suited to wheat, barley, alfalfa, oats, sorghum, and cotton. When it is cultivated, the main problems are maintaining structure and providing protection against overflow and against a slight hazard of wind erosion. Minimum tillage, stubble mulching, and grow-

ing of high-residue crops help to conserve moisture, to prevent surface crusting, and to control erosion. (Capability unit IIw-1; Loamy Bottom Land range site)

Berthoud Series

The Berthoud series consists of grayish upland soils that are moderately sloping to moderately steep. They occur just below the caprock in the western part of Ellis County.

The surface layer is grayish-brown, very friable, and about 8 inches thick. It consists of calcareous fine sandy loam and has fine and medium, granular structure.

The subsoil is light brownish-gray fine sandy loam and has fine, granular structure. It is friable and strongly calcareous. It is more limy with increase in depth and has a visible zone of lime at a depth of about 26 inches.

The substratum consists of light brownish-gray, calcareous deposits derived from the Ogallala formation. It is granular, friable, and permeable.

The surface layer ranges from 6 to 12 inches in thickness, from fine sandy loam to loam in texture, and from dark grayish brown to pale brown in color. In places this layer is leached of lime to a depth of 6 inches. The subsoil is similar to the surface layer in texture. In some places the lime zone is lacking, and in some, loamy fine sand occurs below a depth of 24 inches. The subsoil and substratum range from light grayish brown to brown in color.

These soils are well drained, have moderately rapid permeability, are fair in natural fertility, and have fair moisture-storage capacity. When cultivated, they are subject to wind and water erosion.

The Berthoud soils have a more sandy subsoil than the Mansic soils. They have a thicker, less limy surface layer and a less definite lime zone than the Otero soils.

The moderately sloping Berthoud soils produce fair yields of wheat, sorghum, and other crops. The steeper ones support native vegetation, mostly mid and tall grasses.

Berthoud fine sandy loam, 3 to 5 percent slopes (BeC).—This soil generally occurs below the caliche caprock. Its profile is like the one described for the series. Surface runoff is medium. Included in the areas mapped are areas of Mansic clay loam, 3 to 5 percent slopes, and a small amount of Berthoud fine sandy loam, 5 to 12 percent slopes. The inclusions total less than 5 percent of the acreage.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to wheat, barley, sorghum, and oats. When it is cultivated, the main problems are maintaining fertility, maintaining the organic-matter content, and providing protection against a moderate hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, growing of high-residue crops, and contour stripcropping help to control erosion and to conserve moisture, plant nutrients, and organic matter. (Capability unit IVe-2; Sandy Plains range site)

Berthoud fine sandy loam, 5 to 12 percent slopes (BeD).—This is a strongly sloping soil that occurs below the caprock. Surface runoff is medium where the pasture stand is good and rapid where the pasture is poor or where cultivated crops are grown. The profile is similar to the one described for the series, but the texture generally grades to loamy fine sand below a depth of 24 inches. Included in the areas mapped are areas of Mansic clay loam, 5 to 8 percent slopes, totaling less than 5 percent of the acreage; a few eroded areas; and, where the slopes are steepest, areas of Otero loamy fine sand, totaling less than 5 percent of the acreage.

This soil is not suitable for cultivation, because the moisture-storage capacity is low and the hazard of water erosion is severe. For control of erosion, areas now in cultivation ought to be seeded to sand bluestem, little bluestem, and other native grasses. Areas now in native range need control of sagebrush, regulation of grazing, and reseeding of heavily grazed areas, all of which help to conserve moisture and to control erosion. (Capability unit VIe-5; Sandy Plains range site)

Blown-Out Land (Bg)

This land type occurs in the southeastern part of the county in association with the Brownfield and the Nobscot soils. It consists of nearly barren, severely eroded areas that support a very sparse cover of annual plants. Low dunes of loose sand surround scoured-out areas, and the soil material ranges in texture from sandy clay loam to loose sand. The areas are 10 to 160 acres in size. The slope range is 1 to 8 percent.

This land type is not suitable for cultivation, because the moisture-storage capacity is low and the hazard of wind erosion is severe. Erosion must be controlled before permanent vegetation can be established. Regulation of grazing and other good range practices are needed for control of erosion. (Capability unit VIIIe-1; no range site assigned)

Breaks-Alluvial Land Complex (Bk)

This complex occurs in small valleys cut into smoother uplands along the upper reaches of intermittent streams. It consists of strongly sloping to steep valley sides and small valley floors. The valleys are between 150 and 750 feet wide at the top and are 15 to 50 feet deep. The width of the valley floors is generally less than 150 feet and is most commonly between 20 and 80 feet. Runoff is rapid.

The soil material on the side slopes ranges from sandy loam to light clay loam, but generally it is deep, calcareous loam. The slope range is 5 to 12 percent. The soil material on the valley floors ranges from loamy sand to clay loam, but it is mostly calcareous sandy loam. The slope range is 0 to 1 percent.

Because the slopes are steep and the hazard of water erosion is severe, the soils of this complex are not suitable for cultivation. They are used as range. Sand bluestem, little bluestem, switchgrass, and indiagrass are the most abundant grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed. (Capability unit VIe-7; Loamy Prairie range site)

Broken Land (Bn)

Broken land occurs on steep or hilly areas along drainageways. Runoff is medium to rapid. The slope range is 12 to 30 percent.

The soils in this mapping unit are variable. The surface layer ranges from loamy sand to loam but most commonly is grayish-brown, calcareous sandy loam. The subsoil generally consists of calcareous sandy loam to loamy sand. It is stratified with layers of sand to clay loam. Very gravelly soils are common on knobs and ridges. Locally, the soils are shallow and the red beds outcrop in a few places.

Because the moisture-storage capacity is low and the hazard of water erosion is severe, the soils of this land type are not suitable for cultivation. They are used as range. If the range is in excellent condition, the main grasses are sand bluestem and little bluestem. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-5; Sandy Plains range site)

Brownfield Series

The Brownfield series consists of light-colored, gently sloping or undulating soils. They occur in the southeastern part of Ellis County.

The surface layer is dark grayish brown, very friable, and about 4 inches thick. It consists of noncalcareous fine sand and has weak, fine, granular structure. Below this is a subsurface layer of pink, single-grain fine sand about 15 inches thick. These layers are neutral in reaction.

The subsoil consists of reddish-yellow sandy clay loam that has prismatic structure. It is very hard when dry. The reaction is medium acid.

The substratum consists of strata of pink loamy fine sand and reddish-yellow fine sandy loam. It is hard when dry and friable when moist. The reaction is medium acid.

The combined thickness of the surface and subsurface layers ranges from 10 to 38 inches. In cultivated fields, the surface layer has a color intermediate between that of the surface layer and that of the subsurface layer. The subsoil ranges from 12 to 30 inches in thickness and from reddish yellow to reddish brown in color. The substratum varies slightly in texture, in color, and in the degree of stratification.

These soils are well drained, have moderate permeability, are low in natural fertility, and have fair moisture-storage capacity. There is a severe hazard of wind erosion.

The Brownfield soils have a more clayey subsoil than the Pratt and Nobscot soils. They have a thinner, more sandy surface layer than the Miles soils.

The Brownfield soils produce low yields of wheat. The main crop grown is sorghum. The native vegetation consists of shin oak and generally tall grasses. About half of the acreage is cultivated.

Brownfield fine sand, 1 to 3 percent slopes (BfB).—This is a gently sloping and undulating soil that occurs in the southeastern part of the county. Its profile is like the one described for the series. Runoff is slow. Included in the areas mapped are areas of Nobscot fine sand, rolling, totaling less than 10 percent of the acreage, and of Pratt loamy fine sand, hummocky, totaling less than 5 percent of the acreage.

This soil produces low yields, but it can be used to grow wheat, barley, oats, and sorghum. When it is cultivated, the main problems are maintaining fertility, maintaining the organic-matter content, and providing protection against a severe hazard of wind erosion. Minimum tillage, keeping the direction of the crop rows crossways to the wind, stubble mulching the small grain, and managing the residues from sorghum help to control erosion, to maintain fertility, and to supply organic matter. Most of the sandier knobs ought to be seeded to permanent vegetation. (Capability unit IVe-3; Deep Sand Savannah range site)

Carey Series

The Carey series consists of upland soils that are dark colored and gently sloping. They occur mostly in the northeastern part of Ellis County.

The surface layer is dark brown, friable, and about 11 inches thick. It consists of silt loam and has fine, granular structure and good tilth.

The subsoil is reddish-brown clay loam that has coarse, prismatic structure. It is friable and calcareous. It becomes more red in the lower part and has a layer of lime at a depth of about 40 inches.

The substratum consists of reddish-yellow loam and has coarse, prismatic structure. It is friable, permeable, red-bed material.

The surface layer ranges from 8 to 14 inches in thickness and from dark brown to dark grayish brown in color. The subsoil ranges from silt loam to clay loam in texture and from reddish brown to red or yellowish red in color. The depth to lime ranges from 14 to 40 inches. The lime layer is lacking in places.

The Carey soils are well drained, have moderate permeability, are high in natural fertility, and have good moisture-storage capacity. There is a slight hazard of wind and water erosion and a problem of surface crusting.

The Carey soils have a redder surface layer and a less clayey subsoil than the St. Paul soils and a more clayey profile than the Woodward soils.

Most of the acreage of the Carey soils is cultivated. Wheat and sorghum are the main crops grown. Yields are good. The range vegetation consists mainly of mid native grasses.

Carey silt loam, 1 to 3 percent slopes (CaB).—This soil is on gentle convex slopes on the uplands, mostly in the northeastern part of Ellis County. Its profile is like the one described for the series. Included in the areas mapped are areas of Woodward loam, 1 to 3 percent slopes, totaling less than 10 percent of the acreage, and areas of St. Paul silt loam, 1 to 3 percent slopes, totaling less than 5 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to wheat, sorghum, oats, and barley. The main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind and water erosion. Minimum tillage, terracing, contour farming, and stubble mulching help to conserve moisture and to control erosion. (Capability unit IIe-1; Loamy Prairie range site)

Carwile Series

The Carwile series consists of dark-colored upland soils. They are in depressions between low sand dunes in the central part of Ellis County.

The surface layer is dark grayish brown, friable, and about 6 inches thick. It consists of sandy clay loam and has moderate, coarse, granular structure. The reaction is medium acid.

The subsoil is more clayey than the surface layer. It consists of light yellowish-brown, firm sandy clay loam mottled with reddish yellow. It has prismatic structure that breaks to coarse, subangular blocky. The reaction is slightly acid.

The substratum consists of light-gray, massive fine sandy loam alluvium. It is friable, faintly mottled, and slightly calcareous.

The surface layer ranges from 6 to 14 inches in thickness, from clay loam to loamy fine sand in texture, and from dark grayish brown to gray and brown in color. The subsoil ranges from sandy clay loam to sandy clay in texture and from light yellowish brown to grayish

brown and light olive brown in color. The mottles vary in abundance, size, and color. The depth to lime is generally more than 30 inches.

Carwile soils are imperfectly drained, have slow permeability, are fair in fertility, and have good moisture-storage capacity. They are subject to wind erosion. The main problems are removing excess water and maintaining structure.

The Carwile soils are more poorly drained than the Pratt and Miles soils and have a mottled, finer textured subsoil.

The Carwile soils produce fair yields of wheat and sorghum. The native vegetation consists mostly of tall and mid grasses.

Carwile-Pratt complex (Cp).—This complex occurs on uplands. Low sand dunes, depressions, and potholes are common features. The slope range is 1 to 5 percent. Surface runoff is slow, and water is ponded in the potholes about a third of the time. The profiles of the Carwile and Pratt soils are like the ones described for the Carwile and Pratt series.

The Pratt soil occupies 30 to 50 percent of this complex. It occurs on low sand dunes. The Carwile soil, occupying the remaining acreage, occurs on gentle slopes in the depressions. Potholes occupy less than 10 percent of the complex.

The soils in this complex produce fair yields. Small grain and sorghum are the main crops. The problems are maintaining structure and fertility, removing excess water from the depressions, and providing protection against a moderate hazard of wind erosion on the Pratt soils. Drainage, minimum tillage, stripcropping, stubble mulching, and growing of high-residue crops help to overcome most of the problems. (Capability unit IIIw-1; Sandy Plains range site)

Dalhart Series

The Dalhart series consists of upland soils that are deep, dark colored, and gently sloping to moderately sloping. They occur in the central part of Ellis County.

The surface layer is dark brown, very friable, and about 11 inches thick. It consists of fine sandy loam and has moderate, fine, granular structure and fair tilth. Lime has been leached from this layer.

The subsoil contains more clay than the surface layer. It consists of brown sandy clay loam and has weak, coarse, prismatic structure. This layer is calcareous below a depth of 24 inches and has a zone of visible lime at a depth of about 36 inches.

The substratum consists of old alluvium of fine sandy loam texture. It is friable, limy, and permeable.

The surface layer ranges from 6 to 15 inches in thickness and from dark grayish brown to dark brown in color. In a few places it is loamy fine sand in texture. The subsoil ranges from fine sandy loam to sandy clay loam in texture and from brown to light brown in color. The depth to the lime zone ranges from 15 to 45 inches. The substratum includes thin strata of sand, loamy fine sand, and clay loam.

These soils are well drained, have moderate permeability, are medium in fertility, and have fair moisture-storage capacity. There is a moderate hazard of wind erosion.

The Dalhart soils are limy and are less red than the Miles

soils. They have a finer textured subsoil than the Pratt soils and a more sandy subsoil than the St. Paul soils.

Most of the acreage of the Dalhart soils is cultivated. Yields of wheat and sorghum are good. The smoother slopes can be irrigated successfully.

Dalhart fine sandy loam, 1 to 3 percent slopes (DcB).—This is a gently sloping soil on uplands in the central part of the county. The profile is like the one described for the series. Runoff is slow. Included in the areas mapped are areas of St. Paul silt loam, 1 to 3 percent slopes, totaling less than 7 percent of the acreage, and areas of Manter-Otero fine sandy loams, 1 to 3 percent slopes, totaling less than 8 percent of the acreage.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to wheat, oats, barley, and sorghum. When it is cultivated, the principal problems are preventing surface crusting, maintaining the organic-matter content, and providing protection against a moderate hazard of wind erosion and a slight hazard of water erosion. Minimum tillage, terracing, stubble mulching, and growing high-residue crops help to overcome the problems. (Capability unit IIIe-2; Sandy Plains range site)

Dalhart fine sandy loam, 3 to 5 percent slopes (DcC).—This soil occurs on moderately sloping uplands. Runoff is medium. The profile is similar to the one described for the series, but the surface layer is about 2 inches thinner, the subsoil is less clayey, and the depth to lime ranges from about 16 to 30 inches. Included in the areas mapped are small eroded areas; areas of Manter-Otero fine sandy loams, 3 to 5 percent slopes, totaling less than 10 percent of the acreage; and areas of Mansic clay loam, 3 to 5 percent slopes, totaling less than 5 percent of the acreage.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to sorghum, wheat, oats, and barley. When it is cultivated, the main problems are maintaining fertility, supplying organic matter, and providing protection against a moderate hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, and growing of high-residue crops help to overcome the problems. Most of the acreage is cultivated. (Capability unit IVe-2; Sandy Plains range site)

Elsmere Series

The Elsmere series consists of light-colored soils of the bottom lands. They occur along the major streams adjacent to sandy dunes, but they are rarely flooded.

The surface layer is gray, very friable, and about 12 inches thick. It consists of calcareous loamy fine sand and has weak, very fine, granular structure.

The subsoil consists of pale-brown, single-grain loamy fine sand. It is very friable and calcareous. The lower part is mottled.

The substratum consists of pale-brown, calcareous fine sandy loam and loamy fine sand and is mottled with brown.

The surface layer ranges from 8 to 20 inches in thickness and from gray to very dark gray and grayish brown in color. The color of the subsoil and of the substratum ranges from grayish brown to very pale brown. The depth to the water table fluctuates seasonally between 3 and 8 feet. In some places these soils are saline.

These soils are imperfectly drained and have rapid permeability. There is a severe hazard of wind erosion. The

main management problems are maintaining structure and fertility. Drainage, where feasible, reduces the salinity of these soils.

The Elsmere soils are better drained and have a less sandy subsoil than the Sweetwater soils. They have a more sandy profile than the Wann soils. They are less well drained than the Lincoln soils, which are not mottled, and have a finer textured profile.

The Elsmere soils are best suited to tall and mid grasses. A small acreage is cultivated.

Elsmere loamy fine sand (Ee).—This soil occurs on nearly level, rarely flooded bottom lands. The profile is like the one described for the series. The slope range is 0 to 1 percent. Included in the areas mapped are areas of Wann fine sandy loam and of Sweetwater soils. The inclusions total less than 10 percent of the acreage.

This soil is best suited to grass, but in dry years it can be planted to small grain or sorghum. When it is cultivated, the main problems are maintaining structure and fertility, reducing salinity, and providing protection against a severe hazard of wind erosion. Minimum tillage, stubble mulching, growing of high-residue crops, and removal of excess water help to overcome the problems. Because of salinity and a high water table, only a small acreage is cultivated. (Capability unit IVw-1; Subirrigated range site)

Enterprise Series

The Enterprise series consists of upland soils that are deep, dark colored, and gently sloping to steep. They are adjacent to the Canadian River.

The surface layer is brown, friable, and about 9 inches thick. It consists of calcareous very fine sandy loam and has weak, fine, granular structure.

The subsoil consists of brown, calcareous very fine sandy loam and has moderate, fine and medium, granular structure. It is hard when dry and friable when moist.

The substratum consists of brown loess of very fine sandy loam texture and weak, fine, granular structure. It is hard when dry and friable when moist. Threadlike films of lime occur below a depth of 35 inches.

The surface layer ranges from 7 to 14 inches in thickness and from brown to grayish brown in color. This layer generally is calcareous, but in places it is leached of lime to a depth of 10 inches. The color of the subsoil and substratum ranges from brown to reddish brown.

These soils are well drained, have moderate permeability, are high in natural fertility, and have good moisture-storage capacity. There is a slight hazard of wind erosion, a slight to moderate hazard of water erosion, and a problem of preventing surface crusting after heavy rains.

The Enterprise soils have a thinner and less dark-colored surface layer than the Tipton soils, and they are more sandy. The depth to lime is less than in the Tipton soils.

The gently sloping and moderately sloping Enterprise soils produce good to fair yields of wheat and sorghum. On the steeper slopes the native vegetation consists mostly of mid grasses.

Enterprise very fine sandy loam, 1 to 3 percent slopes (EnB).—This soil is on gently sloping uplands adjacent to the Canadian River. Runoff is slow. The surface layer is slightly thicker and the lime is leached to a slightly greater depth than in the profile described as typical of

the series. Included in the areas mapped are areas of Tipton silt loam, high, totaling less than 5 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to wheat, barley, oats, and sorghum. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, contour farming, and growing of high-residue crops help to overcome these problems. Most of the acreage is cultivated. (Capability unit IIe-1; Loamy Prairie range site)

Enterprise very fine sandy loam, 3 to 5 percent slopes (EnC).—This soil occurs on moderately sloping uplands near the Canadian River. Runoff is medium. The profile is like the one described for the series.

This soil has good moisture-storage capacity and produces fair yields. It is suited to small grain and sorghum. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion. Minimum tillage, terracing, stubble mulching, and growing of high-residue crops help to solve these problems. About half of the acreage is cultivated. (Capability unit IIIe-1; Loamy Prairie range site)

Enterprise very fine sandy loam, 5 to 8 percent slopes (EnD).—This soil occurs on strongly sloping uplands near the Canadian River. Runoff is medium in pastured areas and rapid in cultivated areas. The profile is like the one described for the series. Included in the areas mapped are small eroded areas and also areas of Woodward-Quinlan loams, 5 to 12 percent slopes, totaling about 5 percent of the acreage.

This soil has good moisture-storage capacity and produces fair yields. It is suited to wheat, oats, barley, and sorghum. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion. Minimum tillage, terracing, stubble mulching, growing of high-residue crops, and contour stripcropping help to control erosion and to maintain yields. About a third of the acreage is cultivated. (Capability unit IVe-4; Loamy Prairie range site)

Enterprise very fine sandy loam, 8 to 20 percent slopes (EnE).—This soil occurs on moderately steep to steep uplands near the Canadian River. Runoff is rapid. Except for a slightly thinner surface layer, the profile is similar to the one described for the series. Included in the areas mapped are areas of Likes loamy fine sand, of Broken land, and of Quinlan-Woodward loams, 8 to 20 percent slopes. The inclusions total less than 10 percent of the acreage.

This soil is not suitable for cultivation, because of the slope and a severe hazard of water erosion. It is used for range. Sand bluestem, little bluestem, switchgrass, and indiangrass are the most abundant grasses if the range is in excellent condition. Production of range grasses can be maintained by reseeding, regulation of grazing, and other good range management practices. (Capability unit VIIe-7; Loamy Prairie range site)

Eroded Sandy Land (Er)

Eroded sandy land is made up of severely eroded Otero and Berthoud soils; severely eroded Mansic soils, totaling 10 to 15 percent of the acreage; and minor areas of less eroded soils. All of these soils are deep and light colored. The slope range is 5 to 12 percent. The texture of the surface layer and the subsoil ranges from loamy sand to clay loam, but generally it is fine sandy loam. Rills and gullies are common. The gullies are from 1 to 4 feet deep and from 20 to 100 feet apart.

This land type is not suited to cultivated crops, because of the severe hazard of wind and water erosion. It is used as range. Little bluestem, sand bluestem, indiagrass, and switchgrass are the main grasses if the range is in excellent condition. The gullies should be filled and seeded to grass. Overseeding and regulation of grazing help to control erosion in the rest of the area. (Capability unit VIe-8; Eroded Sandy Land range site)

Gravelly Broken Land (Gb)

Gravelly broken land occurs on moderately steep slopes, steep slopes, and broken slopes. The slope range is 8 to 20 percent. The soil material is varied in texture; the surface layer is predominantly gravelly loamy sand, but it ranges to gravelly loam. The subsoil generally is very gravelly. About 10 to 20 percent of the mapping unit is made up of a soil that has a subsoil of loam and loamy sand that is less than 10 percent gravel. Gravel outcrops make up 5 to 20 percent of the acreage.

Because of droughtiness, steep slopes, and the severe hazard of water erosion, this land type is not suitable for cultivation. It is used as range. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIIe-2; Gravelly Sandy range site)

Likes Series

The Likes series consists of light-colored upland soils that are undulating or hummocky. They are adjacent to the large streams in Ellis County.

The surface layer is grayish brown, very friable, and about 5 inches thick. It consists of loamy fine sand and has weak, fine, granular structure. The reaction is neutral.

The subsoil consists of pale-brown loamy fine sand and has weak, fine, granular structure. It is loose when dry and very friable when moist. The reaction is neutral.

The substratum consists of light yellowish-brown, loose, single-grain, eolian sand. It is strongly calcareous.

The surface layer ranges from 4 to 7 inches in thickness and from dark grayish brown to pale brown in color. The subsoil and the substratum range from sand to loamy fine sand in texture and from light yellowish brown to light brownish gray and very pale brown in color. In some places there is a weak zone of lime. The depth to lime ranges from 0 to 20 inches.

These soils are somewhat excessively drained, have rapid permeability, are fair in natural fertility, and have low moisture-storage capacity. When they are cultivated, there is a severe hazard of wind erosion.

The Likes soils have a less limy surface layer, a more sandy subsoil, and a less distinct lime zone than the Otero soils. They have a coarser textured subsoil than the Pratt soils and are slightly less deep to calcareous material.

The Likes soils are not suitable for cultivation, because of the severe hazard of wind erosion. The native vegetation consists mostly of tall and mid grasses.

Likes loamy fine sand (lf).—This soil occurs in undulating and hummocky areas adjacent to the large streams. Runoff is very slow. The profile is like the one described for the series. The slope range is 1 to 8 percent. Included in the areas mapped are areas of Pratt loamy fine sand and of Otero soils. The inclusions total less than 10 percent of the acreage.

This soil is not suited to cultivation, because the moisture-storage capacity is low and the hazard of wind erosion is severe. It is used as range. Sand bluestem, little bluestem, indiagrass, and switchgrass are the main grasses if the range is in excellent condition. Reseeding and regulation of grazing are needed for control of erosion. (Capability unit VIe-3; Deep Sand range site)

Lincoln Series

The Lincoln series consists of light-colored soils of the bottom lands. They occur along major streams and are frequently flooded.

The surface layer is grayish brown, friable, and about 7 inches thick. It consists of calcareous loamy fine sand and has weak, very fine, granular structure.

The subsoil is light brownish-gray, single-grained fine sand. It is friable and calcareous.

The substratum consists of light-gray, loose, single-grained alluvial fine sand. It is calcareous and permeable.

The surface layer ranges from 3 to 7 inches in thickness, from sand to silt loam in texture, and from grayish brown to pale brown in color. Both the subsoil and the substratum contain thin strata of more clayey material and are light brownish gray to very pale brown in color.

These soils are excessively drained, very rapidly permeable, and low in moisture-storage capacity. There is a severe hazard of water erosion.

The Lincoln soils are unmottled and are better drained than the Sweetwater and Elsmere soils. They have a slightly coarser textured subsoil than the Elsmere soils.

The Lincoln soils are not suitable for cultivation, because they are subject to both water and wind erosion and are frequently flooded. They are used for pasture. They produce a large amount of tall and mid grasses and scattered trees and brush.

Lincoln soils (ln).—These soils occur on nearly level flood plains of the major streams and are frequently flooded. The slope range is 0 to 1 percent. The profile is like the one described for the series. Included in the areas mapped are areas of Sweetwater soils in depressions, totaling less than 10 percent of the acreage.

Because of frequent flooding and the severe hazard of wind and water erosion, these soils are not suitable for cultivation. They are used for range. Sand bluestem, little bluestem, switchgrass, and indiagrass are the main grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed for control of erosion and conservation of moisture. (Capability unit VIe-1; Sandy Bottom Land range site)

Loamy Alluvial Land (La)

Loamy alluvial land occurs along intermittent streams throughout Ellis County. It is on flood plains that are 150 to 500 feet wide and from an eighth of a mile to several miles long. It is frequently flooded. The broad flood plains are dissected by meandering channels 4 to 12 feet deep. The slope range is 0 to 1 percent.

The soil material is stratified. It ranges from fine sandy loam to clay loam in texture and from dark grayish brown to reddish brown in color. It is well drained, unmottled, and calcareous. The uppermost 6 to 24 inches generally consists of recently deposited light-colored sandy loam.

Except for a few areas that are protected against flooding, this land type is not suitable for cultivation. It is used as range. Some areas need to be reseeded to sand bluestem, little bluestem, indiagrass, and switchgrass. Regulation of grazing is needed for control of erosion. (Capability unit Vw-2; Loamy Bottom Land range site)

Mansic Series

The Mansic series consists of deep, dark-colored, gently sloping to strongly sloping upland soils. They occur in the central and northern parts of Ellis County.

The surface layer is dark grayish brown, friable, and about 13 inches thick. It consists of calcareous clay loam and has fine, granular structure.

The color of the upper part of the subsoil is intermediate between that of the surface layer and that of the lower part of the subsoil. The lower part of the subsoil consists of brown clay loam and has coarse, prismatic structure. This layer is friable and has a visible layer of lime at a depth of about 38 inches.

The substratum consists of calcareous clay loam material derived from the Ogallala formation. It is friable and permeable.

The surface layer ranges from 7 to 15 inches in thickness and from clay loam to loam in texture. In eroded areas the color is grayish brown. The subsoil ranges from brown to light brownish gray and light brown in color. The upper part of the subsoil is 4 to 7 inches thick. The depth to the lime layer ranges from 30 to 60 inches.

A profile of Mansic clay loam is shown in figure 5.

The Mansic soils are well drained, have moderate permeability, are high in natural fertility, and have good moisture-storage capacity. There is a slight hazard of wind erosion and a slight to moderate hazard of water erosion.

The Mansic soils are limy and have a slightly coarser textured subsoil than the Richfield and St. Paul soils. They have a finer textured subsoil than the Berthoud soils.

Most of the acreage is cultivated. Wheat is commonly grown. The smoother slopes can be irrigated. The native vegetation consists mostly of mid and short grasses.

Mansic clay loam, 1 to 3 percent slopes (McB).—This soil occurs on gently sloping uplands. The profile is similar to the one described for the series, but generally this soil is leached of lime to a depth of 4 to 7 inches. Runoff is slow. Included in the areas mapped are areas of Richfield clay loam, 1 to 3 percent slopes, totaling less than 3 percent of the acreage; areas of St. Paul silt loam, 1 to 3 percent slopes, totaling less than 10 percent of the acreage; and minor areas of Mansker loam, 1 to 3 percent slopes.

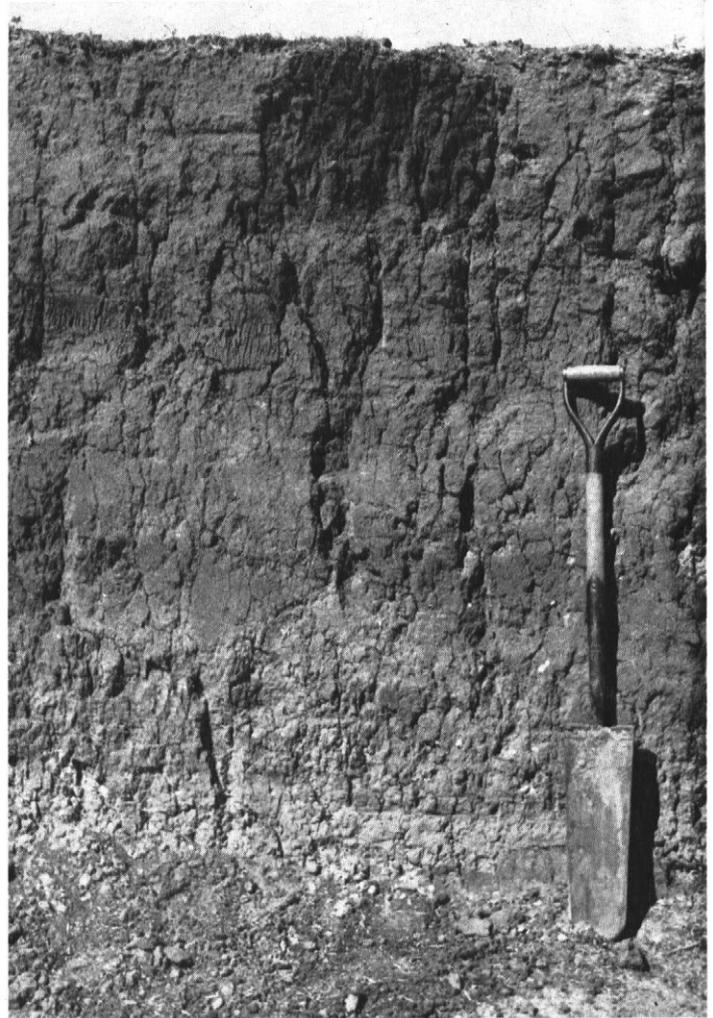


Figure 5.—Profile of Mansic clay loam. The surface layer is about 12 inches thick; the subsoil is clay loam of prismatic structure; a lime zone is at a depth of 4 feet.

This soil has good moisture-storage capacity and produces good yields. It is suited to wheat, sorghum, oats, and barley. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, growing of high-residue crops, and contour stripcropping help to conserve moisture and to control erosion. Most of the acreage is cultivated. (Capability unit IIe-1; Loamy Prairie range site)

Mansic clay loam, 3 to 5 percent slopes (McC).—This soil occurs on moderately sloping uplands. The profile is like the one described for the series. Runoff is medium. Included in the areas mapped are small eroded areas; areas of Richfield clay loam, 3 to 5 percent slopes, totaling less than 5 percent of the acreage; areas of Mansker loam, 3 to 5 percent slopes, totaling less than 5 percent of the acreage; and areas of Berthoud fine sandy loam, 3 to 5 percent slopes, totaling less than 2 percent of the acreage.

This soil has good moisture-storage capacity and produces fair yields. It is suited to small grain and sorghum.

When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion. Minimum tillage, stubble mulching, and contour stripcropping help to conserve moisture and to control erosion. Most of the acreage is cultivated. (Capability unit IIIe-1; Loamy Prairie range site)

Mansic clay loam, 5 to 8 percent slopes (McD).—This soil is on strongly sloping uplands. The profile is similar to the one described for the series, but its surface layer is thinner. Runoff is medium. Included in the areas mapped are small eroded areas; areas of Berthoud fine sandy loam, 5 to 12 percent slopes, totaling less than 5 percent of the acreage; and areas of Mansker loam, totaling less than 5 percent of the acreage.

This soil has good moisture-storage capacity and produces fair yields. It is used mainly for sorghum and small grain. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a moderate hazard of water erosion and a slight hazard of wind erosion. Minimum tillage, terracing, stubble mulching, and stripcropping help to control erosion and to conserve moisture. To help control erosion, many areas are now kept in grass. About half the acreage is cultivated. (Capability unit IVe-4; Loamy Prairie range site)

Mansic clay loam, 3 to 8 percent slopes, eroded (McD2).—This is a moderately eroded, moderately sloping to strongly sloping soil on uplands. Runoff is rapid. About 30 percent of this soil has a surface layer that is thinner than that described for the series and is lighter and browner in color. Rills 4 to 12 inches deep and 1 to 4 feet wide have formed about 10 to 80 feet apart. Some rills are deep enough that the subsoil is exposed. Included in the areas mapped are areas of Mansker loam, totaling less than 5 percent of the acreage.

This soil has good moisture-storage capacity and produces fair yields. The main crops are small grain and sorghum. The major problems are providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion, preventing surface crusting, and maintaining water intake. Minimum tillage, terracing, stubble mulching, and rotations that include grass help to conserve moisture and to control erosion. About a third of the acreage is cultivated. (Capability unit IVe-4; Loamy Prairie range site)

Mansker Series

The Mansker series consists of grayish upland soils that are gently sloping to steep. They occur in the central and northern parts of Ellis County.

The surface layer is grayish brown, friable, and about 11 inches thick. It consists of calcareous loam and has moderate, fine, granular structure.

The subsoil is light brownish-gray loam and has fine, granular structure. It is friable and calcareous. It is more limy with increase in depth, and small caliche rocks are common.

The substratum consists of pink, moderately to strongly consolidated, limy clay loam. It is generally permeable to water and to plant roots.

The surface layer ranges from 6 to 14 inches in thickness and from dark grayish brown to grayish brown in color. The color of the subsoil ranges from grayish brown to very pale brown and to pink. The depth to the caliche ranges from 10 to 20 inches.

A profile of Mansker loam is shown in figure 6.

These soils are well drained, have moderate permeability, are fair in fertility, and have fair moisture-storage capacity. There is a slight to moderate hazard of both wind and water erosion.

The Mansker soils are sandier than the Mansic soils. The depth to the lime layer is less than in the Mansic soils and greater than in the Potter soils.

Most of the gently sloping and moderately sloping areas of Mansker soils are under cultivation. Wheat is the principal crop. Yields of sorghum are fair. The native vegetation consists mainly of short and mid grasses.

Mansker loam, 1 to 3 percent slopes (McB).—This soil occurs on gently sloping uplands. The profile is like the one described for the series. Runoff is medium. Included in the areas mapped are areas of Potter soils, totaling less than 5 percent of the acreage, and areas of Mansic clay loam, 1 to 3 percent slopes, totaling less than 5 percent of the acreage.

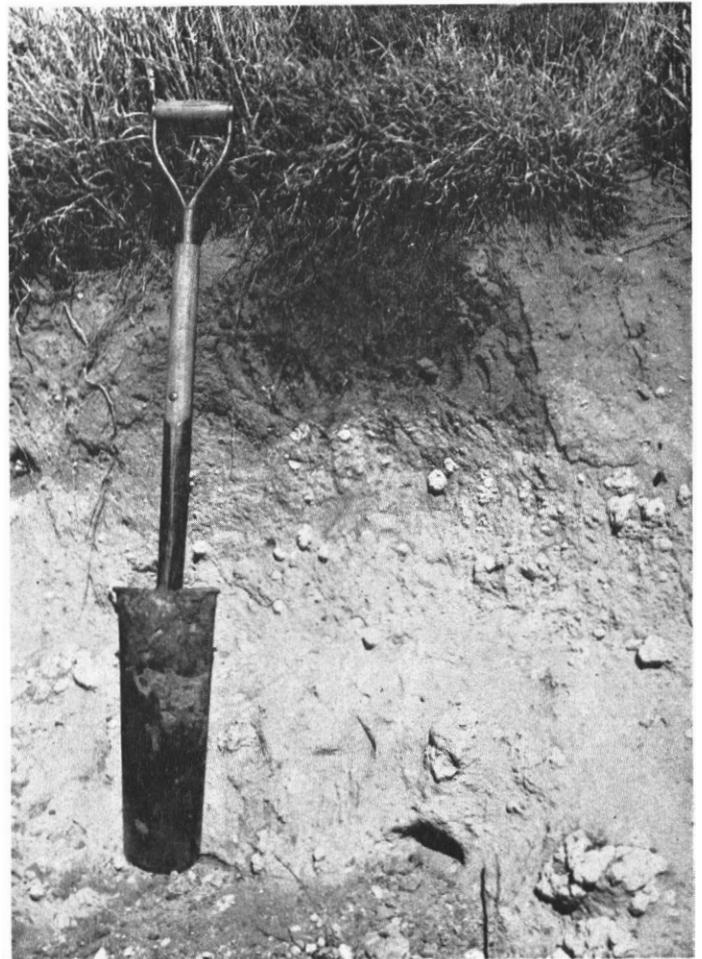


Figure 6.—Profile of Mansker loam. The surface layer is about 11 inches thick; a zone of lime is at a depth of 16 inches.

This soil has fair moisture-storage capacity and produces fair yields. Small grain is grown more often than grain sorghum. The main problems are preventing surface crusting, maintaining structure, and providing protection against a moderate hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, and growing of high-residue crops are practices that help to control erosion and to conserve moisture. Most of the acreage is farmed. (Capability unit IIIe-3; Loamy Plains range site).

Mansker loam, 3 to 5 percent slopes (MaC).—This soil occurs on moderately sloping uplands. The profile is similar to the one described for the series, but the depth to the lime layer generally is less. Runoff is medium. Included in the areas mapped are areas of Potter soils and areas of Mansic clay loam, 3 to 5 percent slopes. The inclusions total less than 10 percent of the acreage.

This soil has fair moisture-storage capacity and is productive. It is used mostly for small grain but can be used for grain sorghum. When it is cultivated, the main problems are maintaining structure and providing protection against a moderate hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, and contour stripcropping help to conserve moisture and to control erosion. About half the acreage is cultivated. (Capability unit IVe-1; Loamy Plains range site)

Mansker-Potter complex, 3 to 5 percent slopes (MpC).—This complex occurs on knobs, ridges, and gentle and moderate slopes. About 30 percent of the acreage is gently sloping. Generally, any given area is about 15 to 30 percent Potter soils, but some areas are about 40 percent Potter soils.

The Potter soils of this complex occur mostly on the knobs and ridges. The Mansker soils occupy the smoother slopes. Soils of this complex have profiles like the ones described for the Mansker and Potter series, but in a few areas where they are associated with sandier soils, their surface layer is fine sandy loam. Runoff is medium. There is a moderate hazard of wind and water erosion. Included in the areas mapped are areas of Likes loamy fine sand, totaling less than 5 percent of the acreage.

The soils of this complex are fair in fertility, have fair moisture-storage capacity, and produce fair yields of small grain. Sorghum yields are poor because iron deficiency causes chlorosis and reduces yields. The main limitations are the high lime content of the surface layer, shallowness to caliche, and a moderate hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, and growing of high-residue crops help to conserve moisture and to control erosion. About a third of the acreage is cultivated. (Mansker soil: capability unit IVe-5; Loamy Plains range site. Potter soil: capability unit IVe-5; Shallow range site)

Mansker-Potter complex, 5 to 20 percent slopes (MpE).—This complex occurs on strongly sloping to steep or rolling uplands. It is about 20 to 40 percent Potter soils.

The Potter soils occupy the knobs and crests of the ridges. The Mansker soils generally occur below the Potter soils on the strong to steep slopes. These soils have profiles like those described for the Mansker and Potter series. In some areas where they are associated with sandier soils, the surface layer is fine sandy loam. Runoff

is rapid. Included in the areas mapped are areas of Likes loamy fine sand, totaling less than 5 percent of the acreage, and areas of Mansic clay loam, 5 to 8 percent slopes, totaling less than 7 percent of the acreage.

The soils of this complex are not suitable for cultivation, because of the severe hazard of water erosion, the depth to the lime layer, and the steepness of the slope. They are used for range. Regulation of grazing and other good management practices are needed for control of erosion. (Mansker soil: capability unit VIe-10; Loamy Plains range site. Potter soil: capability unit VIe-10; Shallow range site)

Manter Series

The Manter series consists of upland soils that are deep and dark colored. They occur on gentle to moderate slopes in the central part of Ellis County.

The surface layer is dark grayish brown, very friable, and about 14 inches thick. It consists of fine sandy loam and has weak, fine, granular structure. Lime has been leached from this layer.

The color of the upper part of the subsoil is intermediate between that of the surface layer and that of the lower part of the subsoil. The lower part of the subsoil is brown fine sandy loam and has weak, coarse, prismatic structure. It is friable and calcareous.

The substratum consists of alluvium of fine sandy loam texture with thin strata of finer textured and coarser textured material. It is very friable and permeable.

The surface layer is 6 to 16 inches thick, and the upper part of the subsoil is about 8 to 14 inches thick. The lower part of the subsoil ranges from brown to very pale brown and pinkish gray in color. The texture of the uppermost 30 inches of the profile generally is fine sandy loam, but it ranges to loam. The depth to lime ranges from 10 to 30 inches.

These soils are well drained, have moderately rapid permeability, are fair in fertility, and have fair moisture-storage capacity. There is a moderate hazard of wind erosion.

The Manter soils have a coarser textured subsoil than the Dalhart soils. They have a thicker, darker colored surface layer than the Otero soils and are leached of lime to a greater depth. The depth to lime is less in the Manter soils than in the Pratt soils.

Most of the acreage of Manter soils is cultivated. Yields of all crops commonly grown in the county are fair. The smoother slopes can be irrigated.

Manter-Otero fine sandy loams, 1 to 3 percent slopes (MrB).—These soils are on gently sloping or somewhat undulating uplands. They have profiles like those described for the Manter and Otero series. Runoff is slow to medium. About 40 to 60 percent of this mapping unit is Manter soil, and about 15 to 25 percent is Otero soil. The rest of the acreage consists of soils having characteristics intermediate between those of the Manter soil and those of the Otero soil. Included in the areas mapped are areas of Dalhart fine sandy loam, 1 to 3 percent slopes, totaling less than 10 percent of the acreage, and areas of soils with strata of loam and clay loam at a depth of less than 36 inches, totaling less than 3 percent of the acreage.

These soils are fair in fertility and have fair moisture-storage capacity. They are suited to grain sorghum and

small grain. When they are cultivated, the main problems are preventing surface crusting, maintaining organic-matter content, and providing protection against a moderate hazard of water erosion. Minimum tillage, terracing to break long slopes and to divert overhead water, stubble mulching, and growing of high-residue crops help to conserve moisture and to control erosion. Most of the acreage is cultivated. (Capability unit IIIe-2; Sandy Plains range site)

Manter-Otero fine sandy loams, 3 to 5 percent slopes (MfC).—These soils occur on moderately sloping uplands. They have profiles like those described for the Manter and Otero series. Runoff is medium. The Manter soil occupies 40 to 60 percent of the acreage, and the Otero soil about 20 to 35 percent. About 10 to 20 percent of the acreage consists of soils having characteristics intermediate between those of the Manter soil and those of the Otero soil. Included in the areas mapped are small eroded areas; areas of Dalhart fine sandy loam, 3 to 5 percent slopes, totaling less than 7 percent of the acreage; and areas of soils that resemble the Manter soils but have strata of clay loam in the uppermost 36 inches.

These soils have fair moisture-storage capacity and are fair in fertility. They are suited to grain sorghum, wheat, barley, and oats. When they are cultivated, the main problems are maintaining fertility, supplying organic matter, and providing protection against a moderate hazard of wind and water erosion. Minimum tillage, terracing to break long slopes, stubble mulching, and growing of high-residue crops are practices that help to overcome these problems. About two-thirds of the acreage is cultivated. (Capability unit IVE-2; Sandy Plains range site)

Miles Series

The Miles series consists of dark-colored upland soils that are gently sloping or moderately sloping. They occur in the southeastern part of Ellis County.

The surface soil is dark brown, friable, and about 8 inches thick. It consists of fine sandy loam and has moderate, fine and medium, granular structure. This layer is slightly acid.

The subsoil is more clayey than the surface layer. It consists of reddish-brown sandy clay loam and has coarse, prismatic structure. It is firm when moist. The reaction is medium acid.

The substratum consists of reddish-brown loamy fine sand and fine sand. It is medium acid.

The surface layer ranges from 5 to 12 inches in thickness and from fine sandy loam to loamy fine sand in texture. It is dark brown or grayish brown in color. The subsoil ranges from 12 to 30 inches in thickness and from reddish brown to light red in color. In most places it has prismatic structure, but in some places it has weak, subangular blocky structure. The substratum varies slightly in texture and color.

These soils are well drained, have moderate permeability, are medium in fertility, and have fair moisture-storage capacity. There is a moderate hazard of both wind and water erosion.

The Miles soils have a thicker, finer textured surface layer than the Brownfield soils. They have a redder, more clayey subsoil than the Pratt soils and a redder

subsoil than the Dalhart soils. They lack the layer of lime that is characteristic of the Dalhart soils.

The gently sloping Miles soils are generally cultivated. Yields of wheat and sorghum are fair. The native vegetation consists mostly of tall and mid grasses.

Miles fine sandy loam, 1 to 3 percent slopes (MfB).—This soil occurs on gently sloping uplands. The profile is like the one described for the series. In a few places the surface layer is loamy fine sand. Runoff is slow. Included in the areas mapped are areas of Brownfield fine sand, 1 to 3 percent slopes, totaling less than 7 percent of the acreage.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to grain sorghum and small grain. When it is cultivated, the main problems are preventing surface crusting, maintaining the organic-matter content, and providing protection against a moderate hazard of wind erosion and a slight hazard of water erosion. Minimum tillage, terracing to break long slopes, stubble mulching, growing of high-residue crops, and contour stripcropping are practices that help to conserve moisture and to control erosion. Most of the acreage is cultivated. (Capability unit IIIe-2; Sandy Plains range site)

Miles fine sandy loam, 3 to 5 percent slopes (MfC).—This soil occurs on moderately sloping uplands. The profile is similar to the one described for the series, but this soil has a thinner surface layer, a less clayey subsoil, and more areas that have a surface layer of loamy fine sand. Included in the areas mapped are areas of Brownfield fine sand, totaling less than 10 percent of the acreage, and minor areas of Nobscot fine sand and Pratt loamy fine sand.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to grain sorghum and small grain. When it is cultivated, the main problems are maintaining fertility, supplying organic matter, and providing protection against a moderate hazard of wind and water erosion. Minimum tillage, terracing to break long slopes and to divert overhead water, stubble mulching, and growing of high-residue crops help to conserve moisture and soil. About a third of the acreage is cultivated. (Capability unit IVE-2; Sandy Plains range site)

Nobscot Series

The Nobscot series consists of grayish upland soils that are hummocky and rolling. These soils occur in the southeastern part of Ellis County.

The surface layer is dark grayish brown, very friable, and about 5 inches thick. The upper part is loamy fine sand and has weak, fine, granular structure, and the lower part is pale-brown, single-grain fine sand. This layer is mildly alkaline.

The subsoil consists of reddish-yellow fine sandy loam and has coarse, prismatic structure. It is hard when dry. The reaction is slightly acid.

The substratum consists of light-brown, very friable, massive fine sand. It is slightly acid.

The surface layer is 13 to 47 inches thick. In cultivated fields the color is between the dark grayish brown of the upper part of the layer and the pale brown of the lower part. The subsoil ranges from 10 to 40 inches in thickness, from loamy fine sand to fine sandy loam in texture, and from reddish yellow to red and reddish brown

in color. The substratum varies slightly in color, and in many places it is loamy fine sand in texture.

The Nobscot soils are somewhat excessively drained, have rapid permeability, are low in natural fertility, have low moisture-storage capacity, and are low in organic-matter content. There is a severe hazard of wind erosion.

The Nobscot soils have a sandier surface layer and a redder subsoil than the Pratt soils. They have a sandier subsoil than the Brownfield soils.

Sorghum is the main crop grown on the Nobscot soils. Yields are low. The native vegetation consists mostly of shin oak and tall grasses.

Nobscot fine sand, rolling (NoE).—This soil has rolling topography and a fairly well-defined drainage pattern. A small acreage occupies strong side slopes. High, individual dunes are scattered throughout areas of this soil. The slope range is 3 to 12 percent. Runoff is slow. The profile is like the one described for the series. Included in the areas mapped are areas of Brownfield fine sand, 1 to 3 percent slopes, and areas of Pratt loamy fine sand, hummocky. The inclusions total less than 5 percent of the acreage.

This soil is not suitable for cultivation, because of droughtiness, steep slopes, and a severe hazard of wind erosion. It is used for range. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-6; Deep Sand Savannah range site)

Nobscot-Brownfield complex, severely eroded (Nc3).—This complex consists of severely eroded Nobscot and Brownfield soils (fig. 7). The slope range is 3 to 8 percent. About 20 to 40 percent of the mapping unit is made up of soils in which the subsoil is exposed. About 40 to 60 percent of the acreage is made up of less severely eroded soils that have less than 6 inches of the original surface layer. Deep gullies, 80 to 200 feet apart, have formed.

Because of a severe hazard of wind and water erosion, the soils of this complex are not suitable for cultivation. They are used for range. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-8; Eroded Sandy Land range site)



Figure 7.—Nobscot-Brownfield complex, severely eroded.

Nobscot-Brownfield fine sands, hummocky (NbC).—This complex occurs in areas characterized by dunes and ridges 4 to 10 feet high and also on smooth, moderate slopes along drainageways. About 20 to 40 percent of the acreage consists of the Brownfield soil, which is between the dunes and generally has a slope of less than 3 percent. Between 60 and 80 percent consists of the Nobscot soil, which is on the steeper parts of the dunes and ridges. The slope range is from less than 3 percent to about 5 percent. Runoff is slow. Included in the areas mapped are areas of Pratt loamy fine sand, hummocky, totaling less than 4 percent of the acreage.

The soils of this complex are not suitable for cultivation, because of droughtiness and a severe hazard of wind erosion. They are best used for range. A few small areas are cultivated. (Capability unit VIe-6; Deep Sand Savannah range site)

Otero Series

The Otero series consists of light-colored upland soils that are undulating and hummocky. They occur in the northwestern part of Ellis County.

The surface layer is grayish brown, very friable, and about 4 inches thick. It consists of calcareous fine sandy loam and has weak, fine, granular structure.

The subsoil consists of light brownish-gray sandy loam and has weak, fine, granular structure. It is soft when dry and very friable when moist. It is strongly calcareous and has a visible zone of lime in the lower part.

The substratum consists of very pale brown, single-grain loamy fine sand. It is friable, highly calcareous, and permeable.

The surface layer ranges from 3 to 6 inches in thickness, from fine sandy loam to very fine sand in texture, and from grayish brown to pale brown in color. The subsoil ranges from fine sandy loam to loamy fine sand in texture and from light brownish gray to very pale brown in color. The substratum contains thin layers that are more clayey and more sandy than the surface layer. The depth to the visible zone of lime ranges from 10 to 30 inches.

These soils are somewhat excessively drained, have moderately rapid permeability, are fair in natural fertility, and have low moisture-storage capacity. There is a severe hazard of wind erosion.

The Otero soils have a more limy surface layer, a more clayey profile, and a more distinct zone of lime than the Likes soils. They have a thinner, lighter colored, more limy surface layer than the Manter soils.

The undulating areas are cultivated, but yields are low. The native vegetation consists mostly of short and mid grasses.

Otero-Mansker complex (Om).—This complex consists of deep to very shallow soils on irregular slopes. The slope range is 3 to 12 percent. Runoff is slow.

Except for the sandy loam surface layer, the profiles are like those described for the Otero and Mansker series. About 30 to 50 percent of the acreage consists of Otero sandy loam and loamy sand; between 20 and 30 percent of Mansker sandy loam and loam; between 5 and 15 percent of Potter loam; between 10 and 20 percent of Mansker clay loam and sandy loam; and between 5 and 20 percent

of Likes loamy fine sand. Fine sandy loams occupy about 60 percent of the total acreage.

Because the moisture-storage capacity is low and the hazard of erosion is severe, the soils of this complex are not suitable for cultivation. They are used as range. Little bluestem, sand bluestem, and sideoats grama are the main grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-2; Limy Sandy Plains range site)

Otero soils, undulating (O1B).—These soils have gentle, irregular slopes and a poorly defined drainage pattern. The slope range is 0 to 3 percent. Runoff is slow. The profile is like the one described for the series. Included in the areas mapped are areas of Likes loamy fine sand and of Pratt loamy fine sand, undulating. The inclusions total less than 10 percent of the acreage.

These soils are fair in fertility and have low moisture-storage capacity. They are suited to small grain and sorghum. When they are cultivated, the main problems are maintaining fertility, supplying organic matter, conserving moisture, and providing protection against a severe hazard of wind erosion. Minimum tillage, stubble mulching, growing of high-residue crops, and strip-cropping crossways to the prevailing winds are practices that help to conserve soil and moisture. About a fourth of the acreage is cultivated. (Capability unit IVE-3; Limy Sandy Plains range site)

Otero soils, hummocky (O1C).—These soils occur on low, round dunes separated by shallow draws. The slope range is 3 to 8 percent. Runoff is medium. Included in the areas mapped are areas of Pratt loamy fine sand, hummocky, and of Likes loamy fine sand. The inclusions total less than 15 percent of the acreage.

Because of a severe hazard of wind erosion and low moisture-storage capacity, these soils are not suitable for cultivation. They are used mostly as range. Sideoats grama, sand bluestem, and little bluestem are common grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed for control of erosion. Only a small acreage of these soils is cultivated. (Capability unit VIe-2; Limy Sandy Plains range site)

Potter Series

The Potter series consists of upland soils that are very shallow, grayish, and moderately sloping to moderately steep. These soils occur in the northern part of Ellis County.

The surface layer is grayish brown, friable, and about 4 inches thick. It consists of calcareous loam and has moderate, fine, granular structure. This layer becomes more limy with depth and contains many small caliche rocks.

The substratum is a very pale brown, moderately or strongly consolidated layer of lime. This layer is at a depth of less than 10 inches.

The surface layer ranges from 3 to 8 inches in thickness and from dark grayish brown to grayish brown in color. In texture, it is predominantly loam, but it ranges from fine sandy loam to clay loam. The substratum is grayish brown to very pale brown. The depth to the substratum is 3 to 10 inches.

These soils are somewhat excessively drained, have moderate permeability, and have low moisture-storage capacity.

The depth to the layer of lime is less in the Potter soils than in the Mansker soils.

The Potter soils are too shallow to be cultivated. The native vegetation consists mostly of short grasses.

Potter soils (Pa).—These soils occur on moderately sloping to moderately steep uplands. The slope range is 3 to 8 percent. The profile is like the one described for the series. Runoff is rapid. Included in the areas mapped are areas of Mansker loam and areas containing outcrops of caliche. The inclusions total less than 15 percent of the acreage.

Because these soils have low moisture-storage capacity and are very shallow to the caliche, they are not suitable for cultivation. They are used as range. Little bluestem, sideoats grama, and hairy grama are the main grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed. (Capability unit VIIs-1; Shallow range site)

Potter-Berthoud complex (Pd).—This complex occurs in areas where drainageways have cut into or through the caliche bed of the Ogallala formation (fig. 8). The side slopes of the drainageways have a gradient of 20 to 50 percent.

The profiles of the Potter and Berthoud soils are like those described for the two series. Runoff is very rapid. The Potter soils occupy 40 to 60 percent of the complex. They occur on the higher slopes and are very shallow over caliche bedrock. The Berthoud soils, which make up 20 to 40 percent of the complex, are on the slopes below the bed of caliche. About 15 to 20 percent of the acreage is Mansker soils, and less than 5 percent is alluvial soils and caliche outcrops.

Because of shallowness, low moisture-storage capacity, and steep slopes these soils are not suitable for cultivation. They are used for range. Little bluestem, sideoats grama, and hairy grama are the main grasses if the range is in excellent condition. Regulation of grazing and other good management practices are needed for control of erosion. (Potter soil: capability unit VIIe-1; Shallow



Figure 8.—Typical landscape of the Potter-Berthoud complex. The Potter soil is on the caliche caprock; the Berthoud soil is on the slopes below the caprock.

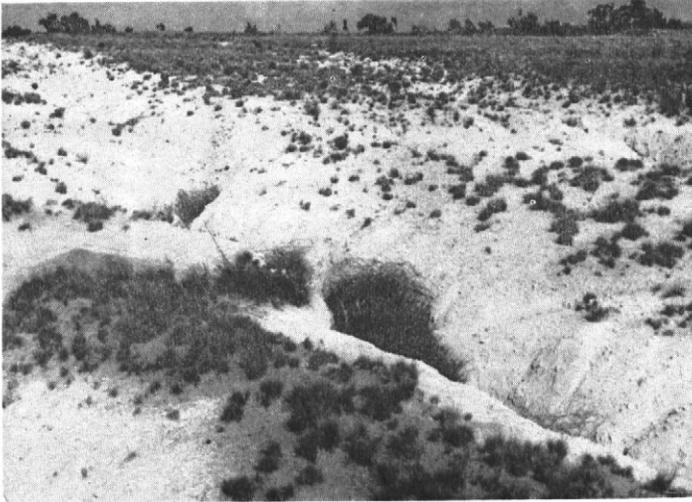


Figure 9.—Typical landscape of Potter-Mansker complex, severely eroded.

range site. Berthoud soil: capability unit VIIe-1; Loamy Prairie range site)

Potter-Mansker complex, severely eroded (Pm3).—This complex consists of Potter and Mansker soils so severely eroded that much of the surface layer has been lost and the subsoil is exposed (fig. 9). Rills and shallow gullies are common. The slope range is 3 to 8 percent.

The Potter soils make up 50 to 70 percent of the complex, and caliche outcrops about 10 to 20 percent. Included in the areas mapped are small areas of uneroded Potter and Mansker soils.

Because of barren rock, ditches, and a severe hazard of water erosion, these soils are not suitable for cultivation. They are used for range. Little bluestem, sideoats grama, and hairy grama are the common grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-11; Shallow range site)

Pratt Series

The Pratt series consists of grayish to light-colored soils. They occur as undulating to duned areas adjacent to the large streams in Ellis County.

The surface layer is grayish brown, very friable, and about 9 inches thick. It consists of loamy fine sand and has weak, fine, granular structure. This layer is slightly acid.

The subsoil is light yellowish-brown loamy fine sand and is 10 to 24 inches thick. It has weak, coarse, prismatic structure that breaks to fine, granular structure. It is very friable, is noncalcareous, and is neutral to mildly alkaline.

The substratum consists of light-brown, eolian loamy fine sand and has weak, fine, granular structure. It is loose when moist and is noncalcareous and mildly alkaline.

The surface layer ranges from 5 to 16 inches in thickness, from loamy fine sand to fine sandy loam in texture, and from dark brown to grayish brown in color. The subsoil ranges from 10 to 24 inches in thickness, from fine sandy loam to loamy fine sand in texture, and from light yellowish brown to strong brown in color. Typically, the

profile is free of lime, but in some places the soil is calcareous below a depth of 30 inches.

These soils are somewhat excessively drained, are rapidly permeable, and have fair to low moisture-storage capacity. There is a moderate to severe hazard of wind erosion.

The Pratt soils have a less red subsoil than the Nobscot soils, are leached of lime to a greater depth than the Likes soils, and have a finer textured subsoil than the Tivoli soils.

About half of the acreage of the Pratt soils in Ellis County is cultivated. Yields of sorghum and other dry-land crops are low to fair. The native vegetation consists mostly of sand sagebrush and tall grasses.

Pratt fine sandy loam, undulating (PbB).—This soil occurs on undulating uplands. The slope range is 1 to 3 percent. The profile, except for the texture of the surface layer and of the subsoil, is like the one described for the series. The surface layer and subsoil are fine sandy loam. In a few places the surface layer is loamy fine sand. Runoff is slow. Included in the areas mapped are areas of Dalhart fine sandy loam, 1 to 3 percent slopes, totaling less than 10 percent of the acreage.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to grain sorghum, which is the common crop, and also to small grain. When it is cultivated, the main problems are providing protection against a moderate hazard of wind erosion, preventing surface crusting, and maintaining the organic-matter content. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping crossways to the prevailing wind are practices that help to conserve soil and moisture. Most of the acreage is cultivated. (Capability unit IIIe-2; Sandy Plains range site)

Pratt fine sandy loam, hummocky (PbC).—This soil occurs on low, round dunes and on slopes along drainageways. The dunes are from 6 to 12 feet high and have side slopes of 3 to 5 percent. The profile, except for the texture of the surface layer and the subsoil, is like the one described for the series. The surface layer and subsoil are fine sandy loam. In a few places the surface layer is loamy fine sand. Runoff is medium. Included in the areas mapped are areas of Dalhart fine sandy loam, 1 to 3 percent slopes, totaling less than 10 percent of the acreage. A soil that has a slightly redder subsoil than Pratt fine sandy loam occurs in a few areas and is associated with the Nobscot and Brownfield soils.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to sorghum and small grain. When it is cultivated, the main problems are providing protection against a moderate hazard of wind erosion, maintaining fertility, and supplying organic matter. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping help to conserve soil and moisture. About half the acreage is cultivated. (Capability unit IVe-2; Sandy Plains range site)

Pratt loamy fine sand, undulating (PfB).—This soil occurs on very low dunes and on slopes along drainageways. The dunes are 2 to 6 feet high, and their side slopes seldom have a gradient of more than 3 percent. The profile is like the one described for the series. Included in the areas mapped are areas of soils that resemble Pratt soils but have a redder subsoil.

This soil has low moisture-storage capacity and produces low yields of sorghum and small grain. When it is cultivated, the main problems are conserving moisture, providing protection against a severe hazard of wind erosion, maintaining fertility, and supplying organic matter. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping crossways to the prevailing winds help to overcome these problems. About half the acreage is cultivated. (Capability unit IVE-3; Deep Sand range site)

Pratt loamy fine sand, hummocky (PfC).—This soil occurs on low, round dunes and on slopes along drainage-ways. The dunes range from 6 to 14 feet in height and their side slopes have a gradient of 3 to 5 percent. The profile is like the one described for the series. Runoff is slow. Included in the areas mapped are areas of Tivoli fine sand, totaling less than 5 percent of the acreage, and areas of Nobscot-Brownfield fine sands, hummocky, totaling less than 5 percent of the acreage.

This soil normally produces low yields. It is used mostly for sorghum and small grain. When it is cultivated, the main problems are maintaining fertility, supplying organic matter, conserving moisture, and providing protection against a severe hazard of wind erosion. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping are practices that help to conserve moisture and soil. About a third of the acreage is cultivated. (Capability unit IVE-3; Deep Sand range site)

Pratt-Tivoli loamy fine sands (Pt).—These soils occur on rounded dunes 15 to 25 feet high. They normally are adjacent to the larger streams. The slope range is 5 to 12 percent. Runoff is slow.

The profile of the Pratt soil is like the one described for the series. Except for the loamy fine sand surface layer, the Tivoli soil is like the one described for the Tivoli series. It makes up 30 to 50 percent of the mapping unit and generally is on the steeper slopes. The Pratt soil makes up 50 to 70 percent of the mapping unit. Included in the areas mapped are only minor areas of other soils.

Because of a low moisture-storage capacity and a severe hazard of erosion, these soils are not suitable for cultivation. They are used as range. Sand bluestem, little bluestem, indiagrass, and switchgrass are the main grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-3; Deep Sand range site)

Quinlan Series

The Quinlan series consists of reddish upland soils that are moderately sloping to steep. They occur in the north-eastern and southeastern parts of Ellis County.

The surface layer is red, very friable, and about 7 inches thick. It consists of calcareous loam and has weak, fine and medium, granular structure.

The substratum consists of red loam that grades into weakly consolidated, silty and sandy red beds. It is calcareous and permeable.

The surface layer ranges from 3 to 7 inches in thickness and from red to reddish brown and yellowish red in color. The substratum ranges from very fine sandy loam to loam

in texture and from red to reddish brown and light red in color. The depth to the stratified silty and sandy red beds ranges from 3 to 10 inches.

These soils are somewhat excessively drained, have moderate permeability, are fair in natural fertility, and have low moisture-storage capacity. When they are cultivated, they are subject to both wind and water erosion.

The Quinlan soils are more shallow over red beds and have a redder surface layer than the Woodward soils.

The moderately sloping Quinlan soils produce fair yields of wheat and sorghum. The steeper slopes support native vegetation consisting mostly of mid and tall grasses.

The Quinlan soils are mapped with the Woodward soils in Ellis County.

Quinlan-Woodward loams, 8 to 20 percent slopes (QwE).—These soils occur in rolling and hilly red-bed areas. They occur mainly on the side slopes of drainageways, but a few areas are on knolls, hills, and sharp ridges between drainageways.

The Quinlan soil makes up about 60 to 80 percent of the mapping unit and is on knolls and sharp ridges. The gradient is most commonly more than 12 percent. The profile is like the one described for the Quinlan series. The Woodward soil makes up the rest of the mapping unit and generally occupies the smoother foot slopes that have a gradient of less than 12 percent. Except for a slightly thinner surface layer, the profile of the Woodward soil is like the one described for the series. Included in the areas mapped are areas of Rough broken land, totaling less than 3 percent of the acreage; areas of Loamy alluvial land, totaling less than 2 percent of the acreage; and areas of very shallow soils underlain by gypsum rock, totaling less than 7 percent of the acreage.

Because of shallowness, steep slopes, and a severe hazard of water erosion, these soils are not suitable for cultivation. They are used as range. Sand bluestem and little bluestem are the main grasses. Regulation of grazing and other good range management practices are needed for control of erosion. (Quinlan soil: capability unit VIe-4; Shallow Prairie range site. Woodward soil: capability unit VIe-4; Loamy Prairie range site)

Richfield Series

The Richfield series consists of upland soils that are deep and dark colored. They occur on gentle to moderate slopes in the northern part of Ellis County.

The surface layer is dark grayish brown, friable, and about 8 inches thick. It consists of clay loam and has weak, fine and medium, granular structure. Lime has been leached from this layer.

The subsoil contains more clay than the surface layer. It consists of dark-brown clay loam and has fine and medium, subangular blocky structure. It is calcareous at a depth of more than 24 inches and has a visible zone of lime at a depth of 48 inches.

The substratum consists of firm clay loam of eolian (windblown) origin. It is limy and permeable.

The surface layer is 5 to 11 inches thick. The color of the subsoil ranges from dark brown to brown and grayish brown. The depth to lime ranges from 10 to 30 inches, and the depth to the visible lime zone from 30 to 60 inches. Buried soils are common.

These soils are well drained, have moderately slow permeability, are high in natural fertility, and have good moisture-storage capacity.

The Richfield soils have a more clayey subsoil than the Mansic soils. They are similar to the St. Paul soils but have a thinner surface layer and generally a more clayey subsoil.

The Richfield soils are well suited to sorghum and to wheat and other small grain. Buffalograss and sideoats grama are the major grasses. The smoother slopes can be irrigated.

Richfield clay loam, 1 to 3 percent slopes (RcB).—This soil occurs on gently sloping uplands. The profile is like the one described for the series. Runoff is medium. Included in the areas mapped are areas of Mansic clay loam, 1 to 3 percent slopes, and of St. Paul silt loam, 1 to 3 percent slopes. These inclusions total less than 10 percent of the acreage. Also included in mapping are areas of Richfield silt loam, totaling less than 5 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to grass, small grain, and sorghum. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, growing of high-residue crops, and contour stripcropping help to conserve moisture and soil. Most of the acreage is cultivated. (Capability unit IIe-1; Hardland range site)

Richfield clay loam, 3 to 5 percent slopes (RcC).—This soil occurs on moderately sloping uplands. The profile is similar to the one described for the series, but in this soil the A1 horizon is thinner and the depth to the calcareous material is less. Runoff is medium. Included in the areas mapped are areas of Mansic clay loam, 3 to 5 percent slopes, totaling less than 8 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to small grain and sorghum. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion. Minimum tillage, terracing, stubble mulching, and growing of high-residue crops help to conserve moisture and soil. Most of the acreage is cultivated. (Capability unit IIIe-1; Hardland range site)

Riverwash (Rw)

Riverwash occurs in the active stream channel of the Canadian River, Clear Creek, and their large tributaries. (In table 1, the acreage of Riverwash is included in that of rivers and streams.) Because of flooding, about 90 percent of the acreage does not support permanent vegetation. The vegetation consists mostly of annual weeds, scattered tamarix, and shrubs.

This land type consists mostly of deep, calcareous, fine quartz sand, with which is mixed some silt, clay, and gravel. Some spots are saline. Included in the areas mapped are minor areas of Lincoln soils.

Riverwash is associated with the Lincoln soils, but, unlike these soils, it is almost bare of permanent vegetation and has no A1 horizon.

This land type provides little or no grazing for livestock. It does not have a range site classification or a capability classification.

Rough Broken Land (Rb)

Rough broken land occurs as deep, narrow valleys, as sharp divides, and as escarpments. The relief is very steep. The slopes exceed 50 percent, and the local differences in elevation generally are between 50 and 200 feet. Runoff is very rapid, and geologic erosion is active.

The soils that make up this land type have loam and silt loam profiles. They are predominantly shallow, but the range is from deep soils on the valley floors to shallow and very shallow soils on the very steep divides. Included in the areas mapped are small areas of rock outcrops.

Because the slopes are steep and the hazard of water erosion is severe, this land type is not suitable for cultivation. Some areas are used for range. Little bluestem and sand bluestem are the main grasses if the range is in excellent condition. Many areas are too steep to be grazed. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIIe-3; Breaks range site)

St. Paul Series

The St. Paul series consists of upland soils that are deep and dark colored. These soils occur on gentle to nearly level slopes in the northeastern part of Ellis County.

The surface layer is dark grayish brown, friable, and about 15 inches thick. It consists of silt loam and has moderate, fine and medium, granular structure. The reaction is neutral.

The upper part of the subsoil contains more clay than the surface layer. It consists of dark-brown silty clay loam and has weak, fine, subangular blocky structure. It is mildly alkaline. The lower part of the subsoil consists of reddish-gray silty clay loam and has medium and coarse, subangular blocky structure. It is firm and calcareous.

The substratum is generally weathered, calcareous, light reddish-brown silty and sandy red-bed material. It is friable and permeable. In places it consists of windblown material that has been darkened by an accumulation of loess. In many places lime is present in the upper part.

The surface layer ranges from 11 to 24 inches in thickness and from very dark grayish brown to dark grayish brown in color. The subsoil ranges from medium loam to silty clay loam in texture and from dark grayish brown to reddish gray in color. The substratum ranges from light reddish brown to dark brown in color. The depth to lime ranges from 20 to 50 inches but is most commonly between 24 and 36 inches. In many places buried soils occur below a depth of 36 inches.

These soils are well drained, have moderate or moderately slow permeability, are high in natural fertility, and have good moisture-storage capacity. Preventing surface crusting and maintaining water intake are problems.

The St. Paul soils have a thicker, less clayey surface layer and redder parent material than the Richfield soils. They have a finer textured subsoil than the Carey soils.

Most of the acreage of St. Paul soils is cultivated. Yields are good. Wheat is the principal crop. The native

vegetation consists mostly of short and mid grasses. If water is available, these soils can be irrigated.

St. Paul silt loam, 0 to 1 percent slopes (ScA).—This soil occupies nearly level uplands. Except for a slightly greater depth to lime, the profile is like the one described for the series. Runoff is slow. Included in the areas mapped are areas of Carey silt loam, 1 to 3 percent slopes, totaling less than 3 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to small grain, sorghum, alfalfa, and sweetclover. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion. Minimum tillage, stubble mulching, and stripcropping are practices that help to overcome these problems. Most of the acreage is cultivated. (Capability unit IIc-2; Hardland range site)

St. Paul silt loam, 1 to 3 percent slopes (ScB).—This soil is on gently sloping uplands. The profile is like the one described for the series. Runoff is medium. Included in the areas mapped are areas of Carey silt loam, 1 to 3 percent slopes, totaling less than 3 percent of the acreage; areas of Dalhart fine sandy loam, 1 to 3 percent slopes, totaling 7 percent of the acreage; and areas of Richfield clay loam, 1 to 3 percent slopes, totaling 3 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to small grain, sorghum, alfalfa, and sweetclover. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind and water erosion. Minimum tillage, terracing, stubble mulching, growing of high-residue crops, and contour stripcropping help to conserve moisture and soil. Most of the acreage is cultivated. (Capability unit IIe-1; Hardland range site)

Spur Series

The Spur series consists of dark-colored soils that are on nearly level flood plains and are occasionally flooded.

The surface layer is dark grayish brown, friable, and about 18 inches thick. It consists of calcareous loam and has moderate, fine, granular structure.

The subsoil consists of brown clay loam and has medium, granular structure. It is friable, calcareous, and permeable.

The substratum consists of alluvium of silt loam and clay loam texture. It is friable, calcareous, and permeable.

The surface layer ranges from 6 to 20 inches in thickness and from dark grayish brown to dark brown and reddish brown in color. In texture, it is predominantly loam but is clay loam in some places. In some places this layer is leached of lime to a depth of 10 inches. The lower part of the profile ranges from loam to silty clay loam in texture and from brown to light yellowish brown and reddish brown in color.

These soils are well drained, have moderate permeability, are high in fertility, and have good moisture-storage capacity. They are easily plowed, and they respond to good management.

The Spur soils are less sandy and have a thicker surface layer than the Bayard and Yahola soils.

Most of the acreage of Spur soils is cultivated. Yields are good. The native vegetation consists mostly of tall and mid grasses.

Spur loam (Sp).—This soil occurs on nearly level flood plains. It is 8 to 20 feet above the stream channel and is rarely flooded. The slope range is 0 to 1 percent. The profile is like the one described for the series. Included in the areas mapped are areas of Bayard fine sandy loam and Yahola fine sandy loam. The inclusions total less than 10 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to small grain, sorghum, alfalfa, and sweetclover. The main problems are preventing surface crusting and maintaining water intake. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping help to overcome the problems. Most of the acreage is cultivated. (Capability unit IIc-1; Loamy Bottom Land range site)

Sweetwater Series

The Sweetwater series consists of light-colored soils of the bottom lands. They occur along the major streams in Ellis County and are rarely to frequently flooded.

The surface layer is gray, friable, and about 12 inches thick. It consists of calcareous silt loam and has weak, fine, granular structure.

The subsoil consists of light-gray fine sand mottled with dark brown. It is single grained, very friable, and calcareous. The water table fluctuates.

The substratum consists of light-gray alluvium of fine sand texture. This material is calcareous, very friable, single grained, and permeable.

The surface layer ranges from 6 to 18 inches in thickness and from loamy fine sand to silty clay loam in texture. The color ranges from gray to very dark grayish brown. Both the subsoil and the substratum are generally fine sand in texture, but in many places there are thin layers of more clayey material. They range from grayish brown to very pale brown and pale yellow in color. The depth to the water table fluctuates seasonally between 1 and 5 feet. Some areas are affected by salinity.

The Sweetwater soils are poorly drained, have moderately slow permeability, are low in fertility, have low moisture-storage capacity, and are moderately alkaline.

The Sweetwater soils are more poorly drained than the Wann and Elsmere soils and have a more sandy subsoil. They are mottled and are more poorly drained than the Lincoln soils.

The Sweetwater soils are not suitable for cultivation, because they have a high water table and are subject to flooding. They have the capacity to produce a large amount of tall and mid grasses.

Sweetwater soils (Sw).—These soils occur on nearly level flood plains of the major streams, generally 4 to 8 feet above the stream channel. They are flooded frequently. There are a few oxbows and swales 50 to 150 feet wide. The slope range is 0 to 1 percent. The profile is like the one described for the series. Included in the areas mapped are areas of Lincoln soils, totaling less than 5 percent of the acreage.

Because of salinity, frequent overflow, and a high water table, these soils are not suitable for cultivation. They are used as range. Switchgrass and indiangrass are the main

grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed. (Capability unit Vw-1; Subirrigated range site)

Tipton Series

The Tipton series consists of upland soils that are deep, dark colored, and nearly level. They occur on the benches of the Canadian River.

The surface layer is dark brown, very friable, and about 16 inches thick. It consists of silt loam and has moderate, fine and medium, granular structure. This layer is leached of lime to a depth of more than 15 inches.

The upper part of the subsoil is intermediate in color between the surface layer and the lower part of the subsoil. The lower part of the subsoil consists of brown silt loam and has fine and medium, granular structure. It is calcareous and very friable.

The substratum consists of loess of silt loam texture. It is limy, permeable, and very friable.

The surface layer ranges from 12 to 20 inches in thickness and from dark brown to dark grayish brown and dark gray in color. The upper part of the subsoil is 4 to 10 inches thick. The lower part of the subsoil ranges from brown to light grayish brown and pinkish gray in color. The depth to lime ranges from 15 to 36 inches, but it is most commonly 17 to 24 inches.

These soils are well drained, have moderate permeability, are high in fertility, and have good moisture-storage capacity. They are slightly susceptible to wind and water erosion.

The Tipton soils have a thicker surface layer and a finer textured subsoil than the Enterprise soils and are leached of lime to a greater depth.

The Tipton soils are among the most productive upland soils in this county. They are well suited to all crops grown in the county. Most of the acreage is cultivated.

Tipton silt loam, high (Th).—This soil occurs on nearly level benches. The slope range is 0 to 1 percent. Runoff is slow. The profile is like the one described for the series. Included in the areas mapped are areas of Enterprise very fine sandy loam, totaling less than 5 percent of the acreage, and areas of St. Paul silt loam, 0 to 1 percent slopes, totaling less than 5 percent of the acreage.

This soil has good moisture-storage capacity and is high in fertility. It is best suited to small grain and sorghum but can be used for alfalfa and sweetclover in years of adequate rainfall. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion. Minimum tillage, terracing, stubble mulching, growing of high-residue crops, and contour strip-cropping help to overcome these problems. (Capability unit IIc-2; Loamy Prairie range site)

Tivoli Series

The Tivoli series consists of upland soils that are light colored and sandy. They are in duned areas adjacent to the large streams in Ellis County.

The surface layer is grayish brown, loose, and about 8 inches thick. It consists of single-grain fine sand. The reaction is medium acid.

The underlying material is pink, loose fine sand. It is slightly acid and permeable.

The surface layer ranges from 4 to 8 inches in thickness and from grayish brown to brown in color. The color of the underlying material ranges from pink to brown and yellowish brown. The reaction is slightly acid to mildly alkaline.

These soils are excessively drained, have very rapid permeability, are low in natural fertility, and have low moisture-storage capacity. There is a severe hazard of wind erosion.

The Tivoli soils are underlain by less red material than the Nobscot soils. They are less coherent and more sandy than the Pratt soils.

The Tivoli soils are not suitable for cultivation. The native vegetation consists mostly of mid and tall grasses.

Tivoli fine sand (Tv).—This soil is in duned areas along the large streams in the county. The dunes commonly are 14 to 30 feet high, but some are as much as 40 feet high. Generally there are seven or eight major dunes per mile, with side slopes of as much as 20 percent gradient. The profile is like the one described for the series. Runoff is slow. Included in the areas mapped are areas of Pratt loamy fine sand, hummocky, and areas of Nobscot fine sand, rolling. The inclusions total less than 10 percent of the acreage. There are also a few small active blowouts.

Because the hazard of wind erosion is severe, the moisture-storage capacity is low, and the slopes are steep, this soil is unsuitable for cultivation. It is used as range. Sand bluestem, little bluestem, indiagrass, and switchgrass are the main grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed. (Capability unit VIIe-4; Dune range site)

Vernon Series

The Vernon series consists of reddish, shallow to moderately deep, moderately steep to steep upland soils. These soils occur in the southeastern part of Ellis County.

The surface layer is red, firm, and about 4 inches thick. It consists of calcareous clay loam and has weak, fine, granular structure.

The subsoil is similar to the surface layer, but it is redder and has moderately fine, granular structure. It is about 15 inches thick.

The substratum consists of red silty and clayey shale of the Permian red beds. This layer is not permeable to moisture or to roots.

The surface layer ranges from 4 to 10 inches in thickness, from clay loam to clay in texture, and from red to pale red and light reddish brown in color. The texture of the subsoil is similar to that of the surface layer. The color is red to pale red. The depth to lime ranges from 0 to 10 inches, and the depth to the substratum ranges from 8 to 25 inches.

These soils are somewhat excessively drained, have moderately slow permeability, are low in natural fertility, and have fair moisture-storage capacity. They are subject to severe water erosion.

The Vernon soils have a more clayey subsoil and parent material than the Woodward and Quinlan soils.

The Vernon soils are not suitable for cultivation. The native vegetation consists mostly of short and mid grasses.

Vernon complex (Vx).—This complex occurs in V-shaped canyons, on knolls, and on ridged hills. The slope range is 5 to 40 percent, but the gradient is commonly 8 to 20 percent. Because they are severely eroded, the knolls and steep slopes have only a sparse cover of vegetation. Runoff is rapid.

The Vernon soils, which occupy 50 to 80 percent of this complex, occur in canyons and on ridged hills. The profile of these soils is like the one described for the Vernon series. A similar but deeper soil occurs on the smoother, less steep slopes and makes up 15 to 30 percent of the complex. Raw, shaly knolls occupy from 10 to 20 percent. Included in the areas mapped are areas of soils that have a gradient of less than 5 percent. The inclusions total less than 3 percent of the acreage.

Because of the severe hazard of water erosion and the steep slopes, the soils of this complex are not suitable for cultivation. They are used as range. Sideoats grama, little bluestem, and sand bluestem are the main grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed for control of erosion. (Capability unit VIe-9; Red Clay Prairie range site)

Wann Series

The Wann series consists of dark-colored soils of the bottom lands. These soils occur on nearly level flood plains of major streams, but they are rarely flooded.

The surface layer is dark grayish brown, friable, and about 12 inches thick. It consists of calcareous fine sandy loam and has moderate, fine, granular structure.

The subsoil consists of pale-brown fine sandy loam that has distinct, strong-brown mottles. It has weak, fine, granular structure. This layer is very friable and calcareous.

The substratum consists of light-brown, single-grain fine sandy loam and alluvium of fine sand texture. It is very friable, calcareous, and permeable.

The surface layer ranges from 7 to 16 inches in thickness and from dark grayish brown to dark gray in color. It is generally fine sandy loam in texture but ranges to loam or clay loam. The subsoil and the substratum are generally fine sandy loam in texture but range to loam and commonly contain thin layers of more sandy material. The color is pale brown to grayish brown and pink. The depth to the fluctuating water table varies between 3 and 12 feet.

The Wann soils are imperfectly drained, have moderately rapid permeability, are fair in fertility, and have fair moisture-storage capacity. There is a slight hazard of wind erosion. Saline spots occur in areas where the water table is high.

The Wann soils are mottled and are more poorly drained than the Bayard soils. They are more clayey than the Elsmere soils. They are better drained than the Sweetwater soils, and they have a more clayey subsoil.

Most of the acreage is cultivated. Yields of wheat and sorghum are good. The native vegetation consists mostly of tall and mid grasses.

Wann fine sandy loam (Wf).—This soil occurs on the nearly level flood plains of Wolf Creek and the Canadian

River. It is rarely flooded. The slope range is 0 to 1 percent. The profile is like the one described for the series. Included in the areas mapped are areas of Bayard fine sandy loam; areas of a darker, more clayey soil with similar drainage; and small saline spots where the depth to the water table is less than 3 feet. The inclusions total less than 5 percent of the acreage.

This soil has fair moisture-storage capacity and produces good yields. It is suited to small grain, sorghum, alfalfa, and sweetclover. When it is cultivated, the main problems are maintaining structure and providing protection against flooding and against a slight hazard of wind erosion. Minimum tillage, stubble mulching, and growing of high-residue crops help to conserve moisture and soil. Most of the acreage is cultivated. (Capability unit IIw-1; Loamy Bottom Land range site)

Woodward Series

The Woodward series consists of reddish, gently sloping to steep soils on the uplands in the northeastern and southeastern parts of Ellis County.

The surface layer is reddish brown, very friable, and about 8 inches thick. It consists of calcareous loam and has weak, fine, granular structure.

The subsoil consists of red loam and is about 13 inches thick. It has weak, fine granular structure and is calcareous and very friable. In places a visible lime layer occurs in the lower parts of the subsoil.

The substratum consists of highly weathered, weakly consolidated, silty and sandy red-bed material. It is friable and permeable.

The surface layer ranges from 8 to 12 inches in thickness and from reddish brown to dark reddish gray and dark brown in color. The subsoil ranges from 8 to 14 inches in thickness, from very fine sandy loam to loam in texture, and from red to reddish brown in color. The visible lime layer is at a depth of more than 15 inches.

These soils are well drained, have moderate permeability, are fair in natural fertility, and have fair moisture-storage capacity. Tillage is good.

The Woodward soils have a less clayey subsoil than the Carey soils. They are deeper over red-bed material and have a darker colored surface layer than the Quinlan soils.

The gently sloping and moderately sloping Woodward soils are cultivated. Yields of wheat and similar crops are fair. The steeper slopes support native vegetation consisting mostly of mid grasses.

Woodward loam, 1 to 3 percent slopes (WoB).—This soil occupies gently sloping uplands. The profile is like the one described for the series. Runoff is medium. Included in the areas mapped are areas of Carey silt loam, 1 to 3 percent slopes, totaling less than 10 percent of the acreage.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to wheat, barley, oats, and sorghum. When it is cultivated, the main problems are preventing surface crusting and maintaining water intake. Minimum tillage, terracing, stubble mulching, and contour stripcropping help to control erosion and to conserve moisture. Most of the acreage is cultivated. (Capability unit IIe-1; Loamy Prairie range site)

Woodward loam, 3 to 5 percent slopes (WoC).—This soil occurs on moderately sloping uplands. It has a

thinner surface layer than the soil described for the series, and is less deep over the red-bed material. Runoff is medium. Included in the areas mapped are areas of Carey silt loam, totaling less than 13 percent of the acreage, and also some areas of Quinlan loam.

This soil has fair moisture-storage capacity and produces fair yields. It is suited to small grain and sorghum. When it is cultivated, the main problems are preventing surface crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion. Minimum tillage, terracing, stubble mulching, and growing of high-residue crops help to conserve moisture and soil. About half of the acreage is cultivated. (Capability unit IIIe-1; Loamy Prairie range site)

Woodward-Quinlan loams, 3 to 8 percent slopes, eroded (WwD2).—These soils occur in moderately sloping to strongly sloping red-bed areas on uplands. They are moderately eroded. Runoff is medium to rapid.

The Woodward soil, occupying 60 to 80 percent of the mapping unit, occurs on the smoother slopes. It has a thinner, redder surface layer than that described for the series. The surface layer is 3 to 7 inches thick. Rills and gullies are common. The Quinlan soil occurs on knobs and crests of ridges and makes up the remaining 20 to 40 percent of the mapping unit. The profile is similar to the one described for the Quinlan series.

Because of shallowness and the severe hazard of water erosion, these soils are not suitable for cultivation. They are used for range. Sand bluestem, little bluestem, and sideoats grama are the main grasses. Regulation of grazing and other good range management practices are needed for control of erosion. (Woodward soil: capability unit VIe-4; Loamy Prairie range site. Quinlan soil: capability unit VIe-4; Shallow Prairie range site)

Woodward-Quinlan loams, 5 to 12 percent slopes (WwE).—These soils have rolling slopes. Runoff is rapid. These soils have a slightly thinner surface layer than the soils described as typical of the Woodward and Quinlan series. The Quinlan soil occupies the steeper slopes on the knobs and ridges and makes up 15 to 30 percent of the mapping unit. About 70 to 85 percent of the mapping unit is Woodward soil. It is on side slopes and concave foot slopes of about 5 to 8 percent gradient. Included in the wider, smoother areas mapped are areas of Carey silt loam, 1 to 3 percent slopes, totaling less than 5 percent of the acreage.

Because of shallowness, steep slopes, and the severe hazard of water erosion, these soils are not suitable for cultivation. They are used for range. Sand bluestem, little bluestem, and sideoats grama are the major grasses if the range is in excellent condition. Regulation of grazing and other good range management practices are needed. (Woodward soil: capability unit VIe-4; Loamy Prairie range site. Quinlan soil: capability unit VIe-4; Shallow Prairie range site)

Yahola Series

The Yahola series consists of reddish soils on the flood plains of major streams in the red-bed areas of Ellis County. These soils are rarely flooded.

The surface layer is reddish brown, very friable, and about 10 inches thick. It consists of calcareous fine sandy loam and has weak, fine, granular structure.

The subsoil consists of light reddish-brown fine sandy loam and contains thin strata of fine sand and loam. This layer has fine, granular structure. It is friable and calcareous.

The substratum consists of light reddish-brown, stratified alluvium of fine sandy loam and fine sand texture. It is very friable, calcareous, and permeable.

The surface layer is 5 to 12 inches thick. The color of the subsoil and the substratum ranges from light reddish brown to red and reddish yellow. The texture of the profile generally is fine sandy loam, but in some places it is very fine sandy loam.

These soils are well drained, have moderately rapid permeability, are high in fertility, and have good moisture-storage capacity. Tillth is good.

The Yahola soils are more sandy than the Spur soils.

Most of the acreage of Yahola soils is cultivated. Yields are good. The native vegetation consists of mid and tall grasses.

Yahola fine sandy loam (Yc).—This soil occurs on nearly level bottom lands that are rarely flooded. The profile is like the one described for the series. The slope range is 0 to 1 percent. Included in the areas mapped are areas of Bayard fine sandy loam and Spur loam. The inclusions total less than 5 percent of the acreage.

This soil has good moisture-storage capacity and produces good yields. It is suited to small grain, sorghum, alfalfa, and sweetclover. When it is cultivated, the main problems are maintaining structure and providing protection against flooding and against a slight hazard of wind erosion. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping help to conserve moisture and soil. Most of the acreage is cultivated. (Capability unit IIw-1; Loamy Bottom Land range site)

Zavala Series

The Zavala series consists of light-colored soils of the bottom lands. These soils occur in rarely flooded areas along streams in the southeastern part of Ellis County.

The surface layer is grayish brown, very friable, and about 11 inches thick. It consists of fine sandy loam and has weak, fine and medium, granular structure. It is slightly acid.

The subsoil consists of grayish-brown fine sandy loam that has weak, fine and medium, granular structure. It is very friable and slightly acid.

The substratum consists of pale-brown, single-grain alluvium of loamy fine sand texture. It is very friable, slightly acid, and permeable.

The surface layer ranges from 8 to 18 inches in thickness, from fine sandy loam to loamy fine sand in texture, and from dark brown to grayish brown in color. The subsoil and the substratum range from pale brown to grayish brown and very pale brown in color. In texture, they are predominantly fine sandy loam, but they contain thin strata of more clayey material and of more sandy material.

These soils are well drained, have moderately rapid permeability, are high in fertility, and have fair moisture-storage capacity. They are typically noncalcareous and slightly acid.

The Zavala soils are finer textured than the Lincoln soils. They are noncalcareous, and the Lincoln and Bayard soils are calcareous.

About half of the acreage of Zavala soils is cultivated. Yields of wheat and sorghum are good. The native vegetation consists of mid and tall grasses.

Zavala fine sandy loam (Za).—This soil occurs on nearly level bottom lands that are dissected by stream channels. It is rarely flooded. The slope range is 0 to 1 percent. The profile is like the one described for the series. Included in the areas mapped are areas of Yahola fine sandy loam, totaling less than 3 percent of the acreage.

This soil has fair moisture-storage capacity and produces good yields. It is suited to small grain, sorghum, alfalfa, and sweetclover. When it is cultivated, the main problems are maintaining structure and providing protection against flooding and against a slight hazard of wind erosion. Minimum tillage, stubble mulching, growing of high-residue crops, and stripcropping are some practices that help to conserve moisture and soil. Most of the acreage is cultivated. (Capability unit IIw-1; Loamy Bottom Land range site)

Use and Management of the Soils

In this section the management of the soils of Ellis County for cultivated crops is discussed; the system of land capability classification used by the Soil Conservation Service is explained briefly; the soils of the county are placed in capability groups according to that system, and management for the soils of each group is discussed; suggestions are given as to the suitability of the soils for irrigation; and predicted average acre yields of the principal crops are given. The soils of this county are grouped according to their suitability for use as range sites, and information that is useful in the management of rangeland is given; the use of the soils for trees and wildlife is discussed; and the soil characteristics that affect engineering uses are given.

Management of the Soils for Cultivated Crops¹

Cultivated soils in Ellis County need management that will conserve moisture, control erosion, maintain fertility, supply organic matter, and preserve good tilth. Following are discussions of practices commonly required in the county. For suggested combinations of practices for specific soils, see "Management by Capability Units."

CONSERVATION CROPPING.—The objective of conservation cropping is to provide an adequate economic return to the farmer and at the same time maintain or improve the condition of the soil and control weeds (fig. 10), insects, and diseases.

A conservation cropping system must include soil-maintaining and soil-improving crops. Legumes, such as sweetclover and alfalfa, and grasses are soil-improving crops. Small grain can be utilized for soil improvement if only the grain is harvested and all the straw is returned to the soil. It is usually necessary to apply nitrogen to speed the decomposition of the straw and to make sure that there will be enough nitrogen for the succeeding crop.

¹By M. D. GAMBLE, conservation agronomist, Soil Conservation Service.



Figure 10.—A wheatfield infested with bindweed.

Low-residue row crops, such as cotton and silage crops, are soil depleting, and the frequency with which they can be grown depends on the nature of the soil. Sometimes a soil-depleting crop should be followed by a cover crop or a green-manure crop that will provide residues to protect and improve the soil.

The crops best suited to the soils and climate of this county are wheat, rye, barley, sorghum, sudan, broom-corn, and cotton. Alfalfa is suited to the soils on the bottom lands and can be grown on the more nearly level of the upland soils in years of favorable rainfall. Native grasses are dependable as warm-season forage, and they are also excellent soil conditioners if rotated with other crops in a long-term conservation system (fig. 11).

MINIMUM TILLAGE.—Minimum tillage is essential in this county. Tillage operations should be limited to the minimum required for the preparation of a seedbed and the control of weeds. Excessive tillage breaks down soil structure. The soils then tend to puddle and crust at the surface. As a result, the circulation of air is obstructed and the intake of water is impeded.



Figure 11.—A field once cultivated and now reseeded to blue grama, sideoats grama, buffalograss, and little bluestem.

Frequent tillage to the same depth tends to pack the soil just below plow depth and to create a compacted layer, called a tillage pan or plowpan, which obstructs the movement of air and moisture, reduces the moisture-storage capacity, and restricts the development of roots. Sandy loams and silt loams are most likely to be affected.

MANAGEMENT OF CROP RESIDUES.—Proper management of crop residues is an important conservation practice in Ellis County.

Stubble mulching is a method of tillage that keeps a protective cover of crop residues 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.

Another system of crop-residue management consists of keeping residues on the surface as a protective cover through the critical erosion period. Coarse textured and moderately coarse textured soils particularly need to be protected against wind erosion. After the residues are plowed under, they are broken down to humus by microorganisms, and some of the nutrients used by the crop are thus returned to the soil. Also, the humus improves the condition of the surface soil by increasing infiltration of water and reducing the tendency to crust.

Advice about the amount of residues needed for protection of specific soils can be obtained from the local representatives of the agricultural agencies.

FERTILIZATION.—The use of fertilizer in an area where the average annual rainfall is 22 inches is of questionable economic value. The response, in terms of increased yields, is best during a sequence of wet years, but some response can be expected in dry years from such soils as Dalhart fine sandy loam and Pratt loamy fine sand. Each farmer needs to decide each year, on the basis of current information, whether any benefit is to be expected from applying fertilizer.

Nitrogen is the fertilizer most likely to be needed. The amount of available nitrogen in a soil is closely related to the amount of surface soil and to the organic-matter content.

Some of the soils are deficient in phosphorus. Alfalfa, small grain, and cotton usually respond if phosphate is applied along with nitrogen. Phosphorus not used in one season is available the following season.

STRIPCROPPING.—Stripcropping consists of growing different kinds of crops, one of them an erosion-resistant crop, in a systematic arrangement of alternate strips, so that the erosion-resistant crop provides a barrier against the wind. It is an effective means of controlling wind erosion on such soils as those of the Dalhart, Manter, and Pratt series (fig. 12). If one of the crops is a high-residue crop, the stubble can be left to provide protection through the winter and the early part of spring. The erosion-resistant crop and the erosion-susceptible crop should be planted in strips of equal width. The width required for effective control depends on the erosion hazard, which in turn depends largely on the texture of the soil and the size of the field. If practical, all strips should be at right angles to the prevailing wind.

CONTOUR FARMING.—Contour farming consists of plowing, planting, and tilling across the slope, instead of up and down the slope. It helps to control water erosion and conserve moisture, increases yields; and makes the use of



Figure 12.—Grain sorghum and wheat in strips on a field of Pratt loamy fine sand, hummocky.

farm machinery easier. This practice is effective on soils of less than 3 percent slope if crop residues are well managed, and it is essential in terraced fields.

FIELD TERRACES AND DIVERSION TERRACES.—A terrace is a combination of a ridge and channel built across the slope to divert or stop the flow of water. Terraces are used to control erosion, to conserve moisture, and to serve as guidelines for contour farming. They are most effective on medium-textured and moderately fine textured soils, such as Carey silt loam or Richfield clay loam. A field terrace is designed mainly to slow or stop movement of water in a field (fig. 13). A diversion terrace is designed and located to protect a cultivated field from runoff from adjoining land. Most terrace systems need vegetated waterways for disposal of excess water.

In this county, where lack of moisture is one of the chief obstacles to good crop yields, field terraces and contour farming appreciably improve yields by increasing the intake of water. The wide-based, channel-type terrace is best suited.



Figure 13.—An area of Mansic clay loam, 3 to 5 percent slopes, that is severely eroded.

GRASSED WATERWAYS.—Grassed waterways are needed in most terraced fields to provide for safe disposal of excess water. They are used to supplement natural drains where terrace systems, diversion terraces, or drainage or irrigation systems have been installed or are planned.

Each waterway must be individually designed. The width, depth, and vegetative cover are determined primarily by the size of the area drained and by the slope, permeability, and erodibility of the soil. Either bermuda-grass or native grass is commonly used for the vegetative cover.

For maintenance of a waterway, it is necessary to mow or spray for control of weeds; to lift farm implements when crossing the waterway; to avoid using the waterway as a farm road; to control grazing by fencing and other means; to apply fertilizer as needed; and to avoid cultivating too close to the waterway.

Capability Groups of Soils

The capability classification is a grouping that shows, in a general way, how suitable soils 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, the subclass, and the 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. There are no class I soils in Ellis County. 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 shown 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 interferes 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 a 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 are subject to little or no erosion but have other limitations that restrict their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, which are 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 soils, and without consideration of possible but unlikely major reclamation projects.

The classes in the capability system, and the subclasses and units in Ellis County are described in the list that follows.

Class I. Soils that have few limitations that restrict their use. (There are no class I soils in Ellis County.)

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

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

Unit IIe-1. Deep or moderately deep, medium-textured or moderately fine textured soils on gently sloping uplands.

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

Unit IIw-1. Deep, imperfectly drained to well-drained, moderately coarse textured soils on nearly level flood plains and terraces; rarely flooded.

Subclass IIc. Soils that are limited by climate.

Unit IIc-1. Deep, medium-textured soils on nearly level flood plains.

Unit IIc-2. Deep, medium-textured soils on nearly level uplands.

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

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

Unit IIIe-1. Deep, medium-textured or moderately fine textured soils on moderately sloping uplands.

Unit IIIe-2. Deep, moderately coarse textured soils on gently sloping or undulating uplands.

Unit IIIe-3. Medium-textured soils on gently sloping uplands; moderately shallow over a lime layer.

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

Unit IIIw-1. Deep, coarse-textured to moderately fine textured soils in depressions and on hummocky uplands.

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 severe erosion if they are cultivated and not protected.

Unit IVe-1. Medium-textured soils on moderately sloping uplands; moderately shallow over limy clay loam.

Unit IVe-2. Deep, moderately coarse textured soils on moderately sloping and hummocky uplands.

Unit IVe-3. Deep, moderately coarse textured or coarse textured soils on gently sloping, undulating, or hummocky uplands.

Unit IVe-4. Deep, medium-textured or moderately fine textured soils on moderately sloping or strongly sloping uplands.

Unit IV-5. Medium-textured or moderately coarse textured soils on moderately sloping uplands; moderately shallow to very shallow over a lime layer.

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

Unit IVw-1. Deep, coarse-textured, imperfectly drained soils on nearly level flood plains along major streams.

Class V. Soils that are not likely to erode but have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture, range, woodland, or food and cover for wildlife.

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

Unit Vw-1. Deep, moderately fine textured to coarse-textured soils on flood plains; poorly drained and frequently flooded.

Unit Vw-2. Deep, moderately coarse textured or medium-textured soils on flood plains; frequently flooded.

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

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

Unit VIe-1. Deep, coarse-textured to medium-textured soils on flood plains; frequently flooded.

Unit VIe-2. Moderately shallow to deep, coarse-textured to medium-textured soils on hummocky uplands.

Unit VIe-3. Deep, coarse-textured soils on undulating to duned uplands.

Unit VIe-4. Medium-textured soils on moderately sloping or strongly sloping uplands; moderately shallow to very shallow over Permian red beds.

Unit VIe-5. Deep, moderately fine textured soils on strongly sloping to steep uplands.

Unit VIe-6. Deep, coarse-textured soils on hummocky or rolling uplands.

Unit VIe-7. Moderately deep or deep, moderately coarse textured or medium-textured soils on moderately steep or steep uplands.

Unit VIe-8. Deep, coarse-textured to moderately fine textured soils on severely eroded uplands.

Unit VIe-9. Moderately fine textured or fine textured soils on moderately steep or steep uplands; shallow to moderately deep over shaly Permian red beds.

Unit VIe-10. Medium-textured or moderately coarse textured soils on strongly sloping to steep uplands; moderately shallow over a consolidated lime layer.

Unit VIe-11. Medium-textured soils on severely eroded uplands; very shallow to moderately shallow over a lime layer.

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 food and cover for wildlife.

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

Unit VIIe-1. Moderately coarse textured or medium-textured soils on steep uplands; very shallow to deep over a lime layer.

Unit VIIe-2. Deep, coarse-textured to medium-textured soils on moderately steep or steep uplands.

Unit VIIe-3. Shallow, medium-textured soils on very steep, broken uplands.

Unit VIIe-4. Deep, coarse-textured soils on duned uplands.

Subclass VIIs. Soils very severely limited by moisture capacity, stones, or other soil features.

Unit VIIs-1. Medium-textured soils on moderately sloping to steep uplands; very shallow over a lime layer.

Class VIII. Soils and landforms that have limitations that preclude their use, without major reclamation, for commercial production of plants and that restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIe. Areas that are so severely eroded that they have little potential for the production of vegetation.

Unit VIIIe-1. Nearly barren, severely eroded areas.

Management by Capability Units ²

The soils of Ellis County have been placed in 33 capability units. In this subsection each unit is described, and the soils in each are listed. Suggestions are given on how to use and manage the soils in each unit. The management of rangeland is described in the section "Range Management."

Capability unit IIe-1

This unit consists of deep or moderately deep, dark-colored or reddish soils that have a medium-textured or moderately fine textured surface layer and a subsoil that is moderately permeable or moderately slowly permeable. These soils are on gently sloping uplands. They are—

Carey silt loam, 1 to 3 percent slopes.

Enterprise very fine sandy loam, 1 to 3 percent slopes.

Mansic clay loam, 1 to 3 percent slopes.

Richfield clay loam, 1 to 3 percent slopes.

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

Woodward loam, 1 to 3 percent slopes.

These soils have good moisture-storage capacity and produce good yields. They are well suited to grass, small grain, and sorghum. Alfalfa and sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are controlling wind and water erosion, keeping the surface from crusting, and maintaining water intake. High-residue crops grown 3 out of 4 years conserve soil and moisture and supply

² By Z. V. GORDON, work unit conservationist, Soil Conservation Service.

enough organic matter to maintain water intake. If all residues are utilized, the rotation can consist of 2 years of wheat, 1 year of a low-cut bundle feed crop, and 1 year of sorghum. The risk of erosion increases if row crops are grown more often than every third year. Stubble mulching or other use of crop residues helps to conserve moisture, to prevent crusting, and to control erosion. If there is an adequate amount of moisture, applications of nitrogen will speed the decomposition of heavy residues. Minimum tillage and variation in depth of tillage help to prevent the formation of a plowpan and to increase the intake of water. Other measures that may be beneficial are diversion terraces, stripcropping, and contour farming, either with or without a terrace system.

Capability unit IIw-1

This unit consists of deep, imperfectly drained to well-drained soils that have a moderately coarse textured surface layer and a subsoil that is moderately rapidly permeable. These soils are on nearly level flood plains and terraces. They are rarely flooded. They are—

Bayard fine sandy loam.
Wann fine sandy loam.
Yahola fine sandy loam.
Zavala fine sandy loam.

These soils are well suited to small grain, sorghum, alfalfa, and grass. They have fair moisture-storage capacity and produce good yields.

The main management problems are providing protection against overflow, conserving moisture, controlling erosion, maintaining structure, and reducing salinity. High-residue crops grown at least 3 out of 4 years conserve soil and moisture and help to preserve structure and to maintain fertility. The rotation can consist of 6 years of alfalfa and 1 year of sorghum. Stubble mulching or other use of crop residues helps to preserve structure and to control erosion. The risk of erosion increases if these soils are used for row crops more than 3 years in succession. Because of the limited moisture-storage capacity, summer fallowing does not conserve enough moisture for crops. Minimum tillage and variation in depth of tillage help to prevent the formation of a plowpan and to increase water intake. Other measures that may be beneficial are diversion terraces, contour farming, and stripcropping. A simple drainage system would reduce the salinity of the Wann soils.

Capability unit IIc-1

This unit consists of Spur loam, a deep, dark-colored soil that has a medium-textured surface layer and a moderately permeable subsoil. This soil is on nearly level flood plains along major streams. It is the most productive bottom-land soil in the county and is well suited to grass, small grain, sorghum, and alfalfa.

The main management problems are keeping the surface from crusting and maintaining water intake. High-residue crops grown 3 out of 4 years conserve soil and moisture and supply enough organic matter to maintain water intake. If all residues are utilized, the rotation can consist of 2 years of sorghum, 1 year of a low-cut silage crop, and 1 year of wheat. Stubble mulching or other use of crop residues helps to conserve moisture and to prevent crusting. Minimum tillage and variation in depth of till-

age help to prevent the formation of a plowpan. Other measures that may be beneficial are diversion terraces and stripcropping. This soil is subject to erosion if used for row crops more than 3 years in succession or if summer fallowed more often than every third year.

Capability unit IIc-2

This unit consists of deep, dark-colored soils that have a medium-textured surface layer and a subsoil that is moderately permeable or moderately slowly permeable. These soils are on nearly level uplands. They are—

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

These are the most productive upland soils in Ellis County. They are best suited to grass, small grain, and sorghum. Alfalfa and sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are keeping the surface from crusting, maintaining water intake, and controlling wind erosion. High-residue crops grown 3 out of 4 years conserve soil and moisture and supply enough organic matter to maintain water intake. If all crop residues are utilized, the rotation can consist of 2 years of sorghum, 1 year of summer fallow, and 1 year of wheat. Stubble mulching or other use of crop residues helps to conserve moisture, to prevent crusting, and to control wind erosion. The risk of erosion increases if these soils are used for row crops more than 3 years in succession or are summer fallowed more often than every third year. Minimum tillage and variation in depth of tillage help to prevent formation of a plowpan. Other measures that may be beneficial are stripcropping, diversion terraces, and contour farming either with or without a terrace system.

Capability unit IIIe-1

This unit consists of deep, dark-colored or reddish soils that have a medium-textured or moderately fine textured surface layer and a subsoil that is moderately permeable or moderately slowly permeable. These soils are on moderately sloping uplands. They are—

Enterprise very fine sandy loam, 3 to 5 percent slopes.
Mansic clay loam, 3 to 5 percent slopes.
Richfield clay loam, 3 to 5 percent slopes.
Woodward loam, 3 to 5 percent slopes.

These soils have good moisture-storage capacity and produce fair yields. They are well suited to grass, small grain, and sorghum. Sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are keeping the surface from crusting, maintaining water intake, and providing protection against a slight hazard of wind erosion and a moderate hazard of water erosion. Growing low-residue crops no more often than every fourth year helps to conserve moisture and soil, to prevent crusting, and to maintain water intake. If all crop residues are utilized, a good crop sequence is 2 years of wheat, 1 year of a low-cut silage crop, and 1 year of sorghum. The risk of erosion increases if these soils are used for row crops more than 3 years in succession or if they are summer fallowed more often than every third year. Stubble mulching or other use of crop residues helps to maintain water intake, to prevent crusting, and to control erosion. Minimum tillage and variation in the depth of tillage help to prevent the formation of a

plowpan and to increase the intake of water. Other measures that are beneficial are a broad-base terrace system, grassed waterways, contour farming, and stripcropping.

Capability unit IIIe-2

This unit consists of deep, dark-colored or light-colored soils that have a moderately coarse textured surface layer and a subsoil that is moderately permeable or moderately rapidly permeable. These soils are on gently sloping or undulating uplands. They are—

- Dalhart fine sandy loam, 1 to 3 percent slopes.
- Manter-Otero fine sandy loams, 1 to 3 percent slopes.
- Miles fine sandy loam, 1 to 3 percent slopes.
- Pratt fine sandy loam, undulating.

These soils have fair moisture-storage capacity and produce fair yields. They are best suited to grass, small grain, sorghum, and broomcorn. Sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are keeping the surface layer from crusting, maintaining organic-matter content, and controlling both wind and water erosion. High-residue crops grown 3 out of 4 years help to maintain the organic-matter content, to prevent surface crusting, and to control erosion. The rotation can consist of at least 4 years of grass, 2 years of wheat, and 1 year of sorghum. The risk of erosion increases if these soils are used for row crops more than 3 years in succession. Because of the limited moisture-storage capacity, summer fallowing does not conserve enough moisture for good yields. Stubble mulching or other use of crop residues helps to maintain the organic-matter content, to prevent crusting, and to control erosion. Minimum tillage and variation in depth of tillage help to prevent formation of a plowpan and to increase water intake. Other measures that may be beneficial are terracing, which will break long slopes and divert runoff, and stripcropping.

Capability unit IIIe-3

This unit consists of Mansker loam, 1 to 3 percent slopes, a grayish, medium-textured soil that is moderately shallow over a lime layer. The subsoil is moderately permeable. This soil is on gently sloping uplands.

This soil has fair moisture-storage capacity and produces fair yields. It is best suited to grass, small grain, and sorghum. Sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are controlling wind and water erosion and maintaining structure. Shallowness to the lime layer is a major limitation. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. The risk of erosion increases if a low-residue crop is included in the rotation or if row crops are grown more than 3 years in succession. Because the moisture-supplying capacity is only fair, summer fallowing does not conserve enough water for good yields. Stubble mulching or other use of crop residues helps to preserve structure, to prevent crusting, and to control erosion. Minimum tillage and variation in the depth of tillage help to prevent formation of a plowpan and to increase water intake. Other measures that are beneficial are stripcropping, constructing a broad-base terrace system, and contour farming with or without a terrace system.

Capability unit IIIw-1

This unit consists only of the Carwile-Pratt complex, a complex of deep, dark-colored to light-colored soils that have a coarse-textured to moderately fine textured surface layer and a subsoil that is rapidly permeable to slowly permeable. These soils are in depressions and on hummocky uplands.

The soils in this complex produce fair yields. They are best suited to grass, small grain, and sorghum. Sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are preserving structure, maintaining fertility, removing excess water from the depressions, and controlling wind erosion. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. The risk of erosion increases if row crops are grown more than 3 years in succession. Summer fallowing does not conserve enough moisture for good yields. Stubble mulching or other use of crop residues helps to conserve moisture, to prevent surface crusting, and to control erosion. Crop rows that are crossways to prevailing winds help to control erosion. Minimum tillage and variation in the depth of tillage help to prevent formation of a plowpan, to increase the intake of water, and to control wind erosion. Other measures that may be beneficial are stripcropping and constructing simple drainage systems in some areas.

Capability unit IVe-1

This unit consists of Mansker loam, 3 to 5 percent slopes, a soil that is moderately shallow over limy clay loam. This soil has a grayish, medium-textured surface layer and is moderately permeable. It occurs on moderately sloping uplands. It has fair moisture-storage capacity and is fairly productive. Grass, small grain, and sorghum are suitable crops. Sweetclover can be grown in years when the moisture supply is favorable.

The main management problems are controlling wind and water erosion and maintaining structure. Shallowness to the lime layer is a major limitation. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. Row crops can be grown in fields that are contoured and terraced, but not for more than 3 years in succession. Because the moisture-storage capacity is only fair, summer fallowing does not conserve enough moisture for good yields. Stubble mulching or other use of crop residues helps to conserve moisture, to prevent crusting, and to control erosion. Minimum tillage and variation in the depth of tillage help to prevent formation of a plowpan and to increase water intake. Other measures that are beneficial are contour farming, stripcropping, grassed waterways, and broad-base terrace systems.

Capability unit IVe-2

This unit consists of deep, light-colored to dark-colored soils that have a moderately coarse textured surface layer and a subsoil that is moderately permeable or rapidly permeable. These soils are on moderately sloping and hummocky uplands. They are—

- Berthoud fine sandy loam, 3 to 5 percent slopes.
- Dalhart fine sandy loam, 3 to 5 percent slopes.
- Manter-Otero fine sandy loams, 3 to 5 percent slopes.
- Miles fine sandy loam, 3 to 5 percent slopes.
- Pratt fine sandy loam, hummocky.

These soils produce fair yields. They are best suited to grass, small grain, sorghum, and broomcorn. Sweetclover can be grown in years when the moisture supply is favorable.

The major management problems are maintaining fertility, maintaining the organic-matter content, and controlling erosion. A cropping system that consists entirely of high-residue crops is needed to conserve moisture and soil. Row crops can be grown no more than 3 years in succession. It is necessary to keep the direction of the crop rows crossways to prevailing winds. Summer fallowing does not conserve enough moisture for good yields. Stubble mulching or other use of crop residues helps to conserve moisture and to control wind erosion. Minimum tillage and variation in the depth of tillage help to prevent formation of a plowpan and to increase water intake. Other measures that are beneficial are strip-cropping, constructing terraces or diversion terraces to break long slopes and to divert runoff, grassed waterways, and contour farming with a terrace system.

Capability unit IVe-3

This unit consists of deep, light-colored soils that have a coarse textured or moderately coarse textured surface layer and a subsoil that is moderately slowly permeable to rapidly permeable. These soils are on gently sloping, undulating, or hummocky uplands. They are—

- Brownfield fine sand, 1 to 3 percent slopes.
- Otero soils, undulating.
- Pratt loamy fine sand, undulating.
- Pratt loamy fine sand, hummocky.

These soils are best suited to grass, sorghum, and broomcorn, but small grain can be grown if an adequate amount of fertilizer is used. Yields are low.

The main management problems are maintaining fertility, maintaining the organic-matter content, conserving moisture, and controlling wind erosion. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. Stubble mulching or other use of crop residues helps to conserve moisture and to control wind erosion. Summer fallowing does not conserve enough moisture for good yields. The risk of erosion increases if row crops are grown more than 3 years in succession. Minimum tillage and variation in the depth of tillage help to prevent the formation of a plowpan. Other measures that are beneficial are establishing permanent vegetation in the sandier areas, strip-cropping, running crop rows crossways to the prevailing winds, and applying fertilizer if there is enough moisture in the subsoil that the fertilizer can be utilized.

Capability unit IVe-4

This unit consists of deep, dark-colored soils that have a medium-textured or moderately fine textured surface layer and a subsoil that is moderately permeable. These soils are on moderately or strongly sloping uplands. They are—

- Enterprise very fine sandy loam, 5 to 8 percent slopes.
- Mansic clay loam, 5 to 8 percent slopes.
- Mansic clay loam, 3 to 8 percent slopes, eroded.

These soils are best suited to grass, small grain, and sorghum. Sweetclover can be grown in years when the moisture supply is favorable. Yields are fair.

The main management problems are keeping the surface from crusting, maintaining water intake, and con-

trolling wind and water erosion. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. Row crops can be grown in fields that are contoured and terraced, but not more than 3 years in succession. Summer fallowing does not conserve enough moisture for good yields. Stubble mulching or other use of crop residues helps to conserve moisture, to prevent crusting, and to control erosion. Minimum tillage and variation in the depth of tillage help to prevent the formation of a plowpan and to increase the water intake. Other measures that may be beneficial are a broad-base terrace system, grassed waterways, contour farming, and strip-cropping.

Capability unit IVe-5

This unit consists only of the Mansker-Potter complex, 3 to 5 percent slopes. The soils of this complex are moderately shallow to very shallow over a distinct lime layer. They have a grayish, medium-textured or moderately coarse textured surface layer, are moderately permeable, and occur on moderately sloping uplands.

These soils are best suited to grass and small grain. Sweetclover can be grown in years when the moisture supply is favorable. Wheat yields are fair, but sorghum yields are poor. Iron deficiency causes chlorosis of sorghum and reduces yields.

The major limitations are the high lime content of the surface layer, shallowness, and a moderate hazard of wind and water erosion. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. Stubble mulching or other use of crop residues helps to conserve moisture and to prevent crusting. Summer fallowing does not conserve soil or moisture. Minimum tillage helps to prevent the formation of a plowpan and to increase water intake. Other measures that are beneficial are a broad-base terrace system, grassed waterways, contour farming, and strip-cropping.

Capability unit IVw-1

This unit consists of Elsmere loamy fine sand, a deep, light-colored soil that has a coarse-textured surface layer and a subsoil that is rapidly permeable. This soil is on nearly level flood plains along major streams.

This soil is best suited to grass. Small grain and sorghum can be grown in dry years, but yields are low.

The main management problems are maintaining structure, maintaining fertility, reducing salinity, and controlling wind erosion. A cropping system that consists entirely of high-residue crops is needed to conserve soil and moisture. The risk of erosion increases if row crops are grown more than 3 years in succession. Summer fallowing does not conserve soil or moisture. Stubble mulching or other use of crop residues helps to conserve moisture and to control wind erosion. Running crop rows crossways to prevailing winds and strip-cropping where practical help to control erosion. Minimum tillage and variation in the depth of tillage help to prevent the formation of a plowpan. Constructing a simple drainage system, where feasible, reduces salinity.

Capability unit Vw-1

This unit consists only of Sweetwater soils. These soils are deep and light colored and have a moderately fine textured to coarse-textured surface layer. They are moder-

ately slowly permeable and poorly drained. They are on flood plains and are frequently flooded.

These soils are not suited to cultivation, because of a high water table, salinity, and frequent flooding. They will produce large amounts of mid and tall native grass. The grass can be cut for hay, but good management is needed to keep the meadows productive. Proper management of the watershed keeps water from filling the depressions. Reseeding of heavily grazed areas, construction of firebreaks, and deferment of grazing are effective management practices. For further discussion, see the description of the Subirrigated range site.

Capability unit Vw-2

This unit consists of Loamy alluvial land, a land type made up of deep, dark-colored soils that have a moderately coarse textured or medium-textured surface layer and are moderately rapidly permeable. This land type occurs on flood plains and is frequently flooded.

This land type is so frequently flooded that it is generally not suited to cultivation. It can be used for range and for wildlife habitats. A few areas can be cultivated if protected from floods.

This unit produces large amounts of mid and tall grasses, which can be grazed or cut for hay. Regulating grazing and mowing in order to maintain a vigorous stand of grass helps to control erosion during floods. Other good management practices are reseeding some cultivated areas and heavily grazed areas with desirable grasses and providing protection against fires. Deferring grazing of pastures and reseeded areas helps to improve the vigor of the more desirable grasses and to control erosion. For further discussion, see the description of the Loamy Bottom Land range site.

Capability unit VIe-1

This unit consists only of Lincoln soils. These are deep, light-colored soils that have a coarse-textured to medium-textured surface layer. They are very rapidly permeable and have a fluctuating water table. They are on flood plains and are frequently flooded.

These soils are not suited to cultivation, because of frequent flooding and the severe hazard of wind and water erosion. They produce good yields of grass, but in places there is a considerable amount of brush in the grass cover.

Yields of grass can be increased by controlling the brush and regulating grazing. Leaving enough residues on the surface to provide a mulch helps to protect the soil from wind and water erosion. Other measures that are beneficial are reseeding overgrazed range to desirable grasses, placing salt in the lightly grazed areas to keep the livestock distributed over the range, and constructing firebreaks. For further discussion, see the description of the Sandy Bottom Land range site.

Capability unit VIe-2

This unit consists of moderately shallow to deep, light-colored soils that have a coarse-textured to medium-textured surface layer. These soils are moderately permeable to very rapidly permeable. They are on hummocky uplands. They are—

Otero-Mansker complex.
Otero soils, hummocky.

Because of a severe hazard of wind erosion and low moisture-storage capacity, these soils are not suited to cultivation. They produce large amounts of grasses if properly managed.

Measures that help to increase the production of grass and to control wind erosion include controlling sagebrush, regulating grazing, reseeding heavily grazed areas to desirable grasses, constructing firebreaks, and placing salt in the lightly grazed areas to keep the livestock distributed over the range. For further discussion, see the description of the Limy Sandy Plains range site.

Capability unit VIe-3

This unit consists of deep, light-colored soils that have a coarse-textured surface layer. These soils are rapidly permeable or very rapidly permeable. They are on high, duned uplands. They are—

Pratt-Tivoli loamy fine sands.
Likes loamy fine sand.

These soils are not suited to cultivation, because the erosion hazard is severe and the moisture-storage capacity is low. They are used for range.

Practices that help to increase yields of grass and to control wind erosion include regulating grazing so that enough residue is left to provide a surface mulch; reseeding heavily grazed areas; placing salt in lightly grazed areas to encourage uniform use of the range; providing protection against fires; and treating for control of brush, then reseeding and deferring grazing until the grass is established. For further discussion, see the description of the Deep Sand range site.

Capability unit VIe-4

This unit consists of moderately shallow to very shallow soils over Permian red beds. These soils have a reddish, medium-textured surface layer and are moderately permeable. They are on moderately sloping or strongly sloping uplands. They are—

Quinlan-Woodward loams, 8 to 20 percent slopes.
Woodward-Quinlan loams, 3 to 8 percent slopes, eroded.
Woodward-Quinlan loams, 5 to 12 percent slopes.

These soils have fair moisture-storage capacity and produce fair yields. The chief problems are controlling erosion and maintaining structure. Shallowness is a major limitation.

Woodward-Quinlan loams, 3 to 8 percent slopes, eroded, needs intensive management if cultivated. High-residue crops and grass are needed in the rotation to help control erosion. Growing low-residue crops for more than 3 years in succession damages the soil structure and decreases the intake of water. Practices that may be beneficial are minimum tillage, stubble mulching, stripcropping, and contour farming with terraces and waterways.

Good range management is needed to maintain a vigorous growth of grass. Regulation of grazing so that about half of the yearly growth of grass is used, reseeding of heavily grazed areas, deferment of grazing, and establishment of firebreaks are important range practices. Water and salt placed in lightly grazed areas help to keep livestock distributed over the range. For further discussion, see the descriptions of the Shallow Prairie and Loamy Prairie range sites.

Capability unit VIe-5

In this unit are deep, grayish soils that have a moderately fine textured surface layer. These soils are moderately rapidly permeable or rapidly permeable. They are on strongly sloping to steep uplands. They are—

Berthoud fine sandy loam, 5 to 12 percent slopes.
Broken land.

These soils are not suitable for cultivation, because the moisture-storage capacity is low and the hazard of water erosion is severe. They are used for range and for wild-life habitats.

Control of sagebrush commonly increases grass production. Other practices that help to increase yields and to control erosion are regulating grazing, reseeding bare areas and heavily grazed areas to desirable grasses, establishing firebreaks, deferring grazing, and placing salt in areas away from water. For further discussion, see the description of the Sandy Plains range site.

Capability unit VIe-6

The sandy soils that make up this unit are on hummocky or rolling uplands. They are deep, light-colored soils that have a coarse-textured surface layer. They are moderately slowly permeable to rapidly permeable. They are—

Nobscot-Brownfield fine sands, hummocky.
Nobscot fine sand, rolling.

These soils generally are not suited to cultivation, because of droughtiness, steep slopes, and a severe hazard of wind erosion. They are best used as range or as wild-life habitats. A few areas of Nobscot-Brownfield fine sands, hummocky, can be cultivated if carefully managed.

Controlling shinnery oak helps to increase grass production. Regulating grazing so as to leave enough residue on the surface to provide a mulch helps to control wind erosion. Other practices that are beneficial are reseeding small blowouts and heavily grazed areas to suitable grasses, establishing firebreaks, deferring grazing, building fences, and placing water and salt in selected spots to encourage uniform use of the range. For further discussion, see the description of the Deep Sand Savannah range site.

Capability unit VIe-7

This unit consists of deep, dark-colored soils that have a moderately coarse textured or medium-textured surface layer. These soils are moderately permeable. They are on moderately steep or steep uplands. They are—

Breaks-alluvial land complex.
Enterprise very fine sandy loam, 8 to 20 percent slopes.

These soils are not suitable for cultivation, because the slopes are steep and the hazard of water erosion is severe. They are used for range and are productive if carefully managed. Suitable practices include reseeding heavily grazed areas to grass, establishing firebreaks, deferring grazing, and placing water facilities and salt in selected spots to keep livestock distributed over the range. For further discussion, see the description of the Loamy Prairie range site.

Capability unit VIe-8

In this unit are deep, light-colored soils that have a coarse-textured to moderately fine textured surface layer. These soils are rapidly permeable to moderately slowly permeable. They are on severely eroded uplands. They are—

Eroded sandy land.
Nobscot-Brownfield complex, severely eroded.

Because of the severe hazard of wind and water erosion, these soils cannot be cultivated. They are of limited use for grazing, and careful range management is necessary to control further erosion. Some range practices include filling ditches, then smoothing the surface and planting grass, providing protection against fires, regulating grazing, and building fences. For further discussion, see the description of the Eroded Sandy Land range site.

Capability unit VIe-9

This unit consists only of the Vernon complex, a group of shallow to moderately deep soils over shaly Permian red beds. These soils have a reddish, moderately fine textured or fine textured surface layer, and they are slowly permeable. They are on moderately steep and steep uplands.

Because of the severe hazard of water erosion and the steep slopes, the soils of this complex are not suitable for cultivation. They are used for range, and they provide food and cover for wildlife. Careful management is required to control erosion. Suitable management practices include reseeding bare areas and heavily grazed areas to desirable grasses, providing protection against fires, and placing water and salt in selected spots to encourage uniform use of the range. For further discussion, see the description of the Red Clay Prairie range site.

Capability unit VIe-10

This site consists only of the Mansker-Potter complex, 5 to 20 percent slopes. The soils of this complex are very shallow or moderately shallow over a consolidated lime layer. They have a grayish, medium-textured or moderately coarse textured surface layer and are moderately permeable. They are on strongly sloping to steep uplands.

These soils are not suitable for cultivation, because of shallowness, steep slopes, and a severe hazard of water erosion. They are used for range and wildlife, but careful management is needed to maintain a good cover of grass. The main practices needed are reseeding heavily grazed areas, deferring grazing of small areas, providing protection against fires, fencing, and distributing water facilities and salt so as to encourage uniform grazing of the range. For further discussion, see the descriptions of the Loamy Plains and Shallow range sites.

Capability unit VIe-11

This unit consists only of the Potter-Mansker complex, severely eroded, a group of grayish, medium-textured soils that are very shallow to moderately shallow over a lime layer. These soils are moderately permeable. They are on severely eroded uplands. There are barren outcrops of rock in many places.

These soils are not suitable for cultivation, because of barren rock, ditches, gullies, and a severe hazard of water erosion. They are best used as range or as wild-life habitats.

Filling, smoothing, and reseeding ditches and regulating grazing help to control further erosion. Other good management practices are protecting pastures from fires, deferring grazing, constructing fences to separate this site from the noneroded sites, and, where possible, placing water facilities and salt in noneroded areas. For further discussion, see the description of the Shallow range site.

Capability unit VIIe-1

This unit consists only of the Potter-Berthoud complex, a group of grayish, medium-textured or moderately coarse textured soils that are very shallow to deep over a lime layer. These soils are on steep uplands. Permeability is moderate or moderately rapid.

These soils are not suitable for cultivation, because they are droughty, shallow, and steep. They are best used as range or as wildlife habitats. Regulating grazing on the surrounding range and reseeding barren areas help to control erosion. Providing protection against fires is a beneficial practice. For further discussion, see the descriptions of the Loamy Prairie and Shallow range sites.

Capability unit VIIe-2

This unit consists of Gravelly broken land, a land type made up of deep, grayish soils that have a gravelly, coarse-textured to medium-textured surface layer and are rapidly permeable to very rapidly permeable. This land type is on moderately steep or steep uplands.

This land type is not suited to cultivation, because the slopes are steep and the hazard of water erosion is severe. It is best used as range or as wildlife habitats.

Regulating grazing so that enough residue is left on the surface to provide a mulch helps to control erosion. Other practices that may be beneficial are reseeding heavily grazed areas, deferring grazing in some areas to allow the better grasses to reseed, and placing salt in ungrazed areas to keep livestock distributed over the range. For further discussion, see the description of the Gravelly Sandy range site.

Capability unit VIIe-3

This unit consists only of Rough broken land, a land type made up of shallow, medium-textured soils on very steep, broken uplands.

This land type is not suited to cultivation, because the slopes are steep and the hazard of water erosion is severe. It is of limited use for grazing, because many areas are not accessible to livestock.

Regulating grazing on the surrounding range and establishing vegetation on barren areas help to control erosion. Conservation practices are needed in some areas to keep gullies from forming. For further discussion, see the description of the Breaks range site.

Capability unit VIIe-4

This unit consists only of Tivoli fine sand, a deep, light-colored soil that has a coarse-textured surface layer and is very rapidly permeable. It is on duned uplands.

This soil is not suited to cultivation because of a severe hazard of wind erosion, low moisture-storage capacity, and steep slopes. Controlling sagebrush and regulating grazing to permit good growth of grasses help to control erosion. The blowout spots should be protected with mulch or other cover and reseeded to grass. Other practices

that are beneficial are fire protection, deferment of grazing, and distribution of water facilities and salt in the lightly grazed areas. For further discussion, see the description of the Dune range site.

Capability unit VIIs-1

This unit consists only of Potter soils. These are grayish, medium-textured soils that are very shallow over a distinct lime layer and are moderately permeable. They are on moderately sloping to steep uplands.

These soils are not suited to cultivation, because they are shallow and have low moisture-storage capacity. They are used for range and wildlife habitats.

Management practices needed to maintain a good growth of grass, and thus to control erosion, include re-seeding of heavily grazed areas, deferment of grazing, protection from fire, and distribution of water facilities and salt in lightly grazed areas to encourage uniform use of the range. For further discussion, see the description of the Shallow range site.

Capability unit VIIIe-1

This unit consists only of Blown-out land, a land type made up of nearly barren, severely eroded areas that are sparsely covered with weeds and annual grasses. Erosion must be controlled by a surface mulch or other protective cover before permanent vegetation can be established. Providing protection from fire, regulating grazing, and other good range management practices help to maintain the vegetation and to control erosion. This land type does not have a range site classification.

Predictions of Crop Yields Under Dryland Farming³

In table 2 are predictions of long-term average acre yields, based on the number of acres planted, for the principal crops grown on the cultivated soils of Ellis County. Yields under two levels of management are given. The figures in columns A are predictions of yields to be expected under management practices commonly used in the county; those in columns B are predictions of yields to be expected under improved management.

These predictions are based on information obtained by interviews with farmers and ranchers, on observations made by members of the soil survey party, and on information obtained from the personnel of Oklahoma State University who have access to research records applicable to the crops and soils of this county. Crop failures were considered in predicting average yields.

Customary management (level A) includes (1) proper seeding rates, appropriate planting dates, and efficient harvesting methods; (2) control of weeds, insects, and plant diseases; (3) terracing and contour farming where necessary; and (4) the use of the moldboard plow and the one-way disk plow.

Improved management (level B) includes (1) proper seeding rates, appropriate planting dates, and efficient harvesting methods; (2) control of weeds, insects, and

³ROY SMITH, soil scientist, Oklahoma Agricultural Experiment Station, assisted in the preparation of this subsection.

TABLE 2.—*Predicted average acre yields under two levels of management*

Yields in columns A are those obtained over a period of years under customary management; those in columns B are yields to be expected under improved management. Absence of figure indicates that crop is not commonly grown, crop is not suited to soil specified, or soil is not arable]

Map symbol	Soil	Wheat		Grain sorghum		Forage sorghum	
		A	B	A	B	A	B
		Bu.	Bu.	Bu.	Bu.	Tons ¹	Tons ¹
Ba	Bayard fine sandy loam.....	15	20	22	30	2.0	2.8
BeC	Berthoud fine sandy loam, 3 to 5 percent slopes.....	8	12	12	16	1.2	1.6
BfB	Brownfield fine sand, 1 to 3 percent slopes.....	6	12	12	22	1.2	2.2
CaB	Carey silt loam, 1 to 3 percent slopes.....	13	18	18	26	1.6	2.5
Cp	Carwile-Pratt complex:						
	Carwile soil.....	13	18	16	20	2.0	3.0
	Pratt soil.....	12	16	20	26	1.8	2.5
DaB	Dalhart fine sandy loam, 1 to 3 percent slopes.....	12	17	18	27	1.8	2.6
DaC	Dalhart fine sandy loam, 3 to 5 percent slopes.....	9	14	14	21	1.2	2.0
Ee	Elsmere loamy fine sand.....			14	20	1.0	1.8
EnB	Enterprise very fine sandy loam, 1 to 3 percent slopes.....	13	17	22	29	2.0	2.7
EnC	Enterprise very fine sandy loam, 3 to 5 percent slopes.....	10	14	18	24	1.5	2.2
EnD	Enterprise very fine sandy loam, 5 to 8 percent slopes.....	6	10			1.2	1.7
McB	Mansic clay loam, 1 to 3 percent slopes.....	11	15	15	20	1.5	2.0
McC	Mansic clay loam, 3 to 5 percent slopes.....	8	12			1.0	1.4
McD	Mansic clay loam, 5 to 8 percent slopes.....	5	8				
McD2	Mansic clay loam, 3 to 8 percent slopes, eroded.....	4	7				
MaB	Mansker loam, 1 to 3 percent slopes.....	10	14	13	18	1.3	1.8
MaC	Mansker loam, 3 to 5 percent slopes.....	7	11	9	13	1.0	1.5
MpC	Mansker-Potter complex, 3 to 5 percent slopes.....	6	9				
MrB	Manter-Otero fine sandy loams, 1 to 3 percent slopes:						
	Manter soil.....	13	18	20	28	4.0	6.0
	Otero soil.....	8	10	12	16	3.0	5.0
MrC	Manter-Otero fine sandy loams, 3 to 5 percent slopes:						
	Manter soil.....	12	16	17	24	3.0	5.0
	Otero soil.....	5	9	10	15	2.0	4.0
MfB	Miles fine sandy loam, 1 to 3 percent slopes.....	11	16	18	27	1.8	2.6
MfC	Miles fine sandy loam, 3 to 5 percent slopes.....	8	13	14	21	1.2	2.0
OtB	Otero soils, undulating.....	7	10	13	17	1.3	1.7
PbB	Pratt fine sandy loam, undulating.....	12	16	20	26	1.8	2.5
PbC	Pratt fine sandy loam, hummocky.....	7	11	15	20	1.4	2.0
PfB	Pratt loamy fine sand, undulating.....	8	12	15	20	1.5	2.0
PfC	Pratt loamy fine sand, hummocky.....			10	15	1.0	1.5
RcB	Richfield clay loam, 1 to 3 percent slopes.....	12	16	15	21	1.5	2.0
RcC	Richfield clay loam, 3 to 5 percent slopes.....	8	12			1.0	1.5
Sp	Spur loam.....	18	25	30	40	2.5	3.2
SaA	St. Paul silt loam, 0 to 1 percent slopes.....	15	20	22	29	2.0	2.7
SaB	St. Paul silt loam, 1 to 3 percent slopes.....	12	17	16	23	1.6	2.4
Th	Tipton silt loam, high.....	15	20	24	32	2.2	2.8
Wf	Wann fine sandy loam.....	12	16	24	32	2.2	3.0
WoB	Woodward loam, 1 to 3 percent slopes.....	12	16	17	22	1.4	2.0
WoC	Woodward loam, 3 to 5 percent slopes.....	9	13	11	16	1.0	1.6
WwD2	Woodward-Quinlan loams, 3 to 8 percent slopes, eroded.....	6	10				
Ya	Yahola fine sandy loam.....	14	19	24	33	2.2	3.0
Za	Zavala fine sandy loam.....	12	17	22	32	2.0	2.8

¹ Oven-dry weight. Multiply by 3 for approximate green weight.

plant diseases; (3) terracing and contour farming where necessary; (4) selection of suitable improved crop varieties; (5) management of crop residues and tillage by suitable methods, so as to control erosion and conserve moisture; and (6) fertilization for maximum economic returns.

Specific conservation practices are discussed in the subsection "Management by Capability Units." Information on suitable improved crop varieties and on fertilizer applications can be obtained from the county agent or from technicians of the Soil Conservation Service.

Irrigation

Irrigation is expensive, but with an efficient irrigation system, yields can be doubled and in some cases quadrupled. The major factors that determine the feasibility of irrigation are the nature of the soil and the quality and quantity of water available (3).⁴

To be suitable for irrigation, a soil must be productive; it must have capacity to store enough water to meet the needs of plants; it must not be too sloping; it must be

⁴ Italic numbers in parentheses refer to Literature Cited, p. 79.

permeable enough that salts will not accumulate; and it must be deep enough to allow for any necessary leveling and to provide an adequate root zone. The soils of Ellis County that are best suited to irrigation are—

Bayard fine sandy loam.
 Carey silt loam, 1 to 3 percent slopes.
 Dalhart fine sandy loam, 1 to 3 percent slopes.
 Enterprise very fine sandy loam, 1 to 3 percent slopes.
 Mansic clay loam, 1 to 3 percent slopes.
 Miles fine sandy loam, 1 to 3 percent slopes.
 Richfield clay loam, 1 to 3 percent slopes.
 St. Paul silt loam, 0 to 1 percent slopes.
 St. Paul silt loam, 1 to 3 percent slopes.
 Spur loam.
 Tipton silt loam, high.
 Wann fine sandy loam.
 Yahola fine sandy loam.
 Zavala fine sandy loam.

Irrigation of these soils is more profitable than irrigation of sandy soils or of more strongly sloping soils.

The main sources of water for irrigation in Ellis County are spring-fed streams of the red beds, underground water in the Ogallala formation, and underground water in the alluvial material along major streams. The depth to the static water level ranges from only a few feet near the streams to about 100 feet in the Ogallala formation.

The quality of the underground water generally is good, but in some places near streams it is poor. The quantity varies from 50 to 800 gallons per minute. About 10 gallons per minute is needed for each acre of irrigated land.

To tap the sources of underground water, wells are needed. Each well should be subjected to a 24- to 48-hour pumping test, which will determine the drawdown, the pumping lift, and the capacity of the well. This information is essential in the selection of an efficient pumping plant and the design of an irrigation system.

A water right is necessary, and it is advisable to acquire one before investing in an irrigation system. An application for a water right must be filed with the Oklahoma Planning and Resources Board.

A surface system is best for some of the soils in this county, and a sprinkler system for others. The selection of a system depends on several factors, including the lay of the land, the cost of leveling, and the kind of crops to be grown. The main types of surface irrigation used in the county are border and furrow. A border system is best suited to loamy soils that have slopes of less than 3 percent. For efficient use of water, a border system requires land leveling, a fairly large stream of water, corrugations on clayey soils, short runs on sandy soils, and close-growing crops on slopes of more than 1 percent.

A furrow system is suitable for all soils that have slopes of less than 5 percent. Small amounts of water can be distributed evenly by this system, and row crops can be irrigated easily. The limitations of a furrow system are the need for short runs on sandy soils and for complicated layouts on rolling land; the maintenance requirements; and the difficulty it causes in harvesting crops.

A sprinkler system is best for nearly level to steep, sandy and loamy soils. The advantages of such a system are that it does not require land leveling, ditches, or a surface drainage system, and that the equipment can be moved from field to field. The disadvantages are the high cost of installation and maintenance, the difficulty of moving a portable system in cultivated fields, the risk of increased fungus growth, and the failure of some crops to

bear fruit if the blossoms are sprinkled. Sprinkler irrigation is not suitable for clayey soils, which take in water slowly.

All crops commonly grown in the county can be grown under irrigation, but irrigated soils need intensive management for control of erosion and maintenance of productivity. A legume should be grown 1 year in 6. Close-growing crops should be grown on steep slopes to help control erosion. If markets are available, irrigation of truck crops and of grass grown for seed is profitable.

Range Management ⁵

About 70 percent of the acreage of Ellis County is used as native range, and about 30 percent is cultivated. Much of the cultivated land is used for the production of feed for livestock.

About 40,000 beef cattle and 4,700 milk cows are kept on the ranches and livestock farms in this county. Cow-calf enterprises constitute the major source of income. Steer-feeding is another source. If small grain is available for grazing, steers may be bought or held over for a year.

The range sites and the general management practices appropriate for most of the rangeland in this county are discussed in this section.

Range sites and condition classes

Different kinds of soils produce different kinds and amounts of range vegetation. Soils enough alike to produce about the same kinds and amounts make up what is called a range site. Each range site produces a distinctive kind of climax vegetation and has management requirements different from those of other range sites. Climax vegetation is the stabilized plant community on a particular site; it reproduces itself and does not change in composition so long as the environment does not change. Generally, the climax vegetation is the most productive combination of forage plants that will grow on a range site.

Range condition is a measure of the present state of the vegetation in relation to the climax vegetation. Four classes of range condition are used to indicate the degree to which the vegetative cover has changed as a result of grazing or other uses. A range is in excellent condition if more than 75 percent of the cover consists of plants that are included in the climax vegetation; it is in good condition if the percentage is between 50 and 75, in fair condition if the percentage is between 25 and 50, and in poor condition if the percentage is less than 25.

Range that is in good or excellent condition yields the most forage and is best protected against loss of soil and water. To keep range in such condition, it is necessary to know what plants each site is capable of producing, to know what management practices will favor the plants that provide the best forage, and to recognize evidence of improvement in or deterioration of range condition. Gradual changes in the vegetation may be overlooked or misunderstood. Extra growth following rain may lead to the conclusion that the range is improving, when actually the long-time trend is toward poorer grasses and lower production. On the other hand, range that has been closely grazed but carefully managed may have a degraded

⁵ By ERNEST C. SNOOK and JACK ENGLEMAN, range conservationists, Soil Conservation Service.

appearance that temporarily conceals its quality and its ability to recover.

Grouping plants according to their response to grazing is an aid in determining range condition. Three groups are used: decreaseers, increaseers, and invaders.

Decreaseers are plants in the climax vegetation that decrease in abundance under continued heavy grazing. Generally, these are the most productive plants on a given site and the ones most palatable to livestock. They tend to recover if grazing pressure is reduced.

Increaseers are plants in the climax vegetation that generally increase in abundance as decreaseers decline. Some plants may increase at first but then decrease if heavy grazing is continued. Increaseers are normally shorter, less productive, and less palatable to livestock than decreaseers. Most of them are displaced by decreaseers under light grazing, but some, such as western ragweed and pricklypear, may have to be controlled by other means.

Invaders are plants that are not part of the climax vegetation. They may be native to nearby sites, or they may have been transported from a considerable distance. Generally, they are less productive, less palatable, and less dependable for forage than the climax plants.

Descriptions of range sites

In this subsection the range sites in Ellis County are described; the soils in each are listed; and the important characteristics and the names of the principal grasses are given.

BREAKS RANGE SITE

This site is made up entirely of Rough broken land. This land type is on steeply sloping uplands and includes deep and steep-walled canyons that impede the movement of livestock. The soils are loamy, and generally they are very shallow, but there are pockets of deeper soils intermixed with scattered barren areas.

Little bluestem and sand bluestem are dominant if the range is in excellent condition. Sideoats grama and hairy grama are the principal increaseers. Invading plants include sand dropseed, red three-awn, and western ragweed. Depletion of the vegetation through overgrazing results in rapid erosion on the steeper slopes and in the canyons.

The area of this site is almost 7,000 acres.

DEEP SAND RANGE SITE

This site consists of deep, sandy soils on uplands. Water intake is rapid, and there are only a few drainageways, because little water runs off. The soils in this site are—

- Likes loamy fine sand.
- Pratt loamy fine sand, hummocky.
- Pratt loamy fine sand, undulating.
- Pratt-Tivoli loamy fine sands.

Small amounts of sand sagebrush and skunkbrush are normal on this site, but sand bluestem, little bluestem, and switchgrass are dominant if the range is in excellent condition. Productivity varies within the site because of the variation in the slope. Sand lovegrass, sand paspalum, blue grama, fall switchgrass, and sagebrush are the common increaseers. Under poor management the production of grass declines, and sand sagebrush, sand dropseed, and annuals take over.

The area of this site is a little more than 100,000 acres.

DEEP SAND SAVANNAH RANGE SITE

This site consists of deep, gently sloping or rolling soils on uplands. Water intake is rapid. Much of the moisture is held in the upper part of the profile, because the underlying material is finer textured. The soils in this site are—

- Brownfield fine sand, 1 to 3 percent slopes.
- Nobscot fine sand, rolling.
- Nobscot-Brownfield fine sands, hummocky.

A scattering of shinnery oak is normal on this site, but little bluestem, sand bluestem, and switchgrass provide the bulk of the forage if the range is in excellent condition. Oak, hairy grama, and sand paspalum are the principal increaseers. Red lovegrass, western ragweed, and annuals are the common invaders. Brush control is one of the measures needed in a program to improve the range.

The area of this site is a little more than 125,000 acres.

DUNE RANGE SITE

This site consists only of Tivoli fine sand, a soil that occurs in areas of steep sand dunes. Grazing should be carefully controlled on this site. Trampling of the steep, loose soil causes considerable damage, and heavy grazing destroys much of the vegetative cover. These dunes readily become active if the vegetative cover is depleted.

Even if the range is in excellent condition, woody plants, such as skunkbush, grapevines, and sandbar willow, make up a considerable part of the cover, but the dominant vegetation is sand bluestem, sand lovegrass, little bluestem, big sandreed, and lemon scurfpea. The principal increaseers are sand paspalum and sand dropseed.

The area of this site is a little more than 3,000 acres.

ERODED SANDY LAND RANGE SITE

This site consists of severely eroded, sandy uplands. Fields once cultivated have been badly gullied. In this site are—

- Eroded sandy land.
- Nobscot-Brownfield complex, severely eroded.

This site is not suited to short grasses. The taller grasses, such as little bluestem, sand bluestem, indiagrass, and switchgrass, should be encouraged. Seeding may be necessary in some places. Sand paspalum and hairy grama are important increaseers. Red lovegrass, sand dropseed, and annuals are common invaders.

The area of this site is about 6,600 acres.

GRAVELLY SANDY RANGE SITE

This site consists of Gravelly broken land, a land type made up of coarse, gravelly, sandy soils on moderate to steep slopes. This land type is in the southern part of the county.

Little bluestem is dominant if the range is in excellent condition, but sideoats grama, sand bluestem, hairy grama, and climax forbs make up a considerable part of the cover. Sideoats grama, hairy grama, and buffalo-grass are the common increaseers. Sand dropseed, hairy tridens, western ragweed, brush, and annuals are common invaders.

The area of this site is a little less than 3,000 acres.

HARDLAND RANGE SITE

This site consists of deep, loamy soils on nearly level to moderately sloping uplands. Nearly all of the acreage is farmed. The soils in this site are—

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

Generally, this site is considered a short-grass range. Most of it has a cover of buffalograss, blue grama, and weeds. If the range is in excellent condition, the cover contains a considerable amount of bluestem, switchgrass, western wheatgrass, and sideoats grama. Heavy grazing rapidly depletes the better grasses; compaction decreases the intake of water and makes the effects of drought more serious. Blue grama and buffalograss are the principal increasers. Silver bluestem, sand dropseed, western ragweed, and annuals are the common invaders.

The area of this site is a little more than 50,000 acres.

LIMY SANDY PLAINS RANGE SITE

This site consists of deep, loamy and sandy soils on hummocky and undulating uplands. These soils are underlain by a highly calcareous layer at various depths. The soils in this site are—

Otero soils, hummocky.
 Otero soils, undulating.
 Otero-Mansker complex.

This site produces a good cover of mid and tall grasses. Sand bluestem, little bluestem, and sideoats grama are dominant if the range is in excellent condition. Heavy grazing results in an increase in sideoats grama and blue grama. If heavy grazing is continued, the site is invaded by hairy grama, buffalograss, red three-awn, hairy tridens, and western ragweed.

The area of this site is about 15,000 acres.

LOAMY BOTTOM LAND RANGE SITE

This site consists of deep, loamy soils that are on bottom lands and are subject to overflow. Most of the acreage is cultivated. Runoff from higher areas furnishes extra moisture, but ordinarily no moisture from the permanent water table is within reach of grass roots. In this site are—

Bayard fine sandy loam.
 Loamy alluvial land.
 Spur loam.
 Wann fine sandy loam.
 Yahola fine sandy loam.
 Zavala fine sandy loam.

Sand bluestem, little bluestem, switchgrass, and indian-grass are dominant if the range is in excellent condition. Sideoats grama, blue grama, vine-mesquite, and western wheatgrass are common increasers. Invading plants include silver bluestem, western ragweed, and sand dropseed. Short grasses and annuals become dominant in areas that are continuously overgrazed.

The area of this site is a little less than 30,000 acres.

LOAMY PLAINS RANGE SITE

This site consists of moderately shallow, loamy soils on gently sloping to steep uplands. These soils are 10 to 20 inches thick and are underlain by a layer of caliche gravel. They are friable, and if the plant cover is maintained they take in water readily. This site is adjacent to caliche outcrops and to Potter soils. Areas made up of the Mansker-

Potter complex are included in this site. The soils in this site are—

Mansker loam, 1 to 3 percent slopes.
 Mansker loam, 3 to 5 percent slopes.
 Mansker soil in Mansker-Potter complex, 3 to 5 percent slopes.
 Mansker soil in Mansker-Potter complex, 5 to 20 percent slopes.

The principal grasses are little bluestem, sand bluestem, and sideoats grama if the range is in excellent condition. Little bluestem is the dominant decreaser. Sideoats grama, blue grama, buffalograss, and a variety of climax forbs are the increasers. Red three-awn and broom snake-weed are common invaders.

The area of this site is a little less than 70,000 acres.

LOAMY PRAIRIE RANGE SITE

This site consists of moderately deep and deep, loamy soils on uplands. These soils take in water readily if a mulch is kept on the surface. Most of the acreage is cultivated. Much of that remaining in native vegetation is on the steeper slopes or consists of small acreages associated with shallower soils. The soils in this site are—

Breaks-alluvial land complex.
 Carey silt loam, 1 to 3 percent slopes.
 Enterprise very fine sandy loam, 1 to 3 percent slopes.
 Enterprise very fine sandy loam, 3 to 5 percent slopes.
 Enterprise very fine sandy loam, 5 to 8 percent slopes.
 Enterprise very fine sandy loam, 8 to 20 percent slopes.
 Mansic clay loam, 1 to 3 percent slopes.
 Mansic clay loam, 3 to 5 percent slopes.
 Mansic clay loam, 3 to 8 percent slopes, eroded.
 Mansic clay loam, 5 to 8 percent slopes.
 Berthoud soil in Potter-Berthoud complex.
 Woodward soil in Quinlan-Woodward loams, 8 to 20 percent slopes.
 Tipton silt loam, high.
 Woodward loam, 1 to 3 percent slopes.
 Woodward loam, 3 to 5 percent slopes.
 Woodward soil in Woodward-Quinlan loams, 3 to 8 percent slopes, eroded.
 Woodward soil in Woodward-Quinlan loams, 5 to 12 percent slopes.

If in excellent condition, this site supports a cover of sand bluestem, little bluestem, and sideoats grama. Heavy grazing results in an increase in sideoats grama and blue grama. If heavy grazing is continued, there is a considerable increase in western ragweed, common broomweed, blue grama, buffalograss, and sand dropseed.

The area of this site is almost 160,000 acres.

RED CLAY PRAIRIE RANGE SITE

This site consists only of the Vernon complex, a complex of strongly sloping to steep, shallow to moderately deep, loamy soils. This site is in the southeastern part of the county.

If in excellent condition, this site supports a cover of little bluestem, sideoats grama, sand bluestem, and blue grama. Blue grama and buffalograss become dominant in areas where heavy grazing has eliminated the more desirable grasses, destroyed the ground litter, and damaged the structure of the surface soil.

The area of this site is about 6,000 acres.

SANDY BOTTOM LAND RANGE SITE

This site is made up entirely of Lincoln soils. These are sandy soils on bottom lands of rivers and large creeks.

They are subject to overflow, and they receive runoff from adjacent uplands. Small areas that have a high water table during part of the growing season are included in this site.

This site normally supports a cover of tall grasses, such as indiagrass, switchgrass, little bluestem, and sand bluestem. An increase in sand dropseed, silver bluestem, woody plants, and annuals is a sign of deterioration of the site.

The area of this site is about 15,000 acres.

SANDY PLAINS RANGE SITE

This site consists of deep, gently sloping to moderately steep, loamy soils on undulating and hummocky uplands. These soils take water readily if properly managed. A large part of the acreage is cultivated. The soils in this site are—

- Berthoud fine sandy loam, 3 to 5 percent slopes.
- Berthoud fine sandy loam, 5 to 12 percent slopes.
- Broken land.
- Carville-Pratt complex.
- Dalhart fine sandy loam, 1 to 3 percent slopes.
- Dalhart fine sandy loam, 3 to 5 percent slopes.
- Manter-Otero fine sandy loams, 1 to 3 percent slopes.
- Manter-Otero fine sandy loams, 3 to 5 percent slopes.
- Miles fine sandy loam, 1 to 3 percent slopes.
- Miles fine sandy loam, 3 to 5 percent slopes.
- Pratt fine sandy loam, hummocky.
- Pratt fine sandy loam, undulating.

Some sand sagebrush is normal on this site, but sand bluestem and little bluestem are dominant if the range is in excellent condition. Sideoats grama, blue grama, and tall dropseed are common increasers. Invading plants include sand dropseed, western ragweed, sand sagebrush, and annuals.

The area of this site is a little less than 124,000 acres.

SHALLOW RANGE SITE

This site consists of loamy upland soils that are moderately sloping to steep and are very shallow over caliche. The Potter soils mapped as part of the Mansker-Potter complex generally are on the steep slopes. The soils in this site are—

- Potter soil in Mansker-Potter complex, 3 to 5 percent slopes.
- Potter soil in Mansker-Potter complex, 5 to 20 percent slopes.
- Potter soil in Potter-Berthoud complex.
- Potter soils.
- Potter-Mansker complex, severely eroded.

Little bluestem and sideoats grama are the principal grasses if the range is in excellent condition. Little bluestem is the dominant decreaser. Sideoats grama, hairy grama, blue grama, buffalograss, and a variety of forbs are increasers. Red three-awn and broom snakeweed are common invaders.

The area of this site is about 31,000 acres.

SHALLOW PRAIRIE RANGE SITE

This site consists of very shallow, moderately sloping to steep, loamy soils over red beds. A small percentage of the acreage consists of barren slopes and of bottoms of draws that are less than 150 feet wide. The soils in this site are—

- Quinlan soil in Quinlan-Woodward loams, 8 to 20 percent slopes.

Quinlan soil in Woodward-Quinlan loams, 3 to 8 percent slopes, eroded.

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

Little bluestem and sand bluestem make up most of the cover if the range is in excellent condition. Under heavy grazing, sideoats grama and blue grama increase. If heavy grazing is continued, the site is invaded by sand dropseed, silver bluestem, and western ragweed, and erosion increases.

The area of this site is a little less than 10,000 acres.

SUBIRRIGATED RANGE SITE

This site is made up of soils on bottom lands along creeks and rivers. The water table varies from season to season, but it is always within reach of the roots of the best range grasses. The soils in this site are—

- Elsmere loamy fine sand.
- Sweetwater soils.

Switchgrass and indiagrass are dominant if the range is in excellent condition. Eastern gamagrass, cordgrass, and common reed occur in lesser amounts. Tall dropseed, inland saltgrass, bullrush, and alkali sacaton are common increasers. Silver bluestem is a common invader. Silver bluestem, inland saltgrass, alkali muhly, western ragweed, and annuals invade if the range is in poor condition.

This is the most productive range site in the county, but it is of limited extent. The area is a little less than 14,000 acres.

Range site productivity

Data on actual production of herbage in the county are limited. Table 3 gives estimates of annual yields for each range site during both favorable and unfavorable weather cycles. Yields may be higher if the weather is unusually favorable for a year or two in a period of favorable weather, and they may be lower if there are periods of extreme drought during unfavorable weather.

TABLE 3.—*Estimated average acre yields of herbage during favorable and unfavorable weather*

Range site	Total annual yield of air-dried herbage	
	Favorable weather	Unfavorable weather
	<i>Pounds per acre</i>	<i>Pounds per acre</i>
Breaks.....	1,800	1,200
Deep Sand.....	3,500	1,400
Deep Sand Savannah.....	3,900	1,600
Dune.....	1,600	800
Eroded Sandy Land.....	2,500	1,300
Gravelly Sandy.....	1,500	600
Hardland.....	3,000	1,300
Limy Sandy Plains.....	2,300	1,000
Loamy Bottom Land.....	5,500	2,000
Loamy Plains.....	3,000	1,500
Loamy Prairie.....	3,800	1,800
Red Clay Prairie.....	2,200	1,000
Sandy Bottom Land.....	3,500	2,000
Sandy Plains.....	4,000	2,000
Shallow.....	2,000	1,200
Shallow Prairie.....	2,500	900
Subirrigated.....	8,000	6,000

The estimates are for range in excellent condition, and they are based on the total amount of air-dried herbage, clipped to the ground. Some of the herbage produced, however, is consumed by rodents and insects, and some is lost through weathering. If grazing is managed so that half of the current annual growth is left, only about 25 to 35 percent may have been consumed by the livestock.

Range management practices

Good range management increases or maintains the number of the best native forage plants and encourages their growth. The main practices needed are the following.

PROPER GRAZING.—Proper grazing is the most important of all range practices and is the foundation of range conservation. In their green leaves, grasses and other plants manufacture the food they need to grow and reproduce. If too much of this green foliage is removed by grazing or mowing, the plant is weakened and stunted. If grazing is controlled so that no more than half of their annual growth is removed, the more desirable forage plants survive.

Management of grazing is a separate problem for each pasture. Some pastures are made up of a mixture of range sites, and there may be different range conditions within one site and within one pasture. Local agricultural agencies have qualified technical personnel who can assist in classifying range according to site and condition class and who can offer suggestions on changes in present grazing practices or suggest a starting rate of grazing.

DEFERRED GRAZING.—Periodically postponing or deferring grazing for a prescribed time during the growing season improves the vigor of plants, allows the better grasses to increase, and improves the overall productivity of the range.

Maximum range improvement can be expected if grazing is deferred during the entire growing season. Deferment during spring increases the vigor and productivity of warm-season grasses. Deferment during fall generally increases the production of seed. Deferment during summer is important in heavily grazed, rough areas, in newly seeded areas, and in sites that are subject to damage by erosion, such as the Eroded Sandy Land site and the Shallow site. Deferred grazing is needed in areas that have been treated for brush control or weed control, to allow the climax grasses to seed and increase.

DISTRIBUTION OF GRAZING.—To obtain an even distribution of grazing is a problem, especially if the pasture is made up of several range sites. Cattle tend to stay away from some parts and to concentrate on other parts. In some pastures, such as those made up of upland and bottom-land areas in the Shallow Prairie site, fences may be necessary for the proper control of grazing. Placing salt in different places from time to time helps to distribute grazing.

It is important that each pasture have a source of water that is dependable during the grazing period (fig. 14). Proper distribution of water facilities encourages uniform grazing of the range and reduces trailing. Generally, water is supplied by ponds, wells, springs, or pipelines. Topography needs to be considered in deciding how far apart watering facilities can be. In areas of broken land watering places should be closer together than in other areas.

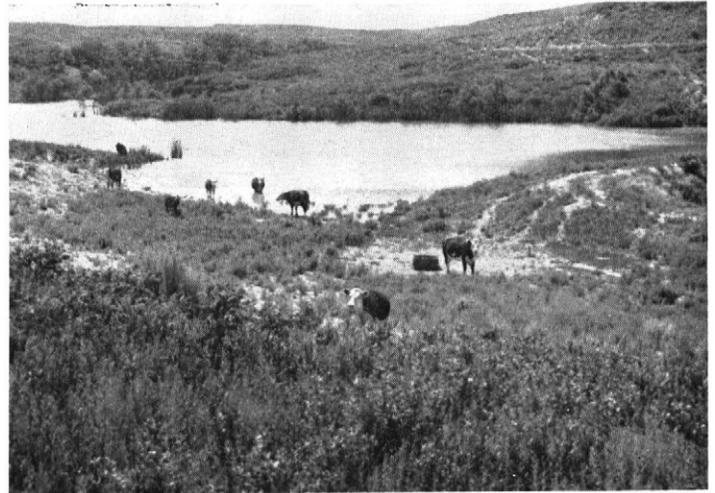


Figure 14.—Ranch ponds provide water for livestock, can be used in a flood-control program, and can be stocked with fish.

RANGE SEEDING.—Seeding depleted cropland and areas not suitable for cultivation is one of the conservation practices most important in Ellis County. About 82,000 acres have been seeded to native grasses.

The seed mixture should be one suitable for the particular range site. The native plants listed in the descriptions of the range sites give the most satisfactory results (fig. 15). Sandy soils, such as the Likes, Pratt, and Nobscot, should be seeded to a mixture of tall and mid grasses. These soils are open and lose little water through runoff. Loamy soils, such as the Mansic, Mansker, and Woodward, should be seeded to a mixture of tall, mid, and short grasses. These soils tend to be droughty and in this rainfall belt do not support so large a proportion of the tall and mid grasses as the sandy soils.

For seeding grasses on soils protected by sorghum stubble, it is best to use a specially designed grass-seed drill.

Information on seeding rates can be obtained from the local agricultural agencies. Generally, it is best to seed



Figure 15.—A field that has been seeded to a mixture of native grasses.



Figure 16.—Deep Sand Savannah range site where shinnery oak was sprayed for 2 years and grazing was deferred in the summer.

native grasses in March and April, but plantings made in January and February have been successful.

Mowing newly seeded areas is not always necessary for control of weeds. It is important to keep cattle off these areas until a good stand of grass is established. Even if the seedlings are too small to be grazed, trampling causes considerable damage.

CONTROL OF WEEDS AND BRUSH.—Brush and weed infestation is a result of the destruction of the original grass sod. As a rule, it is best to allow the natural succession of native plants to crowd out weeds, but chemical sprays may be needed in some places. Mowing or beating is of doubtful value, since good grasses are cut off closely along with the weeds.

Forage yields increase if brush is controlled, but it is more difficult to control brush than to control weeds. Natural succession operates very slowly, since woody plants are long lived and deep rooted. On range that has a cover of sand sagebrush, shinnery oak, skunkbush, and other woody plants, brush can be controlled by the use of chemical sprays (fig. 16) or by mechanical methods. Because of the danger of erosion, it is generally not safe to destroy all the woody plants on steep, choppy sand dunes.

Woodland and Windbreaks ^o

Large areas of the soils of Ellis County developed under forest cover, but there is not enough rainfall to support commercial stands of trees. Remnants of the original stands of post oak, blackjack oak, and shin oak still occupy sizable areas in the uplands. Cottonwood, willow, American elm, hackberry, and bur oak grow on the bottom lands and terraces, and redcedar grows in the rougher areas that border some parts of the streams. Trees of some of these species were important in the economy when the area was first settled, and some oak, elm, and cedar are still cut.

More than 76 miles of field windbreaks have been planted in this county since 1938, but most of the plantings have not been effective in controlling wind erosion. Many were on soils not suitable for trees, and others failed because of lack of cultivation and lack of protection from fire and grazing. The plantings that were successful have demon-

strated the effectiveness of certain species of trees and shrubs for windbreak plantings on several soils in the county.

Table 4 shows the suitability of the soils for field windbreaks, farmstead windbreaks, and post-lot plantings. Some soils are limited in suitability because of shallowness or other unfavorable profile characteristics. Others are limited because plantings would require extra tillage, extra water, or very wide spacing.

To be effective, field windbreaks should be planted in a protective pattern of belts around fields and across large fields. The distance that can be left between belts depends on the characteristics of the soils, the kind of crops to be grown, and the height the trees will reach at maturity. Because of the shortage of moisture, extra space is needed between trees; consequently, a field windbreak occupies a considerable area. Windbreaks are economically practical for the protection of special crops and to help control blowing of overhead irrigation water, but the benefits should be weighed against the benefits to be derived from improved management and suitable cropping systems.

Farmstead windbreaks (fig. 17) are practical, and they are needed in this county. They make the farm home more comfortable, help to reduce fuel costs, and protect livestock from the sun and the wind. They occupy a small area, even if planted on the south, west, and north for year-round protection.

Generally, farmstead windbreaks need not be so high as field windbreaks. Because of this, they can be planted on many soils that are not suitable for field windbreaks, especially if supplemental water can be applied during prolonged droughts.

Trees and shrubs suitable for windbreaks include redcedar, Rocky Mountain juniper, Chinese elm, Siberian elm, one-seed juniper, and the nonornamental arborvitae. Austrian pine and ponderosa pine make fine windbreaks, but they are difficult to establish unless supplemental water can be applied during dry periods.

To be fully effective, belts of no less than three rows (two rows of trees and one row of shrubs) are needed for farmstead and field windbreaks in areas that are not irrigated. Fewer rows are needed if the windbreak is irrigated and if the plantings consist of juniper, arborvitae, and other species that provide protection at ground level the year round. On a dryland site, the most reliable shrubs are desert willow and Kashgar tamarix. They are



Figure 17.—A typical farmstead windbreak.

^o By HEBERT R. WELLS, woodland and biology specialist, Soil Conservation Service.

TABLE 4.—*Suitability of soils for field windbreaks, farmstead windbreaks, and post-lot plantings*

Soil	Soil suitability		
	Field windbreak	Farmstead windbreak	Post lot
Bayard fine sandy loam	Suitable	Suitable	Suitable with limitations.
Berthoud fine sandy loam, 3 to 5 percent slopes	Not suitable	Suitable	Not suitable.
Berthoud fine sandy loam, 5 to 12 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Blown-out land	Not suitable	Not suitable	Not suitable.
Breaks-alluvial land complex	Not suitable	Suitable with limitations	Not suitable.
Broken land	Not suitable	Suitable with limitations	Not suitable.
Brownfield fine sand, 1 to 3 percent slopes	Suitable with limitations	Suitable	Not suitable.
Carey silt loam, 1 to 3 percent slopes	Suitable with limitations	Suitable	Not suitable.
Carwile-Pratt complex	Suitable with limitations	Suitable with limitations	Suitable with limitations.
Dalhart fine sandy loam, 1 to 3 percent slopes	Suitable with limitations	Suitable	Suitable with limitations.
Dalhart fine sandy loam, 3 to 5 percent slopes	Suitable with limitations	Suitable	Suitable with limitations.
Elsmere loamy fine sand	Suitable with limitations	Suitable	Suitable.
Enterprise very fine sandy loam, 1 to 3 percent slopes	Suitable with limitations	Suitable	Suitable with limitations.
Enterprise very fine sandy loam, 3 to 5 percent slopes	Suitable with limitations	Suitable	Suitable with limitations.
Enterprise very fine sandy loam, 5 to 8 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Enterprise very fine sandy loam, 8 to 20 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Eroded sandy land	Not suitable	Suitable with limitations	Not suitable.
Gravelly broken land	Not suitable	Not suitable	Not suitable.
Likes loamy fine sand	Not suitable	Suitable with limitations	Not suitable.
Lincoln soils	Suitable with limitations	Not suitable	Suitable.
Loamy alluvial land	Suitable with limitations	Not suitable	Suitable.
Mansic clay loam, 1 to 3 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Mansic clay loam, 3 to 5 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Mansic clay loam, 5 to 8 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Mansic clay loam, 3 to 8 percent slopes, eroded	Not suitable	Suitable with limitations	Not suitable.
Mansker loam, 1 to 3 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Mansker loam, 3 to 5 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Mansker-Potter complex, 3 to 5 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Mansker-Potter complex, 5 to 20 percent slopes	Not suitable	Not suitable	Not suitable.
Manter-Otero fine sandy loams, 1 to 3 percent slopes	Suitable with limitations	Suitable	Not suitable.
Manter-Otero fine sandy loams, 3 to 5 percent slopes	Suitable with limitations	Suitable	Not suitable.
Miles fine sandy loam, 1 to 3 percent slopes	Suitable with limitations	Suitable	Suitable with limitations.
Miles fine sandy loam, 3 to 5 percent slopes	Suitable with limitations	Suitable	Suitable with limitations.
Nobscoot fine sand, rolling	Not suitable	Not suitable	Not suitable.
Nobscoot-Brownfield fine sands, hummocky	Suitable with limitations	Suitable	Not suitable.
Nobscoot-Brownfield complex, severely eroded	Not suitable	Not suitable	Not suitable.
Otero soils, undulating	Not suitable	Suitable with limitations	Not suitable.
Otero soils, hummocky	Not suitable	Suitable with limitations	Not suitable.
Otero-Mansker complex	Not suitable	Suitable with limitations	Not suitable.
Potter soils	Not suitable	Not suitable	Not suitable.
Potter-Berthoud complex	Not suitable	Not suitable	Not suitable.
Potter-Mansker complex, severely eroded	Not suitable	Not suitable	Not suitable.
Pratt fine sandy loam, undulating	Suitable with limitations	Suitable	Suitable with limitations.
Pratt fine sandy loam, hummocky	Suitable with limitations	Suitable	Suitable with limitations.
Pratt loamy fine sand, undulating	Suitable	Suitable	Suitable with limitations.
Pratt loamy fine sand, hummocky	Suitable	Suitable	Suitable with limitations.
Pratt-Tivoli loamy fine sands	Not suitable	Suitable with limitations	Not suitable.
Quinlan-Woodward loams, 8 to 20 percent slopes	Not suitable	Not suitable	Not suitable.
Richfield clay loam, 1 to 3 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Richfield clay loam, 3 to 5 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Rough broken land	Not suitable	Not suitable	Not suitable.
St. Paul silt loam, 0 to 1 percent slopes	Suitable with limitations	Suitable	Not suitable.
St. Paul silt loam, 1 to 3 percent slopes	Suitable with limitations	Suitable	Not suitable.
Spur loam	Suitable with limitations	Suitable with limitations	Suitable with limitations.
Sweetwater soils	Suitable with limitations	Not suitable	Suitable.
Tipton silt loam, high	Suitable with limitations	Suitable	Suitable.
Tivoli fine sand	Not suitable	Not suitable	Not suitable.
Vernon complex	Not suitable	Not suitable	Not suitable.
Wann fine sandy loam	Suitable	Suitable	Suitable.
Woodward loam, 1 to 3 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Woodward loam, 3 to 5 percent slopes	Not suitable	Suitable with limitations	Not suitable.
Woodward-Quinlan loams, 3 to 8 percent slopes, eroded	Not suitable	Suitable with limitations	Not suitable.
Woodward-Quinlan loams, 5 to 12 percent slopes	Not suitable	Not suitable	Not suitable.
Yahola fine sandy loam	Suitable	Suitable with limitations	Suitable.
Zavala fine sandy loam	Suitable	Suitable with limitations	Suitable.

particularly effective if mowed to ground level every 2 years. Local nurseries can supply ornamental shrubs suitable for irrigated sites.

Some farms and ranches have small areas that are suitable for post lots. The trees most commonly planted for posts are black locust, catalpa, and osage-orange. Except for closer spacing of trees, planting and management are about the same as for windbreaks. After some trees have been cut, the sprouts that develop should be thinned and cultivated for later harvests.

Wildlife and Fish ⁷

Ellis County is dissected by the tributaries of Wolf Creek, the North Canadian (Beaver) River, and the South Canadian River. The numerous streams and the upland areas between the streams provide habitats for many kinds of wildlife. The most common wildlife species are present throughout the county, but the number varies with the native vegetation and the crops grown.

The common birds are bobwhite quail, mourning dove, waterfowl, and many species that eat small insects and seeds. Less common are the ringnecked pheasant, scaled quail, wild turkey, golden eagle, and the lesser prairie chicken. Hawks and owls help to control rodents. The common mammals are cottontail rabbit, jack rabbit, coyote, raccoon, opossum, and skunk. Less common are fox, squirrel, deer, badger, beaver, kit fox, and mink.

In the central and southern parts of the county are large areas of sandy soils, including those of the Nobscot-Brownfield association, the St. Paul-Manter-Dalhart association, the Likes-Otero association, and the Broken land-Berthoud-Enterprise association. These areas, and less extensive tracts of similar soils elsewhere in the county, are well suited to wildlife. The extensive grasslands in these associations support the densest population of lesser prairie chickens in Oklahoma. The numbers of prairie chickens are now increasing in other parts of the county where cropland is being converted to grassland.

The soils of the associations just mentioned are less droughty than finer textured soils, and they are more dependable in providing food and cover for wildlife. They support a variety of tall perennial grasses, such as switchgrass, sand lovegrass, and bluestem. Small clumps and sizable stands of skunkbush, sumac, wild plum, sand sagebrush, shin oak, post oak, and blackjack oak are scattered over the grassland. Several kinds of wild legumes, annual grasses, and broad-leaved plants provide seed and forage the year round.

The many small fields of grain on the better sandy soils attract a large number of quail and some prairie chickens and doves. Fence rows, rights-of-way, and similar strips that are left unmowed provide food and cover for wildlife. Disking the field borders or other areas helps to encourage the growth of grass and weeds, the seeds of which are valuable as food.

Areas of Quinlan and Woodward soils and the steep areas of Rough broken land along the bottom lands of the South Canadian River both provide suitable habitats for deer and turkey. The principal trees are oak, cottonwood, elm, hackberry, and a variety of smaller species, such as

redcedar and chittamwood. The Nobscot soils north of these areas support acorn-producing trees and provide additional food for deer and turkey. Moderate grazing, protection from fire, and regulation of hunting are necessary if deer and turkey are to become important in the county.

The native vegetation on the Mansker, Potter, Richfield, Woodward, Carey, and St. Paul soils in the northern part of the county is characterized by short grasses and by fewer woody plants than the sandy soils. These soils support a sparse cover, consisting mostly of grama, buffalograss, and little bluestem. Annual broad-leaved plants provide seed and forage for wildlife. About 60 percent of the acreage is cultivated. Weeds and waste grain are important sources of food. Undisturbed fence rows and vegetated field borders provide suitable habitats for pheasants. The shallow drainageways support woody plants and tall grasses that provide food and cover for birds and small mammals.

Fisheries and natural nesting places for waterfowl are scarce. Except for a few sloughs, there are no marshlands in the county. The largest body of water is an impoundment of about 200 acres on Coon Creek. Some wildfowl live around the Fort Supply Reservoir, which is just northeast of Ellis County, and around farm ponds, which number about 600. In fall, migrating birds rest and feed in areas of cropland. Food and cover can be made available for a longer period by encouraging the growth of marsh plants above and below dams and by planting browntop millet and Japanese millet around the edge of impoundments when the water is low.

Good fishing is provided by many farm ponds and by the Canadian River, Wolf Creek, and their major tributaries. The number of fish in the ponds increases if aquatic weeds are controlled and the water is kept clear. The ponds are stocked mainly with bass, bluegill, and channel catfish. Generally, the streams contain sunfish and catfish. During periods of high water there are influxes of other kinds of fish from the larger streams outside the county.

Engineering Uses of the Soils ⁸

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion-control structures, drainage systems, irrigation systems, and sewage-disposal systems. The properties most important to the engineer are permeability, shrink-swell potential, consolidation characteristics, texture, plasticity, drainage, grain size, and reaction. Topography and depth to unconsolidated materials are also important.

The information in this report can be used to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of soil properties that will help in the planning of agricultural drainage systems, farm ponds, irrigation systems, terraces, waterways, and diversion terraces.

⁷ By HERBERT R. WELLS, woodland and biology specialist, Soil Conservation Service.

⁸ ROBERT L. BARTHOLIC and WALTER E. HART, agricultural engineers, Soil Conservation Service, assisted in the preparation of this subsection.

3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway, airport, and pipeline locations and in planning detailed investigations at selected locations.
4. Locate probable sources of gravel, sand, and other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs to make maps and reports that will be more useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depth of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Some terms used by soil scientists may not be familiar to engineers, and other terms may have special meanings in soil science. These terms are defined in the Glossary at the back of this report.

Engineering classification, interpretations, and soil test data

Engineers need to know the physical properties of the soil material and the in-place condition of the soils in order to make the best use of the soil maps and the soil survey report. The information and interpretations of most significance to engineers are presented in tables 5, 6, and 7. Additional information can be found in the sections "General Soil Map" and "Descriptions of the Soils."

Following are brief explanations of how the information in the tables was obtained and the significance of some of the items in them.

TABLE 5. Table 5 gives brief descriptions of most of the soils mapped in Ellis County and estimates of the soil properties that affect engineering work. These estimates are based on a typical profile of each soil. The soil profile is divided into significant layers by depth, in inches, from the surface. More detailed descriptions of the soils may be found in the section "Genesis, Classification, and Morphology of the Soils."

Table 5 also gives estimated engineering classifications of the major horizons of the soils in Ellis County, according to the Unified system (8) and according to the system used by the American Association of State Highway Officials (AASHO) (1).

In the AASHO system, classification is based on the physical properties of the soil material and on the field performance of the soils in highways. All soils are classified in seven basic groups: The groups range from A-1 (gravelly soils of high bearing capacity) through A-7

(clay soils having low strength when wet). Within each group, the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best materials to 20 for the poorest. The group index number is shown in parentheses after the soil group symbol, for example A-4(8). (Group index numbers for laboratory-tested soils are given in table 7.)

In the unified system, the soils are grouped on the basis of their texture and plasticity and their performance as material for engineering structures. Soil materials are identified as coarse grained, that is, gravels (G) and sands (S); fine grained, that is silts (M) and clays (C); or highly organic (O). Clean sands are identified by the symbols SW and SP; sands mixed with fines of silt and clay are identified by the symbols SM and SC; silts and clays that have a low liquid limit are identified by the symbols ML and CL; and silts and clays that have a high liquid limit are identified by the symbols MH and CH.

In an engineering handbook for hydrology⁹ developed by hydrologists of the Soil Conservation Service, the Forest Service, and other agencies, the major soils of the United States have been placed in four hydrologic groups. These groups are based on intake of water at the end of long-duration storms, after prior wetting and opportunity for swelling, without consideration of slope or the protective effects of vegetation. They indicate runoff potential and should not be confused with ratings for water yield, which indicate storage capacity.

Group A consists of soils that have a high infiltration rate, even when thoroughly wetted; they are chiefly deep, well drained or excessively drained sands or gravels or both. These soils have a high rate of water transmission and a low runoff potential.

Group B consists of soils that have a moderate infiltration rate when thoroughly wetted and that are chiefly moderately deep to deep, moderately well drained to well drained, and moderately fine textured to moderately coarse textured. These soils have a moderate rate of water transmission.

Group C consists of soils that have a slow rate of infiltration when thoroughly wetted; they are chiefly soils that have a layer that impedes downward movement of water and those soils that are moderately fine textured to fine textured. These soils have a slow rate of water transmission.

Group D consists of soils that have a very slow rate of infiltration when thoroughly wetted; they are chiefly clay soils with a high swelling potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission. (There are no class D soils in Ellis County.)

Table 5 shows the hydrologic group for each of the soils in Ellis County, according to the above classification.

Permeability is based on the rate of movement of water through the soil material in its undisturbed state. This is often referred to as the intake rate. It depends largely on the soil texture and structure.

Available water capacity refers to the amount of water that is held by a soil and that is available to plants.

⁹ ENGINEERING HANDBOOK, HYDROLOGY, SUPPLEMENT A, SEC. 4. Soil Conservation Service, USDA.

TABLE 5.—*Brief descriptions of soils*

Soil symbol	Soil name	Description of soil and site	Hydrologic soil group	Depth from surface
Ba	Bayard fine sandy loam.	Deep, loamy, well-drained soils on bottom lands; rarely flooded.	B	<i>Inches</i> 0 to 12 12 to 42
BeC	Berthoud fine sandy loam, 3 to 5 percent slopes.	Deep, loamy, well-drained, rolling to hilly, upland soils.	B	0 to 8 8 to 26
BeD	Berthoud fine sandy loam, 5 to 12 percent slopes.			
Bg	Blown-out land.	Bare, severely eroded areas consisting of soils of loamy to sandy texture; surrounded by loose sand dunes. All properties variable.		
Bk	Breaks-alluvial land complex.	Deep, well-drained, mixed loamy soils on strongly sloping to steep valley sides and small valley floors. All properties variable.		
Bn	Broken land.	Well-drained, mixed sandy land on very steep slopes. All properties variable.		
BfB	Brownfield fine sand, 1 to 3 percent slopes.	Deep, sandy, well-drained, upland soils; loamy subsoil; subject to wind erosion.	A	0 to 19 19 to 46 46 to 60
CaB	Carey silt loam, 1 to 3 percent slopes.	Deep, loamy, well-drained, upland soils; underlain by soft sandstone at a depth of 4 to 5 feet.	B	0 to 11 11 to 33 33 to 40
Cp	Carwile-Pratt complex.	Deep, loamy, imperfectly drained soils in upland depressions; compact subsoil; occasional ponding. Properties of Carwile soil described here. For properties of Pratt soil, see description of the Pratt soils.	B	0 to 10 10 to 46 46 to 60
DaB	Dalhart fine sandy loam, 1 to 3 percent slopes.	Deep, loamy, well-drained, upland soils.	B	0 to 11 11 to 36 36 to 48
DaC	Dalhart fine sandy loam, 3 to 5 percent slopes.			
Ee	Elsmere loamy fine sand.	Deep, sandy, imperfectly drained soils; water table at a depth of 3 feet.	A	0 to 12 12 to 36
EnB	Enterprise very fine sandy loam, 1 to 3 percent slopes.	Deep, loamy, well-drained, gently sloping to strongly sloping, upland soils.	B	0 to 16 16 to 60
EnC	Enterprise very fine sandy loam, 3 to 5 percent slopes.			
EnD	Enterprise very fine sandy loam, 5 to 8 percent slopes.			
EnE	Enterprise very fine sandy loam, 8 to 20 percent slopes.			
Er	Eroded sandy land.	Deep, sandy and loamy, severely gullied, upland soils. All properties variable.		
Gb	Gravelly broken land.	Deep, gravelly, excessively drained, sandy, upland soils; moderately steep to steep slopes. All properties variable.		
Lf	Likes loamy fine sand.	Deep, sandy, excessively drained, upland soils; undulating and hummocky topography.	A	0 to 13 13 to 60
Ln	Lincoln soils.	Deep, sandy, excessively drained soils on bottom lands; subject to frequent flooding.	A	0 to 7 7 to 60
La	Loamy alluvial land.	Deep, loamy, well-drained soils on bottom lands; subject to frequent flooding. All properties variable.		
McB	Mansic clay loam, 1 to 3 percent slopes.	Deep, loamy, well-drained, gently sloping to strongly sloping, upland soils.	B	0 to 13 13 to 38
McC	Mansic clay loam, 3 to 5 percent slopes.			
McD	Mansic clay loam, 5 to 8 percent slopes.			

and their estimated properties

Classification			Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
Fine sandy loam	SM, SC	A-2 or A-4		100	30 to 40	<i>Inches per hour</i> 2.5 to 5.0	<i>Inches per inch of soil</i> 0.12	Low.
Fine sandy loam	SM	A-2		100	25 to 35	2.5 to 5.0	.12	Low.
Fine sandy loam	ML	A-4		100	50 to 60	2.5 to 5.0	.12	Low.
Fine sandy loam	SM	A-4		100	40 to 50	2.5 to 5.0	.12	Low.
Fine sand	SM	A-2		100	10 to 20	5.0 to 10.0	.07	Low.
Sandy clay loam	SC	A-2 or A-4		100	30 to 40	1.0 to 2.5	.15	Low.
Fine sandy loam	SC	A-2		100	25 to 35	5.0 to 10.0	.07	Low.
Silt loam	ML, CL	A-4		100	65 to 75	0.2 to 0.8	.14	Medium.
Clay loam	ML, CL	A-6		100	65 to 75	0.2 to 0.8	.14	Medium.
Clay loam	CL	A-6		100	40 to 50	0.2 to 0.8	.12	Medium.
Sandy clay loam	CL	A-6		100	55 to 65	0.2 to 0.8	.16	Medium.
Sandy clay loam	SC or CL	A-6		100	45 to 55	0.2 to 0.8	.15	Medium.
Fine sandy loam	SC	A-2		100	25 to 35	2.5 to 5.0	.10	Low.
Fine sandy loam	SM	A-2		100	20 to 30	2.5 to 5.0	.12	Low.
Sandy clay loam	SC	A-6		100	35 to 45	0.2 to 0.8	.15	Medium.
Fine sandy loam	SM, SC	A-2 or A-4		100	30 to 40	2.5 to 5.0	.12	Low.
Loamy fine sand	SM	A-2	100	100	15 to 25	5.0 to 10.0	.10	Low.
Loamy fine sand	SM	A-2	100	95 to 100	10 to 20	5.0 to 10.0	.10	Low.
Very fine sandy loam	ML, CL	A-4		100	80 to 90	0.8 to 2.5	.14	Low.
Very fine sandy loam	ML, CL	A-4		100	75 to 85	0.8 to 2.5	.14	Low.
Loamy fine sand	SM	A-2		100	20 to 30	2.5 to 5.0	.10	Low.
Sand	SP, SM	A-2 or A-3		100	5 to 15	10.0+	.05	Low.
Loamy fine sand	SM	A-2	100	90 to 100	10 to 20	5.0 to 10.0	.10	Low.
Fine sand	SP, SM	A-1 or A-2	90 to 100	75 to 85	5 to 15	10.0+	.07	Low.
Clay loam	ML, CL	A-6		100	80 to 90	0.8 to 2.5	.15	Medium.
Clay loam	CL	A-6		100	65 to 75	0.8 to 2.5	.15	Medium.

TABLE 5.—*Brief description of soils and*

Soil symbol	Soil name	Description of soil and site	Hydro-logic soil group	Depth from surface <i>Inches</i>
McD2	Mansic clay loam, 3 to 8 percent slopes, eroded.			
MaB MaC	Mansker loam, 1 to 3 percent slopes. Mansker loam, 3 to 5 percent slopes.	Moderately shallow, loamy, well-drained, upland soils; moderately to strongly developed layer of caliche at a depth of 10 to 20 inches.	B	0 to 11 11 to 16 16 to 40
MpC MpE	Mansker-Potter complex, 3 to 5 percent slopes. Mansker-Potter complex, 5 to 20 percent slopes.	For properties of Mansker soil, see description of Mansker loam; for properties of Potter soil, see description of the mapping unit, Potter soils.		
MrB MrC	Manter-Otero fine sandy loams, 1 to 3 percent slopes. Manter-Otero fine sandy loams, 3 to 5 percent slopes.	Deep, loamy, well-drained, upland soils. Properties of Manter soil described here. For properties of Otero soil, see description of the Otero Soils.	A	0 to 12 12 to 42 42 to 60
MfB MfC	Miles fine sandy loam, 1 to 3 percent slopes. Miles fine sandy loam, 3 to 5 percent slopes.	Deep, loamy, well-drained, upland soils.	B	0 to 8 8 to 22 22 to 52
NoE	Nobscot fine sand, rolling.	Deep, sandy, upland soils; loamy subsoil; subject to wind erosion.	A	0 to 28 28 to 46 46 to 60
NbC	Nobscot-Brownfield fine sands, hummocky.	For properties of Nobscot soil, see description of Nobscot fine sand, rolling; for description of Brownfield soil, see description of Brownfield fine sand.		
Nc3	Nobscot-Brownfield complex, severely eroded.	Deep, sandy and loamy, upland soils; many gullies. For properties of Nobscot soil, see description of Nobscot fine sand, rolling; for properties of Brownfield soil, see description of Brownfield fine sand.		
OtB OtC	Otero soils, undulating. Otero soils, hummocky.	Deep, sandy and loamy, upland soils; subject to wind erosion.	A	0 to 17 17 to 25 25 to 50
Om	Otero-Mansker complex.	For properties of Otero soil, see description of the Otero soils; for description of Mansker soil, see description of the Mansker loams.		
Pa	Potter soils.	Very shallow, loamy, upland soils, over a moderately to strongly consolidated layer of lime.	C	0 to 7 7+
Pd	Potter-Berthoud complex.	For properties of Potter soil, see description of the mapping unit, Potter soils; for properties of Berthoud soil, see description of Berthoud fine sandy loam.		
Pm3	Potter-Mansker complex, severely eroded.	For properties of Potter soils see description of the mapping unit, Potter soils; for properties of Mansker soil, see description of the Mansker loams.		
PbB PbC	Pratt fine sandy loam, undulating. Pratt fine sandy loam, hummocky.	Deep, loamy, well-drained, upland soils.	A	0 to 8 8 to 23 23 to 44
PfB PfC	Pratt loamy fine sand, undulating. Pratt loamy fine sand, hummocky.	Deep, sandy, upland soils; subject to wind erosion.	A	0 to 60
Pt	Pratt-Tivoli loamy fine sands.	For description of Pratt soil, see description of Pratt loamy fine sand; for description of Tivoli soil, see description of Tivoli fine sand.		

their estimated properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
						<i>Inches per hour</i>	<i>Inches per inch of soil</i>	
Loam.....	ML, CL.....	A-4.....		100	75 to 85	0.8 to 2.5	.15	Medium.
Loam.....	ML.....	A-6.....	90 to 100	85 to 95	70 to 80	0.8 to 2.5	.15	Medium.
Lime layer.....	ML.....	A-4.....	100	90 to 100	50 to 60			
Fine sandy loam.....	SM.....	A-2 or A-4.....		100	20 to 40	2.5 to 5.0	.12	Low.
Fine sandy loam.....	SM.....	A-2 or A-4.....		100	20 to 40	2.5 to 5.0	.12	Low.
Loamy fine sand.....	SM.....	A-2.....		100	20 to 30	5.0 to 10.0	.12	Low.
Fine sandy loam.....	SM.....	A-2.....		100	25 to 35	2.5 to 5.0	.14	Low.
Sandy clay loam.....	SC.....	A-6.....		100	40 to 50	0.8 to 2.5	.14	Medium.
Fine sandy loam.....	SM.....	A-2.....		100	10 to 20	5.0 to 10.0	.14	Low.
Fine sand.....	SP, SM.....	A-3.....		100	10 to 20	5.0 to 10.0	.07	Low.
Fine sandy loam.....	SM.....	A-2.....		100	10 to 20	2.5 to 5.0	.07	Low.
Fine sand and loamy fine sand.	SM, SC.....	A-2.....		100	20 to 30	5.0 to 10.0	.07	Low.
Fine sandy loam.....	SM.....	A-2.....	100	90 to 100	25 to 35	2.5 to 5.0	.12	Low.
Fine sandy loam.....	SM.....	A-2.....	95 to 100	90 to 100	15 to 25	5.0 to 10.0	.10	Low.
Loamy fine sand.....	SM.....	A-2.....	95 to 100	90 to 100	25 to 35	2.5 to 5.0	.12	Low.
Loam.....	SC or CL.....	A-4 or A-6.....		100	45 to 55	0.8 to 2.5	.15	Medium.
Consolidated caliche caprock.								
Fine sandy loam.....	SM.....	A-2.....		100	25 to 35	2.5 to 5.0	.12	Low.
Fine sandy loam.....	SM.....	A-2.....		100	25 to 35	2.5 to 5.0	.12	Low.
Fine sandy loam.....	SM.....	A-2.....		100	20 to 30	5.0 to 10.0	.12	Low.
Loamy fine sand.....	SM.....	A-2.....		100	20 to 30	5.0 to 10.0	.10	Low.

TABLE 5.—*Brief descriptions of soils and*

Soil symbol	Soil name	Description of soil and site	Hydrologic soil group	Depth from surface
QwE	Quinlan-Woodward loams, 8 to 20 percent slopes.	Quinlan soil: Shallow, loamy soils over red beds. Properties of Quinlan soil described here. For properties of Woodward soil, see description of Woodward loam.	C	<i>Inches</i> 0 to 7
RcB RcC	Richfield clay loam, 1 to 3 percent slopes. Richfield clay loam, 3 to 5 percent slopes.	Deep, loamy, well-drained, upland soils.	C	0 to 8 8 to 48 48 to 60
Rb	Rough broken land.	Very shallow to deep, loamy, upland soils; slopes of more than 50 percent.	B	0 to 10
SaA SaB	St. Paul silt loam, 0 to 1 percent slopes. St. Paul silt loam, 1 to 3 percent slopes.	Deep, loamy, well-drained, upland soils over red beds.	C	0 to 15 15 to 56
Sp	Spur loam.	Deep, loamy, well-drained soils on bottom lands; rarely flooded.	C	0 to 8 8 to 18 18 to 60
Sw	Sweetwater soils.	Deep, coarse and loamy, poorly drained soils on bottom lands; water table at a depth of less than 3 feet; frequently flooded.	B	0 to 12 12 to 48
Th	Tipton silt loam, high.	Deep, loamy, well-drained, upland soils.	B	0 to 24 24 to 60
Tv	Tivoli fine sand.	Deep, coarse, excessively drained, upland soils; duned topography.	A	0 to 60
Vx	Vernon complex.	Shallow and moderately deep, loamy and clayey, upland soils; shaly red beds at a depth of 1 to 3 feet.	C	0 to 19 19 to 30+
Wf	Wann fine sandy loam.	Deep, loamy, imperfectly drained soils on bottom lands; water table at a depth of 4 feet.	B	0 to 47 47 to 56
WoB WoC	Woodward loam, 1 to 3 percent slopes. Woodward loam, 3 to 5 percent slopes.	Moderately deep, loamy, upland soils; over red beds.	B	0 to 14 14 to 27 27 to 30
WwD2 WwE	Woodward-Quinlan loams, 3 to 8 percent slopes, eroded. Woodward-Quinlan loams, 5 to 12 percent slopes.	For properties of Woodward soil, see description of Woodward loam; for properties of Quinlan soil, see description of Quinlan-Woodward loams, 8 to 20 percent.		
Ya	Yahola fine sandy loam.	Deep, loamy, well-drained soils on bottom lands; rarely flooded.	B	0 to 28 28 to 44 44 to 60
Za	Zavala fine sandy loam.	Deep, loamy soils on bottom lands; rarely flooded.	A	0 to 11 11 to 39 39 to 60

¹ Impermeable.

Shrink-swell potential is an indication of the volume change to be expected with a change in moisture content. Soils that have a high clay content have a high shrink-swell potential; sandy soils have a low shrink-swell potential.

TABLE 6. Table 6 rates most of the soils in the county as sources of materials for engineering uses and lists specific characteristics that affect the suitability of a soil as a site for engineering structures and those that affect the

need for, or applicability of, engineering structures and practices. The interpretations in this table are based on the estimates given in table 5, on actual test data given in table 7, on field experience, and on the observed performance of the soils.

TABLE 7. Table 7 is a summary of test data for samples taken from modal profiles of nine soils mapped in Ellis County. The modal profile is the one that is most nearly typical of the series. The tests were made by the Mate-

their estimated properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
Loam.....	ML or CL.....	A-4 or A-6.....	100	100	50 to 70	<i>Inches per hour</i> 0.8 to 2.5	<i>Inches per inch of soil</i> .14	Medium.
Clay loam.....	CL.....	A-6.....		100	65 to 75	0.8 to 2.5	.16	Medium.
Clay loam.....	CL, CH.....	A-6.....		100	70 to 80	0.2 to 0.8	.16	High.
Clay loam.....	CL, CH.....	A-6.....		100	70 to 80	0.2 to 0.8	.16	High.
Loam.....	ML.....	A-4.....		100	70 to 80	0.8 to 2.5	.12	Low.
Silt loam.....	ML, CL.....	A-4.....		100	75 to 85	0.2 to 2.5	.14	Medium.
Silty clay loam.....	CL.....	A-6.....		100	75 to 85	0.2 to 0.8	.14	Medium.
Loam.....	ML.....	A-4.....		100	70 to 80	0.8 to 2.5	.15	Medium.
Clay loam.....	ML, CL.....	A-7.....		100	85 to 95	0.8 to 2.5	.15	Medium.
Clay loam.....	ML, CL.....	A-6.....		100	85 to 95	0.8 to 2.5	.15	Medium.
Silt loam.....	ML.....	A-4.....		100	85 to 95	0.2 to 0.8	.18	Low.
Fine sand.....	SP, SM.....	A-1 or A-2.....	100	90 to 100	5 to 15	10.0+	.07	Low.
Silt loam.....	ML, CL.....	A-4.....		100	40 to 50	0.8 to 2.5	.14	Medium.
Silt loam.....	ML, CL.....	A-4.....		100	40 to 50	0.8 to 2.5	.14	Medium.
Fine sand.....	SP to SM.....	A-2 or A-3.....		100	5 to 15	10.0+	.07	Low.
Clay loam.....	ML, CL.....	A-6.....		100	85 to 95	0.2 to 0.8	.16	Medium.
Stratified clayey shale.....	CL.....	A-6.....		100	75 to 85	(¹)		Medium.
Fine sandy loam.....	SM.....	A-4.....		100	40 to 50	0.8 to 2.5	.12	Low.
Loamy fine sand.....	SM, SP.....	A-2.....		100	10 to 20	2.5 to 5.0	.12	Low.
Loam.....	ML.....	A-4.....		100	60 to 70	0.8 to 2.5	.15	Medium.
Loam.....	ML, CL.....	A-4.....		100	55 to 65	0.8 to 2.5	.15	Medium.
Weakly consolidated red beds.....	ML, CL.....	A-4.....		100	75 to 85	0.2 to 0.8	.12	Medium.
Fine sandy loam.....	SM.....	A-4.....		100	35 to 45	2.5 to 5.0	.12	Low.
Fine sandy loam.....	ML.....	A-4.....		100	90 to 100	2.5 to 5.0	.12	Low.
Fine sandy loam.....	SM.....	A-2.....		100	25 to 35	2.5 to 5.0	.12	Low.
Fine sandy loam.....	SM, SC.....	A-2 or A-4.....		100	30 to 40	2.5 to 5.0	.06	Low.
Fine sandy loam.....	SM, SC.....	A-2.....		100	25 to 35	2.5 to 5.0	.06	Low.
Loamy fine sand.....	SM.....	A-2.....		100	10 to 20	5.0 to 10.0	.06	Low.

rials and Research Department, Oklahoma Department of Highways, in accordance with standard procedures of the American Association of State Highway Officials.

The thickness of each horizon sampled is shown in the column headed "Depth." Not all layers of each profile were sampled. Samples of Enterprise very fine sandy loam, for example, were taken at 0 to 9 inches and at 16 to 60 inches.

Liquid-limit and plastic-limit tests measure the effect of

water on the consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content, on a dry basis, at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity in-

TABLE 6.—*Interpretations*

[No interpretations are given]

Soil series and map symbols	Suitability as source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
Bayard (Ba)-----	Fair-----	Not suitable for concrete sand and gravel; good for sand for road subbase.	Good-----	Subject to occasional flooding.
Berthoud (BeC, BeD)-----	Fair-----	Not suitable for concrete sand and gravel; good for sand for road subbase.	Good-----	Moderately sloping to steep topography.
Brownfield (BfB)-----	Poor-----	Poor for concrete sand and gravel; good for sand for road subbase.	Good-----	Subject to severe erosion.
Carey (CaB)-----	Good-----	Not suitable-----	Good-----	Soil features favorable
Carwile (Cp)-----	Fair-----	Not suitable-----	Good-----	Poorly drained; in depressions.
Dalhart (DaB, DaC)-----	Fair-----	Not suitable for concrete sand gravel; good for sand for road subbase.	Fair; slopes easily eroded.	Soil features favorable--
Elsmere (Ee)-----	Poor-----	Fair for sand; very little material more than a quarter of an inch in diameter; good for road subbase.	Poor; slopes subject to severe erosion.	Water table at a depth of more than 3 feet.
Enterprise (EnB, EnC, EnD, EnE).	Good-----	Not suitable-----	Good-----	Gently sloping to steep topography.
Likes (Lf)-----	Poor-----	Fair for sand; no material more than a quarter of an inch in diameter; good for road subbase.	Good; slopes subject to severe erosion.	Hummocky topography.
Lincoln (Ln)-----	Poor to good, but limited in quantity.	Good for concrete sand; limited amount of material more than a quarter of an inch in diameter; good for road subbase.	Poor-----	Subject to frequent flooding.
Mansic (McB, McC, McD, McD2).	Good-----	Not suitable-----	Good-----	Soil features favorable--
Mansker (MaB, MaC, MpC, MpE).	Fair-----	Not suitable-----	Good, but limited in depth; caliche layer at a depth of 10 to 20 inches.	Gently sloping to hilly topography; caliche layer partially consolidated.
Manter (MrB, MrC)-----	Fair-----	Fair; limited and localized source of sand below 3 feet; good for road subbase.	Good-----	Subject to erosion-----
Miles (MfB, MfC)-----	Fair to good-----	Not suitable-----	Good-----	Soil features favorable--

of engineering properties
for miscellaneous land types]

Soil features affecting—Continued				
Farm ponds		Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment			
Soil features favorable for dug ponds.	Fairly stable; subject to piping; no sites suitable for impoundments, because of nearly level topography.	Soil features favorable; subject to occasional flooding.	Nearly level topography; soil features favorable.	Nearly level topography; stable; fertile.
Moderate seepage-----	Moderate to high strength and stability; few suitable sites.	Irrigation limited to moderate slopes.	Terraces are limited to moderate slopes.	Moderately sloping to steep; soil features favorable in natural drainageways.
Moderate seepage-----	Slopes subject to severe erosion; no sites suitable for impoundments, because of undulating topography.	Sandy; subject to wind erosion; rapid intake rate; low water-holding capacity in surface layer. (Sprinkler irrigation is best method.)	Unstable; sandy surface.	Subject to wind and water erosion; generally not needed.
Soil features favorable for dug ponds.	Moderate to high strength and stability; no sites suitable for impoundments, because of gentle slopes.	Soil features favorable-----	Soil features favorable--	Deep; fertile.
Soil features favorable.	Moderate to high strength and stability; no sites suitable for impoundments, because of undulating topography.	Variable slopes; poor drainage; soil features not favorable for flood-type irrigation.	Generally not needed; undulating topography.	Undulating topography; generally no drainage outlets.
Rapid seepage-----	Rapid seepage; subject to piping; no sites suitable for impoundments, because of gentle and moderate slopes.	Rapid intake rate; variable slopes. (Sprinkler irrigation is best method.)	Subject to wind erosion; soil features favorable.	Subject to wind erosion; soil features favorable.
Soil features favorable for dug ponds.	Fairly stable; subject to severe erosion and piping; no sites suitable for impoundments, because of nearly level topography.	Rapid intake rate; low water-holding capacity; high water table; saline areas. (Sprinkler irrigation is best method.)	Subject to severe wind erosion; soil features not favorable.	Subject to severe wind erosion; low water-holding capacity; generally not needed.
Slow seepage-----	High strength and stability; the sites suitable for impoundments are limited to steep slopes.	Variable slopes; otherwise favorable.	Steep slopes not suitable for field terraces; soil features favorable.	Deep; fertile; soil features favorable.
Rapid seepage-----	Fairly stable; rapid seepage; slopes subject to severe erosion; no sites suitable for impoundments, because of hummocky topography.	Rapid intake rate; low water-holding capacity; hummocky topography; generally not cultivated.	Hummocky topography; subject to wind erosion.	Subject to wind erosion; hummocky topography; soil features not favorable.
Soil features favorable for dug ponds because of high water table.	Rapid seepage; poor stability; slopes subject to severe erosion; no sites suitable for impoundments, because of nearly level topography.	Nonarable; frequent flooding.	Nonarable; nearly level topography; subject to frequent flooding.	Subject to frequent flooding; nearly level topography; soil features not favorable.
Slow seepage-----	Fairly stable; the sites suitable for impoundments are limited to steep slopes.	Variable slopes; otherwise favorable.	Soil features favorable -	Deep; fertile; soil features favorable.
Slow seepage-----	Fairly stable; limited depth to caliche layer; the sites suitable for impoundments are limited to steep slopes.	Shallow; restrictive caliche layer; otherwise favorable.	Shallow; variable slopes (1 to 5 percent slopes are suitable for terraces and diversions).	Shallow; soil features favorable.
Rapid seepage-----	Fairly stable; slopes subject to erosion; no sites suitable for impoundments, because of moderate slopes.	Rapid intake rate; variable slopes. (Sprinkler irrigation is best method.)	Subject to wind erosion; soil features generally favorable.	Subject to wind erosion; soil features favorable.
Moderate seepage-----	High strength; fairly stable; no sites suitable for impoundments, because of moderate slopes.	Variable slopes; otherwise features are favorable. (Sprinkler irrigation is best method.)	Subject to wind erosion; soil features generally favorable.	Subject to wind erosion; soil features favorable.

TABLE 6.—*Interpretations of*

Soil series and map symbols	Suitability as source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
Nobscoot (NbC, Nc3, NoE).....	Poor.....	Poor for concrete sand; good for road subbase.	Good if slopes are stabilized.	Sandy; rolling and hummocky topography.
Otero (Om, OtB, OtC).....	Fair.....	Not suitable for concrete sand and gravel; good for sand for road subbase.	Good.....	Sandy; undulating and hummocky topography.
Potter (Pa, Pd, Pm3).....	Poor; very shallow.	Poor for sand; caliche gravel suitable for road surfacing and for road subbase.	Good; caliche layer at a depth of less than 10 inches.	Variable topography; caliche layer partially consolidated.
Pratt (PbB, PbC, PfB, PfC, Pt).	Fair to good.....	Poor for concrete sand and gravel; good for road subbase.	Good.....	Variable slopes; sandy.
Quinlan (QwE).....	Fair to good.....	Not suitable.....	Good; sandstone material at a depth of more than 3 feet.	Sandstone at a depth of more than 3 feet.
Richfield (RcB, RcC).....	Good.....	Not suitable.....	Good.....	Soil features favorable.
St. Paul (SaA, SaB).....	Good.....	Not suitable.....	Good.....	Soil features favorable.
Spur (Sp).....	Good.....	Not suitable.....	Good.....	Subject to flooding.....
Sweetwater (Sw).....	Poor.....	Fair for concrete sand; little material more than a quarter of an inch in diameter; good for road subbase.	Fair.....	Subject to frequent flooding; high water table.
Tipton (Th).....	Good.....	Not suitable.....	Good.....	Soil features favorable..
Tivoli (Tv).....	Poor.....	Fair for concrete sand; little material more than a quarter of an inch in diameter; good for road subbase.	Good; slopes unstable.	Duned topography; highly erosive.
Vernon (Vx).....	Poor.....	Not suitable.....	Depth to shaly red bed is limited.	Rough topography.....
Wann (Wf).....	Good.....	Not suitable.....	Good; slopes subject to severe erosion.	Subject to flooding; high water table.

engineering properties—Continued

Soil features affecting—Continued				
Farm ponds		Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment			
Rapid seepage-----	High erodibility; seepage; no sites suitable for impoundments, because of hummocky and rolling topography.	Rapid intake rate; variable slopes; low water-holding capacity; generally not needed.	Subject to severe wind erosion; soil features generally not favorable.	Subject to severe wind erosion; hummocky and rolling topography; soil features not favorable.
Rapid seepage-----	Fair strength and stability; no sites suitable for impoundments, because of undulating and hummocky topography.	Rapid intake rate; variable slopes; generally not needed.	Undulating, hummocky topography; generally not needed.	Subject to wind erosion; undulating and hummocky topography; generally not needed.
Slow seepage-----	Fairly stable; limited depth to caliche layer; the sites suitable for impoundments are limited to steep slopes.	Very shallow; restrictive caliche layer; generally not needed.	Very shallow; variable slopes; soil features favorable.	Very shallow; soil features favorable.
Rapid seepage-----	Rapid seepage and erodibility; no sites suitable for impoundments, because of undulating and hummocky topography.	Low water-holding capacity; rapid intake rate; variable slopes. (Sprinkler irrigation is best method.)	Subject to severe wind erosion; hummocky topography; generally not needed.	Subject to severe wind erosion; undulating and hummocky topography; generally not needed.
Depth to sandstone is limited.	Moderate strength and stability; the sites suitable for impoundments are limited to rolling and hilly topography.	Very shallow; variable slopes; soil features generally not favorable.	Very shallow to red beds; variable slopes; soil features favorable.	Very shallow; steep slopes.
Slow seepage-----	High strength and stability; no sites suitable for impoundments, because of moderate slopes.	Variable slopes; otherwise favorable.	Soil features favorable.	Deep; fertile.
Slow seepage-----	High strength and stability; no sites suitable for impoundments, because of gentle slopes.	Variable slopes; otherwise favorable.	Soil features favorable.	Deep; fertile.
Slow seepage; soil features favorable for dug ponds.	Fair strength and stability; no sites suitable for impoundments, because of nearly level topography.	Subject to occasional flooding; otherwise favorable.	Nearly level topography.	Deep; fertile; nearly level topography.
Soil features favorable for dug ponds because of high water table.	Rapid seepage; subject to erosion; no sites suitable for impoundments, because of nearly level topography.	Subject to frequent flooding; high water table; salinity.	Subject to frequent flooding; nearly level topography; generally not needed.	Subject to frequent flooding; generally not needed.
Slow seepage-----	Moderate to high strength and stability; no sites suitable for impoundments, because of nearly level topography.	Soil features favorable; generally not cultivated.	Nearly level topography; generally not needed.	Deep; fertile.
Rapid seepage-----	Rapid seepage; slopes subject to severe erosion; no sites suitable for impoundments, because of duned topography.	Nonarable; low water-holding capacity; rapid intake rate.	Subject to severe wind erosion; duned topography; soil features not favorable.	Subject to severe wind erosion; duned topography; soil features not favorable.
Slow seepage; depth to shaly red beds is limited.	Moderate to high strength and stability.	Nonarable; shallow; steep slopes.	Nonarable; shallow; steep slopes.	Nonarable; shallow; droughty; steep slopes.
Soil features favorable for dug ponds because of high water table.	Moderate seepage; high erodibility; no sites suitable for impoundments, because of nearly level topography.	Soil properties favorable; high water table; subject to occasional flooding.	Subject to occasional flooding; nearly level topography.	Subject to occasional flooding; deep; fertile.

TABLE 6.—*Interpretations of*

Soil series and map symbols	Suitability as source of—			Soil features affecting—
	Topsoil	Sand and gravel	Road fill	Highway location
Woodward (WoB, WoC, WwD2, WwE).	Fair to good.....	Not suitable.....	Good; sandstone at a depth of more than 3 feet.	Sandstone below a depth of more than 3 feet.
Yahola (Ya).....	Good.....	Poor; little material more than a quarter of an inch in diameter; sources limited and localized.	Good.....	Subject to occasional flooding.
Zavala (Za).....	Good.....	Poor; little material more than a quarter of an inch in diameter; sources limited and localized.	Good; slopes subject to severe erosion.	Subject to occasional flooding.

dex is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Shrinkage limit is the moisture content at which shrinkage stops. As moisture leaves the soil, the soil shrinks and decreases in volume in proportion to the loss in moisture until a condition of equilibrium is reached where shrinkage stops even if additional moisture is removed. The shrinkage limit is reported as the moisture content, in relation to oven-dry weight, at the time when shrinkage stops. The shrinkage limit of a soil is a general index of clay content. For soils that contain a great deal of clay, the shrinkage limit generally is a low number. For sand that contains little or no clay, the shrinkage limit is close to the liquid limit and therefore is considered insignificant. Sand that contains some silt and clay has a shrinkage limit of about 14 to 25. Clay has a shrinkage limit of about 9 to 14. The load-carrying capacity of a soil is at a maximum when the moisture content is at or below the shrinkage limit. Sand does not follow this rule, because if confined it has a uniform load-carrying capacity within a considerable range of moisture content.

Shrinkage ratio is the ratio of volume change resulting from drying to change in water content. Theoretically, it is also the apparent specific gravity of the dried soil pat.

The field moisture equivalent (FME) is the minimum moisture content at which a smooth soil surface 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. The volume change from FME is the volume change, expressed as a percentage of the dry volume, of the soil mass when the moisture content is reduced from FME to the shrinkage limit.

Mechanical analysis separates the soil components by particle-size classes. The engineering soil classifications given in table 7 are based on data obtained by mechanical analysis and by tests to determine the liquid limit and the plastic limit. Mechanical analysis was made by com-

bined sieve and hydrometer methods. Percentages of clay obtained by the hydrometer test are not suitable for determining USDA soil textural classes.

Conservation structures

The general effect of soil characteristics and topography on dams, terraces, and other conservation structures in Ellis County is discussed, by soil associations, in this subsection. A more detailed description of each association is given in the section "General Soil Map." A colored map at the back of this report shows the general extent and location of the soil associations in the county.

ASSOCIATIONS 1, 8, AND 10.—These associations consist of nearly level, gently sloping, and moderately sloping loamy soils on uplands. The dominant soils in association 1 are Woodward and Carey soils; in association 8, Mansic and Richfield soils; and in association 10, St. Paul, Manter, and Dalhart soils. The soils in these associations are highly productive, and much of the acreage is intensively cultivated. The cultivated areas are subject to wind erosion, but they can be protected effectively by means of terraces, diversion terraces, and waterways. Stubble-mulch tillage is advisable. Natural spillways serve as outlets for terraces in some places, but many waterways have to be constructed. Where runoff is excessive, pipe drops or erosion-control dams are needed to lower water to a safe grade. Generally, one end of a terrace is left open, but if the soils are sandy, both ends are blocked. Broadbase channel-type terraces are the most common, but impounding terraces are effective if the soils have slopes of no more than 2.5 percent and are further protected by stubble mulching.

Good range management is important in these areas. The grassland is subject to considerable water erosion if overgrazed. In many places gullies have formed and are eating back into the cultivated areas. Diversion terraces, pipe drops, and dams help to control gullying.

Water for livestock generally is stored behind impounding-type dams. Because of the silting hazard, the drainage area should consist mostly of grassland. No more

engineering properties—Continued

Soil features affecting—Continued				
Farm ponds		Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment			
Depth to sandstone is limited.	Moderate strength and stability; the sites suitable for impoundments are limited to rolling and hilly topography.	Shallow soil; variable slopes; generally not needed.	Soil features favorable.	Shallow; fertile; soil features favorable.
Near level topography; moderate seepage.	Moderate strength and stability; no sites suitable for impoundments, because of nearly level topography.	Rapid intake rate; subject to occasional flooding; soil features favorable.	Nearly level topography; subject to flooding.	Nearly level topography; deep; fertile; subject to occasional flooding.
Nearly level topography; rapid seepage.	Moderate strength and stability; rapid seepage; no sites suitable for impoundments, because of nearly level topography.	Rapid intake rate; subject to frequent flooding; soil features favorable.	Nearly level topography; subject to flooding.	Nearly level topography; deep; fertile; subject to occasional flooding.

than 30 to 40 percent of it should be cultivated. Cultivated areas should be terraced.

ASSOCIATIONS 2 AND 3.—These associations consist of reddish, loamy, rolling soils on uplands and moderately sandy, hilly soils on uplands. Quinlan and Woodward soils are dominant in association 2, and Enterprise and Berthoud soils and Broken land are dominant in association 3. These soils are mostly on steep side slopes of deep drainageways and in smooth, rolling areas between the drainageways. Most of the acreage is in range, but a few areas on the ridges between drainageways are cultivated.

Many deep gullies are eating back into cultivated areas. Pipe drops or erosion-control dams are about the only satisfactory means of controlling gully erosion. In some places water can be diverted from several gullies to one pipe-drop structure by means of diversion terraces. Waterways are effective in the cultivated areas but are generally not effective in the areas below the cultivated fields. Channel-type terraces, open at one end, are needed on the steeper slopes, and those areas should be further protected by stubble-mulch tillage.

There are a few cultivated fields in flat areas along drainageways. Generally these fields are dissected with drainageways formed by runoff that flows across from higher areas into the main drainageways. By means of diversion terraces, this runoff can be directed into waterways or natural drainageways. Impounding terraces are effective on these nearly level areas, if additional protection is provided through good management of crop residues.

Because of the slope, the grassland in these associations is subject to severe erosion. A good conservation grazing program is needed, and diversion terraces and pipe drops are practical in some areas.

Impounding dams can be used to store water for livestock. Pipe spillways should be installed because emergency spillways generally are not satisfactory. Because silting is a hazard, the drainage area should consist almost entirely of grassland, and conservation measures are needed in all cultivated areas.

ASSOCIATIONS 4 AND 6.—These associations consist of nearly level to steep, moderately sandy and sandy soils on hummocky uplands. Nobscot and Brownfield soils are dominant in association 4, and Pratt and Carwile soils are dominant in association 6.

Most of the acreage has a cover of shinnery oak or sagebrush, but a few small areas are cultivated. Small areas of Carwile soils are covered by water after rains. Conservation structures are not effective.

Water for livestock generally is obtained from wells. Windmills are used to pump the water. A few pit-type ponds have been excavated in areas of Carwile soils. In the first few years these ponds may lose considerable water through seepage. Lenses of silt or sand are likely not to hold water. Some reservoirs have the spoil placed all the way around, with a pipe installed to allow water to enter the basin. This helps to prevent the sand from washing and blowing into the basin.

ASSOCIATIONS 5 AND 9.—These associations consist of sandy soils on steep, duned uplands and limy sandy soils on hummocky uplands. Pratt and Tivoli soils are dominant in association 5, and Likes and Otero soils are dominant in association 9.

Most of the acreage is not suitable for cultivation. The grassland is infested with skunkbush, sand plum, and sagebrush. Drainageways are indefinite, and water becomes trapped in many small pockets.

Wells supply water for livestock. The water is pumped by windmills. Because the drainageways are small and indefinite and the infiltration rate is high, only a few sites are suitable for pit-type ponds.

ASSOCIATION 7.—This association consists of limy, loamy, rolling soils on uplands. Mansker and Potter soils are dominant. Most of the acreage is in range.

Because of steep slopes and outcrops of soft limestone, the soils are subject to water erosion. Some gullies are eating back into fields and good grassland. Diversion terraces, pipe drops, or dams would control this erosion.

Some of the acreage is cultivated. The cultivated areas should be terraced. Diversion terraces are needed to control runoff from higher areas. Waterways are generally

TABLE 7.—Engineering

[Tests performed by the Oklahoma Department of Highways in accordance with standard

Soil name and location	Parent material	Oklahoma report number	Depth	Horizon	Shrinkage limit	Shrinkage ratio
Berthoud fine sandy loam----- NW¼NW¼SW¼SW¼ sec. 11, T. 19 N., R. 25 W. (Modal)	Brownish, calcareous, loamy deposits.	SO-5468	<i>Inches</i> 0 to 8	A1	18	1.72
		SO-5469	8 to 26	C	18	1.72
Brownfield fine sand----- 60 yards north of road, SE¼SE¼SE¼ sec. 10, T. 19 N., R. 22 W. (Modal)	Reddish, noncalcareous, sandy deposits.	SO-5470	0 to 4	A1	⁴ NP	NP
		SO-5471	4 to 19	A2	NP	NP
		SO-5472	19 to 24	B21	16	1.76
		SO-5473	24 to 36	B22	14	1.85
		SO-5474	36 to 46	B3	15	1.86
SO-5475	46 to 60	C1	15	1.82		
Enterprise very fine sandy loam----- NE¼SW¼SW¼SE¼NW¼ sec. 27, T. 17 N., R. 22 W. (Modal)	Brownish, calcareous, loamy, colian deposits.	SO-5476	0 to 9	A1	20	1.59
		SO-5477	16 to 60	C	19	1.70
St. Paul silt loam----- SE¼SW¼SE¼SE¼ sec. 31, T. 21 N., R. 24 W. (Modal)	Brownish and reddish, cal- careous, loamy deposits.	SO-5478	0 to 14	A1	17	1.77
		SO-5479	14 to 22	B21	16	1.83
		SO-5480	22 to 34	B22	13	1.92
		SO-5481	34 to 55	B3	12	1.96
Likes loamy fine sand----- 100 ft. S. and 100 yds. W. of NE. cor. NE¼ sec. 25, T. 24 N., R. 26 W. (Modal)	Brownish, calcareous, sandy, colian deposits.	SO-5490	0 to 5	A1	NP	NP
		SO-5491	5 to 13	C1	NP	NP
		SO-5492	13 to 60	C2	NP	NP
Mansker loam----- 125 yds. W. of NE. cor. NW¼ sec. 33, T. 22 N., R. 25 W. (Modal)	Brownish, very calcareous, loamy Ogallala sediments.	SO-5482	0 to 11	A1	20	1.68
		SO-5483	11 to 26	C1	20	1.69
		SO-5484	16 to 40+	Cca	24	1.57
Nobscoot fine sand----- 460 yds. E. and 30 ft. N. of SW. cor. SE¼ sec. 23, T. 17 N., R. 23 W. (Modal)	Reddish, noncalcareous, sandy deposits.	SO-5485	0 to 5	A1	NP	NP
		SO-5486	5 to 28	A2	NP	NP
		SO-5487	28 to 46	B2	NP	NP
		SO-5488	46 to 60	B3	16	1.82
		SO-5489	60 to 80	C	NP	NP
Spur loam----- 50 ft. SE. of NW. cor. SW¼ sec. 6, T. 21 N., R. 25 W. (Modal)	Brownish and reddish, cal- careous, loamy alluvium.	SO-5493	0 to 8	Ap	20	1.67
		SO-5494	8 to 18	AC	17	1.81
		SO-5495	18 to 60	C	17	1.80
Yahola fine sandy loam----- 30 ft. S. and 60 yds. W. of NE¼NW¼ SW¼SW¼ sec. 32, T. 18 N., R. 22 W. (Modal)	Reddish, calcareous, loamy alluvium.	SO-5496	0 to 10	A1	NP	NP
		SO-5497	14 to 28	C2	NP	NP
		SO-5498	28 to 44	C3	21	1.64
		SO-5499	44 to 60	C4	NP	NP

¹ Mechanical analysis according to AASHO Designation: T 88-57 (1). Results by this procedure may differ somewhat from results 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 pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soil.

needed unless suitable drainage outlets for each terrace are available. The terraces in a few places cut through layers of caliche and, consequently, require more maintenance than those in other fields. Channel-type terraces are effective if one end is open or only partially blocked.

Some stock ponds lose considerable water through seepage, because the underlying soft limestone (caliche) is readily soluble. Ordinarily, such a pond seals well enough

in 2 or 3 years so that seepage is no longer a problem. Ponds in areas where caliche is not widespread function satisfactorily. Pipe spillways should be installed, because emergency spillways ordinarily are not satisfactory. Drainage areas should be kept in grass.

ASSOCIATION 11.—This association consists of sandy and loamy soils in riverbeds, on benches, and on flood plains. Lincoln and Spur soils are dominant. Most of the cul-

test data

procedures of the American Association of State Highway Officials (AASHO) (1)]

Volume change from field moisture equivalent	Mechanical analysis ¹						Liquid limit	Plasticity index	Classification	
	Percentage of fraction passing sieve—			Percentage smaller than—					AASHO ²	Unified ³
	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.				
<i>Percent</i>										
14	100	98	53	33	12	10	25	3	A-4(4)-----	ML.
8	100	98	46	31	17	13	23	3	A-4(2)-----	SM.
NP	100	93	22	17	6	4	NP	NP	A-2-3(0)-----	SM.
NP	100	94	15	10	4	3	NP	NP	A-2-3(0)-----	SM.
16	100	95	33	30	23	22	30	10	A-2-4(0)-----	SC.
28	100	97	48	38	26	24	30	10	A-4(3)-----	SC.
14	100	96	41	35	24	23	30	10	A-4(1)-----	SC.
20	100	96	31	26	21	20	27	8	A-2-4(0)-----	SC.
12	100	97	86	73	12	10	26	4	A-4(8)-----	ML-CL.
10	100	96	82	76	18	15	26	5	A-4(8)-----	ML-CL.
18	100	98	89	82	24	15	31	8	A-4(8)-----	ML-CL.
32	100	98	90	79	29	26	36	12	A-6(9)-----	ML-CL.
32	100	95	78	70	31	27	32	13	A-6(9)-----	CL.
52	100	97	85	73	41	37	43	20	A-7-6(13)-----	CL.
NP	100	82	29	21	8	7	NP	NP	A-2-3(0)-----	SM.
NP	100	86	14	8	5	5	NP	NP	A-2-3(0)-----	SM.
NP	100	83	9	7	5	5	NP	NP	A-3(0)-----	SP-SM.
22	100	99	81	66	24	21	33	8	A-4(8)-----	ML-CL.
32	89	87	74	65	37	31	39	11	A-6(8)-----	ML.
16	97	88	54	42	18	16	33	5	A-4(4)-----	ML.
NP	100	96	17	12	4	3	NP	NP	A-2-3(0)-----	SM.
NP	100	96	8	6	3	1	NP	NP	A-3(0)-----	SP-SM.
NP	-----	100	17	12	11	9	NP	NP	A-2-3(0)-----	SM.
13	100	97	25	21	18	17	24	5	A-2-4(0)-----	SM-SC.
NP	100	96	12	9	8	7	NP	NP	A-2-3(0)-----	SP-SM.
18	-----	100	86	70	24	19	33	7	A-4(8)-----	ML.
43	-----	100	93	80	37	31	41	14	A-7-6(10)-----	ML-CL.
28	-----	100	89	73	28	24	33	11	A-6(8)-----	ML-CL.
NP	-----	100	43	30	12	9	NP	NP	A-4(2)-----	SM.
NP	-----	100	35	24	10	8	NP	NP	A-2-3(0)-----	SM.
12	-----	-----	94	83	22	17	27	3	A-4(8)-----	ML.
NP	100	99	27	18	8	7	NP	NP	A-2-3(0)-----	SM.

² Based on AASHO Designation: M 145-49 (1). Oklahoma Department of Highways classification procedure further subdivides AASHO subgroup A-2-4 into the following: A-2-3(0) when the soil is nonplastic; A-2-4(0) when the plasticity index is between 5 and 10.

³ SCS and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within two points from A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are SM-SC and ML-CL.

⁴ NP-Nonplastic.

tivated acreage is on long, narrow, level benches. Johnsongrass covers large areas of this association.

Controlling runoff from higher areas is the major problem. Diversion terraces and waterways work satisfactorily if the channels are kept open.

Streams supply water for livestock. Occasionally, the streambeds are dry at the surface, but small excavations will produce ample water for livestock.

Drainage, Relief, and Geology¹⁰

The topography of Ellis County is mostly rolling, but throughout the county are small areas that are gently sloping and small areas that are rough and broken. The general slope is from the northwest to the southeast. The

¹⁰ By DAVID B. KITTS, geologist, University of Oklahoma.

highest elevation—about 2,500 feet—is along the western edge of the county, near U.S. Highway No. 60. The lowest—about 1,900 feet—is in the southeastern part of the county along the Canadian River.

The North Canadian (Beaver) River, the Canadian River, and Wolf Creek provide drainage and have shaped the relief. The North Canadian River has cut down to the Permian red beds in the northeastern part of the county. It drains about one-fifth of the county. The slopes between its tributaries are moderate.

Wolf Creek drains the central two-fifths of the county. South of the creek, slopes are mostly moderate. North of the creek, slopes are moderate to steep below the caprock and gentle to moderate above the caprock.

The Canadian River drains the southern two-fifths of the county. It has exposed the Permian red beds at the southern edge of the county. Along the tributaries of this river in the southeastern part of the county are sizable areas of rough broken land. Between Pack Saddle Bridge and Harmon is a large acreage of undulating and rolling sandy deposits. West of U.S. Highway No. 283, the tributaries of the river are one-eighth to one-half mile apart, and the slopes in the areas between the tributaries are moderate to steep. High benches or terraces occur along the river as isolated areas 50 to 400 acres in size.

The drainage pattern of the county is shown in figure 18.

The geologic systems represented in Ellis County are the Permian, the Cretaceous, the Tertiary, and the Quaternary. The Ogallala formation of late Tertiary age is prominent.¹¹ (4).

Figure 18 shows the location and extent of the geologic systems in this county.

PERMIAN SYSTEM.—Permian rocks (identified by "A" in figure 18) are exposed in the northeastern part of the county and in a narrow area that parallels the Canadian River along the southern boundary of the county. Four formations of this system are represented in the county: The Marlow, the Rush Springs, the Cloud Chief, and the Quartermaster. Rush Springs sandstone and the Marlow formation make up the Whitehorse group.

The Marlow formation is the lower member of the Whitehorse group, which consists of rock formations that lie unconformably above the Dog Creek slate formation (not exposed in Ellis County) and below the Cloud Chief formation. The Marlow formation is exposed to narrow strips along the banks of Turkey Creek and the north bank of the Canadian River in the southeastern part of this county. In this area it is about 80 feet thick and consists of fine-grained, reddish-orange, friable sandstone interbedded with brown to reddish-brown, silty claystone. In some places it is capped with 1 to 5 feet of gypsum.

The Rush Springs formation is the upper member of the Whitehorse group. This formation is extensively exposed in both the northeastern and the southeastern parts of the county. Nowhere in the county is it more than 100 feet thick. It consists of fine-grained, reddish-orange, silty sandstone that contains local beds of claystone and gypsum. The sandstone adjacent to the gypsum beds may be indurated with gypsumiferous cement. In the southeast-

ern corner of the county, the Rush Springs formation is exposed on steep slopes along the sides of valleys that open onto the flood plain of the Canadian River.

The Cloud Chief formation lies above the Rush Springs formation and below the Doxey member of the Quartermaster formation. It is the most extensively exposed Permian formation in Ellis County. It is widely exposed in the northeastern part of the county. In the southern part, it is exposed continuously along the valley walls of the Canadian River from the western to the eastern boundary of the county. This formation is variable. It consists of sandstone, mudstone, and shale interbedded with layers of gypsum. The color ranges from red to reddish orange to maroon. In the southern part of the county, this formation is more than 100 feet thick, but in the northeastern part, the upper part is missing and the formation is 25 feet or less thick.

The Quartermaster formation outcrops in the southeastern part of the county and caps the hills of the Cloud Chief formation. In this county it consists only of the Doxey member. It is the youngest exposed Permian formation in Oklahoma.¹² It ranges from 3 to 65 feet in thickness and consists of alternate beds of reddish-brown siltstone, mudstone, and claystone.

CRETACEOUS SYSTEM.—One formation of the Cretaceous system (identified by "B" in figure 19) is represented in Ellis County—Kiowa slate.

Kiowa slate is represented in Ellis County by a single outlier, which is located along the boundary between sec. 11 and sec. 14, T. 24 N., R. 23 W., in the northeastern corner of the county. It consists of thinly laminated shale about 40 feet thick and is capped by a layer of calcareous coquina less than 1 foot thick.

TERTIARY SYSTEM.—Two formations of the Tertiary system (identified by "C" and "D" in figure 18) are represented in Ellis County—the Laverne formation and the Ogallala formation.

The Laverne formation (identified by "C" in figure 18) crops out in an area of about 20 square miles in the northwestern corner of the county (5). It lies unconformably on the formations of the Whitehorse group and below sediments typical of the Ogallala formation. Lithologically, the section consists of interbedded limestone, shale, sandstone, and conglomerate. The Laverne formation is of early Pliocene age.

The Ogallala formation (identified by "D" in figure 18) forms much of the bedrock throughout Ellis County. South of Wolf Creek and east of U.S. Highway No. 283, the Ogallala formation is almost covered with inactive sand dunes. In other areas it is covered by sand deposited by the wind. This sand varies in thickness and does not form dunes.

In the western part of the county, the Ogallala formation is between 300 and 400 feet thick, but in the eastern part, it is 100 feet or less thick. In this county the lower 150 feet of this formation consists mostly of yellowish-brown and light-gray, evenly bedded, fine quartz sand; clay and silt are present but are rare. Calcium carbonate

¹¹ KITTS, D. B. CENOZOIC GEOLOGY OF ELLIS COUNTY, OKLAHOMA. [Unpublished]

¹² LOVETT, F. D. AREAL GEOLOGY OF THE QUARTERMASTER AREA, ROGER MILLS AND ELLIS COUNTIES, OKLAHOMA. 1960. [Unpublished master's thesis. Copy on file at University of Oklahoma, Norman]

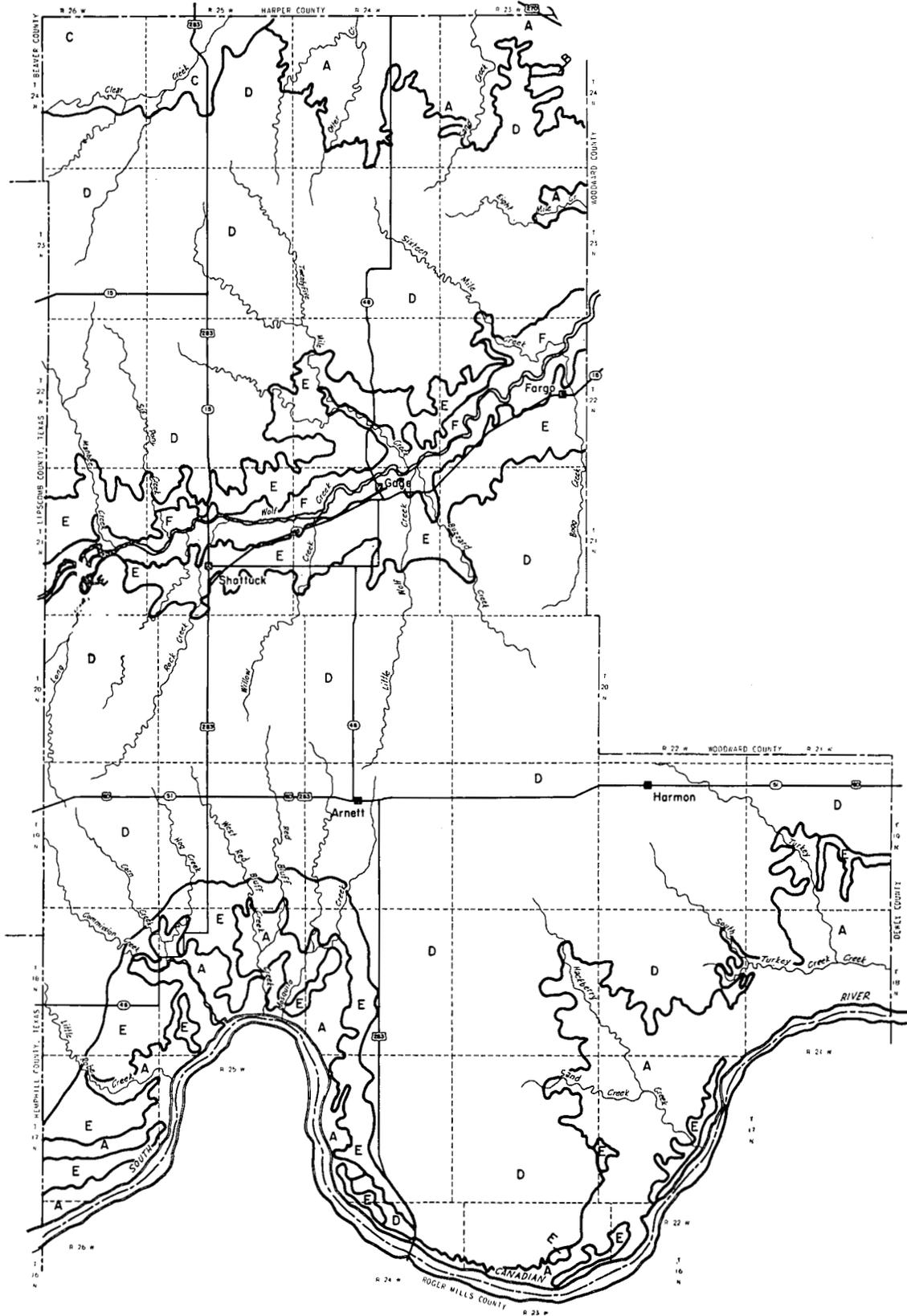


Figure 18.—Geologic systems, formations, and drainage patterns: (A) Permian system; (B) Cretaceous system; (C) Tertiary system; (D) Late Tertiary system (Ogallala formation); (E) Quaternary system.

cement is lacking or occurs in small quantities. The upper 200 feet of the Ogallala formation consists mostly of light-brown, gray, and almost white, massive, fine or medium quartz sand that, in some places, is moderately cemented with calcium carbonate to form mortar beds. Channel sand and gravel are remarkably rare. The Ogallala formation in Ellis County is of early Pliocene and middle Pliocene age.

The topography of the Ogallala formation is variable. In the northwestern part of the county, the surface is not deeply dissected and consists of smooth hills. Along the North Canadian (Beaver) River, Wolf Creek, and the Canadian River, and also along their tributaries, the upper mortar beds are exposed as prominent escarpments and buttes. In the southeastern part of the county, where there are no mortar beds, the topography is almost flat, except for small sand dunes that generally are less than 50 feet high.

QUATERNARY SYSTEM.—Quaternary deposits (identified by "E" in figure 18) occur as terraces above the flood plains of the Canadian River and Wolf Creek.

Along the Canadian River, three terrace levels can be distinguished. The terrace at the highest level occurs intermittently along the river from the western to the eastern boundary of the county. It is most extensive in the western part, where it extends as much as 4 miles back from the river. The deposits consist predominantly of sand and gravel but contain local lenses of silt and clay. Contact with the underlying Permian rock is at a level of 140 to 160 feet above the flood plain, and the top of the terrace is about 220 feet above the flood plain. In most places the terrace is dissected, and in some places the surface is covered with inactive sand dunes, believed to be deposits of Kansan age.

Of the intermediate terrace of the Canadian River, only small remnants still exist. Most of these remnants are less than a square mile in area, though a few in the western part of the county are larger. The terrace deposits overlie Permian rock at a level of 40 to 50 feet above the present flood plain. The top of the terrace, in the few places in which it is preserved, is about 90 feet above the flood plain. The deposits are believed to be of Illinoian or Wisconsin age. Depending on the locality, they consist of gravel, sand, silt, or clay.

The remnants of the low terrace, which closely borders the flood plain of the river, generally are only a few hundred square yards in size. The deposits that form this terrace overlie Permian rock at a level that ranges from a few feet above to a few feet below the present flood plain, and the top of the terrace is 50 feet above the flood plain. Lithologically, the deposits are similar to those that form the intermediate terrace. They are probably of Wisconsin age.

The Wolf Creek terrace complex is difficult to interpret, because it is highly dissected, consists of eolian deposits, and is associated with the lithologically similar Ogallala deposits. Apparently there are two distinct levels, one 30 feet and the other 50 feet above the flood plain. These deposits probably date from no earlier than the late Pleistocene epoch.

Genesis, Classification, and Morphology of the Soils

This section explains the factors that are involved in the formation of soils. It describes briefly the system of soil classification used in the United States, shows how the soils in Ellis County have been classified, and describes the outstanding morphological characteristics of these 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 composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or 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 the 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 that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the nature of the profile and, in extreme cases, determines most of the characteristics. Finally, time is needed to change the parent material into a soil profile. It may be much or little, but generally much time is required to develop a profile that has distinct horizons.

The five factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Parent material is weathered, unconsolidated rock or mineral material from which soil develops. In many soils it is considered to be similar to the C horizon. It affects the color, texture, structure, natural fertility, and other characteristics of the soil.

There are two types of parent material, transported and residual. Residual parent material weathers and develops into soil at the place of origin. Transported material has been geologically eroded, transported, and redeposited by wind or water.

Transported material from which soils have formed in Ellis County consists of eolian deposits of Quaternary age, outwash material of the uplands, and alluvial material of the bottom lands.

Eolian deposits are common throughout Ellis County. They vary in texture from sandy near the rivers to loamy on the uplands. The deposits generally are several feet thick on slopes near the streams and on the more nearly level parts of the upland. On steeper slopes the eolian deposits generally have been thinned by geologic erosion.

Sandy eolian material was deposited during the Pliocene, Pleistocene, and Recent epochs. Reddish, noncalcareous, sandy material was deposited in the southeastern part of this county during the Pleistocene and Pliocene

epochs. The Brownfield, Miles, and Nobscot soils developed from this material (see fig. 3, p. 4). During the Recent epoch, noncalcareous and calcareous sandy material was deposited, mostly along the major streams. The Pratt and Tivoli soils developed from the noncalcareous deposits, and the Likes soils developed from the calcareous deposits.

Loamy eolian material is common in the county. Brown, calcareous, loamy material was deposited on the terraces and the adjacent uplands along the Canadian River during the Recent epoch. The Enterprise and Tip-ton soils developed on the terraces: The Richfield and St. Paul soils developed from calcareous, loamy material deposited on the uplands during the Pliocene and Pleistocene epochs.

The outwash material of the uplands consists of calcareous, sandy and loamy alluvium. It was deposited by streams from the Ogallala and Laverne formations during the Pliocene and Pleistocene epochs. The soils that developed in this material have a thin layer of loess in the upper part of the profile.

The Laverne formation is exposed in the extreme northwestern part of the county. The Otero soils developed in the brownish, calcareous, loamy and sandy material derived from this formation (see fig. 18).

On the uplands south of Wolf Creek is brownish, calcareous, loamy alluvial material derived from the Ogallala formation. The Dalhart, Manter, and Otero soils developed in this material.

Alluvial material occurs on the bottom lands throughout this county. This alluvium was derived from the Laverne formation, the Ogallala formation, and the four formations of the Permian system. Brownish, calcareous, sandy and loamy material derived from the Laverne and Ogallala formations was deposited on some of the flood plains. The sandy material was generally deposited on low bottom lands, near the streams. The Lincoln, Sweetwater, and Elsmere soils developed in this material. The Bayard, Spur, and Wann soils developed in more loamy material that was deposited on higher bottom lands. The Zavala soils developed in noncalcareous, loamy alluvium deposited in the southeastern part of the county. Calcareous, loamy alluvium derived from Permian red beds was the parent material of the Spur and Yahola soils.

The Ogallala formation and the Permian red beds were the sources of residual parent material in Ellis County. The soils that developed in this material generally have a thin layer of loess in the upper part of the profile.

The residual parent material weathered from the Ogallala formation consists of brownish, calcareous, loamy material between moderately to strongly consolidated caliche beds (see fig. 4, p. 5). The Mansker and Potter soils generally developed above the caliche beds, and the Mansic and Berthoud soils developed between the beds.

The Permian rocks from which residual parent material was derived are the Quartermaster formation and the formations that make up the Whitehorse group. Reddish, calcareous, silty or clayey material was derived from the Quartermaster formation. The Vernon soils developed from this material. The material derived from the rocks of the Whitehorse group was also reddish and calcareous, but it was silty or sandy in texture. From this material the Quinlan, Woodward, Carey, and St. Paul soils developed.

Climate and soils

Ellis County has a semiarid to subhumid, continental climate characterized by hot summers, mild autumns, moderately cold winters, and moist, windy springs. Precipitation is more abundant and evaporation more rapid in summer than in the other seasons.

Precipitation, temperature, humidity, and wind are important in the development of soils. Precipitation and temperature act on the parent rock and disintegrate it into material in which plants can live. Throughout the depth of moisture penetration, the biological, physical, and chemical processes react on the parent material, and over a long period of time a soil is formed. The rate of development is greatly accelerated by high temperatures and large amounts of moisture.

The A1 horizon is the first horizon to develop after the decomposition of the first plant growth. Then related horizons begin to develop, largely as a result of translocation of soil material through the action of moisture. The moisture holds in solution the soluble substances, such as lime, and in colloidal suspension the clay particles, which are high in iron and aluminum. Generally, lime moves at a faster rate and to a greater depth than the other substances. It accumulates in a visible zone, or ca horizon (see fig. 6, p. 14). The nature and depth of a lime zone suggest the depth to which water moves.

Clay particles move through the soil at a much slower rate than lime, and they accumulate at a lesser depth to form the B2 horizon. Only mature soils, such as the St. Paul, have a B2 horizon.

In areas of high rainfall, the older soils develop a light-colored, leached zone, called the A2 horizon. This zone results from the removal of clay, iron, and aluminum.

The climate is fairly uniform throughout the county, but a difference in any one of the other soil-forming factors alters the effect of climate on horizon formation and on the degree of development.

Different kinds of parent material alter the effect of climate on soil formation. For example, the silty and clayey red beds are less permeable to water than the loamy red beds. The Vernon soils have silty and clayey parent material and have not weathered long enough to develop a B2 horizon. The Carey and St. Paul soils, which formed from sandy and silty material, do have a B2 horizon. The Vernon soils have a thinner A1 horizon than the Woodward soils, because less water moves down through the profile and more runs off the surface and removes surface soil. The Likes soils formed from calcareous material, and in time can develop into a soil that contains a ca horizon.

The Tivoli soils formed from material that was less calcareous, and they will never have a ca horizon.

Vegetation and animal life

Plants and animals are active in soil formation. They grow in the weathered parent material and produce organic residues. As these residues partly decay, an organic layer (the A1 horizon) is formed. The organic layer gradually thickens until it reaches equilibrium with the climatic processes.

The organic layer is the most fertile part of the soil. It is in this layer that bacteria, fungi, and other microorganisms decompose organic matter, convert humus to simpler forms, liberate plant nutrients, and fix nitrogen.

Larger organisms, such as earthworms, contribute to the translocation of plant residues, to soil aeration, and to the development of soil structure.

The kind and amount of vegetation regulate the thickness of the A1 horizon. Generally, a soil that supports a large amount of vegetation has a thick A1 horizon. The kind and amount of vegetation depends on the moisture supply and on the texture and acidity of the surface layer.

Relief

Relief alters the effect of climate on soil development and horizon formation. If the slope is steep, runoff removes soil material almost as fast as it forms, but if the slope is gentle or nearly level, soil material accumulates. For example, the St. Paul soils, which are nearly level or gently sloping, are deeper and more developed than the Quinlan soils, which are moderately sloping to steep. The Carwile, Sweetwater, Elsmere, and Wann soils are in depressions or on flood plains and have a water table within 5 feet of the surface. Consequently, these soils are mottled, a condition not common in a climate like that of Ellis County.

Time

The length of time required for a soil to develop depends on the combined effects of the other soil-forming factors. The soils of Ellis County range from young, or immature, to old, or mature. The age of soils is indicated by their degree of development. If the soil-forming factors have not been active long enough to form genetically related horizons, the soils are considered young, or immature. The Yahola, Vernon, and Tivoli soils are examples of immature soils in this county. The Mansic soils are considered intermediate in maturity because they have a ca horizon. The St. Paul soils are considered mature soils because they have a B2 horizon. The old soils in the county, such as the Brownfield and Nobscot, have developed an A2 horizon.

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 broader, more inclusive categories for study and comparison of large areas, such as continents (2). In the system of soil classification currently followed in the United States, soils are placed in six categories (6). Beginning with the most inclusive, these categories are the order, the suborder, the great soil group, the family, the series, and the type.

There are three soil orders and thousands of soil types (6). The suborder and family categories have not been fully developed and, thus, have been little used. In soil classification and mapping, attention has been given largely to the recognition of soil types and series within counties or comparable areas and to the subsequent grouping of the series into great soil groups and orders.

The highest category in the system of soil classification consists of the zonal, the intrazonal, and the azonal orders (7). The *zonal order* consists of soils that have evident, genetically related horizons that reflect the dominant influence of climate and living organisms in their formation. The *intrazonal order* consists of soils with evident, genetically related horizons that reflect the dominant influ-

ence of one or more local factors of topography or parent material over the effects of climate and living organisms. The *azonal order* consists of soils that lack distinct, genetically related horizons, commonly because of one or more of the following: youth of parent material, resistance of parent material to change, and steep topography.

The great soil group is the next lower category that has been used in this county. A group consists of several soil series that have the same general sort of profile. Soils of different series within the same great soil group may have significantly different parent material and relief, or they may differ in degree of development. A few soil series have some characteristics of two great soil groups; such series are grouped with the great soil group they resemble most closely but are called intergrades to the other group.

Soil series and soil types are defined and discussed in the section "How This Soil Survey Was Made." The soil series of Ellis County are listed by order and great soil group in table 8, and some of their important characteristics are given. Following the table, there is a brief discussion of the orders and great soil groups represented in this county.

Zonal order

The zonal order consists of soils that have well developed characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation. The zonal order is represented in Ellis County by the Chestnut, Reddish-Brown, Reddish Chestnut, and Red-Yellow Podzolic great soil groups.

CHESTNUT SOILS

The virgin Chestnut soils in Ellis County have an A1 horizon that is moderately thick, is dark brown to grayish brown in color, has granular structure, and is neutral to mildly alkaline. These soils have a slightly lighter colored subsoil that has prismatic to blocky structure. They are generally calcareous in the lower solum. The parent material consists of loamy loess or alluvium. The native vegetation consists of mixed grasses. The soils in Ellis County that most nearly fit the concept of Chestnut soils are those of the Dalhart, Elsmere, Manter, Pratt, Richfield, and Tipton series. The Mansic and Woodward soils also are classified as Chestnut soils, but they have some of the properties of Regosol soils and are considered intergrades toward that great soil group.

The Mansic and Woodward soils resemble Regosols in that they are youthful and have profile characteristics similar to those of the parent material. Like Chestnut soils, they have a dark-colored A1 horizon and a zone of calcium carbonate, but they have no B2 horizon.

REDDISH-BROWN SOILS

The Reddish-Brown soils in Ellis County have a thin, dark grayish-brown A1 horizon, a leached, light-colored A2 horizon, and a reddish-yellow B2 horizon of sandy clay loam. The reaction is medium acid to neutral. The parent material is noncalcareous, loamy material. The native vegetation consists mostly of tall grasses and shin oak. The Brownfield series represents this great soil group in this county.

REDDISH CHESTNUT SOILS

The soils of the Reddish Chestnut group have a dark-brown to dark grayish-brown, slightly acid to mildly al-

TABLE 8.—*Classification of soils by order, great soil group, and series, and some of the factors that affect morphology*

Order, group, and series	Parent material	Slope	Drainage class	Native vegetation
Zonal:				
Chestnut soils—				
Dalhart.....	Brownish, calcareous, loamy deposits.	1 to 5 percent; convex.	Well drained.....	Sand bluestem, little bluestem, and sand sagebrush.
Elsmere.....	Brownish, calcareous, sandy alluvium.	0 to 1 percent; smooth.	Imperfectly drained..	Indiangrass and switchgrass.
Manter.....	Brownish, calcareous, loamy alluvium.	1 to 5 percent; convex.	Well drained.....	Sand bluestem, little bluestem, and some sand sagebrush.
Pratt.....	Brownish, noncalcareous, loamy, eolian deposits.	Undulating.....	Somewhat excessively drained.	Sand sagebrush, sand bluestem, little bluestem, and switchgrass.
Richfield.....	Brownish, calcareous, loamy, eolian deposits.	1 to 5 percent; smooth.	Well drained.....	Little bluestem, blue grama, and buffalograss.
Tipton.....	Brownish, calcareous, loamy, eolian deposits.	0 to 1 percent; smooth.	Well drained.....	Little bluestem, sand bluestem, and sidecoats grama.
Mansic (Intergrade to Regosol)	Brownish, calcareous, loamy deposits.	1 to 8 percent; convex.	Well drained.....	Little bluestem, blue grama, and buffalograss.
Woodward (Intergrade to Regosol).	Reddish, calcareous, loamy Permian red beds.	1 to 8 percent; convex.	Well drained.....	Little bluestem, sand bluestem, and sidecoats grama.
Reddish-Brown soils—				
Brownfield.....	Reddish, noncalcareous, sandy deposits.	Undulating.....	Well drained.....	Shinnery oak, little bluestem, sand bluestem, and switchgrass.
Reddish Chestnut soils—				
Carey.....	Reddish, calcareous, loamy Permian red beds.	1 to 3 percent; convex.	Well drained.....	Little bluestem, sand bluestem, and sidecoats grama.
Miles.....	Reddish, noncalcareous, loamy deposits.	1 to 5 percent; convex.	Well drained.....	Sand bluestem, little bluestem, and some sand sagebrush.
St. Paul.....	Brownish and reddish, calcareous, loamy deposits.	0 to 3 percent; concave.	Well drained.....	Little bluestem, blue grama, and buffalograss.
Red-Yellow Podzolic soils—				
Nobscoot.....	Reddish, noncalcareous, sandy deposits.	Rolling.....	Somewhat excessively drained.	Shinnery oak, little bluestem, sand bluestem, and switchgrass.
Intrazonal:				
Calcisols—				
Mansker.....	Brownish, very calcareous, loamy sediments from the Ogallala formation.	1 to 5 percent; convex.	Well drained.....	Little bluestem, sidecoats grama, blue grama, and buffalograss.
Planosols—				
Carwile.....	Brownish, calcareous, loamy alluvial and eolian deposits.	1 to 3 percent; concave.	Imperfectly drained.	Sand bluestem, little bluestem, and some sand sagebrush.
Azonal:				
Alluvial soils—				
Bayard.....	Brownish, calcareous, loamy alluvium.	0 to 1 percent; smooth.	Well drained.....	Sand bluestem, little bluestem, switchgrass, and indiagrass.
Lincoln.....	Brownish, calcareous, sandy alluvium.	0 to 1 percent; smooth.	Excessively drained..	Indiangrass, switchgrass, little bluestem, and sand bluestem.
Spur.....	Brownish and reddish, calcareous, loamy alluvium.	0 to 15 percent; smooth.	Well drained.....	Sand bluestem, little bluestem, switchgrass, and indiagrass.
Sweetwater.....	Brownish, calcareous, loamy alluvium.	0 to 1 percent; concave.	Poorly drained.....	Indiangrass and switchgrass.
Wann.....	Brownish, calcareous, loamy alluvium.	0 to 1 percent; smooth.	Imperfectly drained..	Sand bluestem, little bluestem, switchgrass, and indiagrass.
Yahola.....	Reddish, calcareous, loamy alluvium.	0 to 1 percent; smooth.	Well drained.....	Sand bluestem, little bluestem, switchgrass, and indiagrass.
Zavala.....	Brownish, noncalcareous, sandy alluvium.	0 to 1 percent; smooth.	Well drained.....	Indiangrass, switchgrass, little bluestem, and sand bluestem.
Lithosols—				
Potter.....	Brownish, very calcareous, loamy, caliche bedrock of the Ogallala formation.	3 to 8 percent; convex.	Somewhat excessively drained.	Little bluestem, sidecoats grama, hairy grama, blue grama, and buffalograss.

TABLE 8.—*Classification of soils by order, great soil group, and series, and some of the factors that affect morphology—Continued*

Order, group, and series	Parent material	Slope	Drainage class	Native vegetation
Azonal—Continued: Lithosols—Continued Vernon.....	Reddish, calcareous, clayey Permian red beds.	8 to 20 percent; hilly.	Somewhat exces- sively drained.	Little bluestem, sideoats grama, blue grama, and buffalograss.
Regosols— Berthoud.....	Brownish, calcareous, loamy deposits.	3 to 8 percent; con- vex.	Well drained.....	Sand bluestem, little blue- stem, and some sand sagebrush.
Enterprise.....	Brownish, calcareous, loamy, eolian deposits.	1 to 8 percent; smooth and con- vex.	Well drained.....	Little bluestem, sand blue- stem, and sideoats grama.
Likes.....	Brownish, calcareous, sandy, eolian deposits.	Undulating and hummocky.	Somewhat exces- sively drained.	Sand sagebrush, sand blue- stem, little bluestem, and switchgrass.
Otero.....	Brownish, calcareous, sandy, eolian and allu- vial deposits.	Undulating and hummocky.	Somewhat exces- sively drained.	Sand bluestem, little blue- stem, and sideoats grama.
Quinlan.....	Reddish, calcareous, loamy Permian red beds.	8 to 20 percent; hilly.	Somewhat exces- sively drained.	Little bluestem, sand blue- stem, and sideoats grama.
Tivoli.....	Brownish, sandy, eolian deposits.	Rolling.....	Excessively drained..	Sand bluestem, sand love- grass, little bluestem, sand sagebrush, and woody plants.

kaline A1 horizon, and a dark-brown to reddish-brown, blocky or prismatic B2 horizon. The lower part of the solum generally is calcareous. The Reddish Chestnut soils in Ellis County developed either in loamy residual material derived from the red beds or in reddish, alluvial and eolian deposits. The vegetation consists of mixed native grasses. The Carey, Miles, and St. Paul series represent this great soil group in Ellis County.

RED-YELLOW PODZOLIC SOILS

The Red-Yellow Podzolic soils in Ellis County have a thin, dark grayish-brown A1 horizon, a leached, light-colored A2 horizon, and a reddish-yellow B2 horizon that has prismatic structure. The reaction is medium acid to mildly alkaline. The parent material is noncalcareous, sandy material of Pliocene or Pleistocene age. The native vegetation consists of tall grasses and shin oak. The Nobscot series represents this great soil group in this county.

Intrazonal order

The intrazonal order is represented in Ellis County by the Calcisol and Planosol great soil groups. The profile characteristics of these soils reflect the overbalancing effect of parent material or relief over the other soil-forming factors.

CALCISOLS

The virgin Calcisols in Ellis County are shallow and have a grayish-brown, moderately alkaline A1 horizon. The parent material is moderately to strongly indurated, impure calcium carbonate. The native vegetation consists of mid and short grasses. The Mansker series represents this great soil group in this country.

PLANOSOLS

The virgin Planosols in Ellis County have a dark grayish-brown, medium acid A1 horizon. The B2 horizon is

mottled light yellowish brown and has subangular blocky structure. The lower part of the solum generally is calcareous. The parent material consists of loamy loess and alluvium. The native vegetation consists of tall and mid grasses. The Carwile soils are the only Planosols in this county.

Azonal order

The azonal order consists of soils that lack genetically related horizons, because of extreme youth, resistant parent material, or steep topography. The characteristics of such soils are similar to those of the parent material. This order is represented in Ellis County by the Alluvial, Lithosol, and Regosol great soil groups.

ALLUVIAL SOILS

The virgin Alluvial soils in Ellis County have a dark grayish-brown to reddish-brown, neutral to moderately alkaline A1 horizon. The parent material consists of loamy and sandy alluvium. These soils occur on rarely to frequently flooded bottom lands. The native vegetation consists of tall and mid grasses, sedges, and trees. The Bayard, Lincoln, Spur, Sweetwater, Wann, Yahola, and Zavala series represent this great soil group in this county.

LITHOSOLS

The virgin Lithosols in Ellis County are shallow or very shallow and have a grayish-brown to red, moderately alkaline A1 horizon. The underlying material contains either a loamy calcium carbonate zone or a clayey red-bed layer. The native vegetation consists of short and mid grasses. The Potter and Vernon series represent this great soil group in this county.

REGOSOLS

The virgin Regosols in Ellis County have a grayish-brown to red, medium acid to moderately alkaline A1

horizon. The parent material consists of either loamy or sandy loess and alluvium or of loamy red beds. In some places lime is lacking in the profile. The native vegetation consists of sand sagebrush and mid and tall grasses. The Berthoud, Enterprise, Likes, Otero, Quinlan, and Tivoli series represent this great soil group in this county.

Technical Descriptions of the Soils

This subsection gives more technical information about the soils of Ellis County than is given in other parts of the report. The soil series are placed in alphabetical order, they are described briefly, and a typical profile of each series is described. (The miscellaneous land types—Blown-out land, Breaks-alluvial land complex, Broken land, Eroded sandy land, Gravelly broken land, Loamy alluvial land, Riverwash, and Rough broken land—which are not identified by series, are not described here.)

BAYARD SERIES

The Bayard soils have a surface layer of dark grayish-brown fine sandy loam and a subsoil of calcareous, brown fine sandy loam alluvium derived from the Ogallala formation. These soils are on bottom lands that are seldom flooded. They are well drained and moderately rapidly permeable. They developed under a cover of mid and tall grasses.

The Bayard soils have a coarser textured subsoil than the Spur soils and a finer textured subsoil than the Elsmere soils. They are better drained than the Wann soils. Both the Elsmere soils and the Wann soils are mottled.

A profile typical of Bayard fine sandy loam is located 1,570 feet north and 1,380 feet west of the southeast corner of sec. 13, T. 21 N., R. 25 W.

- A1—8 to 12 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular structure; slightly hard when dry, very friable when moist; many, fine, fibrous roots; weakly calcareous; clear boundary.
- AC—12 to 42 inches, brown (7.5YR 5/3) fine sandy loam; dark brown (7.5YR 4/3) when moist; weak, fine, granular structure; soft to slightly hard when dry, very friable when moist; numerous fibrous roots; slightly calcareous; clear boundary.
- C—42 to 60 inches, pinkish-gray (7.5Y 6/2) loamy fine sand; brown (7.5YR 5/2) when moist; single grain; loose when dry, very friable when moist; few fibrous roots; moderately calcareous.

The A1 horizon ranges from 5 to 14 inches in thickness and from dark grayish brown to brown in color. Locally, it is winnowed loamy fine sand. The AC horizon ranges from sandy loam to loam (12 to 20 percent clay) in texture and from grayish brown to light brown in color. The depth to the loamy fine sand is more than 20 inches and commonly more than 30 inches. The depth to lime ranges from 0 to 10 inches.

BERTHOUD SERIES

The Berthoud soils have a surface layer of grayish-brown fine sandy loam, an AC horizon of light brownish-gray fine sandy loam, and a C horizon of brownish, calcareous fine sandy loam derived from the Ogallala formation. These soils are on uplands. They are moderately sloping or moderately steep, well drained, and moderately rapidly permeable. They developed under a cover of mid and tall grasses.

The Berthoud soils have a coarser textured subsoil than the Mansic soils and a thicker surface layer than the Otero soils.

A profile typical of Berthoud fine sandy loam is located 1,056 feet north and 90 feet east of the southwest corner of sec. 11, T. 19 N., R. 25 W.

- A1—0 to 8 inches, grayish-brown (10YR 5/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, fine and medium, granular structure; slightly hard when dry, very friable when moist; slightly calcareous; gradual boundary.
- AC—8 to 26 inches, light brownish-gray (10YR 6/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; strongly calcareous; clear boundary.
- Cca—26 to 44 inches, light brownish-gray (10YR 6/2) fine sandy loam; grayish brown (10YR 5/2) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; few threads of segregated lime; strongly calcareous.

The A1 horizon ranges from 6 to 12 inches in thickness, from typically fine sandy loam to loam in texture, and from dark grayish brown to pale brown in color. In places this horizon is leached of lime to a depth of 6 inches. The AC horizon ranges from fine sandy loam to loam (12 to 20 percent clay) in texture. In some places the Cca horizon is lacking, and in some, loamy fine sand occurs below a depth of 24 inches. The AC and the Cca horizons range from light yellowish brown to brown in color.

BROWNFIELD SERIES

The Brownfield soils have a thin surface layer of dark grayish-brown fine sand or loamy fine sand, an A2 horizon of pink fine sand, and a B2 horizon consisting mostly of reddish-yellow sandy clay loam. The C horizon is stratified and consists of pink loamy fine sand and light-brown fine sandy loam. These soils are on uplands. They are gently sloping, well drained, and moderately permeable. They developed under a cover of tall grasses and shin oak.

The Brownfield soils have a finer textured B2 horizon than the Nobscot and Pratt soils and a thinner, coarser textured A1 horizon than the Miles soils.

A profile typical of Brownfield fine sand is located 500 feet west and 360 feet north of the southeast corner of sec. 10, T. 19 N., R. 22 W.

- A1—0 to 4 inches, dark grayish-brown (10YR 4/2) fine sand; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; many fine grass roots and shin oak roots; neutral; clear boundary.
- A2—4 to 19 inches, pink (7.5YR 7/3) fine sand; brown (7.5YR 5/3) when moist; single grain; loose when dry or moist; numerous roots; neutral; irregular boundary.
- B21—19 to 24 inches, yellowish-red (5YR 5/6) sandy clay loam; yellowish red (5YR 4/6) when moist; moderate, coarse, prismatic structure; hard when dry, firm when moist; numerous roots; slightly acid; gradual boundary.
- B22—24 to 36 inches, reddish-yellow (5YR 6/6) sandy clay loam; yellowish red (5YR 5/6) when moist; moderate, coarse, prismatic structure; hard or very hard when dry, firm when moist; numerous roots; medium acid; gradual boundary.
- B3—36 to 46 inches, reddish-yellow (5YR 6/6) sandy clay loam; yellowish red (5YR 5/6) when moist; weak, coarse, prismatic structure; hard when dry, firm when moist; numerous roots; medium acid; gradual boundary.

C1—46 to 60 inches, pink (7.5YR 7/3) loamy fine sand; light brown (7.5YR 6/3) when moist; banded with reddish-yellow (7.5YR 6/6) fine sandy loam that is strong brown (7.5YR 5/6) when moist; massive; hard when dry, friable when moist; few roots; medium acid.

The A1 horizon is 4 to 8 inches thick. Its texture is loamy fine sand or fine sand. Its color is dark grayish brown, except in cultivated fields where material from the A2 horizon has been mixed into the A1 horizon. The A2 horizon ranges from 6 to 30 inches in thickness and from pink to pale brown in color. The B2 horizon generally consists of sandy clay loam (18 to 30 percent clay). It ranges from 12 to 30 inches in thickness and from reddish yellow to reddish brown in color. The C horizon varies slightly in texture, in color, and in the degree of stratification.

CAREY SERIES

The Carey soils have a surface layer of dark-brown silt loam, a B2 horizon of reddish-brown clay loam, and a C horizon of reddish-yellow loam material from the Permian red beds. These soils are gently sloping, well drained, and moderately permeable. They developed under a cover of mid and tall grasses.

The Carey soils have a finer textured profile than the Woodward soils, and they have a well-developed B2 horizon that the Woodward soils lack. They have a slightly redder surface layer and a coarser textured B2 horizon than the St. Paul soils.

A profile typical of Carey silt loam is located 2,510 feet south and 1,980 feet west of the northeast corner of sec. 10, T. 24 N., R. 24 W.

Ap—0 to 3 inches, dark-brown (7.5YR 4/2) silt loam; dark brown (7.5YR 3/2) when moist; weak, very fine, granular structure; soft when dry, friable when moist; many wheat roots; mildly alkaline; clear boundary.

A1—3 to 11 inches, dark-brown (7.5YR 4/2) silt loam; dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist; many wheat roots; mildly alkaline; gradual boundary.

B21—11 to 19 inches, reddish-brown (5YR 4/3) clay loam; dark reddish brown (5YR 3/3) when moist; weak, coarse, prismatic structure; slightly hard when dry, friable when moist; numerous fine roots; mildly alkaline; gradual boundary.

B22—19 to 33 inches, reddish-brown (5YR 4/4) clay loam; dark reddish brown (5YR 3/4) when moist; moderate, medium to coarse, prismatic structure; slightly hard when dry, friable when moist; numerous roots; calcareous; gradual boundary.

B3—33 to 40 inches, reddish-brown (5YR 5/4) clay loam; reddish brown (5YR 4/4) when moist; weak to moderate, coarse, prismatic structure; slightly hard when dry, friable when moist; few roots; calcareous; gradual boundary.

Cca—40 to 60 inches, reddish-yellow (5YR 6/6) loam; yellowish red (5YR 5/6) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist; few roots; strongly calcareous.

The A1 horizon ranges from 8 to 14 inches in thickness and from dark brown to dark grayish brown in color. The B horizon ranges from silt loam to clay loam (24 to 32 percent clay) in texture and from reddish brown to red or yellowish red in color. The Cca horizon ranges from reddish yellow to red in color. In some places this layer is ill defined. The depth to lime ranges from 14 to 30 inches.

CARWILE SERIES

The Carwile soils have a surface layer of dark grayish-brown sandy clay loam, a B2 horizon of mottled light yellowish-brown sandy clay loam, and a C horizon of light-gray fine sandy loam alluvium. These soils are in depressions. They are gently sloping, imperfectly drained, and slowly permeable. They developed under a cover of tall and mid grasses.

The Carwile soils are more poorly drained than the Pratt and Miles soils and have a mottled, finer textured B2 horizon.

A profile typical of the Carwile soils is located 1,980 feet south and 1,254 feet west of the northeast corner of sec. 1, T. 19 N., R. 24 W.

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) light sandy clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, coarse, granular structure; hard when dry, friable when moist; few roots; medium acid; clear boundary.

B1—6 to 10 inches, dark grayish-brown (10YR 4/2) sandy clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, coarse, prismatic structure; very hard when dry, firm when moist; few roots; streaks of organic matter; slightly acid; clear boundary.

B2—10 to 24 inches, light yellowish-brown (2.5Y 6/3) sandy clay loam; light olive brown (2.5Y 5/3) when moist; moderate, coarse, prismatic structure that breaks to moderate, coarse, subangular blocky; very hard when dry, firm when moist; few roots; many, coarse, prominent, reddish-yellow mottles; slightly acid; gradual boundary.

B3—24 to 46 inches, light-gray (2.5Y 7/2) sandy clay loam; light brownish gray (2.5Y 6/2) when moist; weak, fine, granular structure; very hard when dry, firm when moist; few roots; common, coarse, prominent, reddish-yellow mottles; mildly alkaline; gradual boundary.

C—46 to 60 inches +, light-gray (2.5Y 7/2) fine sandy loam; light brownish gray (2.5Y 6/2) when moist; massive; very hard when dry, friable when moist; few roots; faintly mottled; slightly calcareous.

The A1 horizon ranges from 6 to 14 inches in thickness, from clay loam to loamy fine sand in texture, and from dark grayish brown to gray and brown in color. The B2 horizon ranges from sandy clay loam to sandy clay in texture and from light yellowish brown to grayish brown and light olive brown in color. The mottles vary in abundance, size, and color. The depth to lime is more than 30 inches.

DALHART SERIES

The Dalhart soils have a surface layer of dark-brown fine sandy loam, a B2 horizon of brown sandy clay loam, and a visible Cca horizon of pinkish-gray, alluvial fine sandy loam. They are gently to moderately sloping, well drained, and moderately permeable. They developed under a cover of mid and tall grasses.

The Dalhart soils have a finer textured B2 horizon than the Pratt soils. They have a less red B2 horizon than the Miles soils, and they have a Cca horizon. They have a thinner A1 horizon than the St. Paul soils, and they have a sandy clay loam B2 horizon.

A profile typical of Dalhart fine sandy loam is located 2,310 feet west and 132 feet south of the northeast corner of sec. 22, T. 20 N., R. 26 W.

Ap—0 to 5 inches, dark-brown (10YR 4/3) fine sandy loam; dark brown (10YR 3/3) when moist; moderate, fine, granular structure; slightly hard when dry, very friable when moist; many, fine, fibrous wheat roots; mildly alkaline; gradual boundary.

- A1—5 to 11 inches, dark-brown (10YR 4/3) fine sandy loam; dark brown (10YR 3/3) when moist; moderate, medium, granular structure; hard when dry, very friable when moist; many, fine, fibrous roots; mildly alkaline; clear boundary.
- B21—11 to 22 inches, brown (7.5YR 5/4) sandy clay loam; dark brown (7.5YR 4/4) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist; numerous, fine, fibrous roots; mildly alkaline; gradual boundary.
- B22—22 to 36 inches, light-brown (7.5YR 6/4) sandy clay loam of finer texture than the B21 horizon; brown (7.5YR 5/4) when moist; moderate, coarse, prismatic structure that breaks to moderate, medium, granular; hard when dry, friable when moist; few fibrous roots; moderately alkaline; gradual boundary.
- Cca—36 to 48 inches, pinkish-gray (7.5YR 7/2) fine sandy loam; pinkish gray (7.5YR 6/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; few roots; strongly calcareous.

The A1 horizon ranges from 6 to 15 inches in thickness and from dark grayish brown to dark brown in color. The texture generally ranges from fine sandy loam to coarse loam, but in a few places it is loamy fine sand. The B2 horizon ranges from fine sandy loam to sandy clay loam (17 to 30 percent clay) in texture and from brown to light brownish gray or light brown in color. The Cca horizon generally is fine sandy loam in texture, but in some places it includes thin strata of sand, loamy fine sand, and clay loam. It ranges from pinkish gray to brown or yellowish brown in color. The depth to the lime zone ranges from 15 to 45 inches. In some places buried soils occur at a depth of more than 36 inches.

ELSMERE SERIES

The Elsmere soils have a surface layer of gray loamy fine sand and a C horizon of mottled, pale-brown loamy fine sand alluvium. These soils are imperfectly drained and rapidly permeable. They occur on bottom lands but are rarely flooded. They developed under a cover of tall and mid grasses.

The Elsmere soils are more poorly drained than the Lincoln soils and have a mottled finer textured profile. They are better drained and have a finer textured subsoil than the Sweetwater soils, and they are coarser textured than the Wann soils.

A profile typical of Elsmere loamy fine sand is located 2,230 feet east and 130 feet north of the southwest corner of sec. 12, T. 22 N., R. 23 W.

- Ap—0 to 5 inches, gray (10YR 5/1) loamy fine sand; dark gray (10YR 4/1) when moist; weak, very fine, granular structure; soft when dry, very friable when moist; many fine grass roots; strongly calcareous; clear boundary.
- A1—5 to 12 inches, gray (10YR 5/1) loamy fine sand; very dark gray (10YR 3/1) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; many fine grass roots; strongly calcareous; gradual boundary.
- C1—12 to 20 inches, pale-brown (10YR 6/3) loamy fine sand; brown (10YR 5/3) when moist; single grain; hard when dry, very friable when moist; many fine grass roots; strongly calcareous; clear boundary.
- C2—20 to 36 inches, light brownish-gray (10YR 6/2) loamy fine sand; grayish brown (10YR 5/2) when moist; single grain; soft when dry, very friable when moist; numerous roots; many, coarse, distinct, reddish-yellow mottles; strongly calcareous; clear boundary.

- C3—36 to 42 inches, pale-brown (10YR 6/3) fine sandy loam to loamy fine sand; brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; no roots; many, coarse, distinct, brown mottles; highly calcareous.

The A1 horizon ranges from 6 to 20 inches in thickness and from gray to very dark gray and grayish brown in color. The C horizon ranges from grayish brown to very pale brown in color. The depth to the water table fluctuates seasonally between 3 and 8 feet.

ENTERPRISE SERIES

The Enterprise soils have a surface layer of brown very fine sandy loam and a C horizon of brown very fine sandy loam eolian deposits. They are gently sloping to steep, well drained, and moderately permeable. They developed under a cover of mid grasses.

The Enterprise soils have a thinner and a less dark-colored surface layer than the Tipton soils, and they are coarser textured. The depth to lime is less than in the Tipton soils.

A profile typical of Enterprise very fine sandy loam is located 1,518 feet east and 2,310 feet south of the northwest corner of sec. 27, T. 17 N., R. 22 W.

- A1—0 to 9 inches, brown (7.5YR 5/3) very fine sandy loam; dark brown (7.5YR 3/3) when moist; weak, fine, granular structure; soft when dry, friable when moist; many, fine and very fine, fibrous grass roots; many worm casts; slightly calcareous; clear boundary.
- AC—9 to 16 inches, brown (7.5YR 5/3) very fine sandy loam; dark brown (7.5YR 4/3) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; numerous, very fine, fibrous grass roots; numerous worm casts; strongly calcareous; gradual boundary.
- C—16 to 60 inches, brown (7.5YR 5/4) very fine sandy loam; dark brown (7.5YR 4/4) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; numerous very fine grass roots; strongly calcareous; films of lime below a depth of 35 inches.

The A1 horizon ranges from 7 to 14 inches in thickness and from brown to grayish brown in color. In places this horizon is leached of lime to a depth of 10 inches. The C horizon ranges from brown to reddish brown in color.

LIKES SERIES

The Likes soils have a surface layer of grayish-brown loamy fine sand and a C horizon of light yellowish-brown, calcareous, eolian sand. These soils are on undulating and hummocky uplands. They are somewhat excessively drained and rapidly permeable. They developed under a cover of tall and mid grasses.

The Likes soils have a coarser textured subsoil than the Pratt soils and are shallower over the lime zone. They have a less limy surface layer, a coarser textured subsoil, and a less distinct Cca horizon than the Otero soils.

A profile typical of Likes loamy fine sand is located 396 feet west and 162 feet south of the northeast corner of sec. 25, T. 24 N., R. 26 W.

- A—0 to 5 inches, grayish-brown (10YR 5/2) loamy fine sand; dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; many fine grass roots and coarse roots of sand sagebrush; neutral; clear boundary.

- C1—5 to 13 inches, pale-brown (10YR 6/3) loamy fine sand; brown (10YR 5/3) when moist; very weak, fine, granular structure; loose when dry, very friable when moist; numerous fine grass roots, and medium roots of sand sagebrush; neutral; gradual boundary.
- C2—13 to 60 inches, light yellowish-brown (10YR 6/4) sand; yellowish brown (10YR 5/4) when moist; single grain; loose when dry or moist; few roots; strongly calcareous.

The A horizon ranges from 4 to 7 inches in thickness and from dark grayish brown to pale brown in color. The C horizon ranges from sand to loamy fine sand in texture and from light yellowish brown to light brownish gray and very pale brown in color. In some places there is a weak Cca horizon. The depth to lime ranges from 0 to 20 inches.

LINCOLN SERIES

The Lincoln soils have a surface layer of grayish-brown loamy fine sand and a C horizon of light brownish-gray alluvial sand. These soils occur on bottom lands that are frequently flooded. They are excessively drained and rapidly permeable. They developed under a cover of tall and mid grasses.

The Lincoln soils are unmottled and are better drained than the Sweetwater soils and the Elsmere soils. They have a slightly coarser textured subsoil than the Elsmere soils.

A profile typical of the Lincoln soils is located 2,406 feet east and 858 feet south of the northwest corner of sec. 16, T. 21 N., R. 25 W.

- A—0 to 7 inches, grayish-brown (10YR 5/2) loamy fine sand; dark grayish brown (10YR 4/2) when moist; weak, very fine, granular structure; soft when dry, very friable when moist; few grass roots; strongly calcareous; clear boundary.
- C1—7 to 24 inches, light brownish-gray (10YR 6/2) fine sand; grayish brown (10YR 5/2) when moist; single grain; loose when dry or moist; few roots; strongly calcareous; gradual boundary.
- C2—24 to 60 inches, light-gray (10YR 7/2) fine sand; light brownish gray (10YR 6/2) when moist; single grain; loose when dry or moist; very few roots; strongly calcareous.

The A horizon ranges from 0 to 7 inches in thickness, from sand to silt loam in texture, and from grayish brown to pale brown in color. The C horizon ranges from light brownish gray to very pale brown in color. It includes thin strata of finer textured material, but there is not enough of the finer textured material to change the average texture.

MANSIC SERIES

The Mansic soils have a surface layer of dark grayish-brown clay loam, an AC horizon that is grayish brown, and a Cca horizon of light brownish-gray clay loam. The parent material is residuum derived from the Ogallala formation. These soils are gently to strongly sloping, well drained, and moderately permeable. They developed under a cover of mid and short grasses.

The Mansic soils have a finer textured profile than the Berthoud soils. They have a limy surface layer, and they lack the B2 horizon of the Richfield and St. Paul soils.

A profile typical of Mansic clay loam is located 1,650 feet west and 396 feet south of the northeast corner of sec. 29, T. 23 N., R. 24 W.

- Ap—0 to 5 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; weak, fine and very fine, granular structure; slightly hard when dry, friable when moist; few partly decomposed roots; few worm casts; strongly calcareous; clear boundary.
- A1—5 to 13 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; few roots; many worm casts; strongly calcareous; gradual boundary.
- AC—13 to 18 inches, grayish-brown (10YR 5/2) clay loam; dark grayish brown (10YR 4/2) when moist; very weak, coarse, prismatic structure that breaks to moderate, fine, granular; slightly hard when dry, friable when moist; few roots; few worm casts; strongly calcareous; gradual boundary.
- C—18 to 38 inches, brown (10YR 5/3) clay loam; dark brown (10YR 4/3) when moist; weak, medium, prismatic structure that breaks to moderate, medium, granular; soft when dry, friable when moist; few roots; threaded lime; strongly calcareous; gradual boundary.
- Cca—38 to 47 inches, light-gray (10YR 7/2) clay loam; grayish brown (10YR 5/2) when moist; weak, coarse, prismatic structure; soft when dry, friable when moist; few roots; white, threaded lime; strongly calcareous.

The A1 horizon ranges from 7 to 15 inches in thickness. In eroded areas the color is grayish brown. The AC horizon ranges from 4 to 7 inches in thickness. The C horizon ranges from brown to light brownish gray or light brown in color. The Cca horizon is weakly or moderately developed. It occurs at a depth of 30 to 60 inches. The depth to lime ranges from 0 to 10 inches. The texture is predominantly clay loam throughout the profile, but it ranges from loam to clay loam (24 to 32 percent clay).

MANSKER SERIES

The Mansker soils have a surface layer of grayish-brown loam, an AC horizon of light brownish-gray loam, and a Cca horizon of calcareous, pink loam of the Ogallala formation. These soils are gently sloping to steep, well drained, and moderately permeable. They developed under a cover of short and mid grasses.

The Mansker soils are coarser textured than the Mansic soils, and the depth to the Cca horizon is less than in the Mansic soils. The depth to the Cca horizon is greater than in the Potter soils.

A profile typical of Mansker loam is located 2,046 feet east and 96 feet south of the northwest corner of sec. 28, T. 22 N., R. 25 W.

- A1—0 to 11 inches, grayish-brown (10YR 5/2) loam; dark grayish brown (10YR 4/2) when moist; weak or moderate, fine, granular structure; hard when dry, friable when moist; many grass roots; calcareous; gradual boundary.
- AC—11 to 16 inches, light brownish-gray (10YR 6/2) loam; grayish brown (10YR 5/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; many fine roots; strongly calcareous; clear boundary.
- Cca—16 to 40 inches, pink (7.5YR 7/4), strongly consolidated caliche of the Ogallala formation.

The A1 horizon ranges from 6 to 14 inches in thickness and from dark grayish brown to grayish brown in color. The AC horizon ranges from grayish brown to very pale brown and to pink in color. The Cca horizon is moderately to strongly consolidated. The depth to this horizon is 10 to 20 inches. Horizons in the profile range from loam to clay loam in texture.

MANTER SERIES

The Manter soils have a surface layer of dark grayish-brown fine sandy loam and a C horizon of brown, alluvial fine sandy loam. They are gently to moderately sloping, well drained, and moderately rapidly permeable. They developed under a cover of mid and tall grasses.

The Manter soils have a thicker, darker colored A1 horizon than the Otero soils. They are leached of lime to a greater depth than the Otero soils but to a lesser depth than the Pratt soils. They lack the B2 horizon of the Dalhart soils.

A profile typical of Manter fine sandy loam is located 198 feet north and 594 feet west of the southeast corner of sec. 4, T. 20 N., R. 25 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; many fine roots; neutral, clear boundary.

A1—7 to 14 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, very friable when moist; many fine roots; neutral; clear boundary.

AC—14 to 26 inches, brown (10YR 5/3) fine sandy loam; dark brown (10YR 4/3) when moist; weak, coarse, prismatic structure; soft when dry, very friable when moist; numerous fine roots; slightly calcareous; gradual boundary.

C1—26 to 42 inches, brown (10YR 5/3) fine sandy loam; dark brown (10YR 4/3) when moist; weak, coarse, prismatic structure; soft when dry, very friable when moist; numerous roots; threaded lime; strongly calcareous; clear boundary.

C2—42 to 60 inches, pale-brown (10YR 6/3), stratified loamy fine sand, sandy clay loam, or fine sandy loam; brown (10YR 5/3) when moist; single grain or granular structure; soft when dry, very friable when moist; few roots; threaded lime; strongly calcareous.

The A1 horizon ranges from 6 to 16 inches in thickness. Typically, it is dark grayish brown in color. The C horizon ranges from brown to very pale brown and pinkish gray. To a depth of 30 inches, the profile generally is fine sandy loam to loam (10 to 20 percent clay). The depth to lime ranges from 10 to 30 inches.

MILES SERIES

The Miles soils have a surface layer of dark-brown fine sandy loam, a B2 horizon of reddish-brown sandy clay loam, and a C horizon of reddish-brown, noncalcareous loamy fine sand. These soils are gently to moderately sloping, well drained, and moderately permeable. They developed under a cover of mid and tall grasses.

The Miles soils have a redder B2 horizon than the Dalhart soils, and they lack a Cca horizon. They have a redder and finer textured B2 horizon than the Pratt soils. They have a thicker and finer textured A1 horizon than the Brownfield soils and lack an A2 horizon.

A profile typical of Miles fine sandy loam is located 1,518 feet north and 228 feet west of the southeast corner of sec. 5, T. 19 N., R. 22 W.

Ap—0 to 4 inches, dark-brown (7.5YR 4/3) fine sandy loam; dark brown (7.5YR 3/3) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; few roots; slightly acid; clear boundary.

A1—4 to 8 inches, dark-brown (7.5YR 4/3) fine sandy loam; dark brown (7.5YR 3/3) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; few roots; slightly acid; clear boundary.

B1—8 to 12 inches, reddish-brown (5YR 4/3) sandy clay loam; dark reddish brown (5YR 3/3) when moist; weak, medium, prismatic structure; hard when dry, friable when moist; slightly acid; gradual boundary.

B2—12 to 22 inches, reddish-brown (5YR 5/4) sandy clay loam; reddish brown (5YR 4/4) when moist; weak, coarse, prismatic structure; hard when dry, firm when moist; medium acid; gradual boundary.

B3—22 to 42 inches, yellowish-red (5YR 5/6) fine sandy loam; yellowish red (5YR 4/6) when moist; weak, coarse, prismatic structure; slightly hard when dry, friable when moist; medium acid; gradual boundary.

C—42 to 70 inches, reddish-brown (5YR 5/3) bands of loamy fine sand and fine sand; reddish brown (5YR 4/3) when moist; structureless; slightly hard when dry, friable when moist; medium acid.

The A1 horizon ranges from 5 to 12 inches in thickness and from dark brown to grayish brown in color. Typically, the texture is fine sandy loam, but in some places it is loamy fine sand. The B2 horizon ranges from 10 to 30 inches in thickness and from reddish brown to light red in color. In most places it has prismatic structure, but in some places it has weak, subangular blocky structure. The C horizon varies slightly in texture and color.

NOBSCOT SERIES

The Nobscot soils have a surface layer of dark grayish-brown fine sand or loamy fine sand, an A2 horizon of pale-brown sand, a B2 horizon of reddish-yellow fine sandy loam, and a C horizon of light-brown fine sand. These soils are hummocky or rolling, somewhat excessively drained, and rapidly permeable. They developed under a cover of shin oak and tall and mid grasses.

The Nobscot soils have a coarser textured B2 horizon than the Brownfield soils. They are deeper than the Pratt soils and have a redder B2 horizon.

A profile typical of a Nobscot soil is located 1,386 feet east and 96 feet north of the southwest corner of sec. 23, T. 17 N., R. 23 W.

A1—0 to 5 inches, dark grayish-brown (10YR 4/2) loamy fine sand; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; many shin oak roots; mildly alkaline; clear boundary.

A2—5 to 28 inches, pale-brown (10YR 6/3) fine sand; brown (10YR 5/3) when moist; single grain; soft when dry, very friable when moist; numerous roots; mildly alkaline; irregular boundary.

B2—28 to 46 inches, reddish-yellow (5YR 6/6) fine sandy loam; yellowish red (5YR 5/6) when moist; weak, coarse, prismatic structure; hard when dry, very friable when moist; numerous roots; slightly acid; gradual boundary.

B3—46 to 60 inches, reddish-yellow (5YR 6/8) fine sand; pink (7.5YR 7/4) when moist; banded with yellowish-red (5YR 5/8) loamy fine sand that is light brown (7.5YR 6/4) when moist; massive; hard when dry, very friable when moist; few roots; slightly acid; gradual boundary.

C—60 to 80 inches, light-brown (7.5YR 6/5) fine sand; brown (7.5YR 5/5) when moist; massive; slightly hard when dry, very friable when moist; few roots; slightly acid.

The A1 horizon is 3 to 7 inches thick. The texture is loamy fine sand or fine sand. The color is dark grayish brown except in cultivated fields where material from the lighter colored A2 horizon has been mixed into the A1.

horizon. The A2 horizon ranges from 10 to 40 inches in thickness and from pale brown to pink in color. The B2 horizon ranges from 10 to 40 inches in thickness, from loamy fine sand to fine sandy loam (5 to 16 percent clay) in texture, and from reddish yellow to red and reddish brown in color. The C horizon varies slightly in color, and in many places it is loamy fine sand in texture.

OTERO SERIES

The Otero soils have a surface layer of grayish-brown fine sandy loam and a Cca horizon of light-gray fine sandy loam and loamy fine sand alluvial strata. These soils are undulating and hummocky, somewhat excessively drained, and moderately rapidly permeable. They developed under a cover of short and mid grasses.

The Otero soils have a thinner, lighter-colored, and more limy A horizon than the Manter soils. They have a more limy surface layer, a finer textured profile, and a more distinct Cca horizon than the Likes soils.

A typical profile of Otero soils is located 2,260 feet west and 280 feet south of the northeast corner of sec. 14, T. 24 N., R. 26 W.

- A—0 to 4 inches, grayish-brown (10YR 5/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; many fine grass roots; highly calcareous; clear boundary.
- Cl—4 to 17 inches, light brownish-gray (10YR 6/2) sandy loam; grayish brown (10YR 5/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; numerous fine grass roots; highly calcareous; gradual boundary.
- Cca1—17 to 25 inches, light-gray (10YR 7/2) fine sandy loam; light brownish gray (10YR 6/2) when moist; massive; slightly hard when dry, firm when moist; few roots; highly calcareous; clear boundary.
- Cca2—25 to 50 inches, very pale brown (10YR 7/3) loamy sand; pale brown (10YR 6/3) when moist; single grain; slightly hard when dry, friable when moist; few roots; highly calcareous.

The A horizon ranges from 3 to 6 inches in thickness, from fine sandy loam to loamy fine sand in texture, and from grayish brown to pale brown in color. The C horizon ranges from fine sandy loam to loamy sand in texture and from light brownish gray to very pale brown in color. The depth to the Cca horizon ranges from 10 to 30 inches.

POTTER SERIES

The Potter soils have a surface layer of grayish-brown loam over a layer of consolidated caliche that consists of highly calcareous deposits derived from the Ogallala formation. These soils are gently sloping to steep, somewhat excessively drained, and moderately permeable.

The depth to the layer of caliche is less in the Potter soils than in the Mansker soils.

A profile typical of Potter loam is located 2,178 feet south and 396 feet east of the northwest corner of sec. 34, T. 22 N., R. 25 W.

- A1—0 to 4 inches, grayish-brown (10YR 5/2) loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; many fine grass roots; scattered caliche; strongly calcareous; clear boundary.
- C—4 to 7 inches, grayish-brown (10YR 5/2) loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; many fine grass roots; many weathered caliche fragments $\frac{1}{4}$ inch to 3 inches in diameter; highly calcareous; clear boundary.

Dr—7 to 10 inches, very pale brown (10YR 8/3) consolidated caliche caprock; very pale brown (10YR 7/3) when moist.

The A1 horizon ranges from 3 to 8 inches in thickness and from dark grayish brown to grayish brown in color. In texture it is predominantly loam, but it ranges from fine sandy loam to clay loam. The C horizon ranges from grayish brown to very pale brown in color. The depth to the layer of caliche is 3 to 10 inches. This horizon is moderately or strongly consolidated.

PRATT SERIES

The Pratt soils have a surface layer of grayish-brown loamy fine sand, a B2 horizon of light yellowish-brown loamy fine sand, and a C horizon of light-brown, eolian loamy fine sand. These soils are undulating to duned, somewhat excessively drained, and rapidly permeable. They developed under a cover of tall and mid grasses.

The Pratt soils are finer textured than the Tivoli soils. They are leached of lime to a greater depth than the Likes soils, and they have a B2 horizon, which the Likes soils lack. They have a less red B2 horizon than the Nobscot soils, and they lack an A2 horizon.

A profile typical of Pratt loamy fine sand is located 330 feet south and 1,056 feet west of the northeast corner of sec. 28, T. 22 N., R. 23 W.

- A1—0 to 9 inches, grayish-brown (10YR 5/2) loamy fine sand; dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; many roots; neutral to slightly acid; gradual boundary.
- B2—9 to 26 inches, light yellowish-brown (10YR 6/4) loamy fine sand; yellowish brown (10YR 5/4) when moist; weak, fine, granular structure to weak, coarse, prismatic; soft when dry, very friable when moist; neutral to mildly alkaline; noncalcareous; diffuse boundary.
- C—26 to 60 inches, light-brown (7.5YR 6/4) loamy fine sand; brown (7.5YR 5/4) when moist; weak, fine, granular structure that breaks to single grain; loose when dry or moist; mildly alkaline.

The A1 horizon ranges up to 16 inches in thickness, from fine sandy loam to loamy fine sand in texture, and from dark brown to grayish brown in color. The B2 horizon ranges from 10 to 24 inches in thickness, from fine sandy loam to loamy fine sand in texture, and from light yellowish brown to strong brown in color. The C horizon ranges from loamy fine sand to fine sandy loam in texture and from light brown to yellowish brown or reddish yellow in color. Typically, the profile is free of lime, but in some places the soil is calcareous below a depth of 30 inches.

QUINLAN SERIES

The Quinlan soils have a surface layer of red loam and a C horizon of weakly consolidated red loam from the Permian red beds. These soils are moderately sloping to steep, somewhat excessively drained, and moderately permeable. They developed under a cover of mid and tall grasses.

The Quinlan soils are more shallow over red beds and have a redder surface layer than the Woodward soils.

A profile typical of Quinlan loam is located 360 feet north and 66 feet east of the southwest corner of sec. 4, T. 17 N., R. 22 W.

- A1—0 to 7 inches, red (2.5YR 4/6) loam; dark red (2.5YR 3/6) when moist; weak, fine and medium, granular structure; soft when dry, very friable when moist; many fine grass roots; slightly calcareous; clear boundary.
- C—7 to 15 inches, red (2.5YR 5/8) loam; red (2.5 4/8) when moist; weakly consolidated, stratified, silty and sandy Permian red beds.

The A1 horizon ranges from 3 to 7 inches in thickness and from red to reddish brown and yellowish red in color. The C horizon ranges from loam to very fine sandy loam in texture and from red to reddish brown and light red in color. The depth to the stratified, weakly consolidated red beds ranges from 3 to 18 inches.

RICHFIELD SERIES

The Richfield soils have a surface layer of dark grayish-brown clay loam, a B21 horizon of dark-brown clay loam, and a Ccab horizon of dark grayish-brown, eolian clay loam. The soils are gently or moderately sloping, well drained, and moderately slowly permeable. They developed under a cover of short and mid grasses.

The Richfield soils have a B2 horizon, which the Mansic soils lack, and they are leached of lime to a greater depth than the Mansic soils. They have a finer textured A horizon, a slightly finer textured B2 horizon, and a less red C horizon than the St. Paul soils.

A profile typical of Richfield clay loam is located 1,848 feet south and 284 feet east of the northwest corner of sec. 6, T. 22 N., R. 25 W.

- Ap—0 to 4 inches, dark grayish-brown (10YR 4/2) light clay loam; very dark grayish brown (10YR 3/2) when moist; weak, fine to medium, granular structure; hard when dry, friable when moist; numerous fine roots; mildly alkaline; gradual boundary.
- A1—4 to 8 inches, dark grayish-brown (10YR 4/2) light clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure that grades to weak, very fine, subangular blocky; hard when dry, firm when moist; numerous fine roots; mildly alkaline; gradual boundary.
- B1—8 to 13 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, subangular blocky structure; hard when dry, firm when moist; few roots; mildly alkaline; clear boundary.
- B21—13 to 24 inches, dark-brown (10YR 4/3) clay loam; dark brown (10YR 3/3) when moist; moderate, medium and fine, subangular blocky structure; hard when dry, firm when moist; mildly alkaline; gradual boundary.
- B22—24 to 32 inches, dark-brown (10YR 4/3) heavy clay loam; dark brown (10YR 3/3) when moist; moderate, medium, subangular blocky structure; very hard when dry, very firm when moist; slightly calcareous; gradual boundary.
- B3ca—32 to 48 inches, dark-brown (10YR 4/3) clay loam; dark brown (10YR 3/3) when moist; moderate, coarse, prismatic structure that breaks to weak, medium, subangular blocky; hard when dry, firm when moist; few roots; strongly calcareous; gradual boundary.
- Ccab—48 to 60 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; threaded lime; strongly calcareous.

The A1 horizon is 4 to 11 inches thick. The B2 horizon is clay loam (32 to 40 percent clay). The B2 horizon and the Ccab horizon range from dark brown to brown and grayish brown in color. The depth to the calcareous layers ranges from 10 to 30 inches. Buried horizons are common.

ST. PAUL SERIES

The St. Paul soils have a surface layer of dark grayish-brown silt loam, a B22 horizon of reddish-gray silty clay loam, and a C horizon of reddish, calcareous silty clay loam over Permian red beds. These soils are on uplands. They are nearly level to gently sloping, well drained, and moderately slowly permeable. They developed under a cover of mid and short grasses.

The St. Paul soils have a thicker, coarser textured A1 horizon, a slightly coarser textured B2 horizon, and generally, a redder C horizon than the Richfield soils. The B2 horizon of the St. Paul soils is finer textured and less reddish than that of the Carey soils, and it has subangular blocky rather than prismatic structure.

A profile typical of St. Paul silt loam is located 1,920 feet north and 460 feet west of the southeast corner of sec. 6, T. 24 N., R. 23 W.

- A1—0 to 15 inches, dark grayish-brown (10YR 4/2) silt loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; hard when dry, friable when moist; many, fine, fibrous wheat roots; neutral; clear boundary.
- B1—15 to 25 inches, dark-brown (7.5YR 4/2) silty clay loam; dark brown (7.5YR 3/2) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist; many fine roots; mildly alkaline; gradual boundary.
- B21—25 to 35 inches, brown (7.5YR 5/3) silty clay loam; dark brown (7.5YR 4/3) when moist; weak, fine and medium, subangular blocky structure; hard when dry, firm when moist; many fine roots; mildly alkaline; gradual boundary.
- B22—35 to 44 inches, reddish-gray (5YR 5/2) silty clay loam; dark reddish gray (5YR 4/2) when moist; moderate, medium and coarse, subangular blocky structure; very hard when dry, firm when moist; numerous fine roots; moderately calcareous; gradual boundary.
- B3—44 to 56 inches, reddish-brown (5YR 5/4) silty clay loam; reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky structure; very hard when dry, firm when moist; numerous fine roots; strongly calcareous; gradual boundary.
- C—56 to 64 inches, light reddish-brown (5YR 6/4) light silty clay loam; reddish brown (5YR 5/4) when moist; moderate, fine and medium, granular structure; hard when dry, friable when moist; few roots; strongly calcareous.

The A1 horizon ranges from 11 to 18 inches in thickness and from very dark grayish brown to dark grayish brown in color. The B2 horizon ranges from clay loam to silty clay loam (32 to 38 percent clay) in texture and from brown to reddish gray in color. The C horizon is brown to light reddish brown or light red. The depth to lime ranges from 20 to 50 inches but is most commonly 24 to 36 inches.

SPUR SERIES

The Spur soils have a surface layer of dark grayish-brown loam and a C horizon of brown, alluvial clay loam. These soils are on bottom lands but are seldom flooded. They are well drained and moderately permeable. They developed under a cover of tall and mid grasses.

The Spur soils are finer textured than the Bayard and Yahola soils and have a thicker A1 horizon.

A profile typical of Spur loam is located 2,600 feet north and 40 feet east of the southwest corner of sec. 6, T. 21 N., R. 25 W.

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; many fine grass roots; slightly calcareous; clear boundary.

A1—8 to 18 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many fine roots; slightly calcareous; gradual boundary.

C—18 to 60 inches, brown (10YR 5/3) clay loam; dark brown (10YR 4/3) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; many fine grass roots; strongly calcareous.

The A1 horizon ranges from 6 to 20 inches in thickness and from dark grayish brown to dark brown and reddish brown in color. Typically, the texture is loam, but it ranges from loam to clay loam. The C horizon ranges from loam to silty clay loam (20 to 32 percent clay) in texture and from brown to light yellowish brown and reddish brown in color.

SWEETWATER SERIES

The Sweetwater soils have a surface layer of gray loamy to sandy material and a C horizon of mottled grayish-brown, alluvial fine sand that generally is moist. These soils are on bottom lands and are flooded frequently. They are poorly drained and moderately slowly permeable. They developed under a cover of tall and mid grasses.

The Sweetwater soils are more poorly drained than the Lincoln soils, and they are mottled. They are more poorly drained than the Wann and Elsmere soils and have a coarser textured subsoil.

A profile typical of a Sweetwater soil is located 200 feet south and 200 feet west of the northeast corner of sec. 17, T. 21 N., R. 25 W.

A11—0 to 4 inches, gray (10YR 5/1) silt loam; very dark gray (10YR 3/1) when moist; weak, fine, granular structure; hard when dry, friable when moist; strongly calcareous; clear boundary.

A12—4 to 12 inches, dark-gray (10YR 4/1) silty clay loam; very dark gray (10YR 3/1) when moist; weak, medium, subangular blocky structure; very hard when dry, firm when moist; strongly calcareous; clear boundary.

C1—12 to 32 inches, light-gray (10YR 7/2) fine sand; grayish brown (10YR 5/2) with many, coarse, distinct, dark-brown mottles when moist; single grain; loose when dry, very friable when moist; calcareous; abrupt boundary.

C2—32 to 48 inches, light-gray (10YR 7/2) fine sand; grayish brown (10YR 5/2) when moist; single grain; loose when dry, very friable when moist; calcareous.

The A horizon ranges from 0 to 18 inches in thickness, from loamy fine sand to silty clay loam in texture, and from gray to very dark grayish brown in color. The C horizon generally is fine sand, but in many places it is stratified with thin layers of finer textured material. It ranges from grayish brown to very pale brown and pale yellow. The depth to the water table fluctuates seasonally between 1 and 5 feet. Some areas are affected by salinity.

TIPTON SERIES

The Tipton soils have a surface layer of dark-brown silt loam and a C horizon of brown, eolian silt loam. These soils are nearly level, well drained, and moderately permeable. They developed under a cover of mid and tall grasses.

The Tipton soils have a thicker, darker colored surface layer and a finer textured profile than the Enterprise soils, and they are leached of lime to a greater depth. They have a coarser textured subsoil than the St. Paul soils.

A profile typical of Tipton silt loam is located 2,508 feet south and 198 feet east of the northwest corner of sec. 27, T. 17 N., R. 22 W.

A1—0 to 16 inches, dark-brown (7.5YR 4/2) silt loam; dark brown (7.5YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, very friable when moist; many fine roots; mildly alkaline; gradual boundary.

AC—16 to 24 inches, dark-brown (7.5YR 4/3) silt loam; dark brown (7.5YR 3/3) when moist; moderate, fine and medium, granular structure; slightly hard when dry, very friable when moist; many fine roots; slightly calcareous below a depth of 20 inches; moderately alkaline; gradual boundary.

C—24 to 60 inches, brown (7.5YR 5/4) silt loam; dark brown (7.5YR 4/4) when moist; moderate, fine and medium, granular structure; slightly hard when dry, very friable when moist; few very fine roots; strongly calcareous.

The A1 horizon ranges from 12 to 20 inches in thickness and from dark brown to dark grayish brown or dark gray in color. The AC horizon ranges from 4 to 10 inches in thickness. The C horizon ranges from brown to light reddish brown and pinkish gray in color. The depth to lime ranges from 15 to 36 inches but is most commonly 17 to 24 inches.

TIVOLI SERIES

The Tivoli soils have a surface layer of grayish-brown fine sand and a C horizon of pink, eolian fine sand. These soils have a duned topography. They are excessively drained and very rapidly permeable. They developed under a cover of tall and mid grasses.

The Tivoli soils have a coarser textured, less coherent profile than the Pratt soils. They lack both the A2 horizon and the B2 horizon of reddish-yellow fine sandy loam that are typical of the Nobscot soils.

A profile typical of Tivoli fine sand is located 2,040 feet south and 1,860 feet west of the northeast corner of sec. 13, T. 21 N., R. 26 W.

A1—0 to 8 inches, grayish-brown (10YR 5/2) fine sand; dark grayish brown (10YR 4/2) when moist; single grain; loose when dry or moist; many sage and grass roots; medium acid; gradual boundary.

C—8 to 50 inches, pink (7.5YR 7/3) fine sand; light brown (7.5YR 6/3) when moist; single grain; loose when dry or moist; numerous grass roots; slightly acid.

The A1 horizon ranges from 4 to 8 inches in thickness and from grayish brown to brown in color. The C horizon ranges from pink to brown and yellowish brown.

VERNON SERIES

The Vernon soils have a surface layer of red clay loam and an AC horizon of red clay loam over silty and clayey shale of the Permian red beds. These soils are strongly sloping or steep, somewhat excessively drained, and slowly permeable. They developed under a cover of short and mid grasses.

The Vernon soils have a finer textured subsoil and more clayey parent material than the Woodward and Quinlan soils.

A profile typical of Vernon clay loam is located 2,040 feet east and 530 feet south of the northwest corner of sec. 36, T. 18 N., R. 23 W.

- A1—0 to 4 inches, red (2.5YR 4/6) clay loam; dark red (2.5YR 3/6) when moist; weak, fine, granular structure; hard when dry, firm when moist; many fine roots; calcareous; gradual boundary.
- AC—4 to 19 inches, red (2.5YR 5/6) clay loam; red (2.5YR 4/6) when moist; weak to moderate, fine, granular structure; hard when dry, firm when moist; many fine roots; calcareous; gradual boundary.
- Dr—19 to 30 inches, red (10R 5/6), stratified silty and clayey shale of the Permian red beds; red (10R 4/6) when moist.

The A1 horizon ranges from 4 to 10 inches in thickness, from clay loam to clay (27 to 42 percent clay) in texture, and from red to pale red and light reddish brown in color. In texture, the AC horizon is similar to the A1 horizon. It ranges from red to pale red in color. The depth to lime ranges from 0 to 10 inches, and the depth to the Dr horizon from 8 to 25 inches.

WANN SERIES

The Wann soils have a surface layer of dark grayish-brown fine sandy loam and a C horizon of mottled, pale-brown, alluvial fine sandy loam. These soils are on bottom lands that are seldom flooded. They are imperfectly drained and moderately rapidly permeable. They developed under a cover of tall and mid grasses.

The Wann soils are better drained than the Sweetwater soils and have a finer textured subsoil. They are finer textured than the Elsmere soils, and they are mottled and more poorly drained than the Bayard soils.

A profile typical of Wann fine sandy loam is located 2,230 feet north and 150 feet east of the southwest corner of sec. 2, T. 21 N., R. 24 W.

- Ap—0 to 5 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; hard when dry, very friable when moist; few, fine, fibrous roots; strongly calcareous; clear boundary.
- A1—5 to 12 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; few fine roots; strongly calcareous; gradual boundary.
- C1—12 to 27 inches, pale-brown (10YR 6/3) fine sandy loam; brown (10YR 5/3) when moist; hard when dry, very friable when moist; few fibrous roots; strongly calcareous; clear boundary.
- C2—27 to 42 inches, pale-brown (10YR 6/3) fine sandy loam; brown (10YR 5/3) when moist; few, fine, distinct, strong-brown mottles; weak, fine, granular structure; hard when dry, very friable when moist; very few roots; strongly calcareous; gradual boundary.
- C3—42 to 47 inches, light brownish-gray (10YR 6/2) sandy clay loam; grayish brown (10YR 5/2) when moist; many, coarse, faint, strong-brown iron mottles; massive; hard when dry, friable when moist; no roots; strongly calcareous; abrupt boundary.
- C4—47 to 56 inches, light-brown (7.5YR 6/4), stratified fine sandy loam and fine sand; brown (7.5YR 5/4) when moist; single grain; hard when dry, very friable when moist; no roots; strongly calcareous.

The A1 horizon ranges from 7 to 16 inches in thickness and from dark grayish brown to dark gray in color. Its texture is dominantly fine sandy loam, but in places it is loam or clay loam. The subsoil ranges from fine sandy

loam to loam (15 to 25 percent clay) in texture and from pale brown to grayish brown and pink in color. The depth to the water table fluctuates between 3 and 12 feet.

WOODWARD SERIES

The Woodward soils have a surface layer and an AC horizon of reddish-brown loam. The substratum consists of weakly consolidated silty and sandy red-bed material. These soils are gently sloping to steep, well drained, and moderately permeable. They developed under a cover of mid and tall grasses.

The Woodward soils are deeper than the Quinlan soils, and they have a darker colored A1 horizon. They lack the B2 horizon of the Carey soils.

A profile typical of Woodward loam is located 2,580 feet west and 100 feet south of the northeast corner of sec. 11, T. 24 N., R. 24 W.

- A1—0 to 8 inches, reddish-brown (5YR 4/4) loam; dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few fine roots; calcareous; gradual boundary.
- AC—8 to 14 inches, reddish-brown (5YR 5/4) loam; reddish brown (5YR 4/4) when moist; moderate, medium or fine, granular structure; soft when dry, friable when moist; few roots; strongly calcareous; gradual boundary.
- C1—14 to 27 inches, red (2.5YR 5/6) loam; red (2.5YR 4/6) when moist; weak, fine, granular structure; soft when dry, very friable when moist; strongly calcareous; clear boundary.
- Cca—27 to 30 inches, red (2.5YR 5/8) very fine sandy loam; red (2.5YR 4/8) when moist; visible limy layer consisting of partly weathered, weakly consolidated silty and sandy material of the Permian red beds.

The A1 horizon ranges from 0 to 12 inches in thickness and from reddish brown to dark reddish gray and dark brown in color. The C horizon ranges from very fine sandy loam to loam in texture and from red to light reddish brown in color. The Cca horizon is at a depth of more than 15 inches. The depth to the stratified red beds is 18 to 50 inches.

YAHOLA SERIES

The Yahola soils have a surface layer of reddish-brown fine sandy loam and a C horizon of light reddish-brown, alluvial fine sandy loam. These soils are on bottom lands that are seldom flooded. They are well drained and moderately rapidly permeable. They developed under a cover of mid and tall grasses.

The Yahola soils are coarser textured than the Spur soils.

A profile typical of Yahola fine sandy loam is located 1,000 feet north and 660 feet east of the southwest corner of sec. 32, T. 18 N., R. 22 W.

- A1—0 to 10 inches, reddish-brown (5YR 5/4) fine sandy loam; reddish brown (5YR 4/4) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; many, fine, fibrous grass roots; slightly calcareous; clear, smooth boundary.
- AC—10 to 14 inches, reddish-brown (2.5YR 5/4) fine sandy loam; reddish brown (2.5YR 4/4) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; many very fine roots; slightly calcareous; clear, smooth boundary.

- C1—14 to 28 inches, light reddish-brown (2.5YR 6/4), stratified fine sand, fine sandy loam, and loam in layers $\frac{1}{2}$ inch to 2 inches thick; reddish brown (2.5YR 5/4) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; numerous, very fine, fibrous roots; strongly calcareous; clear, smooth boundary.
- C2—28 to 44 inches, red (2.5YR 5/6) silt loam of low silt and clay content; red (2.5YR 4/6) when moist; weak, medium, granular structure; hard when dry, friable when moist; few very fine roots; strongly calcareous; clear, smooth boundary.
- C3—44 to 60 inches, light reddish-brown (5YR 6/4), stratified fine sandy loam and fine sand; reddish-brown (5YR 5/4) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; very few roots; strongly calcareous.

The A1 horizon ranges from 0 to 12 inches in thickness. The C horizon ranges from light reddish brown to red and reddish yellow in color. The texture of the A1 and the C horizons is dominantly fine sandy loam, but in places it is very fine sandy loam.

ZAVALA SERIES

The Zavala soils have a surface layer of grayish-brown fine sandy loam and a C horizon of noncalcareous, pale-brown, alluvial fine sandy loam. These soils are on bottom lands that are seldom flooded. They are somewhat excessively drained and moderately rapidly permeable. They developed under a cover of mid and tall grasses.

The Zavala soils are noncalcareous and are finer textured than the Lincoln soils, and they are more excessively drained than the Bayard soils.

A profile typical of Zavala fine sandy loam is located 2,240 feet east and 130 feet north of the southwest corner of sec. 2, T. 19 N., R. 22 W.

- A1—0 to 4 inches, grayish-brown (10YR 5/2) loamy fine sand; very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular structure; hard when dry, very friable when moist; numerous, fine, fibrous grass roots; neutral; clear boundary.
- A11—4 to 11 inches, dark-brown (10YR 4/3) fine sandy loam; dark brown (10YR 3/3) when moist; weak, fine and medium, granular structure; slightly hard when dry, very friable when moist; many fine grass roots; slightly acid; clear boundary.
- AC—11 to 18 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular structure; slightly hard when dry, very friable when moist; few roots; slightly acid; clear boundary.
- C1—18 to 24 inches, pale-brown (10YR 6/3) fine sand; brown (10YR 5/3) when moist; single grain; soft when dry, very friable when moist; no roots; medium acid; clear boundary.
- C2—24 to 39 inches, grayish-brown (10YR 5/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, fine and medium, granular structure that breaks to single grain; slightly hard when dry, very friable when moist; no roots; slightly acid; clear boundary.
- C3—39 to 60 inches, pale-brown (10YR 6/3) loamy fine sand; brown (10YR 5/3) when moist; single grain; loose when dry, very friable when moist; no roots; slightly acid.

The A horizon ranges from 0 to 18 inches in thickness and from grayish brown to dark brown in color. Its texture is dominantly fine sandy loam, but in places it is loamy fine sand. The C horizon ranges from pale brown to grayish brown and very pale brown in color. Its texture is generally fine sandy loam (less than 15 percent clay).

Mechanical and Chemical Analysis of the Soils

The soil survey reports of Texas, Cimarron, and Roger Mills Counties give data obtained by mechanical and chemical analysis of samples taken from soils of the Carey, Dalhart, Mansker, Nobscot, Richfield, and St. Paul series. These soils are essentially the same as those of the same series mapped in Ellis County. The data are useful to soil scientists in classifying soils and in developing concepts of soil genesis. If properly interpreted, the data are related to the practical aspects of soil management for the production of crops and grass and for other uses.

General Nature of the County

Additional information about Ellis County is given in this section. It will be useful mainly to persons not familiar with the county. It tells about the development, natural resources, agriculture, climate, transportation, markets, and community facilities of the county.

Settlement and Development

The area that now makes up Ellis County originally belonged to the Creek, Seminole, Cheyenne, Arapaho, and Cherokee Indians. Ellis County was created during the Oklahoma Constitutional Convention from the northern part of Day County and the southwestern part of Woodward County.

The area that is now the southern part of Ellis County was opened for settlement on April 19, 1892. This area and the northern part of the present Roger Mills County were designated as County "E" before Oklahoma became a State, and then as Day County. The northern part of Ellis County was first included in the area designated as County "N," and then as part of Woodward County.

Most of the early settlers lived on farms. They established homesteads on quarter sections of land. Some areas were not suited to cultivation, and some of the settlers quit farming and gave up their homesteads. As a result, the other farming units increased in size.

In 1960, the population of the county was 5,457, and that of Arnett, the county seat, was 547. Other centers of population include Shattuck (population 1,625), Gage (population 482), and Fargo (population 291).

Natural Resources

The natural resources of Ellis County include water, petroleum, natural gas, gravel, and caliche.

The water supply comes mainly from wells and ponds. Water for towns is generally supplied by wells. Wells and ponds supply water for agricultural needs. More than 600 ponds provide water for livestock. Windmills are commonly used for pumping water on farms and ranches. Springs, artesian wells, and perennial streams are additional sources of water for some farmers and ranchers. The water is of good quality.

Petroleum and natural gas have been discovered in the county and further explorations are underway. The production of natural gas is the principal industry in the

county. The northwestern part of the county is being developed as a producing field, and many other wells are dotted over the county. Many wells produce both natural gas and distillates.

There are many caliche beds that furnish material for road surfacing. A few gravel pits provide good-quality gravel in local areas.

Transportation and Markets

Ellis County is served by two railroads. The main line of the Santa Fe serves Fargo, Gage, and Shattuck. The Missouri-Kansas-Texas Railroad crosses the northeastern corner of the county.

Federal and State highways form a good network of paved roads. U.S. Highway No. 60 and State Highway No. 51 extend east to west across the central part of the county. U.S. Highway No. 283 runs north and south through Shattuck and Arnett. State Highways No. 46, No. 15, and No. 51 branch out as paved or graveled roads that connect the towns.

In farm areas, graded dirt, gravel, or caliche roads, laid out on section lines, provide access to the hard-surfaced roads. The range areas have few roads.

Grain elevators at Shattuck, Gage, and Fargo furnish facilities for storage, rolling, grinding, or mixing feed, and also provide commercial feed for livestock. Many dairy farmers market their milk at Amarillo, Tex. Livestock is marketed at sale rings in Shattuck or in Woodward, Woodward County. Poultry products are sold locally and also outside the county.

Most of the city parks have many recreational facilities. Artesian Beach, near Gage, provides facilities for fishing, swimming, and picnicking. There are many farm ponds that are spring fed, and they provide excellent fishing. Hunting and fishing are available in the area developed by the Oklahoma Wildlife Department in the southwestern part of the county. Quail are plentiful and can be hunted throughout the county. Other game birds and animals have smaller populations.

Agriculture

This subsection gives some statistics on agriculture in Ellis County, as reported by the U.S. Census of Agriculture for 1959.

Much of the income from agriculture is derived from beef cattle, dairy products, wheat, and sorghum. Farmers have modern equipment and power machinery. Electric power is widely used. The homes are equipped with modern facilities.

About 250,200 acres is cropland; about 7,800 acres is forest and woodland; and about 3,400 acres is used for other agricultural purposes. In 1959, there were 820 farms in the county. The average size was about 853 acres.

The main crops grown in the county are wheat and sorghum. Wheat, the principal cash crop, is grown primarily for grain, but much of the wheat acreage is also pastured. Both grain sorghum and forage sorghum are grown. Many dairy farmers grow forage sorghum for ensilage. In 1959, wheat was grown on 97,878 acres, and sorghum for all purposes on 30,905 acres. Other crops, such as barley, oats, rye, broomcorn, cotton, alfalfa, and sweetclover, are grown to a lesser extent.

In this county much of the farm income is derived from the sale of livestock and livestock products. Beef cattle and dairy cattle are the chief livestock. In 1959, there were 44,005 cattle and calves, of which 4,731 were dairy cattle.

Climate¹³

Ellis County has the subhumid, temperature, continental climate typical of the central part of the Southern Great Plains region. Masses of cold, dry air from the north and masses of warmer, moist air from the Gulf of Mexico alternately influence the weather.

Seasonal changes are gradual. Winter is moderately cold. Sunshine and warm southerly winds generally return within 3 or 4 days after the passage of the cold, northern storms. Spring is a season of variable weather, high precipitation, and frequent severe local storms and tornadoes. Summer is hot and wet. The high temperatures are moderated by cold nights, low humidity, and cooling breezes. Autumn has long periods of pleasant weather interspersed with soaking rains.

Ellis County has wide variations in temperature. Temperatures are highest in July and August. Readings of 110° F. were recorded on 5 days between June 25, 1911, and August 13, 1936. December and January are the coldest months. The record low temperature of -18° occurred on January 12, 1912. The mean annual temperature is 58.5°. The mean monthly temperature is 35.8° in January and 80.6° in July, and the mean daily variation is 26.3°. In the past 30 years, readings of zero or below have been recorded on 36 days in 16 different years. On the average, there were only 10 days each year when the temperature did not rise above freezing. Temperatures of 90° occur as early as March and as late as October, and temperatures of 100° occur as early as May and as late as September. Temperatures of 90° or higher occur on an average of 78 days per year, and temperatures of 100° or higher on 15 days per year. The greatest number of days in any one year having a temperature of 100° or higher was 44 days in 1934. In July of that year, temperatures of 100° or higher occurred on 24 days, of which 15 days were consecutive.

The average annual precipitation in Ellis County, based on a 30-year period at Arnett, is slightly more than 21 inches, but the annual total has ranged from a low of 11.58 inches in 1910 to a high of 38.96 inches in 1941. The amount and distribution of rainfall are favorable for crops. About 37 percent of the annual precipitation falls in summer during late afternoon and early evening thunderstorms; 32 percent falls in spring during hard showers and thundershowers; 20 percent falls in autumn during heavy showers; and 11 percent falls in winter during fairly gentle rains. Summer is the wettest season, and May is the wettest month. Occasionally, 2 to 4 inches of rain falls in 24 hours. Wet spells are infrequent, but occasionally they delay harvesting, and they may delay planting or necessitate the replanting of some crops. In most years, hard rains cause some loss of crops, seed, and soil.

The average annual snowfall is about 11 inches in the southern part of Ellis County and about 13 inches in the

¹³ By STANLEY HOLBROOK, State climatologist, U.S. Weather Bureau.

TABLE 9.—*Temperature and precipitation data*

[All data from records kept at Arnett, Ellis County, for the years 1931-60]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
					Inches	Inches	Inches	Number	Number
January	48.4	23.3	69	6	.66	0.2	1.5	6	2
February	52.7	26.9	70	11	.96	.1	2.4	4	2
March	60.6	32.9	78	17	1.17	.1	2.1	3	2
April	70.8	43.9	87	30	2.12	.4	4.3	2	4
May	78.4	53.9	93	40	3.68	1.5	6.9	0	-----
June	88.8	61.3	100	54	3.42	.9	6.4	0	-----
July	93.5	67.6	103	61	2.28	.2	5.1	0	-----
August	93.8	67.1	104	59	2.38	.2	4.2	0	-----
September	85.4	58.9	96	46	1.66	.1	3.6	0	-----
October	74.1	47.4	88	35	2.07	.1	5.6	0	-----
November	60.4	33.0	69	18	.74	0	2.1	1	3
December	51.5	26.2	70	13	.69	0	1.5	3	2
Year	71.5	45.2	¹ 105	² -2	21.83	13.9	30.4	19	3

¹ Average annual highest temperature.

² Average annual lowest temperature.

northern part. The heaviest snow in a single season was 47.6 inches in 1911-12; the heaviest in 1 month was 18 inches in February 1912; and the heaviest in 1 day was 12 inches, occurring on December 23, 1918. Snow seldom stays on the ground more than 4 or 5 days, but occasionally it stays for several weeks.

Table 9 shows, by months, the average daily maximum temperature, the average daily minimum temperature, and the average precipitation at Arnett for the period 1931-60.

The prevailing winds are from the northwest in winter and from the south the rest of the year. The average windspeed is about 14 miles an hour, but the velocity ranges from 11 miles an hour in August to 16 miles an hour in March and April. Strong winds of 25 to 40 miles an hour

and gusts of 80 miles an hour associated with violent squall lines and severe thunderstorms are most common in spring. A windspeed of 83 miles an hour, averaged over a period of 1 minute, occurs every 50 years. Tornadoes are the storms most dreaded in the county, but only 32 tornadoes have been recorded in Ellis County since 1875. The Woodward tornado on April 9, 1947, was the most severe.

Hailstorms are destructive to crops and property. In 16 different years in the last 38 years, 27 hailstorms have caused damage in Ellis County. Probability computations show that in about 58 percent of the years no destructive hailstorm will occur, that in 81 percent of the years no more than 1 destructive hailstorm will occur, and that in 89 percent of the years no more than 2 destructive hailstorms will

TABLE 10.—*Probabilities of freezing temperatures in spring and in fall*

[Based on data from records kept at Buffalo, Harper County; at Hammon, Roger Mills County; at Reydon, Roger Mills County; and at Woodward, Woodward County]

Probability	Dates for given probability at temperature levels shown				
	16° F.	20° F.	24° F.	28° F.	32° F.
Spring:					
1 year in 10, later than	March 25	April 3	April 9	April 15	May 1
2 years in 10, later than	March 17	March 27	April 3	April 10	April 25
5 years in 10, later than	March 2	March 14	March 24	March 31	April 14
Fall:					
1 year in 10, earlier than	November 13	November 3	October 30	October 21	October 10
2 years in 10, earlier than	November 20	November 10	November 4	October 25	October 14
5 years in 10, earlier than	December 5	November 23	November 11	November 3	October 23

occur. Over half of the hailstorms occur in strips more than 10 miles long, and almost 75 percent occur before July.

In Ellis County large amounts of water are lost through evaporation. Moisture received during July and August is often rapidly evaporated by high temperatures and hot, dry winds. The average annual lake evaporation is 64 inches, and 9.6 percent of this occurs from May through October. Sometimes summer-growing crops are harmed to such an extent by the winds that they do not recover. Crops growing on clayey soils are the most susceptible to summer drought and wind parching.

The average freeze-free season is 192 days, and the variation within the county is only a few days. This is adequate time for the crops to mature. The latest freeze recorded was on May 11, 1946, and the earliest was on October 5, 1932. Late frosts occasionally kill or cause serious damage to fruit buds but seldom reduce yields of small grain. Early frosts often reduce cotton yields.

Table 10 gives the probable dates of freezing temperatures in spring and in fall.

Ellis County has a climate that is generally favorable to the normal sequence of agricultural operations. Except during prolonged and severe droughts, the unfavorable variations in temperature and precipitation can be offset by good management. Except for a few days following a heavy rain or snow, it is possible to do farmwork almost any time during the year.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is impaired.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available moisture capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Buried soil. A developed soil, once exposed but now overlain by a more recently formed soil.

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, as in the Southwestern States. The material may consist of soft, thin layers in the soil; or it may consist of hard, thick beds just beneath the solum; or it may be exposed at the surface by erosion.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented 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, easily crushed under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, can be crushed 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 material, and tends to stretch somewhat and pull apart, rather than to 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.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Genesis, soil. The manner in which a soil originated, with special reference to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

A horizon.—The mineral horizon at the surface. It has an accumulation of organic matter, has been leached of soluble minerals and clay, or shows the effects of both.

B horizon.—The horizon in which clay minerals or other material has accumulated, or that has developed a characteristic blocky or prismatic structure, or that shows the effects of both processes.

C horizon.—The unconsolidated material immediately under the true soil.

D horizon.—Any layer, or stratum, underlying the C horizon, or the B horizon if no C horizon is present.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to relatively level plots surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards, to confine the flow of water to one direction.

Furrow.—Water is applied in small ditches made by cultivation implements used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Irrigation water is released at high points and flows to the field without control of distribution.

Level terrace. A terrace that follows the contour exactly, as contrasted with a graded terrace. Used only on permeable soils where conservation of moisture for crops is particularly important or where outlet channels are not practical.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

Morphology, soil. The makeup of the soil, including the texture, structure, consistence, color, and other physical, mineralogical, and biological properties of the various horizons of the soil profile.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils generally indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common, and many*; size—*fine, medium, and coarse*; contrast—*faint, distinct, and prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Natural drainage. Refers to the conditions that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Imperfectly or somewhat poorly drained soils are wet for significant periods but not all the time. If podzolic, they commonly have mottling below 6 to 16 inches in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid*.

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

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 thus:

	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
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

Residual material. Unconsolidated, partly weathered mineral material that accumulates over disintegrating solid rock.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants, but that does not contain excess exchangeable sodium.

Sand. As a soil separate, individual rock or mineral fragments 0.05 to 2.0 millimeters in diameter. Most sand grains consist of quartz, but they may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *very coarse sand* (2.0 to 1.0 millimeters); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeters); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. Living roots and other plant and animal life are largely confined to the solum.

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 without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that the water soaks into the soil or flows slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of

increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, parks, and gardens.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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