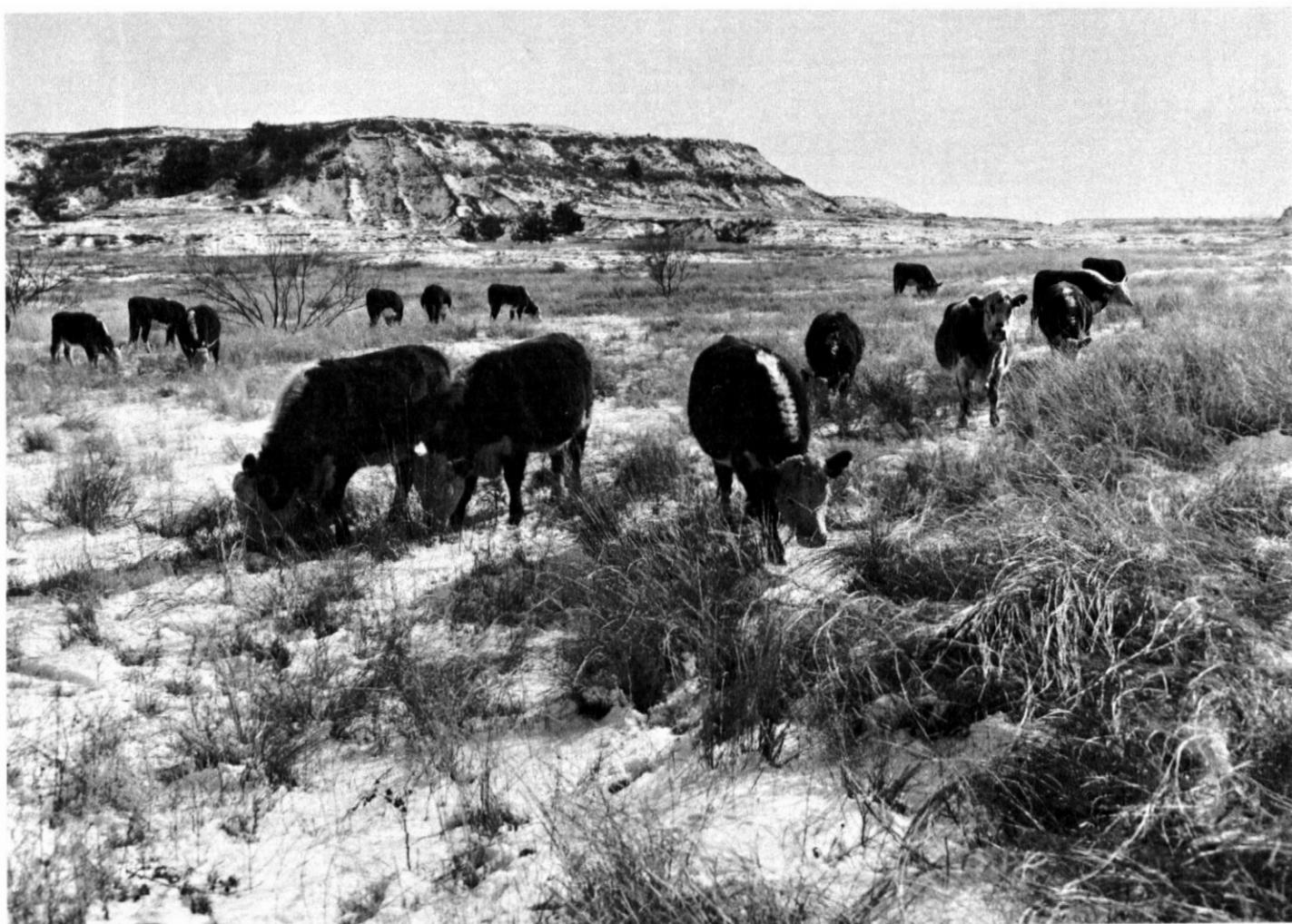


Issued October 31, 1968

SOIL SURVEY

Major County, Oklahoma



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
In cooperation with
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1960-63. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1963. This survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station as part of the technical assistance furnished to the Major County Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Major County, Okla., contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in judging the suitability of tracts of land for agriculture, industry, or recreation.

Locating Soils

All of the soils of Major County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. 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 and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described and also the page for the capability unit and range site in which the soil has been placed. It also gives the woodland suitability group.

Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the

same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils in the descriptions of the soils and in the discussions of the capability units, range sites, and windbreak suitability groups.

Foresters and others can refer to the section "Woodland, Windbreaks, and Post Lots," where the soils of the county are grouped according to their suitability for windbreaks and trees.

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Wildlife."

Ranchers and others interested in range can find under "Range Management" groupings of the soils according to their suitability for range, and also the plants that grow on each range site.

Engineers and builders will find under "Engineering Uses of Soils" tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "Formation and Classification of Soils."

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

Cover picture.—Cattle grazing tall grasses in winter on Vernon clay loam, 0 to 3 percent slopes. Sloping to steep area in background is the Vernon-Gypsum outcrop complex.

Contents

	Page		Page
General soil map		Descriptions of the soils—Continued	
1. Weymouth-Vernon-Gypsum outcrop association.....	1	Sand dunes, Lincoln material.....	36
2. Dill-Rough broken land association.....	1	Shellabarger series.....	36
3. Vernon-Tillman-Badland association.....	3	St. Paul series.....	37
4. St. Paul-Carey association.....	3	Sweetwater series.....	38
5. Meno-Shellabarger-Pratt association.....	4	Tillman series.....	39
6. Grant-Pond Creek association.....	4	Tipton series.....	40
7. Nobscot-Pratt association.....	4	Tivoli series.....	41
8. Tivoli-Pratt association.....	5	Treadway series.....	42
9. Port-Canadian-McLain-Reinach association.....	6	Vernon series.....	42
10. Lincoln-Sweetwater association.....	6	Weymouth series.....	44
11. Renfrow-Vernon association.....	6	Yahola series.....	47
How this survey was made	8	Use and management of soils	47
Descriptions of the soils	8	Capability groups of soils.....	47
Alluvial land.....	8	Management by capability units.....	48
Breaks-Alluvial land complex.....	9	Predictions of dryland yields.....	54
Canadian series.....	9	Range management.....	54
Carey series.....	10	Range sites and condition classes.....	56
Carwile series.....	10	Descriptions of the range sites.....	56
Clayey alluvial land.....	11	Woodland, windbreaks, and post lots.....	59
Dill series.....	11	Windbreak suitability groups.....	60
Elsmere series.....	13	Wildlife.....	61
Enterprise series.....	13	Soil associations as wildlife habitat.....	61
Eroded loamy land.....	14	Engineering uses of soils.....	62
Grant series.....	14	Engineering classification systems.....	63
Kirkland series.....	15	Estimated engineering properties of soils.....	63
LaCasa series.....	15	Engineering interpretations of soils.....	74
Leshara series.....	17	Engineering test data.....	74
Lincoln series.....	17	Geology	74
McLain series.....	18	Formation and classification of soils	77
Meno series.....	18	Factors of soil formation.....	77
Miller series.....	19	Parent material.....	77
Nash series.....	19	Plant and animal life.....	78
Nobscot series.....	20	Climate.....	78
Ortello series.....	20	Relief.....	78
Pond Creek series.....	21	Time.....	79
Port series.....	21	Classification of soils.....	79
Pratt series.....	22	General nature of the area	79
Quinlan series.....	23	Physiography.....	80
Reinach series.....	23	Climate.....	81
Renfrow series.....	24	Natural resources.....	82
Rough broken land, clayey.....	24	Agriculture.....	82
Rough broken land, loamy.....	25	Literature cited	83
	25	Glossary	83
	28	Guide to mapping units	Following 84
	28		
	29		
	30		
	30		
	32		
	33		
	34		
	35		
	36		

SOIL SURVEY OF MAJOR COUNTY, OKLAHOMA

FIELDWORK BY FERRIS P. ALLGOOD, ARLIN J. CONRADI, CLIFFORD E. RHOADS, AND
R. C. BRINLEE, SOIL CONSERVATION SERVICE

SURVEY WRITTEN BY FERRIS P. ALLGOOD

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

MAJOR COUNTY is in the northwestern part of Oklahoma (fig. 1). The county has an extent of 616,320 acres, or about 963 square miles. Fairview, near the center of the county, is the county seat. The county is dissected in the northern and eastern parts by the Cimarron River and, in the southwestern corner, by the North Canadian River. The soils are loamy throughout most of the county, but there are large acreages of sandy soils and small acreages of clayey soils.

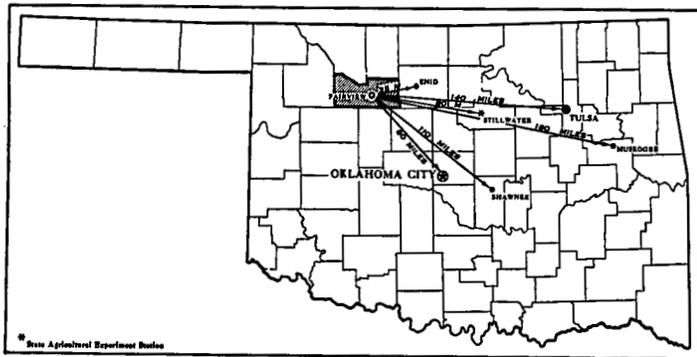


Figure 1.—Location of Major County in Oklahoma.

Major County is mainly agricultural. Most of the cropland is dryfarmed. Beef production is important in some areas. About 37 percent of the area is cropland, of which about 2,000 acres is irrigated. Nearly 55 percent of the area is range, of which about 85,000 acres is woodland grazed.

Wheat is the main cash crop, though much sorghum is grown for grain, grazing, and silage. Much of the land used for crops is better suited to permanent pasture because cultivated fields are susceptible to soil blowing and water erosion. Crop failure is not common, but only the best dryland soils produce favorable yields in droughty seasons.

General Soil Map

The general soil map at the back of this soil survey shows, in color, the soil associations in Major County. A soil association is a landscape that has a distinctive propor-

tional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The eleven soil associations in Major County are described in the following pages.

1. Weymouth-Vernon-Gypsum Outcrop Association

Moderately deep to shallow, gently sloping to moderately steep, calcareous, loamy soils, gypsum-capped buttes, and blufflike escarpments

This association is in the western part of the county in a single broad area that is mostly above the rims of escarpments. Buttes capped with gypsum and blufflike escarpments rise 50 to 175 feet above the general landscape. These rugged areas are called Glass Mountains because of the glossy luster of gypsum strata and the speckled debris of pearly and crystal clear gypsum. This association covers about 17 percent of the county. A typical pattern of its major soils is shown in figure 2.

Weymouth soils make up about 40 percent of this association; Vernon soils, 30 percent; and Gypsum outcrop, 10 percent. Of the remaining 20 percent, about 15 percent is Rough broken land and Clayey alluvial land, and 5 percent is LaCasa soils. The soils in this association developed in shale and clay weathered from Permian red beds. The red beds have imparted a reddish color to the soils.

Weymouth soils are moderately deep and well drained to somewhat excessively drained. They have a reddish-brown, granular clay loam surface layer. The subsoil consists of reddish-brown, calcareous, or moderately alkaline friable clay loam that absorbs water readily. Weymouth soils are

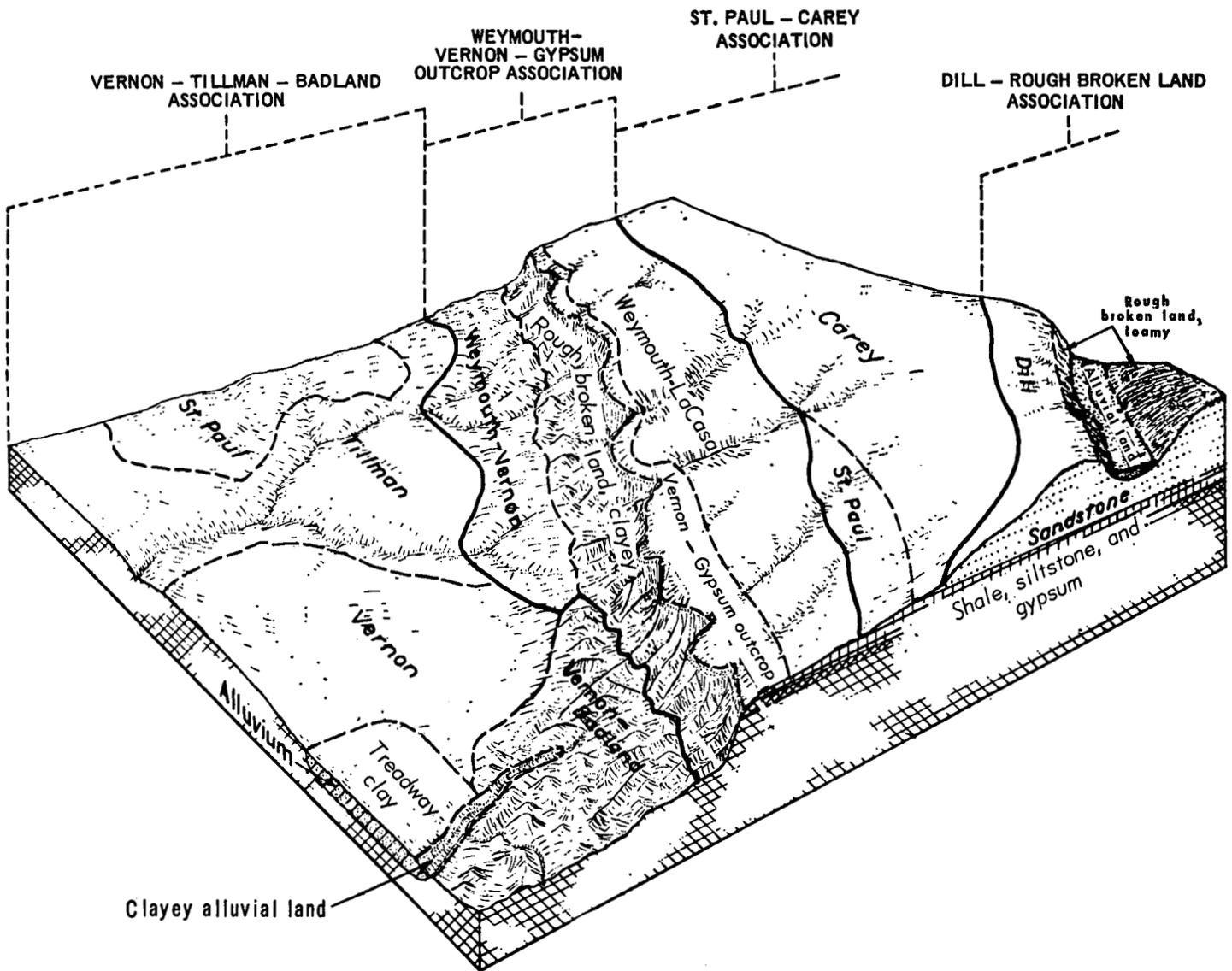


Figure 2.—Soil associations in the western part of the county.

closely intermingled with Vernon soils on strong slopes cut by steep drainageways and are closely intermingled with LaCasa soils on more gentle slopes.

Vernon soils are calcareous and are shallow over calcareous unweathered red shale. Their surface layer is reddish-brown clay loam over reddish, weakly weathered clay loam. Vernon soils absorb water very slowly and, because they are shallow, have a limited capacity for storing moisture.

LaCasa soils are deeper and more mature than Weymouth and Vernon soils. They have a dark, granular clay loam surface layer and a subsoil of moderately compact clay loam that absorbs water slowly. The surface layer is noncalcareous, and the subsoil is alkaline or calcareous.

The Weymouth soils, intermingled with LaCasa soils, occur in an area that is drained by gullylike draws that have limy banks and a floor of loamy alluvium. As these draws become deeper, they cut through areas where Weymouth and Vernon soils are closely intermingled. Where

the draws are deepest, they run into areas of Rough broken land, clayey, consisting of steep slopes and walls of escarpments in red beds. Along the rims of the Rough broken land are areas of Vernon soils and outcrops of gypsum. The Vernon soils occur where the red beds are near the surface. The outcrops of gypsum are prominent. The areas of Weymouth soils intermingled with Vernon soils lie in a belt between areas of Weymouth soils intermingled with LaCasa soils and areas of intermingled Rough broken land, rims of gypsum outcrops, and Vernon soils.

About one-third of this association, mostly the smoother areas of Weymouth and LaCasa soils, is cultivated. Much of the cultivated acreage on moderate slopes is moderately damaged by erosion.

The average-sized farm is about 230 acres. Some ranches in the association range from 640 to 1,280 acres in size. Most ranches have some areas suitable for cultivation that are used to produce supplementary feed. Also in this association are a few dairy farms.

The native vegetation on this soil association is mainly mid and short grasses that provide excellent grazing where management is good. Some tall grasses grow in low areas. Areas of Rough broken land provide shelter and some grazing during cold weather. Wheat is the main cultivated crop, but grain sorghum is also grown.

Controlling erosion and conserving moisture are the main concerns in managing dryfarmed soils in this association. In places damage by erosion has been severe. To help control erosion and maintain or improve the soils, farmers use stubble mulching, terraces, and contour tillage.

Well water is difficult to locate in this area. Much of the ground water contains such a high percentage of gypsum and other salts that it is not suitable for home use.

In this association, where there is no gypsum, the soil material and the terrain are excellent for constructing farm ponds. Many ponds have been built that supply water for livestock and are also used for recreation.



Figure 3.—Landscape and vegetation of the Dill-Rough broken land association. The tree-lined canyons are Rough broken land.

2. Dill-Rough Broken Land Association

Deep to moderately deep, gently sloping to moderately steep, loamy soils on broad upland divides and Rough broken land in areas dominated by dissected sandstone

This soil association consists of broad divides separated by steep drainageways that have canyonlike sides. Except for Griever Creek, the drainageways have cut 25 to 75 feet into the soft rock. Griever Creek, in the heart of this association, has cut to a depth of more than 200 feet in places and is more than 500 feet wide in places. This association is in a single broad area in the western part of the county. It covers about 6 percent of the county. Figure 2 shows the position of its major soils.

Dill soils make up about 70 percent of this association, and Rough broken land makes up about 20 percent. The remaining 10 percent is mostly Carey, St. Paul, and Yahola soils. The Dill soils are on the smooth slopes of the broad divides.

Dill soils have a reddish, very friable fine sandy loam surface layer and subsoil that absorb water readily. Available moisture capacity is medium. Most of the steeper areas of these soils are near the rims of Rough broken land. From these rims, the slopes grade 50 to 150 feet to the wall of the canyon; then the wall drops abruptly for 10 to 25 feet to the bottom of the canyon. The rim of the canyons consists of drifted soil material and colluvial material. Raw, reddish sandstone is exposed on the canyon walls. The floors of the canyons are 15 to 275 feet wide and are covered with alluvial sediments. In the broadest areas, these sediments are deepest and support a fair cover of grasses. In the narrower channels, however, grasses have had little chance in gaining a foothold.

Dill soils have a cover of mid and tall grasses and sand sagebrush and a few scattered cedar trees. Vegetation along the rims of the canyons includes tall and mid grasses and sand sagebrush and many cedars mixed with broad-leaved trees (fig. 3).

The average-sized farm is about 300 acres, and the average-sized ranch is about 1,280 acres. Most of the cultivated areas are gently sloping. Small sloping areas have been cultivated, but much of this has been returned to grass because the hazard of erosion is severe. The steeper and

rougher areas are used as range. Sorghum and wheat are the main crops, and they are well suited if management is good. Unprotected areas are susceptible to water erosion and soil blowing.

Management of crop residue and stubble mulching are good practices of management. Overgrazing is the main concern on rangeland, but most well-managed sites have a good cover of grass. In the canyonlike areas, grazing is generally limited to the rims, but where livestock can get to them, some of the bottoms of the canyons provide good grazing. The breaks provide some shelter for livestock during severe cold spells.

In some places near creeks and in the canyons, springs provide a flow of water. Many ponds along the lower drains are fed by springs. Every farm or ranch generally has a dependable source of ground water. The soils in this association are suitable for constructing ponds, but plants are needed to protect the fill against soil blowing and water erosion.

3. Vernon-Tillman-Badland Association

Shallow and deep, nearly level to moderately sloping, loamy soils with clayey subsoils, rugged draws, and partly barren Badland

This association consists of nearly level to moderately sloping areas, rugged draws, and Badland. It lies below and adjacent to the blufflike escarpments in the western part of the county. Large tracts, of raw, red, shaly red-bed material occur throughout the association. This association covers about 7 percent of the county. Figure 2 shows the position of its major soils.

The Tillman soils make up 35 percent of this association; the Vernon soils, 35 percent; and Badland, 20 percent. The remaining 10 percent consists mostly of Treadway, Carey, St. Paul, Weymouth, and LaCasa soils and of scattered areas of alluvial soils.

This association slopes generally northward. It is drained by gullylike draws that are partly filled with clayey alluvium washed from surrounding eroded areas.

Treadway soils are at the mouth of these drains where alluvium fans out in a broad apron. These soils consist of compact reddish clay that is low in fertility.

The Tillman soils are well drained. They have a dark loamy surface layer that is underlain by a subsoil of blocky, very slowly permeable, reddish-brown clay. The surface layer is neutral to alkaline, and the subsoil is alkaline or calcareous.

Vernon soils are also well drained, but they are not so well developed as Tillman soils and are calcareous throughout the profile. Vernon soils are shallow and have a reddish-brown surface layer. The surface layer is underlain by reddish, partly weathered, very slowly permeable beds of clay and shale that contain some concretions.

In many places Vernon soils are intermingled with Badland. Badland consists of barren red shale and clay sprinkled with fragments of gypsum. During rains, runoff washes and scours the surface.

About one-half of this association is cultivated. Wheat is the main crop, but sorghums are also grown. The main concerns in managing dryfarmed areas are conserving moisture and controlling erosion. Erosion, a constant hazard on the sloping soils, can be controlled by terraces, contour tillage, and stubble mulching.

The average-sized farm is about 320 acres. Most of the rough, erodible areas are used as range. The average-sized ranch is about 640 acres. Smooth tracts of Tillman and Vernon soils and of Clayey alluvial land in draws support a dense cover of short and mid grasses. A sparser stand of grass grows in the rougher areas of Vernon and Treadway soils and on Badland. The vegetation on this association consists mostly of scattered mesquite, cactus, and clumps and bunches of short and mid grasses. Overgrazing is the main concern in managing rangeland, and range is improved most by regulating grazing.

In this association many ponds are built for the purpose of supplying water for livestock. Most of these ponds are stocked with fish. The landscape and the soil material, except for the pockets of gypsum, are excellent for constructing ponds. The pockets of gypsum do not make stable fill, for moisture dissolves the gypsum and permits leakage or even washouts.

4. St. Paul-Carey Association

Deep, nearly level to sloping, loamy soils of the uplands

This association consists of three small, nearly level to sloping areas of the uplands along the western boundary of the county. One of these areas is in the northwestern corner, one is about midway between the northern and southern boundaries of the county, and one is in the southwestern corner. These areas are cut by gullylike drainage ways that have raw, red banks and concave floors that are covered with loamy sediment. The association occupies about 2 percent of the county. Figure 2 shows the position of its major soils.

St. Paul soils make up 40 percent of this association, and Carey soils make up about 40 percent. The remaining 20 percent consists mostly of Dill, Weymouth, LaCasa, Enterprise, and Tipton soils.

St. Paul soils are deep, nearly level to moderately sloping, and well drained. They have a dark silt loam surface layer underlain by a silty clay loam subsoil that has mod-

erately slow permeability. Carey soils are also well drained. They have a brown to dark-brown silt loam surface layer and a very friable, permeable reddish subsoil.

The Tipton soils are in flat terracelike areas. These deep soils lie in a belt between Carey and St. Paul soils, where they developed in loamy or silty alluvial or colluvial material. Along the rim of these flat terraces are deep, calcareous Enterprise fine sandy loams.

About three-fourths of this association is cultivated. The average-sized farm is about 320 acres. The steeper and rougher areas cut by draws are used as range. Most farms have small areas of range. Short and mid grasses make up the native vegetation.

Wheat is the main crop in this association, but sorghums are also grown. Wheat pastures provide grazing in favorable seasons. Most ranchers raise beef cattle, but there are a few dairy farms in the association. Intensive conservation measures are needed in sloping dryfarmed areas. Small spots throughout the association have been damaged severely by soil blowing and water erosion.

A supply of good well water is difficult to locate in this association. The wells that have been drilled produce a large amount of water, but its content of gypsum is high. Generally the landscape and soil material are excellent for constructing farm ponds, though in places deposits of gypsum are troublesome. The gypsum dissolves easily, and then seepage is likely and fills may be destroyed.

5. Meno-Shellabarger-Pratt Association

Deep, undulating, sandy and loamy soils of the uplands

Broad, undulating areas, commonly called sandy land, make up this association. These areas are in the southeastern and north-central parts of the county. They cover about 14 percent of the county.

Meno soils make up about 28 percent of this association; Shellabarger soils, 25 percent; and Pratt soils, 22 percent. The rest is made up mostly of Carwile, Ortello, and Nobscot soils, and of a few areas of soils on bottom lands.

The Meno soils are gently undulating and occur in large areas. The Shellabarger soils occupy broad nearly level to gently sloping areas. Pratt soils are less extensive and are gently undulating in most places. All of these soils developed in sandy material that probably was deposited by water and reworked by wind. A typical pattern of these soils is shown in figure 4.

The Meno soils have a brown to dark-brown loamy fine sand surface layer that is underlain by a brown sandy clay loam subsoil mottled with shades of brown and gray. This mottling indicates that the subsoil has been moist for long periods. Meno soils absorb water readily and store a large amount for plant use.

The Shellabarger soils are less sandy than the Meno soils. They have a brown to dark-brown fine sandy loam surface layer that is underlain by a reddish-brown sandy clay loam subsoil. These soils are friable and granular. Water penetrates rapidly, and much of it is stored for plant use. The Carwile soils are intermingled with the Shellabarger soils in depressions where water may collect and stand for several days.

Pratt soils have a loamy fine sand surface soil. Their subsoil is friable, permeable, slightly sticky loamy fine sand or fine sandy loam.

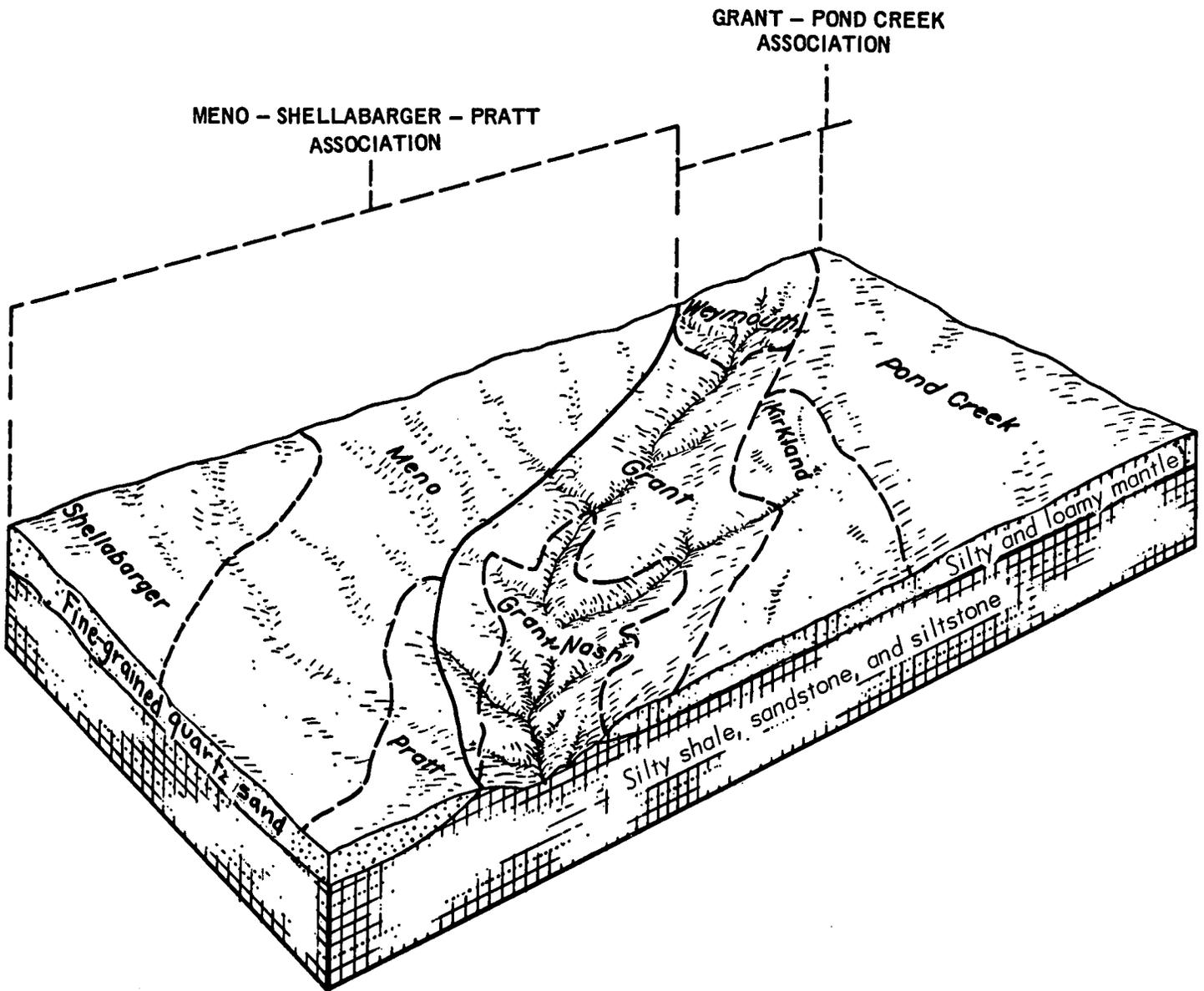


Figure 4.—Soil associations in the eastern part of the county.

Except during intensive rains, only a little water runs off these sandy soils. Most of the runoff is trapped in narrow depressions, but a small part flows through shallow sandy drainageways to the larger streams.

About 90 percent of this association is cropland. The average-sized farm is about 320 acres. Grain sorghum, small grain, and alfalfa and other locally grown legumes are well suited. Watermelons, potatoes, and other truck crops are grown in small areas. Some of the more delicate truck crops are onions, cucumbers, and bell peppers. A few fields are irrigated, mostly by sprinklers. Tall grasses are dominant in the areas in native grass. In the native pasture there are scattered trees, mostly blackjack oak and a few other kinds of oak.

The severe hazard of soil blowing is the main concern of management. These soils blow if they are left bare or are not properly managed. To control soil blowing, farmers

practice stubble mulching, use good residue management, and plant cover crops. The main cover crops are Austrian winter peas and mung beans.

Most of the water used by livestock comes from wells. Sources of ground water are numerous in this soil association.

6. Grant-Pond Creek Association

Deep, nearly level to sloping, loamy soils in a broad upland area that is cut by several streams

This association consists of a single smooth, broad area of tableland that is cut by several streams. It is in the northeastern corner of the county and includes the town of Meno. The association covers about 6 percent of the county. Figure 4 shows the position of its major soils.

Grant soils make up about 34 percent of the association, and Pond Creek soils make up 30 percent. Kirkland soils are important minor soils and occupy 15 percent of the association. The remaining 21 percent consists mostly of Weymouth, Nash, Port, Reinach, Ortello, and Vernon soils.

Grant soils are on ridges and slopes along drainageways and in some strongly sloping areas are closely intermingled with Nash soils. Grant soils have a reddish-brown silt loam surface layer. Their subsoil is friable light silty clay loam that takes in water well.

Pond Creek soils are more nearly level than Grant soils and are darker and more strongly developed. They have a dark-brown to dark grayish-brown silt loam surface layer and a moderately tight subsoil that contains more clay than the surface layer. Water penetrates the Pond Creek soils at a moderately slow rate, but available moisture capacity is fairly high.

Grant and Pond Creek soils are noncalcareous to a depth of about 3 feet in most places and to a depth of 4 to 6 feet in a few places. The surface layer and subsoil generally are about neutral in reaction.

Kirkland soils are in broad slightly undulating areas. These deep soils have a silt loam surface layer and a compact, very slowly permeable subsoil.

Most soils in this association are well drained. Runoff ranges from slow in nearly level areas to rapid in sloping areas. Turkey and Indian Creeks are the larger streams. Turkey Creek cuts the northeastern corner of the association, and Indian Creek cuts the western edge. Runoff passes through draws to these streams. The draws have raw, brown banks and are partly filled with alluvium. On bottom lands along the larger streams are areas of Port and Reinach soils.

About 90 percent of this association is cultivated, and about 10 percent is range. Many farms are made up entirely of either Grant or Pond Creek soils. The smoother areas are cultivated, and the draws and steeper slopes are used as range. Areas of range are small and are often heavily grazed. Big bluestem and little bluestem are dominant in properly used range, but blue grama and buffalo-grass are most abundant where grazing has been heavy. The soils of this association are well suited to small grains and sorghums if management is good. In winter livestock graze wheat pastures, and many farmers increase their herds when wheat pastures are good. A few dairy farms are scattered throughout this association.

A good source of ground water is difficult to locate. Most of the water used by livestock is from ponds that have been built along draws and drainageways. The soil material in this association is well suited for constructing the embankments of ponds.

7. Nobscot-Pratt Association

Deep, undulating to rolling, sandy soils of the uplands

This association is in two large, undulating to rolling, sandy areas on the uplands where the natural cover was mainly blackjack oak and tall grasses. One of these areas is in the southwestern corner of the county, and the other is in the eastern half. This is the largest soil association in the county; it covers about 24 percent of the county. Figure 5 shows the position of the major soils.

Nobscot soils make up about 60 percent of this associa-

tion, and Pratt soils, about 20 percent. The remaining 20 percent consists mainly of Ortello, Carwile, Tivoli, Meno, and Shellabarger soils.

The Nobscot and Pratt soils developed in wind-deposited sand under vegetation consisting of oak, mostly blackjack oak, and tall grasses. Nobscot soils are on rolling dunes and hummocks. They have a thin, dark grayish-brown surface layer. It is underlain by a layer of very pale-brown, leached fine sand that is about 1 foot thick, and that, in turn, is underlain by a yellowish-red subsoil. The subsoil consists of thin lenses of fine sandy loam.

The Pratt soils developed under tall grasses and sand sagebrush and are less sandy than the Nobscot soils. They occupy gently undulating to rolling areas. Pratt soils have a brownish loamy fine sand surface layer and a sticky loamy fine sand to fine sandy loam subsoil.

Water soaks into the Nobscot and Pratt soils rapidly, but little is stored for the use of plants. Because Nobscot soils contain less clay than the Pratt soils, they dry out more quickly. Little water runs off either kind of soil unless rainfall is intensive. Most of the runoff is trapped in narrow depressions scattered through the association. In these depressions are well-drained Shellabarger soils intermingled with somewhat poorly drained Carwile soils. The trapped water sometimes delays tillage. The small areas of Ortello soils that occur in this association have a fine sandy loam surface layer underlain by a friable fine sandy loam subsoil.

About one-third of this association is cultivated. The average-sized farm is about 320 acres. The rolling sandhills are used as range, and the easily accessible level to gently sloping areas are cultivated. Native tall grasses provide excellent grazing if range is well managed. In some places the range has been improved by removing the sagebrush and oak trees. During cold weather timbered areas provide shelter for livestock.

Most of the cultivated fields range from 5 to 40 acres in size. Grain sorghum is the main forage crop, and a small acreage is in wheat. The gently undulating to hummocky Pratt and Nobscot soils, and the Ortello soils, are well suited to truck crops if management is good. Excellent watermelons are grown and are shipped to markets throughout the United States. Many are sold at roadside stands. Other truck crops grown are pumpkins, potatoes, and tomatoes. A few farms have small orchards. On most of these, peaches and apples are grown for home use and for local sale.

Conserving moisture and controlling soil blowing are the main concerns in managing the dryfarmed soils. Evidences of damage by soil blowing are the blowouts, the mounds along fences, and the choked ditches along roads. For reducing the hazard of erosion, many farmers grow cover crops, manage crop residues well, and use stubble mulching.

Wells supply most of the water for livestock. The water is easily accessible and of good quality. In some depressions where the soil material can hold water, pit ponds have been constructed.

8. Tivoli-Pratt Association

Deep, duned and hummocky, sandy soils of the uplands

This soil association occupies the sandhills on the north bank of the North Canadian and Cimarron Rivers. It par-

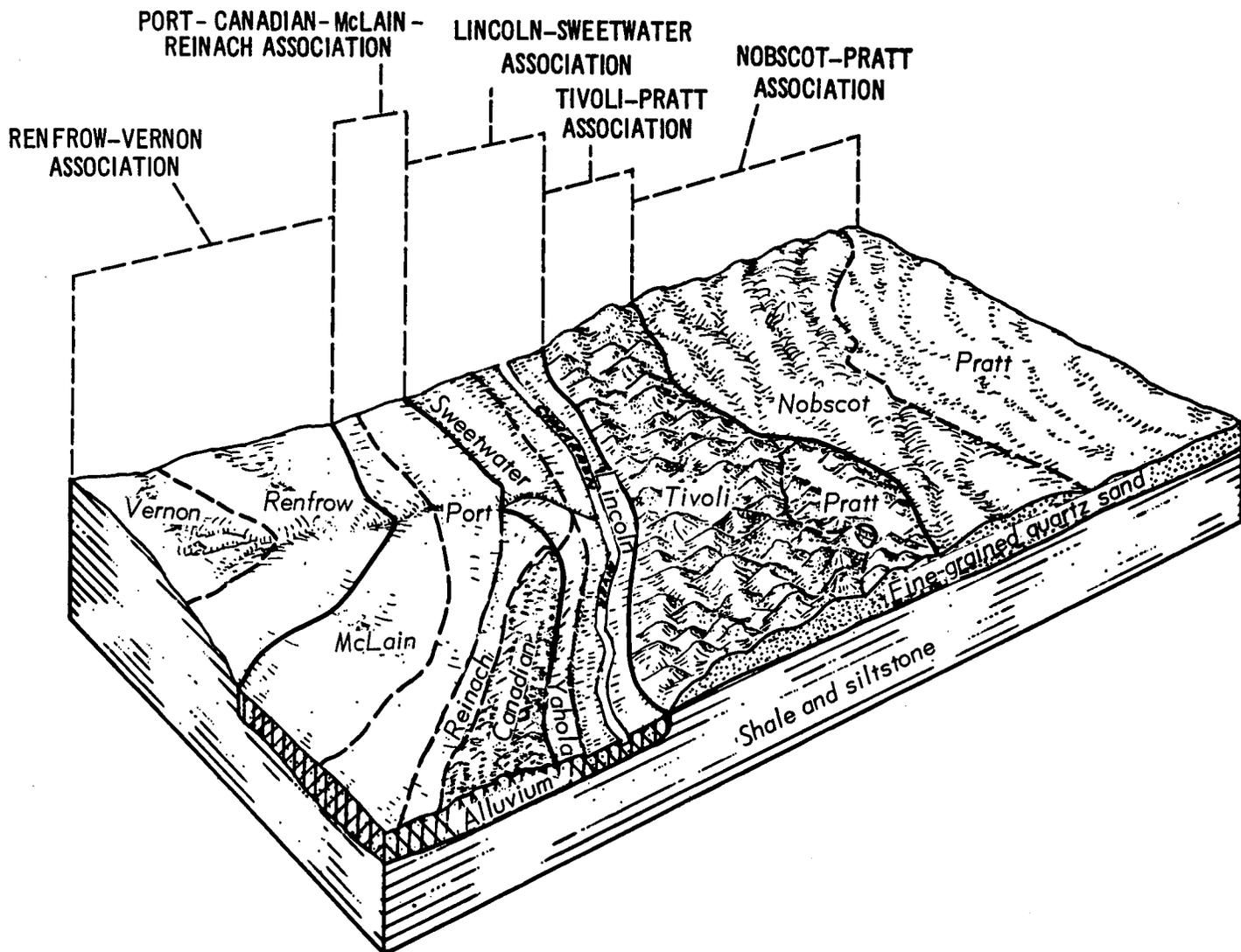


Figure 5.—Soil associations in the central part of the county.

allels these streams in a belt of undulating sand dunes that are shifted by the wind and range from 15 to 40 feet in height. The highest dunes are in a strip between two rows of low dunes. One row is near the streams, and the other is near the northern edge of the association. The low dunes consist of Sand dunes, Lincoln material. The highest dunes are Tivoli soils that merge with Pratt soils to the north. This association covers about 5 percent of the county. Figure 5 shows the position of its major soils.

The Tivoli soils make up about 35 percent of this association, and the Pratt soils make up about 30 percent. Sand dunes, Lincoln material, account for about 15 percent, and the remaining 20 percent is Carwile, Shellabarger, Ortello, Meno, and Nobscot soils.

Tivoli soils are young, weakly developed sand dunes. They have a yellowish-brown, loose fine sand surface layer that blows severely if the cover of vegetation is thinned or removed. Beneath this is reddish-yellow, loose, wind-shifted fine sand that soaks up water readily but has low available moisture capacity. More stable areas of Tivoli

soils occur with the Pratt soils and have a loamy fine sand surface layer.

The Pratt soils have a brownish loamy fine sand surface layer. Their subsoil is sticky loamy fine sand that soaks up water well.

Sand dunes, Lincoln material, shows little or no soil development. It consists of drifts of calcareous sand that have been deposited by wind. The drifts are held in place by a moderately thick cover of plants. Runoff, except when rains are intensive, is almost negligible. Even during intensive rains, most of the runoff is taken in by the sand or is caught in depressions before it reaches drainageways. These depressions contain darker and deeper soils.

The soils of this association are not suitable for cultivation, and nearly all areas are used as range. No farm or ranch is made up entirely of the soils in this association.

Good management of grazing is needed for maintaining a protective cover that will stabilize the soils, for soil blowing is severe where there is not enough cover. During periods of drought, the steep areas of Tivoli soils are most

susceptible to soil blowing, but forage can be produced if grazing management is good. The narrow depressions scattered through the Tivoli soils provide good grazing and, in winter, provide protection for the livestock. Also, these depressions support a few scattered shade trees that benefit livestock, and wildlife as well. The vegetation on Tivoli soils is mostly tall grasses, sand sagebrush, plum bushes, sumac, and skunkbush. On Pratt soils and Sand dunes, Lincoln material, are mid grasses, tall grasses, sand sagebrush, and skunkbush. The grasses decrease and the brush increases where grazing is heavy.

Ground water is the most dependable source of water for livestock. In the depressions, this water is generally near the surface. Most wells are in these depressions, and the water is pumped by windmills.

9. Port-Canadian-McLain-Reinach Association

Deep, nearly level, loamy soils of the bottom lands

This association is made up of deep, fertile bottom lands along the Cimarron River and its tributaries. Most areas are on terraces above the level of ordinary flooding. The association covers about 11 percent of the county. Figure 5 shows the position of the major soils.

Port soils make up about 25 percent of this association; Canadian soils, 20 percent; McLain soils, 15 percent; and Reinach soils, 8 percent. The remaining 32 percent consists mostly of Miller, Yahola, and Lincoln soils. The soils of this association developed under a dense cover of native grass, mostly mid and tall grasses.

Port soils have a dark-colored silt loam to fine sandy loam surface layer and a friable, permeable subsoil. Canadian soils have a thick, dark-colored fine sandy loam surface layer that is underlain by a reddish-brown to grayish-brown subsoil. The subsoil absorbs water rapidly. McLain soils have a dark-brown silty clay loam surface layer and a heavy silty clay loam subsoil that is slowly permeable. The very fine sandy loam surface layer of Reinach soils rests on a very friable, permeable subsoil.

Most areas of Port, Canadian, Reinach, and McLain soils are nearly level, but a few areas are gently sloping. These soils are well drained.

The Miller soils in this association are generally near the bottom lands. They are young, calcareous, and reddish-brown soils that have a clay profile and a very slowly permeable subsoil.

More than 90 percent of this association is cultivated. Areas used as grassland are those dissected by drainage ways or those in narrow strips adjoining draws.

The soils in this association are suited to the crops commonly grown in the county. Alfalfa, sorghums, wheat, and other small grains are well suited. Some farmers specialize in growing alfalfa. On all the soils good management is needed if favorable yields are to be maintained. The Canadian soils are most susceptible to soil blowing.

Good sources of ground water are difficult to find, but a few wells have been dug in the bottom land and produce good water. Salts, however, make most of the ground water unsuitable for home use or for irrigation. These soils produce well in places where water for irrigation is available.

10. Lincoln-Sweetwater Association

Deep, nearly level, sandy and loamy soils of the bottom lands

This soil association consists of the sandy and loamy bottom lands along the Cimarron and North Canadian Rivers. It covers about 5 percent of the county. Figure 5 shows the position of the major soils.

Lincoln soils make up about 50 percent of this association, and Sweetwater soils make up about 10 percent. The remaining 40 percent consists mostly of Sand dunes, Lincoln material, and of Elsmere, Yahola, and Leshara soils.

The Lincoln soils are closer to the stream channels and are more sandy than the Sweetwater soils. Also, Lincoln soils are more susceptible to cutting, to deposition of sand, to scouring during floods, and to shifting of the streambed. The areas of Lincoln soils adjacent to the low streambanks may be flooded several times a year, but other parts may be flooded only when floods are extremely high.

The Sweetwater soils are scattered through the association. They are flooded occasionally, mostly by backwater. The flooding normally damages these soils very little, except where the stream channel changes course and cuts through vegetated areas. Sweetwater soils have a surface layer ranging from silty clay loam to fine sandy loam. It is underlain by a waterlogged sandy subsoil. These soils are poorly drained, but they are well suited for forage and in places are used as meadow.

The sandy Lincoln soils are less productive than the Sweetwater soils, but they produce fair grazing if management is good. Some of the areas have been improved by reseeding grasses. The main management needed is that necessary to prevent overgrazing.

Much of the water needed by livestock is supplied by small potholes that are fed by a high water table. Windmills are used for pumping water from some of the shallow wells. In a few places water for livestock is obtained from pits that have been dug below the level of the high water table.

11. Renfrow-Vernon Association

Deep and shallow, nearly level to moderately steep, loamy soils of the uplands with clayey subsoils

This association is in areas that are commonly called deep and shallow hardland. Most of the association is southeast of Fairview, but there is a small area north of the town. Generally, the association slopes toward the valley of the Cimarron River. It is smooth in most places, but there are shallow, narrow draws and small eroded areas where the raw shale of the red beds is exposed. This soil association covers about 3 percent of the county. Figure 5 shows the position of the major soils.

Renfrow soils make up about 35 percent of the association, and Vernon soils make up 20 percent. The remaining 45 percent consists mostly of Dill, Quinlan, Pond Creek, Kirkland, Shellabarger, Weymouth, and Grant soils.

The Renfrow soils are deep, nearly level to gently sloping, and well drained. They have a reddish-brown silty clay loam surface layer and a compact, slowly permeable clay subsoil.

The Vernon soils are shallow, nearly level to moderately steep, and well drained. They occur in and are adjacent

to the more eroded parts of the association. These soils are calcareous and have a reddish-brown clay loam surface layer. Their subsoil is clay loam to clay, and it contains fragments of unweathered shale in the lower part.

The Quinlan soils are shallow, and the Dill soils are deep and moderately deep. These soils developed in weathered sandstone of the red beds.

Generally, the nearly level to gently sloping soils in this association are well drained, and the strongly sloping and moderately steep soils are excessively drained. Runoff water flows through shallow vegetated draws to the larger streams and then to the Cimarron River.

Most areas of the soils in this association are cultivated. Wheat and grain sorghum are the main crops. Yields are favorable if there is adequate moisture. In dryfarmed areas, moisture conservation and erosion control are most needed. Practices used are terracing, management of crop residues, and stubble mulching. Several areas of permanent grasses are in the steeper, rougher parts of the association. These grasses are mid and tall and are of good quality where management is good. Poorly managed range has short grasses, annuals, and weeds. Regulation of grazing is the most needed practice of range management.

Well water is difficult to locate in this area. The soil material and the landscape are generally suitable for constructing farm ponds. Many farm ponds have been constructed to hold runoff water so that it can be used by livestock.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Major 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 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 survey 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, all the soils of one series have major horizons that 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.

Port and Dill, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with 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. Port fine sandy loam and Port silt loam are two soil types in the Port series. The difference in texture of their surface layers is apparent from their names.

Some 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, Dill fine sandy loam, 1 to 3 percent slopes, is one of several phases of Dill fine sandy loam, a soil type that ranges from nearly level to strongly sloping.

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 woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this survey 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 so small in 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 soil in it, for example, Grant-Nash silt loams, 5 to 8 percent slopes. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be classified by soil series. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Clayey alluvial land or Eroded loamy land, 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 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 surveys. On basis of the yield and practice tables and other data, the soil scientists set up trial groups, and then test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists 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.

Descriptions of the Soils

This section describes the soil series and mapping units of Major County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure in this section is first to describe the soil series and then to describe, in smaller print, a profile rep-

resentative of the series and the range of soil characteristics within the series. Next, in larger print, are the descriptions of the mapping units within the series. The farmer and general reader probably will need to read only the material in larger print, or the descriptions of the series and of the mapping units. The soil scientists and others who require more information need to read this material in larger print and the material in finer print as well.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of soil series. Clayey alluvial land and Eroded loamy land, for example, are miscellaneous land types and do not belong to a soil series; nevertheless, they are listed in alphabetic order along with the series.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit, range site, and windbreak suitability group in which the mapping unit has been placed. The pages on which each

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

Soils	Area	Extent	Soils	Area	Extent
	<i>Acres</i>	<i>Percent</i>		<i>Acres</i>	<i>Percent</i>
Alluvial land.....	7, 451	1. 2	Pratt loamy fine sand, undulating.....	50, 158	8. 1
Breaks-Alluvial land complex.....	9, 313	1. 5	Pratt loamy fine sand, hummocky.....	12, 109	2. 0
Canadian fine sandy loam, 0 to 1 percent slopes.....	4, 657	. 7	Pratt loamy fine sand, rolling.....	9, 099	1. 5
Canadian fine sandy loam, 1 to 3 percent slopes.....	8, 376	1. 3	Quinlan loam, 1 to 3 percent slopes.....	583	(¹)
Carey silt loam, 1 to 3 percent slopes.....	2, 507	. 4	Quinlan loam, 3 to 5 percent slopes, eroded..	670	. 1
Carey silt loam, 3 to 5 percent slopes.....	3, 189	. 5	Reinach very fine sandy loam.....	5, 694	. 9
Carey silt loam, 4 to 8 percent slopes, eroded..	2, 436	. 4	Renfrow silty clay loam, 0 to 1 percent slopes..	963	. 2
Carwile-Shellabarger complex, 0 to 1 percent slopes.....	9, 281	1. 5	Renfrow silty clay loam, 1 to 3 percent slopes..	6, 445	1. 0
Clayey alluvial land.....	4, 366	. 7	Rough broken land, clayey.....	8, 160	1. 3
Dill fine sandy loam, 1 to 3 percent slopes....	8, 884	1. 4	Rough broken land, loamy.....	9, 579	1. 6
Dill fine sandy loam, 3 to 5 percent slopes....	3, 852	. 6	St. Paul silt loam, 0 to 1 percent slopes.....	626	. 1
Dill fine sandy loam, 3 to 8 percent slopes, eroded..	6, 915	1. 1	St. Paul silt loam, 1 to 3 percent slopes.....	4, 954	. 8
Dill fine sandy loam, 5 to 12 percent slopes....	11, 058	1. 8	St. Paul silt loam, 3 to 5 percent slopes.....	995	. 2
Elsmere loamy fine sand.....	4, 119	. 7	Sand dunes, Lincoln material.....	5, 070	. 8
Enterprise fine sandy loam, coarse variant, 1 to 3 percent slopes.....	1, 419	. 2	Shellabarger fine sandy loam, 0 to 3 percent slopes.....	23, 199	3. 7
Enterprise fine sandy loam, coarse variant, 3 to 5 percent slopes.....	870	. 1	Sweetwater soils.....	3, 700	. 6
Eroded loamy land.....	1, 363	. 2	Tillman clay loam, 0 to 1 percent slopes.....	2, 630	. 4
Grant silt loam, 1 to 3 percent slopes.....	10, 176	1. 7	Tillman clay loam, 1 to 3 percent slopes.....	11, 834	1. 9
Grant silt loam, 3 to 5 percent slopes.....	5, 307	. 9	Tillman clay loam, 3 to 5 percent slopes.....	4, 060	. 7
Grant-Nash silt loams, 5 to 8 percent slopes..	525	(¹)	Tipton silt loam, 0 to 1 percent slopes.....	2, 602	. 4
Grant-Nash silt loams, 4 to 8 percent slopes, eroded..	2, 986	. 5	Tivoli fine sand, rolling.....	12, 992	2. 1
Kirkland silt loam, 0 to 1 percent slopes.....	8, 515	1. 4	Treadway clay.....	1, 052	. 2
Leshara loam.....	1, 422	. 2	Vernon clay loam, 0 to 3 percent slopes.....	4, 028	. 7
Lincoln loams.....	2, 858	. 5	Vernon soils, 3 to 5 percent slopes, eroded....	1, 700	. 3
Lincoln soils.....	13, 936	2. 3	Vernon-Badland complex, 1 to 3 percent slopes.....	15, 778	2. 6
McLain silty clay loam.....	11, 544	1. 9	Vernon-Gypsum outcrop complex.....	19, 186	3. 1
Meno loamy fine sand, 0 to 3 percent slopes....	26, 091	4. 2	Weymouth loam, 1 to 3 percent slopes.....	1, 958	. 3
Miller clay.....	2, 670	. 4	Weymouth loam, 3 to 5 percent slopes, eroded..	1, 142	. 2
Nobscot fine sand, hummocky.....	13, 252	2. 2	Weymouth-LaCasa complex, 1 to 3 percent slopes.....	1, 990	. 3
Nobscot fine sand, rolling.....	80, 892	13. 1	Weymouth-LaCasa complex, 3 to 5 percent slopes.....	2, 587	. 4
Nobscot-Pratt complex, duned.....	11, 041	1. 8	Weymouth-LaCasa complex, 3 to 5 percent slopes, eroded..	8, 350	1. 4
Nobscot-Pratt complex, hummocky.....	3, 456	. 6	Weymouth-Vernon complex, 5 to 12 percent slopes.....	47, 144	7. 6
Ortello fine sandy loam, undulating.....	5, 054	. 8	Yahola fine sandy loam.....	7, 287	1. 2
Pond Creek silt loam, 0 to 1 percent slopes....	6, 958	1. 2	River channels.....	7, 287	1. 2
Pond Creek silt loam, 1 to 3 percent slopes....	5, 647	. 9			
Port fine sandy loam.....	1, 205	. 2			
Port silt loam.....	17, 118	2. 8			
			Total.....	616, 320	100. 0

¹ Less than 0.1 percent.

capability unit and range site are described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

In the description of the soil series and of the mapping units, terms for texture, structure, consistence, and other soil properties are used. Some of these terms require explanation.

Texture indicates 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."

Structure is the arrangement of soil particles into aggregates, or clusters, that are separated in the soil mass from adjoining aggregates. The shape of these aggregates are described by terms such as *granular*, *angular blocky*, and *subangular blocky*.

Terms for consistence denote the feel of the soil and the ease with which a lump can be crushed by the fingers. Common terms of consistence are *loose*, *friable*, *plastic*, and *firm*. Consistence is given for a dry, wet, or moist soil. Unless otherwise specified, the consistence given in this survey is for a moist soil.

Terms for available moisture capacity denote the ability of a soil to hold water that plants can use. *Low*, *moderate*, and *high* are examples of terms used to indicate available moisture capacity.

Other terms used in this survey are defined in the Glossary and some of them are explained in detail in the "Soil Survey Manual" (6).¹

Alluvial Land

Alluvial land (Ad) is in and along drainageways that extend through valley areas below areas of the erosional upland. It consists of loamy soil material in a slightly entrenched draw in which the channel is filled with raw alluvium. Slopes range from 0 to 5 percent. During periods of flooding, there is much scouring and deposition of soil material. Areas of Alluvial land generally are likely to be flooded about twice each year. Through the larger areas a trickle of water runs several months a year. The areas typically range from 150 to 400 feet in width and from a few hundred feet to more than a mile in length. The widest part is at the sharp bends.

The soil profile in this land consists of deep, loamy, and highly stratified material. The surface layer is loam, clay loam, silt loam, silty clay loam, or fine sandy loam.

This rough land is so susceptible to erosion that it is not suited as cropland, but it is well suited as range (fig. 6). Although the narrow belts along the main channels are bare or almost so, the loamy deposits generally have a good cover of vegetation. The vegetation is mostly tall and mid grasses, and there are a few scattered saltcedars, tamarisks, cottonwoods, and willows. The grasses are mainly bluestem, sand bluestem, and indiagrass in well-managed areas but are buffalograss, sand dropseed, windmillgrass, and weeds in excessively grazed areas. The amount of forage available could be increased by sprigging or seeding

suitable grasses. Good grazing has been produced in some areas by sprigging bermudagrass.

Areas of Alluvial land provide excellent food and cover for wildlife. (Capability unit Vw-3; Loamy Bottomland range site; windbreak suitability group 2)

Breaks-Alluvial Land Complex

Breaks-Alluvial land complex (Bk) is in areas of soils in the smooth uplands and consists of broken rims, or breaks, and of Alluvial land in gullylike drainageways. Slopes range from 0 to 5 percent in the Alluvial land part of this complex and from 8 to 20 percent in the Breaks part. The Breaks part makes up 50 to 75 percent of any area mapped, and the Alluvial land makes up 25 to 50 percent.

The gullylike drainageways zigzag and have abrupt banks and concave floors filled with recently deposited sediment. These drainageways drain areas of Weymouth, La-Casa, Carey, and St. Paul soils in the western part of the county and areas of Grant, Pond Creek, and Weymouth soils in the eastern part. Narrow strips of these soils are included in this complex and, in raw banks, they show a profile of the respective soil. Below the narrow banks are the concave floors, which are made up of alluvial and colluvial material. This material generally has a loam, silt loam, clay loam, or fine sandy loam texture, but in places it is as sandy as the material in the Lincoln soils.

Because it is so rugged and so susceptible to erosion, this land is not suited as cropland. It is well suited as range. In the well-managed areas, the grasses are mostly mid and tall grasses, mainly big bluestem, switchgrass, western wheatgrass, Canada wildrye, purpletop, and indiagrass. In poorly managed areas, the dominant grasses are blue grama, buffalograss, silver bluestem, sand dropseed, red three-awn, and scattered annuals or weeds. Trees dot the edges of some areas. These trees are mostly cedar in the western part of the county and elm in the eastern part. (Both soils are in capability unit VIe-1; Breaks part is in the Loamy Prairie range site, and Alluvial land is in the Loamy Bottomland range site; both soils are in windbreak suitability group 2)

Canadian Series

The Canadian series consists of deep fine sandy loams on bottom lands. These soils are very friable, easily worked, and well drained. Slopes are smooth and nearly level to gently sloping. Broad areas of these soils lie along Cottonwood, Deep, and Sand Creeks in the central part of the county. Smaller areas are on low terraces along the major streams.

The surface layer of these soils is grayish-brown, granular fine sandy loam about 18 inches thick. The subsoil is about 14 inches thick and consists of brownish, very friable fine sandy loam. At a depth of about 32 inches is a layer of calcareous loamy fine sand similar to the material from which the Canadian soils formed. In places this layer is stratified with thin bands of fine sandy loam and loam. These soils are about neutral in the surface layer and are increasingly calcareous as depth increases.

Canadian soils developed in stratified sandy alluvium consisting of sediments sorted by water. The plant cover was mid and tall grasses.

¹ Italic numbers in parentheses refer to Literature Cited, p. 83.



Figure 6.—Livestock grazing on Alluvial land. This land lies in slightly entrenched draws and is below higher soils on bottom lands.

Canadian soils are naturally well drained. Internal drainage is medium, and permeability is moderate.

Canadian soils occur with Lincoln, Port, Reinach, Enterprise, Yahola, Leshara, McLain, Elsmere, and Miller soils. Canadian soils are more fertile and less sandy than the Lincoln soils but are more sandy than the McLain, Miller, Reinach, or Port soils. They lack the subirrigated subsoil of the Elsmere and Leshara soils. Canadian soils are more deeply leached of lime than the Yahola soils. Their subsoil is more sandy and stratified than that of the Enterprise soils.

Typical profile of Canadian fine sandy loam, 0 to 1 percent slopes, on a slope of less than 0.5 percent, 900 feet east and 400 feet north of the southwest corner of section 30, T. 20 N., R. 15 W., on north side of road in cultivated field:

- A1—0 to 18 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular structure; soft when dry, very friable when moist; numerous roots; non-calcareous; pH 7.0; clear boundary.
- B—18 to 32 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, granular structure; soft when dry, very fri-

able when moist; numerous roots; calcareous; clear boundary.

- C—32 to 50 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 4/3) when moist; single grain (structureless); soft when dry, very friable when moist; calcareous.

The A horizon ranges from 10 to 22 inches in thickness and from grayish brown to strong brown in color. The B horizon is fine sandy loam in most places. These soils are normally neutral to slightly alkaline in the surface layer and are calcareous in the lower horizons.

Canadian fine sandy loam, 0 to 1 percent slopes (CaA).—This is a deep soil on bottom lands, above the level of ordinary flooding. It occurs along the North Canadian and Cimarron Rivers and their tributaries, and in broad areas scattered on the high bottom lands along Sand, Deep, and Cottonwood Creeks, in the central part of the county. The profile of this soil is the one described as typical of the Canadian series.

This soil absorbs water rapidly and has moderately high available moisture capacity.

Included with this soil in the mapping were areas of Port silt loam, Port fine sandy loam, Elsmere loamy fine sand, and Reinach very fine sandy loam. These inclusions do not

exceed 10 percent of any area mapped as this soil. Also included were areas of a soil similar to Canadian soils except for its reddish-brown surface layer. These areas make up as much as 30 percent of some areas mapped. In some places a dark buried soil occurs below a depth of 30 inches.

Where this Canadian soil is cultivated, soil blowing is a concern and has caused moderate damage. In the damaged spots the wind has blown away the fine particles of clay and organic matter and has left a winnowed surface layer of loamy fine sand 1 to 3 inches thick. Little water runs off this soil unless rains are intensive, and this runoff is mostly from clean-tilled fields. A few areas receive runoff from higher slopes, and a few small strips next to streams are occasionally flooded.

Except for a few small strips, this soil is cultivated. Wheat is the main crop, but sorghum also grows well. Other small grains and alfalfa are suited and are grown in small areas. (Capability unit IIe-2; Loamy Bottomland range site; windbreak suitability group 1)

Canadian fine sandy loam, 1 to 3 percent slopes (CoB).—This is a deep, loamy soil on bottom lands. This soil lies along the Cimarron River and is above the level of ordinary flooding. Extensive areas are also along Cottonwood, Sand, and Deep Creeks.

This soil has a profile similar to the one described as typical of the series, but its surface layer is slightly thinner and its depth to calcareous material is slightly less. The surface layer, about 10 inches thick, is strong-brown fine sandy loam. The subsoil is about 14 inches thick and consists of friable, strong-brown fine sandy loam. The subsoil absorbs water readily and has moderate to high available moisture capacity.

Included with this soil in the mapping were a few areas on low ridges or mounds that have had their surface layer changed by soil blowing. In these places the surface layer on south-facing slopes is fine sandy loam slightly redder than normal; the north-facing slopes have a thin accumulation of winnowed loamy fine sand. These eroded areas make up less than 5 percent of any mapped area. In other places erosion is indicated by drifting along fence rows and by windblown material that fills ditches along roads. Also included were areas of Port, Enterprise, and Yahola soils that may make up 15 percent of a mapped area. The largest inclusions make up as much as 30 percent of a mapped area and consist of a reddish-brown soil similar to this soil.

Except for a few narrow strips, all of this soil is cultivated. About equal amounts of wheat and sorghum are grown. This soil is suited to those crops and to other small grains and legumes commonly grown in the county. The main concerns in managing this soil are maintaining fertility and controlling wind erosion. (Capability unit IIIe-3; Loamy Bottomland range site; windbreak suitability group 2)

Carey Series

The Carey series consists of deep, friable, gently sloping to sloping soils. These soils are on the rolling uplands in the western part of Major County.

The surface layer is dark-brown silt loam about 8 inches thick. It is friable and has granular structure. The subsoil is about 35 inches thick. The upper part of the subsoil is

friable, reddish-brown heavy silt loam. In this layer are large, distinct prisms that are easily crushed into granules. The lower part of the subsoil is reddish silty clay loam that has less pronounced structure than the upper part and contains more clay. Below a depth of about 43 inches, the soil material is red, partly weathered, calcareous loam (fig. 7).

The Carey soils developed in material derived from interbedded calcareous sandstone, siltstone, and shale of the Permian red beds. The plant cover was mostly mid and tall grasses.

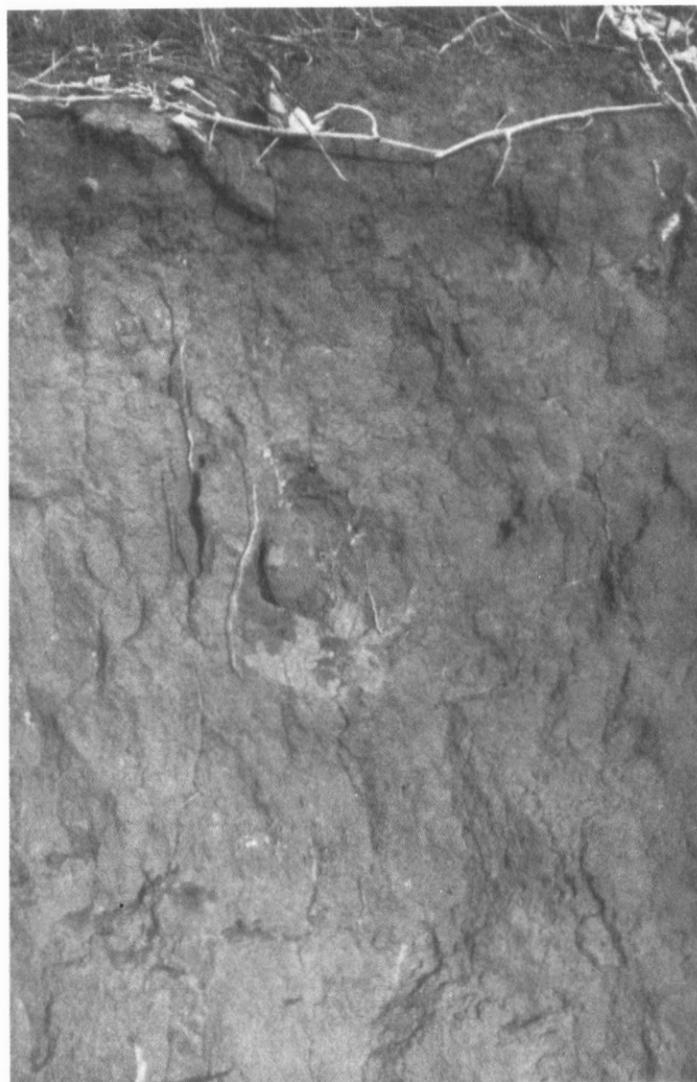


Figure 7.—Representative profile of Carey silt loam.

These soils are naturally well drained, and they are moderately permeable to water and air.

Carey soils are near the St. Paul, Weymouth, LaCasa, and Dill soils. The subsoil of Carey soils contains less clay than that of the St. Paul soils. Carey soils are more silty than the Weymouth or LaCasa soils but are less sandy than the Dill soils and, unlike them, have a calcareous substratum. They have a more distinct subsoil than that of the Tipton soils.

Typical profile of Carey silt loam, 3 to 5 percent slopes,

about 280 feet east and 260 feet north of the southwest corner of the northwest quarter of section 28, T. 22 N., R. 16 W., on east side of road in cultivated field:

- Ap—0 to 8 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; upper 4 inches of plow layer is about 1 chroma and 1 value higher; moderate, medium and fine, granular structure; soft to slightly hard when dry, friable when moist; noncalcareous; pH 7.0; clear boundary.
- B21t—8 to 23 inches, reddish-brown (5YR 4/4) heavy silt loam, dark reddish brown (5YR 3/3) when moist; strong, coarse, prismatic structure and strong, medium and fine, granular structure; hard when dry, friable to firm when moist; noncalcareous; pH 7.5; few, thin, patchy clay skins on surface of peds; clear boundary.
- B22t—23 to 43 inches, red (2.5YR 5/6) light silty clay loam, red (2.5YR 4/6) when moist; weak, coarse, prismatic and moderate, medium and fine, granular structure; hard when dry, firm when moist; noncalcareous; pH 7.5; few, thin, patchy clay skins on surface of peds; gradual boundary.
- C1—43 to 52 inches, red (2.5YR 5/6) heavy loam, red (2.5YR 4/6) when moist; weak, fine, granular structure to massive; slightly hard when dry, friable when moist; calcareous and has threads of lime; gradual boundary.
- C2—52 to 60 inches, red (2.5YR 5/6) loam, red (2.5YR 4/6) when moist; partly weathered sandstone in the upper part of the horizon and partly weathered shale in the lower part; massive; calcareous.

The A horizon ranges from dark brown to reddish brown in color and from 6 to 12 inches in thickness. It is silt loam in most places but is loam or very fine sandy loam in small areas. Depth to calcareous soil material ranges from 20 to 44 inches but is generally between 38 and 43 inches. A calcium carbonate horizon occurs in some places, but it is faint. In some places these soils contain a few small concretions of lime below a depth of 38 inches.

Carey silt loam, 1 to 3 percent slopes (CrB).—This soil is on broad, smooth ridges and lower slopes, where it occurs with other, more sloping Carey soils. The surface layer ranges from 9 to 12 inches in thickness and is thicker than the surface layer of the profile described as typical for the Carey series. The subsoil, about 15 inches thick, is friable heavy silt loam that is moderately permeable.

Included with this soil in the mapping were areas of St. Paul and Dill soils that are too small to be shown separately on the soil map.

Unprotected areas of this soil are likely to be damaged by soil blowing and water erosion. During heavy rains, runoff cuts rills and shallow gullies. Plowing easily erases these rills and gullies, but the soil lost through erosion cannot be regained.

Except for poorly accessible areas, all of this soil is cultivated. Winter wheat is the main crop, but some grain sorghum is also grown. (Capability unit IIe-1; Loamy Prairie range site; windbreak suitability group 2)

Carey silt loam, 3 to 5 percent slopes (CrC).—This soil occupies side slopes of ridges of the moderately sloping uplands in the western part of Major County. It is the most extensive Carey soil in the county. Its profile is the one described for the series.

Included with this soil in the mapping were a few small areas of eroded Carey soils and some areas of Carey soils that have a loam or very fine sandy loam surface layer. These inclusions are mostly near larger areas of Dill soils. Also included were areas of the St. Paul, Dill, Weymouth, and LaCasa soils.

In a few areas this Carey soil makes up entire farms about 160 acres in size, but the average-sized areas range

from 15 to 50 acres. A large acreage is cultivated. Areas in native grasses produce abundant forage where management is good. Winter wheat is the main cultivated crop, but other small grains and grain sorghum are also grown.

Management is needed that controls erosion and maintains soil structure and fertility. Practices are also needed for preventing surface crusting. (Capability unit IIIe-2; Loamy Prairie range site; windbreak suitability group 2)

Carey silt loam, 4 to 8 percent slopes, eroded (CrD2).—This sloping soil is on long side slopes of ridges. It is inextensive in this county. Its surface layer has been thinned by erosion, and some of the subsoil has been mixed with it through tillage. In some eroded areas rills and shallow gullies scar the surface, and unless protection is provided, others are likely to appear after heavy rains. Some of these rills and gullies cannot be erased by normal tillage. The subsoil ranges from about 16 to 35 inches in thickness and consists of silt loam and silty clay loam. Calcareous soil material begins at a depth ranging from about 20 to 35 inches.

Included with this soil in the mapping were areas of Carey silt loam, 3 to 5 percent slopes, and small areas of Dill, Weymouth, and LaCasa soils.

Unless practices are used for controlling erosion, this soil soon will be unsuited to crops. Seeding areas, including waterways, in native grasses is a good practice. Suitable grasses for this purpose are little bluestem, big bluestem, sideoats grama, blue grama, and buffalograss. (Capability unit IVe-3; Loamy Prairie range site; windbreak suitability group 3)

Carwile Series

The Carwile series consists of deep, dark soils that occupy small swales and depressions throughout the sandy areas of the county. Because the surface is slightly concave, water collects and stands on these soils after heavy rains.

The surface layer is dark colored and about 1 foot thick. It ranges from fine sandy loam to clay loam in texture. It has granular structure and is very friable when moist but is slightly hard when dry.

The subsoil is about 34 inches thick. It is very firm when wet and very hard when dry, and it is not readily penetrated by air, water, and plant roots. The upper part of the subsoil is sandy clay that has coarse blocky structure. The lower part consists of sandy clay loam that has medium blocky structure. In both parts, the subsoil is mottled with yellowish, brownish, and grayish colors. This mottling indicates wetness.

Below a depth of 46 inches, the material is mottled strong-brown and very pale brown fine sandy loam. This material is hard when dry and very friable when moist.

Carwile soils are moderately well drained to somewhat poorly drained. Because they are in swales or slight depressions, these soils catch runoff from adjacent areas. In some places water covers these soils for several days after periods of heavy rains. The plowing of cultivated fields is often delayed.

Carwile soils occur closely with Shellabarger soils but are darker and contain more clay. They are near the Pratt, Ortello, Nobscot, Tivoli, and Meno soils but are less sandy and more strongly developed than those soils.

Typical profile of a Carwile soil that has a fine sandy loam surface layer, 150 feet west and 195 feet north of the southeast corner of the southwest quarter of section 9, T. 20 N., R. 9 W., on north side of road in cultivated field:

- A1—0 to 12 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; slightly hard when dry, very friable when moist; pH 6.5; gradual boundary.
- B2t—12 to 32 inches, mottled yellowish-brown (10YR 5/6), dark-gray (10YR 4/1), and light-gray (10YR 7/1) sandy clay; weak, coarse, blocky structure; very hard when dry, very firm when moist; pH 7.5; diffuse boundary.
- B3—32 to 46 inches, mottled yellowish-brown (10YR 5/6), gray (10YR 5/1), and strong-brown (7.5YR 5/6) sandy clay loam; weak, medium, blocky structure; hard when dry, friable when moist; pH 7.5; diffuse boundary.
- C—46 to 56 inches +, mottled strong-brown (7.5YR 5/6) and very pale brown (10YR 7/3) fine sandy loam; massive; hard when dry, very friable when moist; pH 8.0.

The A1 horizon ranges from clay loam to fine sandy loam. Grayish colors or mottling is within a depth of 20 inches in some places. The B2t horizon ranges from sandy clay to heavy sandy clay loam in texture and averages more than 35 percent clay; it ranges from light gray to dark yellowish brown in color. Mottling ranges from faint to prominent. The B3 horizon ranges from sandy clay to sandy clay loam. The C horizon ranges from fine sandy loam to sandy clay loam. In places below a depth of 30 inches, there is a dark-colored buried soil that ranges from fine sandy loam to clay.

Carwile-Shellabarger complex, 0 to 1 percent slopes (CsA).—This complex consists of Carwile and Shellabarger soils in swales that are scattered through the sandy areas of Major County. These soils are so intermingled that it is not practical to map them separately. They occur in slightly concave depressions surrounded by more sloping Pratt and Nobscot soils. Areas mapped average about 6 to 10 acres in size. After heavy rains, water collects on a large part of this complex and stands for a few hours, but the water gradually retreats to low spots and stands there for several days.

Carwile soils make up 25 to 45 percent of this complex, and Shellabarger soils, 25 to 40 percent. The remaining acreage consists of Pratt, Ortello, Meno, and Nobscot soils.

The Carwile soil has a profile similar to the one described as typical of the Carwile series. This soil occurs in the lowest parts of depressions. Because the subsoil is very permeable, the water may stand long enough to delay planting or drown crops. Because the Carwile soil is in small scattered strips, areas are not evident unless marked by standing water (fig. 8).

The surface layer of the Shellabarger soil is generally fine sandy loam, but in small areas it is loam. The subsoil is friable sandy clay loam. The Shellabarger soil is generally on the upper slopes of the concave areas.

About 95 percent of this complex is cultivated. The main crops are sorghums and wheat and other small grains. Most crops commonly grown in the county are suited if simple practices are used to prevent water from standing in the low areas. (Capability unit IIw-2, Sandy Prairie range site, and windbreak suitability group 1)

Clayey Alluvial Land

Clayey alluvial land (C_y) consists of alluvial, clayey soil material, in and along slightly entrenched drainage-



Figure 8.—Low, concave areas of Carwile soil where water is ponded in a wheatfield.

ways leading from higher areas of erosional deposits from red beds. Slopes range from 0 to 5 percent. Most of the drainageways head near the foot slopes along red-bed buttes and escarpments and extend into the valleys below for a distance of several hundred feet to more than a mile. The areas range from 100 to more than 300 feet in width. Much of the land is in areas surrounded by broad areas of Vernon-Badland complex, 1 to 3 percent slopes. The soil material is deep, reddish, compact, and clayey on the floors of the drainageways, and it is cut by narrow, raw, gully-like draws 2 to 8 feet wide and 2 to 4 feet deep. Along the draws are small, scattered spots of accumulated salts.

On much of this land, the vegetation is mid and tall grasses, mostly western wheatgrass, little bluestem, side-oats grama, switchgrass, and sand bluestem. Salt-tolerant grasses, mostly coarse alkali sacaton and saltgrass, grow in saline spots. All these grasses benefit from the runoff water that drains through the draws, but during floods the soil material is carried away from the overgrazed areas. This land is only suitable as range. Good management is needed to prevent overgrazing so that areas are stabilized. (Capability unit Vw-4; Heavy Bottomland range site; wind-break suitability group 4)

Dill Series

The Dill series consists of deep and moderately deep, gently sloping to strongly sloping, reddish-brown soils. These soils occur in the western part of Major County on broad divides between canyonlike drainageways.

The surface layer is reddish-brown fine sandy loam about 7 inches thick. It is very friable and has granular structure. The subsoil, about 17 inches thick, is red fine sandy loam that is porous and permeable. In this layer the soil material is arranged in friable, coarse prisms that are easily crushed to medium granules. Light-red, noncalcareous fine sandy loam is at a depth of 24 inches, and weakly cemented, noncalcareous, red sandstone is at about 40 inches. A soil profile representative of the Dill series is shown in figure 9.

Dill soils developed in material weathered from sandstone and compact sand of the Permian red beds. The plant cover was mostly tall and mid grasses.



Figure 9.—Profile of Dill fine sandy loam, 1 to 3 percent slopes, in which the thick surface layer is underlain by a friable, prismatic subsoil of loam to fine sandy loam with no accumulated lime.

Dill soils occur with but are higher and more sandy than the Carey, St. Paul, Weymouth, and LaCasa soils. The calcareous substratum in the Carey soils is missing in the Dill soils. Dill soils also occur with the Quinlan soils but are deeper.

Typical profile of Dill fine sandy loam, 1 to 3 percent slopes, about 300 feet east and 96 feet south of the southwest corner of the northeast quarter of section 33, T. 22 N., R. 16 W., on west side of road in cultivated field:

- A1—0 to 7 inches, reddish-brown (5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; pH 6.5; clear boundary.
- B2—7 to 24 inches, red (2.5YR 5/6) fine sandy loam, red (2.5YR 4/6) when moist; weak, coarse, prismatic structure; slightly hard when dry, very friable when moist; noncalcareous; pH 7.0; clear boundary.
- C—24 to 40 inches, light-red (2.5YR 6/6) fine sandy loam; contains lenses of loamy fine sand and soft, weathered, very fine sandstone; structureless; soft when dry, friable when moist; noncalcareous; pH 7.0.
- R—40 to 50 inches +, weakly cemented, red, noncalcareous sandstone.

The A1 horizon ranges from 6 to 10 inches in thickness and from reddish brown to dark brown in color. The B2 horizon ranges from fine sandy loam to loam and is generally red, reddish brown, and yellowish red when dry. Depth to soft weathered fragments of sandstone ranges from 20 to 54 inches. The upper part of the profile generally is slightly acid to neutral, and the C horizon is weakly alkaline.

Dill fine sandy loam, 1 to 3 percent slopes (DfB).—This soil is in the western part of the county. It occurs on undulating uplands in fairly broad areas surrounded by areas of more sloping Dill soils. The profile of this soil is similar to the profile described for the Dill series, but in places the surface layer has been damaged by soil blowing. Along the fence rows of some fields, soil has accumulated in ridges that are generally less than 2 feet high.

Included with this soil in the mapping were small areas of Carey, St. Paul, and Quinlan soils.

Most of this Dill soil is cropland. Wheat, grain sorghum, and forage sorghum are the main crops.

Management is needed that prevents the wind from winnowing fine particles of clay and organic matter from the surface layer. This loss of clay particles and organic matter lowers fertility and increases the hazard of erosion. (Capability unit IIIe-4; Sandy Prairie range site; windbreak suitability group 2)

Dill fine sandy loam, 3 to 5 percent slopes (DfC).—This gently sloping soil is on ridges and side slopes of the uplands. Most of it is in the western part of Major County.

The surface layer consists of about 6 inches of fine sandy loam. The subsoil, about 16 inches thick, is friable and permeable to air and water. Below a depth of 22 inches, the substratum grades to weakly consolidated sandstone at a depth ranging from 20 to 48 inches.

Included with this soil in the mapping were small spots of Carey and St. Paul soils. Small spots of Quinlan soils generally occur at the highest points in the mapped areas.

Surface runoff is medium but is more rapid than on Dill fine sandy loam, 1 to 3 percent slopes. In most places erosion is not more than slight, but in cultivated fields some spots have a winnowed surface layer. These spots are coarser textured than fine sandy loam because the wind has removed fine particles. Some sheet erosion caused by heavy rains has left shallow rills, but these are generally easily erased through normal tillage. On unprotected fields, however, severe erosion is likely.

About 90 percent of this soil is cultivated, mainly to wheat, grain sorghum, and forage sorghum. This soil is suited to crops because it is easily worked and has moderate fertility and available moisture capacity. An adequate cover of crop residue is needed to protect this soil from erosion. (Capability unit IIIe-4; Sandy Prairie range site; windbreak suitability group 2)

Dill fine sandy loam, 3 to 8 percent slopes, eroded (DfD2).—This soil occurs along the rims and narrow ridges of divides between deep canyonlike drainageways in the western part of Major County. The areas range between 5 and 25 acres in size. The smaller areas in cultivated fields are generally along the rims of natural drains or draws. The larger areas may make up an entire field. Most of this soil is at the crest of the ridges from which Dill fine sandy loam, 5 to 12 percent slopes, extends on the side slopes. Runoff is medium to rapid.

Nearly all of this soil has been cultivated. Erosion has thinned the original surface layer so much that tillage mixes material from the redder fine sandy loam subsoil

into the remaining darker colored surface layer. All of the plow layer is the former subsoil. Depth to sandstone is generally less than 36 inches. A few rills and shallow gullies mark the area. Along fence rows are low drifts of soil blown from the fields. Unprotected areas are susceptible to soil blowing and water erosion.

Included with this soil in the mapping were areas of Quinlan soils, along the western edge of the county, that total as much as 15 percent of some mapped areas.

This soil was damaged by erosion after it was cultivated. It is better suited as rangeland than as cropland. Less than 50 percent of the acreage remains in cultivation, and most of this is in forage sorghum that is fed to livestock as supplementary feed. Native grasses have been reseeded in many areas, and a few areas are left idle.

Intensive management is needed to protect cultivated areas from further erosion. If erosion continues, fertility decreases and plowing is more difficult. (Capability unit IVe-5; Sandy Prairie range site; windbreak suitability group 3)

Dill fine sandy loam, 5 to 12 percent slopes (DfE).—This soil occurs with other Dill soils in the western part of Major County. It is on the sharp ridges and abrupt rims of divides that adjoin the rims of Rough broken land, loamy. Slopes are uneven.

The surface layer is about 6 inches thick and consists of reddish-brown fine sandy loam. The subsoil is red fine sandy loam. It is underlain by sandstone, commonly at a depth ranging from 20 to 36 inches. The sandstone is somewhat nearer the surface of this soil than it is under the less sloping Dill soils.

Included with this soil in the mapping were areas of the Quinlan soils totaling as much as 15 percent of some mapped areas along the western edge of the county. Also included were small areas of Carey and St. Paul soils and a few spots of Rough broken land, loamy.

Strong slopes make this soil unsuited as cropland. It is well suited as range. Nearly all of it is used as range. The broad areas are excellent for ranches, and in winter livestock find refuge in the breaks and ravines. Well water is used in a few places for livestock, but most of the water comes from deep ponds constructed in the adjoining draws and canyons.

Most of this soil is in large areas of range where the vegetation is mostly mid and tall grasses and sand sagebrush. A few cedar trees dot the areas. The grasses are mostly sand bluestem, little bluestem, big bluestem, indian-grass, and sideoats grama. In excessively grazed areas, sand sagebrush is increasing. (Capability unit VIe-2; Sandy Prairie range site; windbreak suitability group 3)

Elsmere Series

In the Elsmere series are nearly level, deep, grayish-brown loamy fine sands that have a wet subsoil. These soils are in scattered areas on bottom lands along the Cimarron and North Canadian Rivers. Some large areas occur south of Chester in the southwestern part of the county and around Cleo Springs in the southeastern part. Elsmere soils are above the level of ordinary flooding.

The surface layer is grayish-brown loamy fine sand about 1 foot thick. It is soft to very friable and easily worked. Underlying the surface layer, and extending to a depth of

50 inches, is very pale brown loamy fine sand mottled with gray and strong brown. Mottling increases with increasing depth. The mottling indicates long periods of wetness. Sandy clay loam is at a depth of 50 inches.

The water table is generally at a depth of about 38 inches. Above the water table, these soils are rapidly permeable and easily penetrated by plant roots. They are generally calcareous through the profile and, in places, are slightly saline or salty. In these areas a white film is on the surface.

Elsmere soils developed in deposits of sandy, water-sorted material washed from the sandy uplands. The native vegetation was mostly mid and tall grasses.

Elsmere soils occur with the Leshara, Canadian, Lincoln, and Sweetwater soils. Elsmere soils are more sandy than the Leshara soils and are more sandy and have a higher water table than the Canadian soils. The surface layer of the Elsmere soils is more sandy than that of the Sweetwater soils and is darker and thicker than that of the Lincoln soils.

Typical profile of Elsmere loamy fine sand, 300 feet east and 200 feet north of the southwest corner of section 16, T. 20 N., R. 16 W., on north side of the road in cultivated field:

- A1—0 to 12 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; loose when dry or moist; calcareous; clear boundary.
- C1—12 to 34 inches, very pale brown (10YR 7/4) loamy fine sand, yellowish brown (10YR 5/4) when moist; mottled with gray and strong brown; single grain; loose when dry or moist; calcareous; clear boundary.
- C2—34 to 50 inches, very pale brown (10YR 7/4) loamy fine sand, light yellowish brown (10YR 6/4) when moist; mottled with gray; single grain; loose when dry or moist; water table at a depth of 38 inches; few, small, hard concretions of lime; calcareous.
- IIC3—50 to 58 inches, very pale brown (10YR 7/3) sandy clay loam, brown (10YR 5/3) when moist; massive; hard when dry, slightly sticky when wet; horizon saturated with ground water; few, small, hard concretions of lime; calcareous.

The A1 horizon, when dry, is mostly grayish brown to brown. It is very dark brown to grayish brown when moist. Grayish-brown to very pale brown colors extend to a depth of 30 inches or more. Mottling in the C horizons ranges from faint to prominent. Depth to the water table ranges from 2 to 7 feet but averages about 3 feet. In places salinity is slight, but not enough to more than slightly damage crops.

Elsmere loamy fine sand (0 to 1 percent slopes) (Ee).—This soil is in scattered areas on bottom lands along the Cimarron and North Canadian Rivers. It lies above the normal level of flooding in a belt between sandy soils on dunes near the streams and sandy soils on uplands. Most areas range from about 10 to 30 acres in size. This soil is deep and nearly level, and it has a high water table. Its profile is the one described as representative of the Elsmere series.

Included with this soil in the mapping were areas of Leshara and Canadian soils. These included areas are in low spots.

Because the subsoil is subirrigated by the fluctuating water table, the choice of crops is limited to those that tolerate wetness. In wet seasons plant growth is retarded because the water table is high. Growth is favorable in normal seasons when the water table remains below a depth of 3 feet. If the surface dries, the hazard of soil blowing is high.

Sorghums, mostly forage sorghum, are the main crops, and a small acreage is used for corn and cotton. About half of the acreage is cultivated, and about half is used as meadow or range. (Capability unit IVw-1; Subirrigated range site; windbreak suitability group 2)

Enterprise Series

No soils typical of the Enterprise series were mapped in Major County, but a coarse variant of the series was recognized. The soils are deep, friable, gently sloping to moderately sloping fine sandy loams. They are brown to reddish brown and friable. They developed in a mantle consisting of sandy deposits blown from the flood plains of streams nearby. These soils occur on terraces on uplands along the Cimarron River and its tributaries.

The surface layer is brown, calcareous fine sandy loam about 10 inches thick. It is friable and has granular structure. Underlying the surface layer is also friable, granular, calcareous fine sandy loam, but this material is reddish brown and about 20 inches thick. Water and air readily penetrate this layer. It is underlain by loose, light reddish-brown, calcareous loamy sand.

Enterprise soils formed in a mantle of fine sandy loam. The plant cover was mostly mid and tall grasses.

These soils are well drained. Permeability is moderately rapid, and runoff is medium.

In this county Enterprise soils occur closely with the Tipton, Yahola, Canadian, Pratt, and Tivoli soils. Enterprise soils are redder than the Tipton soils and lack their slight accumulation of clay in the subsoil. They are redder than the Pratt or Ortello soils and, unlike them, have a calcareous subsoil. Enterprise soils are less sandy than the Tivoli, Yahola, or Canadian soils. The leaching of lime is not so deep in the Enterprise soils as in the Canadian.

Profile of Enterprise fine sandy loam, coarse variant, 1 to 3 percent slopes, 900 feet north and 100 feet east of the southwest corner of the southeast quarter of section 2, T. 23 N., R. 16 W., on east side of road in native range:

- A1—0 to 10 inches, brown (7.5YR 5/4) fine sandy loam dark brown (7.5YR 3/4) when moist; moderate, medium, granular structure; soft when dry, very friable when moist; calcareous; gradual boundary.
- B—10 to 30 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) when moist; weak, medium, granular structure; soft when dry, very friable when moist; calcareous; gradual boundary.
- C—30 to 54 inches +, light reddish-brown (5YR 6/4) loamy sand, reddish brown (5YR 5/4) when moist; structureless (single grain); loose when moist and dry; calcareous; few pebbles as much as one-fourth inch in diameter.

The A1 horizon of this variant ranges from reddish brown to brown when it is dry and from dark brown to dark reddish brown when it is wet. This layer ranges from 6 to 12 inches in thickness. It is mildly alkaline or calcareous. In a few places a winnowed layer, 1 to 2 inches thick, is at the surface. The B horizon is calcareous. The C horizon is sand in some places. In many places an older, buried soil that is normally calcareous and darker than the soil described is below a depth of 36 inches.

Enterprise fine sandy loam, coarse variant, 1 to 3 percent slopes (EnB).—This soil occurs mainly in the northwestern part of the county near the Cimarron River and its tributaries. It lies on the rims of the uplands, immediately above the soils on bottom lands. On its gently sloping surface are uneven, low ridges and mounds that do

not form a definite drainage pattern. The profile of this soil is the one described as a coarse variant of the Enterprise series.

Water soaks into this soil rapidly, and available moisture capacity is fairly good. Except during heavy rains, only a little water runs off, because most of it is absorbed in low places. In spots, the surface layer is winnowed; much of the clay and organic matter has blown away.

Included with this soil in the mapping were a few small areas of Tipton, Yahola, and Pratt soils that are too small to be shown separately on the soil map.

About 70 percent of this soil is cultivated; the rest is used as range. The main crops are sorghums and wheat. Also grown are other small grains and forage crops suited to the area. Where management is good, tall grasses produce abundant forage, but in excessively grazed areas sand sagebrush and less desirable grasses invade. Management is needed that controls soil blowing. Sorghums grown in spots damaged by erosion generally are affected by chlorosis because essential plant nutrients are lacking. (Capability unit IIIe-5; Sandy Prairie range site; wind-break suitability group 2)

Enterprise fine sandy loam, coarse variant, 3 to 5 percent slopes (EnC).—This soil of the uplands occurs with gently sloping Enterprise fine sandy loam, coarse variant, 1 to 3 percent slopes, but it has more runoff. Runoff is medium.

The surface layer ranges from 6 to 12 inches in thickness and is thickest on the lower slopes and thinnest at the crests of slopes. The surface layer is fine sandy loam. The subsoil is friable, granular fine sandy loam that is porous and permeable to roots, air, and water. In some places this soil is winnowed and has a lighter colored surface layer than normal because fine particles of mineral and organic material have blown away. Water erosion is evident at the crests of a few slopes.

This soil is in long strips, 300 to 500 feet wide, that are below the rims of upland terraces. Tipton and Pratt soils are on the terraces above, and Yahola soils are on the bottom lands below. Small areas of these associated soils—Tipton, Pratt, and Yahola—were included in the mapping of this soil.

About half of this soil is cultivated, and the rest is range. Wheat and sorghums are the main crops. They are well suited under good management, but in places, particularly the eroded spots, sorghum is stunted because of a lack of plant nutrients and the resulting chlorosis. The main practices needed are those that control soil blowing. (Capability unit IIIe-5; Sandy Prairie range site; wind-break suitability group 2)

Eroded Loamy Land

Eroded loamy land (Er) consists of soils, on uplands, that have been severely damaged by both sheet and gully erosion. Slopes range from 2 to 8 percent. The soils have been so severely damaged that little of the original soil profile remains. Nearly all of the dark surface layer and, in places, much of the subsoil have been removed by erosion. In most places the present surface layer ranges from silt loam to clay loam, but in small pockets it is fine sandy loam or clay. In some areas raw, limy earth is exposed at the surface. In many fields there are shallow rills and gullies, most of which cannot be crossed easily with farm

machines. Because the remaining soil slows penetration by water, runoff is rapid and further gully and sheet erosion is likely.

Eroded loamy land occurs mainly in the western part of the county with the Carey, Weymouth, LaCasa, and St. Paul soils. In the northwestern part of the county it is near the Grant, Weymouth, and Pond Creek soils. Areas generally range from about 5 to 20 acres in size.

This land is highly erosive and is not suited as cropland. Most fields have been cultivated, but they were abandoned or reseeded to grass when crop yields became low. Small areas in natural drains that receive water from adjacent terraces have been used as grassed waterways. A cover of permanent grass is needed on this land to protect it from erosion. (Capability unit VIe-3; Loamy Prairie range site; windbreak suitability group 4)

Grant Series

The Grant series consists of gently sloping to sloping, deep, moderately dark silt loams on uplands. These soils are in broad areas along the rims of tableland near Meno and Ringwood in the northeastern part of the county. Small areas are in the south-central part of the county.

The surface layer is about 10 inches thick and consists of reddish-brown to dark reddish-brown silt loam. It is friable and granular. The subsoil, about 24 to 30 inches thick, consists of permeable, porous, reddish-brown light silty clay loam. The material in the subsoil is arranged in coarse prisms that crush easily to medium granules. Beneath a depth of 40 inches is yellowish-red loam material similar to the material from which these soils formed.

Grant soils formed in a mantle of material that is mostly of loam, silt loam, clay loam, or very fine sandy loam texture. The plant cover was mid and tall grasses.

Grant soils are well drained to somewhat excessively drained. They absorb water at a medium rate and have fairly high available moisture capacity. Runoff is medium in gently sloping and moderately sloping areas but is medium to rapid in the more strongly sloping areas. A plow pan has formed in some places.

Grant soils occur mainly with the Pond Creek, Weymouth, and Nash soils. They have redder, less distinct subsoil layers than the Pond Creek soils. Grant soils are not so red as the Nash soils but have more distinct horizons. They are leached of lime to a greater depth than the Weymouth soils.

Typical profile of Grant silt loam, 1 to 3 percent slopes, 429 feet west and 100 feet north of the southeast corner of the southwest quarter of section 1, T. 22 N., R. 9 W., on north side of road in cultivated field:

- A1—0 to 10 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) when moist; weak, fine and medium, granular structure; hard when dry, very friable when moist; noncalcareous; pH 7.0; gradual boundary.
- A3—10 to 16 inches, reddish-brown (5YR 4/3) heavy silt loam, dark reddish brown (5YR 3/3) when moist; weak, coarse, prismatic and moderate, medium, granular structure; slightly hard when dry, very friable when moist; noncalcareous; pH 7.1; gradual boundary.
- B2t—16 to 32 inches, reddish-brown (5YR 4/4) light silty clay loam, dark reddish brown (5YR 3/4) when moist; moderate, coarse, prismatic and moderate, medium, granular structure; slightly hard to hard when dry, very friable when moist; noncalcareous; pH 7.2; gradual boundary.

B3—32 to 40 inches, yellowish-red (5YR 4/6) light silty clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, granular structure; slightly hard when dry, very friable when moist; many fine and medium pores; noncalcareous; pH 8.0; gradual boundary.

C1—40 to 48 inches, yellowish-red (5YR 5/6) heavy loam, yellowish red (5YR 4/6) when moist; structureless (massive); soft to slightly hard when dry, very friable when moist; noncalcareous, pH 8.0; gradual boundary.

C2—48 to 60 inches +, yellowish-red (5YR 5/8) loam; contains small fragments of soft to slightly hard sandstone; yellowish red (5YR 4/8) when moist; structureless (massive); slightly hard when dry, friable to very friable when moist; calcareous; no visible lime.

The A1 horizon ranges from 6 to 15 inches in thickness, and from reddish brown to brown when dry, or from dark reddish brown to brown when wet. In a few spots it is loam or very fine sandy loam. The B horizons range from heavy silt loam to light silty clay loam in texture and from 20 to 40 inches in thickness. When dry, the B3 horizon ranges from yellowish red to red. Depth to calcareous material ranges from 36 inches to more than 6 feet.

Grant silt loam, 1 to 3 percent slopes (GrB).—This gently sloping soil is in broad areas in the uplands in the northeastern part of the county. It occurs in the natural drains and on the ridges that lead from or border broad, flat areas of Pond Creek soils north of Meno and Ringwood. The profile of this soil is the one described as typical of the Grant series.

Because this soil is well drained, very friable, and permeable, it is suited as cropland. About 85 percent of the acreage is cropland; the rest is native range. Winter wheat is the main crop, but other small grains and sorghums also are grown.

Soil blowing is the main concern in cultivated fields, but most cultivated fields are only slightly eroded. A few scattered spots are moderately eroded. Because plowing has been excessive, the material in the surface layer is pulverized and blows readily. Sheet erosion is more damaging than gully erosion, but runoff during heavy rains cuts shallow gullies or rills in unprotected fields. Plowing erases the rills and gullies, but the fertility lost is not so easy to regain. (Capability unit IIe-1; Loamy Prairie range site; windbreak suitability group 2)

Grant silt loam, 3 to 5 percent slopes (GrC).—This extensive, moderately sloping soil occurs mostly in the northeastern part of the county on smooth side slopes of drainage ways in the uplands. It occurs with other Grant soils. The profile is normally slightly thinner than the one in the soil described as typical of the Grant series. In most places the surface layer is thinnest at the crests of slopes, but thickness increases downslope.

Included with this soil in the mapping were small areas of Weymouth and Nash soils that are too small to be shown separately on the map.

This Grant soil is somewhat excessively drained to well drained. In unprotected areas runoff is excessive and the increased erosion accounts for the variable thickness of the surface layer. This soil is friable and granular and permeable to air and water.

About 85 percent of this soil is cultivated; the rest is range. Wheat is the main crop, but grain sorghum is also grown when moisture is adequate.

Erosion, though generally slight, is the main concern of farmers. The slopes of this soil are susceptible to water erosion, and the barren fields blow severely, especially during dry periods. In some fields erosion is indicated by

shallow rills and light-colored spots. If erosion is allowed to continue, fertility declines, tillage is difficult, and surface crusting retards the start of growing plants. (Capability unit IIIe-2; Loamy Prairie range site; windbreak suitability group 2)

Grant-Nash silt loams, 5 to 8 percent slopes (GnD).—This complex consists of Grant silt loam and Nash silt loam on the long slopes of drainageways that extend from the tableland in the northeastern part of the county. Most of the Grant soil extends from about halfway upslope to the crest of the slope. The Nash soil is on the rim of the crest or is near the drainageway at the bottom. The Grant soil makes up 50 to 60 percent of this complex, and the Nash soil makes up 40 to 50 percent.

Included with these soils in the mapping were small areas of Weymouth loam that are too small to map separately. These included areas generally are near the highest points of the landscape.

The profile of the Grant soil is somewhat similar to that described for the series, but it has a surface layer that is only about 7 inches thick. The subsoil, about 20 to 30 inches thick, is slightly more dense than the surface layer.

The Nash soil has a reddish-brown silt loam surface layer that averages about 1 foot in thickness. The subsoil is yellowish-red, granular, friable silt loam about 16 inches thick. It is not so prominent as the subsoil of the Grant soil. In the Nash soil, structure is not so well defined below a depth of 28 inches as it is above. The subsoil grades to weakly consolidated sandstone at a depth of about 32 inches.

The soils in this complex absorb water at a medium rate, and they have good available moisture capacity. Only small amounts of water run off grassed areas, but runoff is rapid in the few cleared areas.

Nearly all of the acreage of these soils is in native grass, but small areas are cultivated. Wheat is the main crop, but grain sorghum grows well where moisture is adequate. In cultivated areas intensive management is needed for controlling erosion and maintaining fertility. These soils are better used as range than as cropland. Large amounts of mid and tall grasses are produced if grazing is not excessive, but short grasses increase in overgrazed areas. (Capability unit IVe-2; Loamy Prairie range site; windbreak suitability group 3)

Grant-Nash silt loams, 4 to 8 percent slopes, eroded (GnD2).—This complex consists of sloping, moderately eroded soils that occur on uplands near other Grant soils. About 50 to 60 percent of this complex consists of Grant soils, and about 40 to 50 percent, of Nash soils. The Grant soil is predominantly in slightly concave areas on the lower slopes and at the crest of the slopes. The Nash soil is mainly on the rim of the crest of slopes and near the drainageways, especially the more pronounced ones, at the bottom of the slopes.

Included with these soils in the mapping were small spots of Weymouth soils, mostly near the highest points, and of Pond Creek soils in concave areas near the foot slopes. In most places the small spots of Weymouth soils have been eroded. These eroded areas make up about 5 percent of most areas mapped, but in places they make up almost 15 percent. These spots have light-colored limy material on the surface and contain small pebble-sized concretions of lime.

In cultivated areas both sheet erosion and soil blowing are serious concerns. Sheet erosion has caused the most damage because it has gradually washed away the soil material and has thinned the surface layer considerably. In many places the remaining layer consists of material brought from the subsoil. In addition to sheet erosion, shallow, branching rills and drains have been cut into side slopes. Some of the shallow rills and drains can be erased through tillage, but a few cannot because they are too large. On unprotected fields, soil blowing is a hazard during droughts.

About 85 percent of this complex is cultivated. The rest has been abandoned or reseeded to grass, or it is native range. Winter wheat is the main crop, but grain sorghum can be grown when moisture is adequate. These soils are unsuitable as cropland unless they are well managed. (Capability unit IVe-3; Loamy Prairie range site; windbreak suitability group 3)

Kirkland Series

The Kirkland series consists of deep, dark, nearly level soils on uplands. These soils have a compact, clayey subsoil and locally are called tightland. They are in broad areas that surround the town of Meno in the northeastern part of the county. Smaller areas are in the south-central part. The surface is slightly uneven, for there are concave depressions and convex rises.

The surface layer is dark-brown silt loam about 9 inches thick. It has granular structure and is permeable. In some fields a plowpan forms in the surface layer. The subsoil, about 30 inches thick, is more clayey and less permeable than the surface layer. The upper part of the subsoil, a dark grayish-brown silty clay, has subangular blocky structure. In the lower part of the subsoil the material is arranged in shiny blocks that have continuous clay films on their surface. Below a depth of 39 inches, the soil material is yellowish-red sandy clay loam similar to that from which the soils formed.

Kirkland soils formed in a mantle consisting of material derived from Permian red beds. The native vegetation was mostly mid and tall grasses.

Kirkland soils have very slow permeability and slow runoff.

These soils occur with the Renfrow and Pond Creek soils. They are less friable and contain more clay in the subsoil than the Pond Creek soils and are less red than the Renfrow.

Typical profile of Kirkland silt loam, 0 to 1 percent slopes, 270 feet south and 100 feet east of the northwest corner of section 16, T. 22 N., R. 9 N., on east side of road in cultivated field:

- Ap—0 to 9 inches, dark-brown (10YR 4/3) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; very hard when dry, firm when moist; pH 7.0; abrupt boundary.
- B21t—9 to 20 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; strong, medium and coarse, subangular blocky structure; very hard when dry, very firm when moist; pH 7.2; gradual boundary.
- B22t—20 to 34 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; strong, coarse, blocky structure; very hard when dry, very firm when moist; pH 7.3; gradual boundary.

B3—34 to 39 inches, strong-brown (7.5YR 5/6) clay loam, dark brown (7.5YR 4/2) when moist; weak, coarse, blocky structure; very hard when dry, very firm when moist; calcareous; gradual boundary.

C—39 to 48 inches +, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; structureless (massive); calcareous; some threads of lime.

The Ap horizon varies slightly from silt loam in some places. It ranges from 5 to 10 inches in thickness. Depth to calcareous soil material generally ranges from 14 to 40 inches.

Kirkland silt loam, 0 to 1 percent slopes (KrA).—This soil occurs on uplands in broad areas that surround the town of Meno in the northeastern part of the county. Smaller areas are in the south-central part. The surface of this soil appears slightly wavy because of slight concave depressions and convex rises. The profile of this soil is the one described as typical of the Kirkland series. The subsoil consists of a dense silty clay that absorbs water very slowly, and the whole soil is slightly droughty.

Included with this soil in the mapping, and totaling as much as 40 percent of some mapped areas, were soils that have a surface layer about 15 inches thick. These inclusions have a thicker surface layer and are more permeable than the Kirkland soil. Also included were a few small areas of Ortello soils. The Kirkland soil is generally in the slightly depressional areas, but the included soils are uniformly on the slight rises.

About 95 percent of this soil is cultivated. Wheat and other small grains and sorghums grow well when there is enough moisture.

In some places farming is across the natural drains that cut across cultivated fields, though erosion is greater in the drains than it is in other parts of the fields. The drains range from 1 to 2 feet in depth and from 2 to 10 feet in width. In areas adjacent to these drains, the surface layer has been thinned by water erosion.

Erosion is lessened if permeability is increased by adding humus and crop residue. Management is needed for controlling erosion and maintaining soil fertility. (Capability unit IIs-1; Claypan Prairie range site; windbreak suitability group 3)

LaCasa Series

In the LaCasa series are deep, dark, gently sloping to moderately sloping soils that have a clay loam surface layer and a moderately tight, reddish subsoil. These soils are extensive in the western part of the county, where they are closely intermingled and were mapped in complexes with the Weymouth soils.

The surface layer of LaCasa soils is dark-brown clay loam about 10 inches thick. This layer is slightly hard when dry, but it is friable and crumbles easily when moist. Structure is granular. The subsoil, about 21 inches thick, is moderately tight, dark reddish-gray or reddish-brown clay loam that contains slightly more clay on the upper part than in the lower. The upper part has subangular blocky structure, but the lower part is calcareous and has angular blocky structure. Underlying the subsoil is weakly granular or massive, yellowish-red clay loam that is calcareous and contains concretions of lime. Shale or clay of the red beds generally lies at a depth ranging from 50 to 75 inches.

The LaCasa soils developed in material weathered from the Permian red beds. The native vegetation was mostly short and mid grasses.

LaCasa soils are generally well drained but are somewhat excessively drained in moderately sloping, unprotected areas. Permeability is moderately slow and runoff is medium to rapid.

LaCasa soils occur closely with the Weymouth, St. Paul, Carey, Dill, Vernon, and Tillman soils. They have less clay in the subsoil and are more permeable than Tillman soils. LaCasa soils are less calcareous than the Weymouth and Vernon soils and have a more distinct profile. They are slightly redder than the St. Paul soils and are calcareous near the surface. They contain more clay than Carey soils and are less sandy than the Dill.

Typical profile of a LaCasa soil that has a clay loam surface layer, about 660 feet south and 200 feet east of the northwestern corner of the southwest quarter, section 29, T. 21 N., R. 13 W., on the east side of road in native pasture:

A1—0 to 10 inches, dark-brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; pH 7.2; gradual boundary.

B2t—10 to 14 inches, dark reddish-gray (5YR 4/2) heavy clay loam, dark reddish brown (5YR 3/2) when moist; weak, fine, subangular blocky and weak, medium, granular structure; hard when dry, firm when moist; pH 7.5; clay skins on soil peds; clear boundary.

B3—14 to 31 inches, reddish-brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, blocky structure; hard when dry, firm when moist; clay skins and stains of organic matter on ped faces; calcareous; gradual boundary.

C1ca—31 to 36 inches, yellowish-red (5YR 5/6) clay loam, yellowish red (5YR 4/6) when moist; weak, medium, granular structure; hard when dry; calcareous; few concretions of calcium carbonate; gradual boundary.

C2—36 to 50 inches, yellowish-red (5YR 5/6) clay loam, yellowish red (5YR 4/6) when moist; structureless (massive); calcareous; few concretions of calcium carbonate but less than in the Cca horizon.

The A1 horizon, when dry, ranges from brown to dark grayish brown. It ranges from 6 to 12 inches in thickness. The B horizons, when dry, range from light reddish brown to dark reddish gray. Calcareous material generally begins at a depth of 5 to 15 inches, but it may be at the surface or at a depth of 20 inches. Accumulations of lime concretions in the C horizon range from none to 5 percent of the soil mass.

Leshara Series

The Leshara series consists of deep, nearly level, dark, loamy soils that have a high water table. These soils are on bottom lands along the North Canadian and Cimarron Rivers. They lie about 10 to 20 feet above the streambeds and are seldom flooded, though they developed in materials deposited by floodwaters. Leshara soils are inextensive in Major County. Most areas are near Chester in the southwestern part of the county and near Ames in the southeastern part.

The surface layer is dark gray to very dark gray loam about 16 inches thick. It is friable, has granular structure, and generally is calcareous at the surface. Underlying the surface layer is grayish massive loam that is mottled with yellowish brown. This layer is about 22 inches thick. It is calcareous and contains a few crystals of calcium. Water saturates this soil at a depth of 34 inches. Below a depth

of 38 inches, the material is mottled light yellowish-brown or yellowish-brown fine sandy loam. This material grades to pink or brown fine sand at a depth of about 47 inches. It is highly calcareous.

These soils are somewhat poorly drained because of the high water table. In places, these soils are moderately saline.

Leshara soils developed in water-laid sediments that range from clay loam to sand in texture. The native vegetation was mostly mid and tall grasses.

Leshara soils occur with the Elsmere, Yahola, Canadian, and Lincoln soils. They are less sandy than the Elsmere, Yahola, and Lincoln soils. The Leshara soils are also less sandy than the Canadian soils, which do not have a high water table. The subsoil of Leshara soils is less sandy than that of the Sweetwater soils.

Typical profile of Leshara loam, 175 feet south and 35 feet east of the northwest corner of the northeast quarter of section 20, T. 20 N., R. 16 W., on south side of road in cultivated field:

- A1—0 to 16 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/1) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; numerous roots; calcareous; pH 8.0; gradual boundary.
- AC—16 to 38 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) when moist; mottled with yellowish brown; structureless (massive); few crystals of calcium; calcareous; pH 8.0; water table at a depth of 34 inches; gradual boundary.
- IIC1—38 to 47 inches, light yellowish-brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) when moist; structureless (massive); mottled with varying shades of yellowish brown; slightly hard when dry, friable when moist; calcareous; pH 8.3; horizon saturated by ground water; gradual boundary.
- IIIC2—47 to 56 inches +, pink (7.5YR 7/4) fine sand, brown (7.5YR 5/4) when moist; structureless (single grain); soft when dry, loose when moist; calcareous; pH 8.5; horizon saturated by ground water.

The A1 horizon is clay loam or silt loam in places, mostly in shallow swales. In some places, the AC horizon contains more clay than normal. The substratum ranges from loam to fine sand. In some areas, there is a buried dark-colored clay loam soil below a depth of 40 inches.

Leshara loam (0 to 1 percent slopes) (le).—This nearly level soil occurs on bottom lands in scattered areas along the North Canadian and Cimarron Rivers and Deep Creek. The profile of this soil is the one described for the Leshara series.

Included with this soil in the mapping were small areas of Elsmere and Canadian soils.

Because water movement is impeded by a high water table, this soil is somewhat poorly drained. Surface drainage is good, except in the slight depressions that hold water for several days after heavy rains. Soluble salts are sometimes brought to the surface, and white crusts form where the salts accumulate. As most soluble salts are removed during heavy rains, crops are seldom damaged.

This soil is used for forage sorghum, grain sorghum, cotton, and corn, but in wet seasons these crops grow poorly. At times this soil is too wet for planting, and at times wetness interferes with harvesting. The crops are suited, however, in seasons when rainfall is low or medium, for the plants are subirrigated by the high water table. Forage on well-managed range is abundant.

This soil is damaged most by excessive runoff from higher areas, though soil blowing is a slight hazard. If

the soil is tilled when moisture is excessive, its surface puddles and soil structure breaks down. Management of crop residue is especially needed for providing humus and organic matter, which improve soil structure and help control erosion. (Capability unit IIw-1; Subirrigated range site; windbreak suitability group 1)

Lincoln Series

The Lincoln series consists of deep, sandy, nearly level soils that formed in alluvium recently deposited on the low flood plains along the larger streams. Except in a few high areas, these soils vary because new sandy and loamy material is deposited during each flood.

These soils vary in texture, color, and depth, but in most places the surface layer is light-brown to brown, calcareous, loose fine sand about 8 inches thick. This layer is structureless. It is underlain by brown calcareous sand that is highly stratified with layers of loamy fine sand and fine sandy loam. Below a depth of 18 inches is loose, pink, calcareous sand several feet thick.

The recently deposited sediments in which the Lincoln soils formed are mostly sand, but they are stratified with thin lenses of material that vary widely in texture. The soil profile has been slightly modified by additions of organic matter from the vegetative cover. Mid and tall grasses make up most of the present vegetation, and there are a few cottonwoods and considerable brush.

Permeability is rapid, but these soils are occasionally covered by floodwater. The water table is generally at a depth of 4 to 10 feet.

These soils occur closely with the Yahola and Canadian soils but are more sandy.

Typical profile of a Lincoln soil that has a fine sand surface layer; in native range:

- A1—0 to 8 inches, light-brown (7.5YR 6/4) fine sand, brown (7.5YR 5/4) when moist; single grain (structureless); loose when dry, very friable when moist; calcareous; gradual boundary.
- IIC1—8 to 18 inches, brown (7.5YR 5/4) highly stratified sand, loamy fine sand, and fine sandy loam; average texture is light loamy fine sand that is brown (7.5YR 5/4) when moist; finer textured strata are brown to dark brown (7.5YR 4/4); structureless; coarser textured strata are loose when dry and very friable when moist; finer textured strata are hard when dry and very friable when moist; calcareous; clear boundary.
- IIC2—18 to 60 inches, pink (7.5YR 8/4) sand and appreciable amount of coarse sand, pink (7.5YR 7/4) when moist; single grain (structureless); loose when moist and dry; calcareous.

The A1 horizon ranges from clay loam to sand in texture and from 1 to 10 inches in thickness. This layer, when dry, ranges from light brownish gray to reddish brown. The finer textured material has the more reddish colors. Beneath the A1 horizon is highly stratified material that is dominantly sand. In most places these soils are calcareous throughout. In some places, generally near the streambed, a few pebbles are scattered throughout the profile. The water table is generally at a depth of about 5 feet in dry periods and at a depth of at least 4 feet in moist periods. In some places there is a little mottling within 4 feet of the surface.

Lincoln loams (0 to 1 percent slopes) (ln).—Nearly all of the acreage of these soils is on the outside edge of high flood plains along the Cimarron River. Flooding is only occasional. Generally, only backwater damages crops, and its damage is slight.

This soil has a dark-brown, calcareous, loamy surface

layer about 5 inches thick. It is underlain by reddish-brown, calcareous sandy clay loam that is about 12 inches thick and has granular structure. Below a depth of 15 inches is loose, pink, calcareous sand several feet thick. Water moves rapidly through this sand.

Lincoln soils are droughty, but deep-rooted plants can obtain moisture because the water table is normally at a depth of about 4 feet. In dry seasons, however, the water table drops to a depth of 8 feet or more and is out of reach of most deep-rooted plants.

Alfalfa is the main crop, but it is grown with only limited success. The fluctuating water table tends to make these soils too wet or too dry for dependable growth of alfalfa. Much of the acreage was cultivated, but because yields were low these soils have been left idle and have grown up in weeds, or they have slowly returned to grass or have been reseeded to grass. Some pastures of bermudagrass have been established.

About 80 percent of the acreage of these soils is now used as range; the rest is cropland. These soils are well suited as range and, under good management, produce large amounts of forage. Management for controlling soil blowing is needed so that the loamy part of these soils is retained. Because depth is limited, these soils are quickly damaged by erosion. (Capability unit IVs-1; Loamy Bottomland range site; windbreak suitability group 2.)

Lincoln soils (0 to 1 percent slopes) (ls).—These young, deep, sandy soils occur on the low flood plains along creeks and rivers in Major County. They are variable because new material is deposited on them by floodwater.

The surface layer varies in texture but is mostly light-brown fine sand that is calcareous and about 8 inches thick. It is underlain by stratified, calcareous sand, loamy fine sand, or fine sandy loam that is about 10 inches thick, and in turn, is underlain by several feet of sand.

These soils formed in alluvium, most of which was recently washed in from the surrounding uplands. Texture varies according to the source of the alluvium. Generally, areas of these soils farthest from streams are the less sandy but are the most variable in texture. Because Lincoln soils are adjacent to the stream channel, there is much scouring and redeposition during floods, especially near the channels. Lincoln soils are flooded more than any other soils in the county. Areas along the rivers are flooded about twice a year, but areas along the creeks are flooded more frequently. Along the rivers, generally only the low flood plains are flooded. In about once in 10 years, when rainfall is especially heavy, the entire area is flooded.

These soils are not suited to crops and are not farmed. Flooding damages plants, and in some places the soils are droughty in dry periods. Except for a few dense stands of saltcedar, vegetation is generally sparse near the stream channels. Other vegetation on Lincoln soils consists of grapevines and clumps of sand plum, sand sagebrush, and tamarack. Trees, mostly cottonwoods and a few willows, are in scattered areas. Stands of grasses grow away from the streams or in the less flooded areas.

Well-managed areas of grass on Lincoln soils provide good grazing. In these areas the grasses include sand bluestem, little bluestem, switchgrass, indiagrass, purpletop, and Canada wildrye. Some of the better areas have been seeded to grasses to increase forage. Lincoln soils, however, are susceptible to soil blowing where there is not enough protective cover. In heavily grazed areas, bare

spots and weeds are increasing. Also increasing in these areas are western wheatgrass, vine-mesquite, big sandreed, tall dropseed, purple lovegrass, sand paspalum, and sand lovegrass. (Capability unit Vw-1; Sandy Bottomland range site; windbreak suitability group 2)

McLain Series

The McLain series consists of deep, nearly level soils on low terraces along the Cimarron River and its tributaries. Broad areas of this soil lie in the valley surrounding Fairview.

The surface layer is dark-brown silty clay loam about 1 foot thick. It is friable, has granular structure, and is easily tilled when the moisture content is favorable. In some places a plowpan has formed in this layer. The subsoil, about 18 inches thick, is reddish brown and contains more clay than the surface layer. In this layer the soil material is friable and is arranged in large prisms that are easily crushed into subangular blocks. Below a depth of 30 inches the soil material is massive and is not so friable as it is above that depth. It is calcareous silty clay that grades to light-red, calcareous clay at a depth of about 40 inches. The calcareous soil material contains a few small concretions of lime.

The McLain soils developed in sediments washed from the Permian red beds. These sediments range from silt loam to clay and extend several feet below the profile described. The plant cover was mostly tall and mid grasses. McLain soils are moderately well drained and have slow permeability.

McLain soils occur with the Miller, Port, Reinach, and Canadian soils. They contain less clay and are more friable than the Miller soils and are more deeply leached of lime. McLain soils are less friable and have a more distinct subsoil than Port soils and are less sandy than the Reinach and Canadian soils.

Typical profile of McLain silty clay loam, about 950 feet north and 325 feet east of the southwest corner of section 21, T. 21 N., R. 11 W.:

- A1—0 to 12 inches, dark-brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/4) when moist; moderate, medium, granular structure; hard when dry, friable when moist; noncalcareous; pH 7.0; clear boundary.
- B2t—12 to 30 inches, reddish-brown (5YR 4/3) heavy silty clay loam, dark reddish brown (5YR 3/3) when moist; weak, coarse, prismatic and weak, medium, subangular blocky structure; hard to very hard when dry, friable when moist; noncalcareous; pH 7.5; gradual boundary.
- C1—30 to 40 inches, reddish-brown (2.5YR 4/4) light silty clay, dark reddish brown (2.5YR 3/4) when moist; massive (structureless); hard to very hard when dry, friable to firm when moist; calcareous; few, hard, very small concretions of lime; clear boundary.
- C2—40 to 60 inches, light-red (2.5YR 6/6) light clay, red (2.5YR 5/6) when moist; massive (structureless); hard when dry, friable when moist; calcareous; few, small, hard concretions of lime.

The A1 horizon ranges from dark brown to dark reddish brown. It is clay loam, silt loam, loam, or very fine sandy loam in small areas. The B2t horizon, when dry, ranges from reddish brown to brown in color and from light silty clay to heavy clay loam in texture. Depth to material that is finer textured than clay loam ranges from 12 to 36 inches. The upper part of the profile ranges from mildly alkaline to slightly acid, but the soil material is calcareous at a depth of 20 to 38 inches. Buried soils that are generally darker than McLain soils but are similar in texture occur in places below depths of 30 inches.

McLain silty clay loam (0 to 1 percent slopes) (Mc).— This soil occurs mainly on high stream terraces in the eastern half of Major County along the Cimarron River and its tributaries. It is one of the best soils in the county for farming. Broad, smooth areas of this nearly level soil lie in the valley surrounding Fairview. Some areas cover more than a quarter of a section. The profile of this soil is the one described as typical of the McLain series.

Water soaks into this soil slowly, but available moisture capacity is high.

Included with this soil in the mapping were some small areas of Port, Miller, Canadian, and Reinach soils. Also included, in areas less than an acre in size, were slickspots. These areas are whitish during dry periods.

Except for small strips in range, this soil is used as cropland. Most crops common in the county grow well. Wheat, alfalfa, and sorghums are the main crops. Areas in rangeland are generally small and are heavily grazed in places. Mid and tall grasses grow in the well-managed areas, and large amounts of annuals or weeds grow in excessively grazed areas.

This soil is easily managed, but plowpans form in some fields if the soil is plowed when too wet or if depth of plowing is not varied. Prominent plowpans can be broken up by subsoiling. The surface crusts or puddles easily where the surface layer has been pulverized by tillage. Management is needed for maintaining soil structure and fertility. (Capability unit I-1; Loamy Bottomland range site; windbreak suitability group 2)

Meno Series

In the Meno series are deep loamy fine sands that occur on gently undulating to slightly concave uplands. The most extensive areas are around Ames and Ringwood in the eastern part of the county.

The surface layer is brown to dark-brown loamy fine sand about 24 inches thick. It is friable and has granular structure. The subsoil is about 20 inches thick. Its upper part is brown light sandy clay loam that is faintly mottled with grayish brown and strong brown. It is friable and has granular structure. The lower part consists of brown sandy clay loam that is mottled with brownish or grayish colors. It is friable and has weak subangular blocky structure. Below a depth of 44 inches is massive, mottled strong-brown to grayish-brown fine sandy loam. This material is similar to that in which the soils formed and is easily penetrated by the roots of plants. These soils have been leached throughout and are medium acid.

Meno soils formed in thick deposits of sandy material stratified with clay loam to sand. This material probably is old alluvium modified by wind. The native vegetation was mid and tall grasses and a few scattered scrub oaks.

The Meno soils are moderately well drained. Permeability is moderate; the subsoil absorbs and holds large quantities of available water. There is little runoff, except after heavy rains, and then the runoff water is generally absorbed in low places.

These soils occur with the Shellabarger, Carwile, Pratt, Nobscot, and Ortello soils. They are not so well drained as the Shellabarger soils and are more mottled in the subsoil.

Meno soils are less clayey than the Carwile soils and less grayish in the subsoil. They have slightly more clay in the

subsoil than in the Pratt, Nobscot, and Ortello soils, which are not mottled.

Typical profile of Meno loamy fine sand, 0 to 3 percent slopes, 670 feet north and 350 feet east of the southwest corner of the southeast quarter of section 24, T. 20 N., R. 9 W.:

- A11—0 to 10 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) when moist; weak, medium, granular structure; soft when dry, very friable when moist; pH 5.6; gradual boundary.
- A12—10 to 24 inches, brown (7.5YR 5/4) loamy fine sand, dark brown (7.5YR 4/3) when moist; weak, medium, granular structure; soft when dry, very friable when moist; pH 6.0; clear boundary.
- B21t—24 to 34 inches, brown (7.5YR 5/4) light sandy clay loam, dark brown (7.5YR 4/4) when moist; faintly mottled with grayish brown and strong brown; weak, medium, granular structure; pH 6.0; gradual boundary.
- B22t—34 to 44 inches, mottled brown (7.5YR 5/4), strong-brown (7.5YR 5/6), and gray (10YR 6/1) sandy clay loam; weak, medium, subangular blocky structure; hard when dry, friable when moist; pH 6.0; diffuse boundary.
- C—44 to 60 inches +, mottled strong-brown (7.5YR 5/6) and grayish-brown (10YR 5/2) fine sandy loam; massive (structureless); pH 6.0.

The A horizon ranges from dark brown to light brownish gray. The A12 horizon is faintly mottled in the lower lying areas. The Bt horizons range from sandy clay loam to heavy fine sandy loam that has a content of clay of about 17 to 20 percent. Depth to a horizon containing distinct mottles ranges from 20 to 30 inches. The mottles in the lower part of the B22t horizon range from distinct to prominent and are more yellowish and grayish than the soil mass. The horizons below the Bt horizons are stratified in some places. The strata range from loamy fine sand to sandy clay loam. Below a depth of 48 inches, there is an occasional layer of dark-colored heavy sandy clay loam to clay loam. Reaction of the A horizons is medium acid to neutral. In places free carbonates occur below a depth of 60 inches.

Meno loamy fine sand, 0 to 3 percent slopes (MeB).— This nearly level to gently undulating soil is in a broad, sandy belt that extends from the southeastern corner of the county through Ames, Ringwood, and Cleo Springs to the north-central part. The largest areas are around Ames. The profile of this soil is the one described as typical of the Meno series.

Included with this soil in the mapping were small areas of Pratt, Ortello, Shellabarger, Nobscot, and Carwile soils.

About 90 percent of this soil is cropland; the rest is pasture or range. Wheat is planted in some places, and it is suited, but this soil is especially well suited to grain sorghum, forage sorghum, Austrian Winter peas, and cowpeas. This soil is suitable for irrigation, but only a small acreage is irrigated.

Soil blowing is the main concern of management. The surface layer has been winnowed in some cultivated fields and is coarser textured than loamy fine sand because fine particles and organic matter have been removed by wind. Also, the surface layer is lighter colored than in the soil described as typical of the series. (Capability unit IIe-3; Deep Sand range site; windbreak suitability group 2)

Miller Series

In the Miller series are deep, reddish-brown soils that have a clay plow layer and a compact clay or silty clay subsoil. These nearly level soils are on flood plains along

the Cimarron River valley and tributaries that flow from the erosional, broken red beds in Major County.

The surface layer is dark reddish-gray, calcareous clay about 7 inches thick. It is thinly crusted on the surface in most cultivated fields, and in places a plowpan has formed at plow depth. Underlying the surface layer is calcareous, reddish-brown, compact silty clay about 27 inches thick. It is very sticky when wet and very hard when dry. Structure is subangular blocky. Below a depth of 34 inches is calcareous, massive, firm clay that is reddish in color and very hard when dry. In the soil mass are seams or thin lenses consisting of crystals.

Miller soils formed in clay-textured sediment washed from the erosional beds of shale and clay of the Permian red beds. The plant cover was short and mid grasses and scattered mesquite bushes.

Miller soils are droughty and very slowly permeable to air and water. Because runoff is slow from nearly level areas, more time is allowed for this soil to absorb rainwater.

Miller soils occur with the Port, Reinach, Canadian, and McLain soils but have a thinner, less dark surface layer, have a higher content of clay, and are less deeply leached of clay. Miller soils also occur with the Treadway soils but are not so platy in structure, contain more organic matter, and are less compact.

Typical profile of Miller clay 1,320 feet east and 175 feet south of the northwest corner of section 19, T. 22 N., R. 12 W., on south side of road in cultivated field.

Ap—0 to 7 inches, dark reddish-gray (5YR 4/2) clay, dark reddish brown (5YR 3/2) when moist; moderate, medium, granular structure; hard when dry, friable to firm when moist; weakly calcareous, ¼-inch surface crust; calcareous; weak plowpan in lower part of horizon; clear boundary.

B—7 to 34 inches, reddish-brown (2.5YR 4/4) light silty clay, dark reddish brown (2.5YR 3/3) when moist; moderate, medium, subangular blocky structure; very hard when dry, firm when moist; calcareous; gradual boundary.

C—34 to 52 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) when moist; some seams of gypsum crystals; massive (structureless); very hard when dry, firm when moist; calcareous.

The A horizon is silty clay or heavy clay loam in small areas. In places a darker buried soil occurs below a depth of 20 inches. In most places Miller soils are calcareous at the surface. In a few areas, the surface layer is strongly alkaline but noncalcareous.

Miller clay (Mr).—This smooth, nearly level soil is on bottom lands along the Cimarron River and along its tributaries that flow from the erosional, broken red beds. Slopes range from 0 to 1 percent. The profile of this soil is the one described as typical of the Miller series.

Included with this soil in the mapping were small areas of McLain and Port soils. Also included were areas of slickspots that generally are as much as 2 acres in size.

About 85 percent of this soil is used as cropland, and the rest is range. Wheat is the main crop, but most other small grains grow fairly well. Because this soil is droughty, summer crops are the least successful.

Management is needed mainly to prevent puddling, to reduce surface crusting, and to increase the intake of water. Surface crusting slows the intake of water, and water is taken into the tight subsoil very slowly. In some places a plowpan further restricts the intake of water. Where this soil is intensively cultivated or where it contains little or-

ganic matter, it puddles when wet and crusts and cracks when dry. Effective use of crop residue on the surface is especially needed to help maintain or improve soil structure. (Capability unit IIIs-1; Heavy Bottomland range site; windbreak suitability group 4)

Nash Series

The Nash series consists of deep to moderately deep, friable silt loams on uplands near Ringwood and Meno in the northeastern part of Major County. These soils are sloping.

The surface layer is reddish-brown, granular silt loam about 12 inches thick. The subsoil, about 16 inches thick, is yellowish-red silt loam. This layer is porous and permeable. Its material is arranged in coarse prisms that crush easily into granules. Underlying the subsoil is massive silt loam that contains a few, very small concretions of lime. Weakly consolidated, noncalcareous sandstone commonly is at a depth of about 32 inches.

The Nash soils formed in material weathered from soft to hard siltstone, sandstone, and silty shale of the Permian red beds. These soils formed under native mid and tall grasses.

Nash soils are generally well drained. They have medium to rapid runoff and medium permeability.

In Major County the Nash soils occur with the Grant, Pond Creek, and Weymouth soils. They are less deeply leached of lime than the Grant and Pond Creek soils and have a less developed profile. Nash soils do not have the prominent layer of accumulated lime concretions that occur in the Weymouth soils.

In this county the Nash soils are mapped only in complexes with the Grant soils.

Typical profile of a Nash silt loam, about 700 feet north and 400 feet west of the southeast corner of section 36, T. 23 N., R. 9 W., on west side of road in cultivated field:

A1—0 to 12 inches, reddish-brown (5YR 5/4) silt loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; pH 7.0; gradual boundary.

B—12 to 28 inches, yellowish-red (5YR 5/6) silt loam, yellowish red (5YR 4/6) when moist; moderate, medium, granular and weak, coarse, prismatic structure; hard when dry, friable when moist; noncalcareous; pH 7.5; gradual boundary.

C—28 to 32 inches, reddish-yellow (5YR 6/6) silt loam, yellowish red (5YR 4/6) when moist; massive (structureless); hard when dry, friable when moist; pH 8.0; soil is generally noncalcareous but has a few, very small concretions of lime.

R—32 to 41 inches +, weakly consolidated, red, noncalcareous sandstone.

The A1 horizon ranges from 6 to 14 inches in thickness. It ranges from brown to reddish brown when dry and from dark reddish brown to dark brown when moist. This layer is loam or very fine sandy loam in a few places. The B horizon ranges from 6 to 18 inches in thickness and from yellowish brown to yellowish red in color. Both the A1 horizon and the B horizon range from neutral to alkaline. The substratum (C horizon) is neutral or weakly calcareous.

Nobscot Series

The Nobscot series consists of hummocky to dunelike sandy soils on rolling uplands. These uplands are or were covered with blackjack oak and an undergrowth of brush and mid and tall grasses.

These soils have a dark grayish-brown fine sand surface layer about 5 inches thick. Beneath this is a leached layer of loose, very pale brown fine sand about 1 foot thick. In most cultivated fields, the thin dark surface layer is not evident, because it has been mixed with material from the light-colored layer below, or it has been blown away.

The subsoil is a yellowish-red sandy layer that contains bands about $\frac{1}{4}$ to $\frac{1}{2}$ inch thick and 1 to 8 inches apart. These thin bands are redder and contain slightly more clay than the material between them. The subsoil is generally loamy fine sand that crumbles easily and has granular structure.

Below a depth of 46 inches is reddish-yellow light loamy fine sand. In the upper part are a few thin bands of the redder, more cohesive soil like that in the bands in the subsoil, but these bands decrease in number with increasing depth. This sandy material is similar to the deep, wind-deposited noncalcareous quartz sand from which the soils developed.

Nobscot soils are somewhat excessively drained. They have rapid permeability and absorb water rapidly. Runoff is slight except when rains are intensive, and even then the runoff generally is absorbed before it reaches a drainage way. These soils are neutral to medium acid.

Nobscot soils occur mainly with Pratt, Tivoli, Shellabarger, and Carwile soils. They have a more sandy surface layer than the Pratt, Shellabarger, Meno, and Ortello soils and have a leached layer (A2 horizon). Unlike the Tivoli soils, Nobscot soils have a textural subsoil and a leached layer, or A2 horizon. They have a less mature profile than the Carwile soils, and a subsoil that contains less clay.

Typical profile of Nobscot fine sand, rolling, 1,200 feet north and 100 feet east of the southwest corner of the northwest quarter of section 19, T. 20 N., R. 13 W., on east side of road in native vegetation.

- A1—0 to 5 inches, dark grayish-brown (10YR 4/2) fine sand, very dark grayish brown (10YR 3/2) when moist; weak, medium and coarse, granular structure; soft when dry, very friable when moist; pH 7.0; irregular, clear boundary.
- A2—5 to 17 inches, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) when moist; single grain (structureless); loose when dry or moist; pH 6.0; gradual boundary.
- B2t—17 to 46 inches, yellowish-red (5YR 5/6) loamy fine sand containing thin bands of light sandy clay loam or fine sandy loam from 1 to 4 inches apart; yellowish red (5YR 4/6) when moist; weak, fine, granular structure; soft when dry, loose when moist; pH 6.0; diffused boundary.
- C—46 to 60 inches +, reddish-yellow (7.5YR 7/6) light loamy fine sand, reddish yellow (7.5YR 6/6) when moist; massive; soft when dry, very friable to loose when moist; pH 6.0; few bands like those in B2t horizon in the upper part.

The A1 horizon ranges from 4 to 10 inches in thickness. Thickness varies considerably within a few inches. The surface layer is mostly fine sand, but there are spots of loamy fine sand, generally on the lower slopes. Colors range from dark grayish brown to brown.

The B2t horizon ranges from heavy fine sand to loamy fine sand and contains thin bands of sandy clay loam and fine sandy loam. These thin bands are $\frac{1}{4}$ to $\frac{1}{2}$ inch thick and are 1 to 8 inches apart. When the B2t horizon is dry, it ranges from reddish yellow to brown.

Nobscot fine sand, rolling (NcD).—Broad areas of this sandy soil occur in Major County under vegetation consisting of blackjack oak and tall and mid grasses. Slopes

range from 5 to 8 percent. This soil is extensive near Chester in the southwestern part of the county, near Cleo Springs in the north-central part, and near Ringwood and Ames in the eastern part. It lies in a broad belt between the sandy duned areas of Tivoli soils that border the Cimarron and North Canadian Rivers and the more gently sloping areas of Pratt, Ortello, Meno, and Shellabarger soils to the north. The profile of this soil is the one described as typical of the Nobscot series.

Included with this soil in the mapping were small areas of Pratt, Ortello, Tivoli, Shellabarger, and Carwile soils.

Plant roots easily penetrate this sandy soil. The soil absorbs water rapidly, and there is no runoff during light rains. Even during intensive rains, most runoff water is absorbed before it reaches the drainageways or the small depressions that are scattered throughout the area.

Because of the strong slopes and the loose sandy surface layer that is likely to blow, this soil is better suited as rangeland than as cropland. Nearly all of it is used as rangeland. Many grazing areas are made up entirely of this soil, which may cover as much as a section. The native vegetation is mostly blackjack oak and mid and tall grasses. Good range management is needed for maintaining a good growth of desirable grasses and for eliminating a heavy growth of timber and brush. Where the timber is killed by spraying or is eliminated by good range management, areas of this soil support an abundant growth of grasses (fig. 10). (Capability unit VIe-4; Deep Sand Savannah range site; windbreak suitability group 2)

Nobscot fine sand, hummocky (NcC).—The largest areas of this hummocky sandy soil are on uplands near Ames and Ringwood in the eastern part of the county. Smaller acreages are scattered throughout the vast sandy areas. Slopes range from 3 to 5 percent.

This soil has a slightly thicker, dark sandy layer than the soil described for the series. The surface layer is fine sand about 6 to 10 inches thick. Beneath this is a light-colored, leached layer of fine sand that ranges from 6 to 14 inches in thickness. The subsoil, about 1 foot thick, is generally loamy fine sand, but it contains irregular, thin bands of heavy fine sandy loam about 1 inch thick and 3 to 4 inches apart. Below the subsoil, the material is loamy fine sand to sand and several feet thick.

Included with this soil in mapping were small areas of Shellabarger, Meno, Ortello, and Pratt soils. Also included were moderately eroded areas that make up about 5 percent of the area mapped.

This loose, sandy soil soaks up water rapidly and has medium available moisture capacity in the subsoil. Because soil blowing is likely, farming is difficult and only small areas have been cleared for cultivation. Unprotected areas blow severely in windy periods, and the clay and humus are rapidly removed from the soil. Some cultivated fields show signs of moderate erosion. In these eroded areas the surface is lighter than normal in color. In the more eroded areas, the yellowish-red material of the subsoil is above plow depth.

This soil can be cultivated if management is good, but it is better used for tame pasture or range. The crops grown are mostly special crops, such as watermelons, but rye, vetch, and some sorghum are also grown, mostly for bundle feed. Soil blowing reduces fertility and damages plants. The blowing sand scars watermelons and makes them less desirable for market. (Capability unit IVe-6;



Figure 10.—An area of Nobscot fine sand, rolling, where timber has been eliminated and the grasses are plentiful.

Deep Sand Savannah range site; windbreak suitability group 2)

Nobscot-Pratt complex, hummocky (NpC).—This complex consists of Nobscot fine sand and Pratt loamy fine sand on uplands that have slopes of 3 to 5 percent. These soils are so intermingled that it is not practical to map them separately. They are mostly in the southwestern part of the county in a gradation belt between broad areas of Pratt soils and broad areas of Nobscot soils. In areas under native vegetation, scattered blackjack oak and a few cedars are on the Nobscot soils and sand sagebrush is on the Pratt soils. The grasses on this complex are mostly mid and tall.

Nobscot fine sand makes up 40 to 70 percent of this complex, and Pratt loamy fine sand makes up 30 to 50 percent. Patterns of these soils are not definite, but the Nobscot soils are on the lower slopes in only a few places.

Inclusions of Shellabarger, Ortello, Carwile, and Meno soils make up 10 to 15 percent of many areas. These inclusions are mostly in low areas or swales. Other inclusions are moderately eroded areas in cultivation that make up less than 10 percent of mapped areas. In spots on the south-facing slopes, little of the darker surface layer remains.

The Nobscot soil has a dark-colored fine sand surface layer about 5 to 10 inches thick. Between the surface layer and the subsoil is a pale or light-colored layer of fine sand about 6 to 8 inches thick. The subsoil is porous loamy fine sand that is several feet thick and grades to sandy material below a depth of 46 inches.

The surface layer of the Pratt soil is brown or dark-brown loamy fine sand about 6 to 12 inches thick. Beneath this is a brown loamy fine sand subsoil about 15 to 22 inches thick. The subsoil is more sticky than the surface layer. Below the subsoil is sandy material that is several feet thick in most places.

Water is absorbed rapidly by these soils, and little of it runs off unless rains are intensive. The amount of runoff depends partly on the amount of vegetation. Most of the excess water is caught in the swales scattered between mounds and ridges. Available moisture capacity is medium to low because the subsoil is porous, but the water present is readily used by plants.

This complex of soils is suitable for cultivation, but soil blowing makes management difficult. Farmers and ranchers who need land for growing feed clear small areas. Because controlling erosion is difficult where small grain is grown, sorghum is the main crop. Vetch or rye is grown

for pasture and as cover crops. Watermelons are also grown.

The main concerns in managing these soils are conserving moisture and controlling soil blowing. Soil blowing not only damages the soil but also injures plants, especially the newly emerged seedlings. Blowing sand scars watermelons and makes them less desirable for market. Overgrazing is the main problem on rangeland. (Capability unit IVe-6 and windbreak suitability group 2; Nobscot soil is in Deep Sand Savannah range site, and Pratt soil is in Deep Sand range site)

Nobscot-Pratt complex, duned (NpD).—This complex consists of deep sandy soils on duned uplands that have slopes of 5 to 20 percent. These soils occur in such an intricate pattern that it is not practical to map them separately. Broad areas of these soils occur in the southwestern part of the county in a gradation belt between broad areas of Nobscot soils and broad areas of Pratt soils. The Nobscot soils developed under a cover of blackjack oak, juniper, and mid and tall grasses. The Pratt soils developed under a cover consisting mainly of sand sagebrush mixed with mid and tall grasses (fig. 11).



Figure 11.—Area of Nobscot-Pratt complex, duned. Pratt soil is in the area of grasses and sand sagebrush, and Nobscot soil is in the area of blackjack oak.

Nobscot fine sand makes up from 40 to 70 percent of this complex, and Pratt loamy fine sand makes up 30 to 60 percent. Inclusions consisting mainly of Carwile, Shellabarger, Ortello, and Meno soils are in depressions and may make up 5 to 15 percent of any area mapped.

The Nobscot soil has a profile similar to that described for the Nobscot series, but in many places its lighter colored leached layer is thinner and less distinct. The Nobscot soil has a dark-colored fine sand surface layer about 4 to 10 inches thick. A layer of light-colored fine sand 4 to 8 inches thick lies between the surface layer and the subsoil. The subsoil contains bands that are slightly more sticky than the soil between them, but the texture of the subsoil averages light loamy fine sand.

The Pratt soil has a dark-colored loamy fine sand surface layer over a sticky loamy fine sand subsoil. The sub-

soil grades to light loamy fine sand or sand below a depth of 30 inches.

The sandy soils of this complex are porous and soak up water rapidly, but they have low available moisture capacity.

These soils are well suited as rangeland, and nearly all of the acreage is used for that purpose. Because slopes are strong and soil blowing is likely, these soils are not suitable for cultivation. Grasses grow abundantly, however, where range management is good. In some areas the growth of grasses has been increased by controlling the timber and practicing good range management. (Capability unit VIe-5 and windbreak suitability group 2; Nobscot soil is in Deep Sand Savannah range site, and Pratt soil is in Deep Sand range site)

Ortello Series

The Ortello series consists of deep, friable, permeable fine sandy loams on uplands. These gently undulating soils occur with sandy soils of the uplands.

The surface layer is dark-brown fine sandy loam about 1 foot thick. It is friable and has medium granular structure. In places a thin plowpan has formed in this layer. The subsoil is about 20 inches thick. It is friable, permeable fine sandy loam that is slightly more clayey than the fine sandy loam of the surface layer. The material in the subsoil is arranged in coarse prisms that crush easily to medium granules. From the subsoil to a depth of 54 inches or more is reddish-yellow heavy loamy fine sand. This underlying material is massive but is easily penetrated by water and plants. The profile of these soils ranges from neutral to medium acid.

The Ortello soils formed mostly in sands that have been deposited by water and reworked by wind. The native vegetation was mostly mid and tall grasses.

The Ortello soils are well drained. Permeability is moderately rapid, and runoff is medium.

Ortello soils occur with the Pratt, Tivoli, Nobscot, Meno, Shellabarger, Carwile, and Enterprise soils. They have a less sandy subsoil than the Pratt, Tivoli, and Nobscot soils but have a more sandy subsoil than the Shellabarger and Carwile soils. Ortello soils are less red than the Enterprise soils and are leached of lime to a greater depth.

Typical profile of Ortello fine sandy loam, undulating, 300 feet south and 200 feet east of the northwest corner of the northeast quarter of section 32, T. 21 N., R. 9 W., on the west side of road in cultivated field:

- Ap—0 to 6 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; weak, medium, granular structure; soft when dry, very friable when moist; pH 5.8; abrupt boundary.
- A1—6 to 12 inches, dark-brown (10YR 4/3) fine sandy loam that is about 10 percent clay, dark brown (10YR 3/3) when moist; moderate to weak, medium, granular and weak, coarse, prismatic structure; hard when dry, friable when moist; pH 6.2; clear boundary.
- B2t—12 to 32 inches, brown (7.5YR 5/4) fine sandy loam that is about 13 percent clay and is more cohesive than the horizon above, dark brown (7.5YR 4/4) when moist; moderate, medium, granular and weak, coarse, prismatic structure; hard when dry, friable when moist; pH 6.5; gradual boundary.
- C—32 to 54 inches +, reddish-yellow (7.5YR 6/6) heavy loamy fine sand, strong brown (7.5YR 5/6) when moist; massive (structureless); soft when dry, friable when moist; pH 7.0.

The A horizon ranges from 6 to 14 inches in thickness. In spots the top 2 to 4 inches is winnowed. These winnowed spots are loamy fine sand that is lighter colored than the unwinnowed fine sandy loam. When dry, the A horizon ranges from brown to dark grayish brown and the B2t horizon generally ranges from brown to light brown. The profile ranges from medium acid to neutral. In some places a darker colored buried soil occurs at a depth of 30 inches.

Ortello fine sandy loam, undulating (OrB).—This is an inextensive soil that, in most areas, is adjacent to Pratt loamy fine sand, undulating, Meno loamy fine sand, 0 to 3 percent slopes, and Shellabarger fine sandy loam, 0 to 3 percent slopes. The profile of this soil is the one described as typical of the Ortello series. Slopes range from 0 to 3 percent.

Water enters and moves through this soil rapidly. Available moisture capacity is good. Runoff is slight, and during heavy rains the water is generally absorbed or is trapped in swales before it reaches drainageways.

Included with this soil in the mapping were small areas of Pratt, Meno, Carwile, and Shellabarger soils.

About 95 percent of this soil is dryfarmed; the rest is range. Sorghums are well suited because natural fertility is fairly high and moisture is readily available. Wheat grows well if management is good. Other small grains and cowpeas are also grown. In excessively grazed areas, brush, weeds, and undesirable grasses invade the range. Soil blowing is a severe hazard, especially in clean-tilled fields. The fertility of parts of some cultivated fields has been reduced because wind has removed the fine soil particles and organic matter in the top 2 to 4 inches. (Capability unit IIe-3; Sandy Prairie range site; windbreak suitability group 2)

Pond Creek Series

Pond Creek series consists of deep, dark, nearly level silt loams. These soils occupy broad, smooth areas in the uplands near Meno in the northeastern part of Major County. Small areas are in the south-central part.

The surface layer is dark-brown silt loam about 1 foot thick. It has granular structure and is friable, permeable, and easily tilled when moisture content is favorable. In some places a plowpan has formed. The subsoil is brown silty clay loam about 50 inches thick. The upper part of this layer has granular structure, and it is more friable than the lower part. The lower part is moderately permeable to slowly permeable to air and water and has medium subangular blocky structure. Below a depth of 62 inches is friable, calcareous, yellowish-red silty clay loam. It is massive but is easily penetrated by plants. This material is similar to the material from which these soils formed.

The material in which these soils formed is mostly of silt loam, loam, clay loam, and very fine sandy loam texture. The native vegetation was mid and tall grasses.

The Pond Creek soils are naturally well drained. Runoff is slow in nearly level areas, but it is medium in gently sloping areas. Permeability is moderate to moderately slow.

Pond Creek soils occur with the Grant, Nash, Kirkland, Renfrow, Weymouth, and St. Paul soils. They are darker and less red than the Grant or Nash soils and contain slightly more clay in the subsoil. But Pond Creek soils contain less clay in the subsoil than do Kirkland and Renfrow soils. The leaching of lime is deeper in the Pond

Creek soils than it is in the St. Paul soils. The profile of Pond Creek soils is more mature than that of the Weymouth.

Typical profile of Pond Creek silt loam, 0 to 1 percent slopes, 150 feet south and 80 feet west of northeast corner of the northeast quarter of section 36, T. 23 N., R. 9 W., on west side of road in native range:

- A1—0 to 12 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; plentiful fibrous roots; noncalcareous; pH 6.8; clear boundary.
- B1—12 to 20 inches, dark-brown (7.5YR 4/2) light silty clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; pH 7.0; gradual boundary.
- B2t—20 to 42 inches, brown (7.5YR 5/2) silty clay loam, dark brown (7.5YR 4/4) when moist; moderate to strong, medium, granular structure and weak, medium, subangular blocky structure; slightly hard to hard when dry, firm when moist; noncalcareous; pH 7.0; gradual boundary.
- B3—42 to 62 inches, reddish-brown (5YR 5/3) silty clay loam, dark reddish brown (5YR 3/3) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; noncalcareous; pH 7.2; gradual boundary.
- C—62 to 72 inches, yellowish-red (5YR 5/6) light silty clay loam, yellowish red (5YR 4/6) when moist; massive (structureless); hard when dry, friable when moist; calcareous; pH 7.5.

The A1 horizon ranges from 8 to 16 inches in thickness. It is loam or light clay loam in small areas. This layer, when dry, ranges from brown to dark grayish brown. The C horizon, when dry, ranges from reddish yellow to brown. These soils are generally slightly acid to mildly alkaline. They are calcareous at a depth ranging from 4 to 6 feet. In some places a dark-colored, friable buried soil that is silt loam to silty clay loam occurs below 3 feet.

Pond Creek silt loam, 0 to 1 percent slopes (PcA).—This deep, dark, nearly level soil occupies the broad, smooth areas near Meno in the northeastern part of the county and small areas southeast and northwest of Fairview. Its profile is the one described for the Pond Creek series.

Included with this soil in the mapping were small areas of Kirkland silt loam and Grant silt loam.

Most of this Pond Creek soil is cropland, but a small acreage is rangeland and is excessively grazed. This soil is among the most productive in the county. Wheat, the main crop, and sorghums are suitable but grow best in years when there is enough moisture. Small grains, such as rye, oats, and barley, are also suitable.

The main concerns in managing this soil are maintaining soil fertility and controlling erosion. Plowing at the same depth or when moisture is excessive causes plowpans in some fields. Weeds and the less desirable grasses invade in the excessively grazed areas. (Capability unit I-2; Loamy Prairie range site; windbreak suitability group 2)

Pond Creek silt loam, 1 to 3 percent slopes (PcB).—This soil occurs in the vicinity of Meno in the northeastern part of the county, and near Fairview in the central part. It normally is in areas that range between 5 and 25 acres in size, but a few areas cover 100 acres or more. It occurs at the rims of large areas of Pond Creek silt loam, 0 to 1 percent slopes, and generally borders a drainageway or areas of Grant soils. Small areas of Grant silt loam, 1 to 3 percent slopes, were included with this soil in the mapping.

Most of this soil is dryfarmed, mainly to winter wheat. Other small grains and sorghums also grow well in years when moisture is sufficient.

This soil has more runoff and is more susceptible to erosion than Pond Creek silt loam, 0 to 1 percent slopes. Water erosion is the main concern of management. After heavy rains sheet erosion is severe on barren fields and gradually removes soil material and its organic matter. Surface crusting is then likely. Also, because of the loss of organic matter, soil structure breaks down, permeability becomes slower, and seedbeds become more difficult to prepare.

Management is needed for protecting cultivated areas from further erosion and for improving the rate of water intake. (Capability unit IIe-1; Loamy Prairie range site; windbreak suitability group 2)

Port Series

The Port series consists of deep, dark, friable soils on bottom lands or smooth terraces along streams. These nearly level soils are well drained, though flooding ranges from seldom to occasional.

The surface layer is about a foot thick and consists of dark-brown, friable, granular silt loam that is easily tilled. In some places a plowpan has formed. Underlying the surface layer is reddish-brown clay loam that is arranged in coarse prisms. This layer is friable and crumbles easily when it is moist. At a depth of about 22 inches is yellowish-red, calcareous clay loam that has moderate, coarse, prismatic structure and is friable and readily penetrated by roots.

These soils are fertile and have moderately high available moisture capacity. Permeability is moderate, mainly because a large number of earthworms have been active throughout the soil.

Port soils formed in water-sorted materials of silt loam, loam, and clay loam texture that were deposited by floodwater. The plant cover was mostly mid and tall grasses.

Port soils occur mainly with the McLain, Miller, Reinach, Canadian, and Yahola soils. The subsoil (AC horizon) of the Port soils has more clay and less sand than that of the Reinach, Canadian, or Yahola soils but has less clay and is more friable than the subsoil of the McLain or Miller soils. Structure in the subsoil is more distinct in the Port soils than in the Tipton.

Typical profile of Port silt loam, 300 feet south and 75 feet east of the northwest corner of the southwest quarter of section 14, T. 21 N., R. 12 W., on east side of road in cultivated field:

- A1—0 to 13 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; strong, medium, granular structure; hard when dry, very friable when moist; noncalcareous; pH 7.5; gradual boundary.
- AC—13 to 22 inches, reddish-brown (5YR 4/4) light clay loam, dark reddish brown (5YR 3/3) when moist; moderate, coarse, prismatic structure; hard when dry, very friable when moist; noncalcareous; pH 7.5; gradual boundary.
- C1—22 to 33 inches, yellowish-red (5YR 5/6) clay loam, yellowish red (5YR 4/6) when moist; moderate, coarse, prismatic structure; hard when dry, friable when moist; calcareous; gradual boundary.
- C2—33 to 60 inches +, red (2.5YR 5/6), stratified fine sandy loam and clay loam, red (2.5YR 4/6) when moist; massive to weak, medium, granular structure; hard when dry, friable when moist; calcareous.

The A1 horizon is generally silt loam, but it is fine sandy loam in a smaller acreage. In areas that are mostly silt loam, there are small areas of clay loam, loam, and light silty clay loam. In areas of fine sandy loam, the top 1 to 3 inches is winnowed and is heavy loamy fine sand. When dry, the surface layer ranges from brown to dark reddish gray. In cultivated areas the Ap horizon is calcareous in places.

Port silt loam (0 to 1 percent slopes) (Pr).—This soil occurs in smooth areas along the main creeks and rivers in Major County and is deep, dark, and nearly level. Areas are large in the valley of the Cimarron River and in the valley surrounding Fairview. Some large areas extend along Eagle Chief Creek in the north-central part of the county and along Turkey Creek in the northeastern part. The profile of this soil is the one described as typical of the Port series.

Included with this soil in the mapping were small areas of Canadian and Reinach soils and of Port fine sandy loam. Also included were slick spots in areas less than 1 acre in size.

Normally, erosion is slight, though sheet erosion by wind and water is damaging. In places runoff from higher areas damages this soil during periods of intense rainfall. Erosion is greatest in natural drainageways where water washed away the soil. Plowing generally obliterates these eroded places, but the soil taken away is not easily replaced. Floodwater covers this soil occasionally, mostly along small streams, but the damage is slight because the floods are caused by slow-moving backwater and are of short duration.

Except for a few narrow strips, this soil is cropland. Winter wheat is the main crop, but large fields of alfalfa also are grown. Sorghums and other crops suited to the area grow well when there is enough moisture. (Capability unit I-1; Loamy Bottomland range site; windbreak suitability group 1)

Port fine sandy loam (Pf).—This deep, dark, nearly level soil occurs near Fairview in the broad valley that extends through the central part of Major County. Slopes range from 0 to 1 percent. The surface layer is fine sandy loam about 1 foot thick. It is very friable and has granular structure and is underlain by a friable, granular clay loam subsoil. The subsoil is permeable and has moderately high available moisture capacity. In some spots, the fine particles of clay and organic matter have been winnowed by wind and the surface layer is loamy fine sand 1 to 3 inches thick.

Included with this soil in mapping were small areas of Canadian and Reinach soils and of Port silt loam.

Erosion is generally slight, but soil blowing has intensively damaged small areas. Water erosion is a hazard where runoff from the higher slopes is excessive. Floodwater from nearby streams seldom reaches this soil.

Nearly all of the acreage is cropland. Among the well-suited crops are wheat, sorghums, and alfalfa. This soil blows readily unless management provides stubble mulching, use of crop residues, or other practices. (Capability unit IIe-2; Loamy Bottomland range site; windbreak suitability group 1)

Pratt Series

The Pratt series consists of deep, friable, rapidly permeable loamy fine sands of the uplands. These soils are in duned areas and are undulating, hummocky, or rolling.

The surface layer is about 6 inches thick and consists of brown to dark-brown loamy fine sand. In places a thin plowpan has formed in this layer. The subsoil, about 19 inches thick, is friable, granular, permeable material that ranges from moderately coherent loamy fine sand to fine sandy loam. Beneath the subsoil is lighter colored, loose, structureless loamy fine sand that is easily penetrated by roots (fig. 12).



Figure 12.—Profile of a Pratt loamy fine sand.

Pratt soils formed in sandy deposits laid down by wind. They are well drained to excessively drained and rapidly permeable. The plant cover was mostly mid and tall grasses and scattered sagebrush.

Pratt soils occur mainly with the Tivoli, Nobscot, Shellabarger, Ortello, and Meno soils. The surface layer of Pratt soils is more sandy than that of the Shellabarger, Carwile, or Ortello soils, and the subsoil is more sandy than that of the Meno soils. The profile of Pratt soils is less sandy than that of the Tivoli and Nobscot soils, and it lacks the leached horizon (A2 horizon) common in the Nobscot soils.

Typical profile of Pratt loamy fine sand, undulating, 225 east and 300 feet south of the northwest corner of the northwest quarter of section 22, T. 23 N., R. 12 W., on east side of road in cultivated field:

- A1—0 to 6 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) when moist; weak granular structure; loose when dry or moist; pH 6.7; clear boundary.
- B2t—6 to 25 inches, brown (7.5YR 5/4) coherent loamy fine sand, dark brown (7.5YR 4/4) when moist; weak, medium, granular structure; loose when dry, loose to very friable when moist; pH 6.7; gradual boundary.
- C1—25 to 43 inches, reddish-yellow (7.5YR 6/6) loamy fine sand, strong brown (7.5YR 5/6) when moist; single grain; loose when dry or moist; pH 6.7.
- C2—43 to 54 inches +, reddish-yellow (7.5YR 6/6) light loamy fine sand, strong brown (7.5YR 5/6) when moist; single grain; loose when dry or moist; pH 6.5.

The A1 horizon ranges from 6 to 14 inches in thickness and, when dry from brown to dark brown in color. When moist, this layer ranges from dark brown to dark grayish brown. The A1 horizon is light brown in spots where the wind has blown away particles of organic matter. When dry, the B2t horizon ranges from light yellowish brown to dark brown or brown. The profile ranges from slightly alkaline to slightly acid. A darker colored, buried soil occurs in places below a depth of 30 inches.

Pratt loamy fine sand, undulating (PtB).—This deep, moderately dark, sandy soil lies in belts between the sandy soils under a cover of blackjack timber and the prairie soils on the uplands. Slopes range from 0 to 3 percent. The profile of this soil is the one described as typical of the Pratt series.

Included with this soil in mapping were small areas of Ortello, Shellabarger, Meno, Carwile, and Nobscot soils. The Shellabarger and Carwile soils lie in narrow swales and depressions throughout the mapped areas. They total less than 10 percent of most mapped areas, but in places they cover as much as 40 percent.

Pratt loamy fine sand soaks up water rapidly and has medium available moisture capacity. About 70 percent of the acreage has been cleared and is cultivated. Sorghums are the main crop (fig. 13), for this soil supplies moisture in larger amounts to sorghums than do some of the other hardland soils. Wheat and other small grains grow well.



Figure 13.—Grain sorghum planted on a Pratt loamy fine sand.

In some fields watermelons do well, but in others they are scarred by blowing sand particles and less desirable for market.

Unprotected areas are highly susceptible to soil blowing. In windy seasons so much organic matter and so many fine particles are removed by wind that some spots in cultivated fields have a winnowed surface layer. In most cultivated fields, the hazard of erosion is moderate and only about 5 percent of the areas are moderately eroded. This soil needs management for maintaining productivity when tilled. The included areas of Shellabarger and Carwile soils are difficult to till in wet periods. On rangeland, practices are needed on Pratt loamy fine sand, undulating, to prevent overgrazing and to keep less desirable grasses and brush from invading. (Capability unit IIIe-7; Deep Sand range site; windbreak suitability group 2)

Pratt loamy fine sand, hummocky (PtC).—This deep, sandy soil occurs mainly in strips that range from 10 to 50 acres in size. These strips are between areas of more sloping, sandy Nobscot soils and areas of the undulating Pratt soils. Slopes range from 3 to 5 percent. Except that the surface layer is generally thinner, the profile of this soil is similar to the one described for the Pratt series.

This soil soaks up water rapidly, and there is little runoff. Runoff is mostly from unprotected fields during heavy rains, though most of it is trapped in the narrow depressions of the hummocky landscape. Tillage is difficult in these depressions because they remain wet for a long time in wet periods.

Included with this soil in the mapping were Shellabarger and Carwile soils in small depressions and small areas of Nobscot fine sand. These inclusions do not make up more than 15 percent of any area mapped.

Because unprotected areas are highly susceptible to soil blowing, this soil is better suited as rangeland than as cropland. Only small areas have been cleared for cultivation, and most of this is used for forage crops. In cultivated fields management is needed that provides a continuous cover of growing crops or crop residue. A mixture of rye and vetch planted in fall provides suitable cover and also provides grazing in winter for livestock. Watermelons grow well on this soil, but they are grown only in small amounts. Blowing soil particles scar the surface of the melons and makes them less desirable for market.

Good range management is needed for forage production. In the excessively grazed areas, mostly sand sagebrush, sand plum, skunkbush, and other shrubs are increasing and the good grasses are decreasing. (Capability unit IVe-6; Deep Sand range site; windbreak suitability group 2)

Pratt loamy fine sand, rolling (5 to 8 percent slopes) (PtD).—This deep, sandy soil lies in large areas between large areas of Tivoli soils and of other Pratt soils. Large areas are in a belt north of the Tivoli soils on the north banks of the North Canadian and Cimarron Rivers and south of the less sloping Pratt soils on undulating to hummocky landscape. The landscape is one of low dunes that are 100 to 400 feet between the tops of the dunes. Some of the dunes are long and others are rounded or cone shaped. The Pratt soils are on the lower parts of the dunes, and small inclusions of the Tivoli soils are at the top.

Included with this soil in the mapping, and totaling 30 to 50 percent of the mapped area, were broad areas of Tivoli soils. In these included areas, the Tivoli soils are not

so dark colored as the Pratt soils and are less clayey in the subsoil. Also included, in depressions, are small areas of Shellabarger and Carwile soils.

This Pratt soil has a loamy fine sand surface layer overlying a loamy fine sand subsoil that is lighter colored. The subsoil is slightly more cohesive than the surface layer, but it is friable and absorbs water readily.

Nearly all of this soil is used for range. Soil blowing is severe in cultivated areas when crops fail. Because of the difficulty of farming, most areas that were once cultivated have been returned to grass.

Range that is well managed produces excellent mid and tall grasses, mostly big bluestem and little bluestem. Weeds, sagebrush, skunkbush, and other undesirable plants increase in heavily grazed areas. (Capability unit VIe-6; Deep Sand range site; windbreak suitability group 4)

Quinlan Series

In the Quinlan series are reddish-brown loams that are shallow over calcareous, fine-grained sandstone. These soils are inextensive in this county and occur mostly east of Fairview and south of the Cimarron River.

The surface layer is about 6 inches thick and consists of reddish-brown loam that is very friable and has granular structure. The subsoil, a yellowish-red very fine sandy loam, is spotted with pinkish gray. This material weathered from calcareous sandstone and is similar to the material from which these soils formed. It is massive, friable, and moderately permeable to water and air. Calcareous, weakly consolidated sandstone is below a depth of 16 inches.

The Quinlan soils formed in material weathered from calcareous sandstone of the Permian red beds. The native vegetation was mostly mid and tall grasses.

Water penetrates these soils at a moderate to rapid rate, but water-holding capacity is limited.

Quinlan soils occur with the Dill and Grant soils but are more shallow over sandstone. They have less clay in the subsoil than Vernon soils.

Typical profile of Quinlan loam, 1 to 3 percent slopes, about 925 feet east and 110 feet north of the southwest corner of the southwest quarter of section 30, T. 21 N., R. 10 W.:

- A—0 to 6 inches, reddish-brown (5YR 5/4) loam, dark reddish brown (5YR 3/4) when moist; strong, medium and fine, granular structure; soft when dry, very friable when moist; calcareous; clear boundary.
- B—6 to 16 inches, yellowish-red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) when moist; pinkish-gray (5YR 7/2), fine and distinct spots are common; weak, fine, granular structure; slightly hard when dry, friable when moist; few roots; gradual boundary.
- C—16 to 30 inches +, red (2.5YR 5/6), calcareous, weakly consolidated sandstone, red (2.5YR 4/6) when moist; spotted with light gray (5YR 7/1) when dry; massive.

The A horizon ranges from 4 to 8 inches in thickness and, when dry, from reddish brown to yellowish red. In places this horizon is very fine sandy loam. Depth to unweathered, weakly consolidated sandstone ranges from 10 to 20 inches. In some gently sloping areas below eroded slopes, these soils are covered with a mantle of soil material 3 to 6 inches thick.

Quinlan loam, 1 to 3 percent slopes (Q1B).—This shallow soil occurs mostly in an area east of Fairview on the valley slopes south of the Cimarron River. Its profile is the one described as typical of the Quinlan series.

Included with this soil in the mapping were some areas of Quinlan loam that have a solum more than 20 inches thick. Most of these included areas are below higher eroded slopes where soil has accumulated in a thin mantle. Also included were small areas of Grant, Dill, and Vernon soils.

This Quinlan soil is only slightly eroded; less than 5 percent of any area mapped has been moderately eroded. In most fields the erosion is caused by wind, but in some fields runoff water has cut shallow rills that can be obliterated by ordinary tillage.

Most of this soil has been cultivated, but a few places have been reseeded to grass. Small grains are the principal crops. Sorghums are also grown, but in scattered eroded spots plant nutrients are lacking and chlorosis has developed. Because this soil is shallow, it is easily damaged or destroyed by erosion. Protection from both soil blowing and water erosion is needed. Barren fields blow severely, especially during dry windy periods. (Capability unit IIIe-6; Shallow Prairie range site; windbreak suitability group 3)

Quinlan loam, 3 to 5 percent slopes, eroded (QIC2).—This moderately eroded, shallow soil is on uplands. It occurs with Quinlan loam, 1 to 3 percent slopes. The total acreage in Major County is small. The larger areas of this soil are east of Fairview on the valley slopes south of the Cimarron River.

The surface layer of this soil has been thinned by erosion. It is about 5 inches thick and consists of yellowish-red loam that is friable and has weak granular structure. The subsoil is loam and is slightly more reddish than the surface layer. Although water soaks in this soil fairly rapidly, available moisture capacity is limited because sandstone is near the surface. Runoff water collects quickly after heavy rains and is damaging where the surface is not protected.

Included with this soil in the mapping were small, severely eroded areas at the top of knobs. These included areas were not mapped separately, because they are less than 1 acre in size and are too small to be managed separately. They make up less than 5 percent of any area mapped. In these included areas tillage has mixed small fragments of sandstone into the surface layer, which is lighter colored and more reddish than the less eroded areas of surrounding soils. Also included in mapping were small areas where the surface layer has been only slightly damaged by erosion. These areas are mostly in native grasses.

Nearly all of this soil has been cultivated, but many fields have been returned to grass. Small grains are the main crops, though sudangrass is grown in places. Most of the areas are generally deficient in plant nutrients. Chlorosis is common among grain sorghum, and even if management is good, yields are generally low. Unless management of this soil is improved, this soil will become unsuitable for crops. (Capability unit IVe-3; Shallow Prairie range site; windbreak suitability group 4)

Reinach Series

The Reinach series consists of deep, dark-brown to reddish-brown, well-drained very fine sandy loams. These nearly level soils are on flood plains above the areas that normally receive overflow. Most areas of these soils are in the valley of the Cimarron River and along its tributaries. Broad areas are along Sand Creek and Deep Creek.

The surface layer is dark-brown very fine sandy loam about 1 foot thick. It is friable and has medium granular structure. This layer is easily tilled when moisture is favorable. The subsoil to a depth of about 48 inches consists of material arranged in coarse prisms that easily crumble to granules. The upper part of the subsoil is reddish-brown, noncalcareous loam. The lower part consists of yellowish-red, calcareous very fine sandy loam that is permeable and has moderately high available moisture capacity. The material to a depth of 54 inches is very friable and easily penetrated by water and roots.

Reinach soils formed in reddish, calcareous, water-deposited sediments that are mostly of fine sandy loam and loamy fine sand texture. The native vegetation was mid and tall grasses.

The Reinach soils are well drained and moderately permeable. They absorb water readily and have moderately high capacity for storing it. A plowpan has formed in some places.

The Reinach soils occur with the McLain, Miller, Port, and Canadian soils. The subsoil is less stratified in the Reinach soils than in the Yahola, and leaching is to a greater depth. Reinach soils are less sandy than the Canadian soils. They have a more sandy subsoil than the Port soils and a more sandy surface layer and subsoil than the McLain or Miller soils.

Typical profile of Reinach very fine sandy loam, 114 feet east and 60 feet north of the southwest corner of the northwest quarter of section 22, T. 20 N., R. 10 W., on east side of the road in cultivated field:

- A11—0 to 12 inches, dark-brown (7.5YR 4/4) very fine sandy loam, dark brown (7.5YR 3/2) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; pH 7.0; gradual boundary.
- A12—12 to 20 inches, reddish-brown (5YR 4/3) loam, dark reddish brown (5YR 3/3) when moist; moderate, coarse, prismatic structure and moderate, medium, granular structure; slightly hard when dry, very friable when moist; noncalcareous; pH 7.0; gradual boundary.
- C1—20 to 48 inches, yellowish-red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) when moist; weak, coarse, prismatic and moderate, medium, granular structure; slightly hard when dry, very friable when moist; calcareous; gradual boundary.
- C2—48 to 54 inches, reddish-brown (5YR 5/4) loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist; calcareous; few fine veinlets of lime.

The A11 horizon ranges from 10 to 18 inches in thickness. This layer is loam and thin, winnowed fine sandy loam in a few places. The A12 horizon ranges from heavy loam to fine sandy loam. The profile is noncalcareous above a depth of 20 inches and is calcareous at a depth ranging from 20 to 35 inches.

Reinach very fine sandy loam (Ra).—Most of this deep, dark, well-drained soil occurs on the bottom lands along the Cimarron River valley and its tributaries; some large areas are along Sand Creek and Deep Creek. Slopes range from 0 to 1 percent. The profile of this soil is the one described as typical of the Reinach series. This soil soaks up water readily and holds a large amount available for plants.

Included with this soil in the mapping were small areas of Port and Canadian soils.

This soil has been damaged only slightly by soil erosion, but small accumulations along fence rows indicate soil

blowing. A few areas receive runoff water from higher slopes. Floodwater from nearby streams reaches only small parts of some fields, generally as backwater that causes little or no damage to crops.

Nearly all this soil is cropland. It is one of the best soils in the county for farming; wheat, alfalfa, sorghums, and other crops commonly grown in the area are well suited. Only ordinary practices of management are generally needed. (Capability unit I-1; Loamy Bottomland range site; windbreak suitability group 1)

Renfrow Series

In the Renfrow series are deep, nearly level to gently sloping, reddish-brown silty clay loams. These soils are locally called hardlands. They occur in the uplands east of Fairview.

The surface layer is about 8 inches thick and consists of reddish-brown silty clay loam of medium granular structure. A plowpan has formed in some places. Although the surface layer is hard when dry, it is friable and crumbles easily when moist. The subsoil is reddish-brown, very slowly permeable clay about 24 inches thick. In the upper 14 inches, material in the subsoil is arranged in medium-sized blocks that have a coating of clay films and shiny varnished faces. The 28- to 38-inch horizon of the subsoil also is blocky and contains a few small concretions of lime. Clay films in the subsoil are less pronounced as depth increases. Reddish-brown, calcareous silty clay loam material is below a depth of 38 inches.

Renfrow soils formed in red shale and clay of the Permian red beds. The native vegetation consisted of mid and tall grasses.

These soils are well drained, but permeability is very slow.

Renfrow soils occur with the Vernon, Pond Creek, and Grant soils. Renfrow soils are deeper and are leached of lime to a greater depth than the Vernon soils. The clay subsoil distinguishes the Renfrow soils from the Pond Creek and Grant soils, which have a silty clay loam subsoil.

Typical profile of Renfrow silty clay loam, 1 to 3 percent slopes, about 1,290 feet south and 140 feet east of the northwest corner of the northwest quarter of section 15, T. 20 N., R. 10 W., on east side of road in native pasture:

- A1—0 to 8 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) when moist; moderate, medium and fine, granular structure; hard when dry, friable when moist; noncalcareous; pH 6.7; clear boundary.
- A3—8 to 14 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, granular structure; hard when dry, friable when moist; noncalcareous; pH 7.0; clear boundary.
- B21t—14 to 28 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate, coarse and medium, blocky structure; very hard when dry, very firm when moist; clay films pronounced on horizontal faces, patchy on vertical faces; noncalcareous; pH 7.8; gradual boundary.
- B22t—28 to 38 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; weak, coarse, subangular blocky structure; very hard when dry, very firm when moist; clay films, but less pro-

nounced than in B21t horizon; calcareous; a few fine concretions of calcium carbonate in lower 4 inches; gradual boundary.

- B3—38 to 54 inches, reddish-brown (2.5YR 4/5) heavy silty clay loam, dark reddish brown (2.5YR 3/5) when moist; weak, fine, blocky structure; very hard when dry, very firm when moist; calcareous.

The A1 horizon ranges from about 6 inches to 12 inches in thickness and, when dry, from brown to dark reddish brown in color. In places the A1 horizon is silt loam or clay loam. Depth to calcareous material ranges from 14 inches in gently sloping areas to 30 inches in nearly level areas.

Renfrow silty clay loam, 0 to 1 percent slopes (RcA).—This deep, nearly level soil occurs mostly on the uplands southeast of Fairview. It is fairly inextensive in this county, but some broad areas total more than 50 acres.

The profile is slightly thicker than the one described for the series. The surface layer is silty clay loam about 1 foot thick. It has granular structure and is friable and easily tilled when the content of moisture is favorable.

Included with this soil in mapping were small areas of Pond Creek and Kirkland soils that do not cover more than 15 percent of any area mapped.

About 90 percent of this soil is cultivated, mainly to wheat. Other small grains and some sorghums are grown when moisture is favorable.

Erosion is not difficult to control on this soil, but areas that do not have enough vegetative cover blow, especially when the soil is dry. When the soil is moist, the soil particles tend to hold together and are not so likely to blow away. Droughtiness is a hazard because of the very slowly permeable subsoil, but runoff is slow and more time is allowed for water to penetrate the soil. Droughtiness is increased where plowpans develop or where the surface crusts after puddling. (Capability unit IIs-1 and Claypan Prairie range site; windbreak suitability group 3)

Renfrow silty clay loam, 1 to 3 percent slopes (RcB).—Most of this soil lies in the uplands east of Fairview. It is the most extensive Renfrow soil in the county; the mapped areas range from about 20 to 100 acres in size. Slopes generally are long and smooth, and they average about 2 percent. The profile of this soil is the one described as typical of the Renfrow series.

Included with this soil in mapping were small areas of Pond Creek, Grant, and Vernon soils.

About 80 percent of this soil is cultivated; the rest is range. Wheat, the main crop, is well suited, but other suitable small grains are also grown. Sorghums grow well if moisture is adequate.

Water erosion is the main hazard in cultivated areas. Soil blowing is also a hazard in plowed fields that are dry and not protected. The very slowly permeable subsoil not only makes the soil droughty but also increases runoff by retarding the intake of water. In some places intensive tillage breaks down the structure of the surface layer, and this soil puddles when it is wet and crusts when it dries. The crust seals and increases runoff. Also, small plants emerge through the crusts with difficulty, and stands of crops are poor.

Areas in rangeland are generally small and are grazed with other areas of adjacent soils. Maintaining the better grasses by preventing misuse of grazing land is the main purpose of management. (Capability unit IIIe-1; Claypan Prairie range site; windbreak suitability group 3)

Rough Broken Land, Clayey

Rough broken land, clayey (Ro) consists mainly of side slopes of the steep rugged buttes and blufflike escarpments. It is material of the red beds, crowned with a ledge of whitish gypsum. Slopes dominantly range from 0 to 20 percent. These rugged areas are called Glass Mountains because a brilliant whitish luster gleams from scattered seams, strata, and debris of gypsum.

The buttes and escarpments tower 50 to 175 feet above the valley floor. The protruding crown of gypsum is about 5 to 10 feet thick. It rests on exposed red-bed shales and clay beds that form a jagged wall 15 to 75 feet above the steep foot slopes made up of erosion drifts. These drifts are deep and consist of soil material that crept downslope from the upper rims of the buttes and escarpments. This soil material is mostly reddish clay loam, much of which is mixed with films of soft powdery gypsum. It is friable to very friable. Gravel and gypsum the size of boulders have broken from the upper rims and rolled or slid down to the lower slopes (fig. 14).

Areas of Rough broken land, clayey, form a rim that extends upward to broad areas of higher soils. Much water

runs onto these steep, broken areas from these higher areas. This runoff gouges out many gullies. Also, barren areas are gradually cut away. Above the foot slopes, only a few spots have enough soil for the growth of plants. On the foot slopes where the soil material is deeper, the vegetative cover is fair.

Near the foot slopes of Rough broken land, clayey, are small areas of Vernon, Tillman, and Weymouth soils. Broad areas of gypsum outcrops and of Vernon and Weymouth soils are above the upper rims. Small areas of all of these associated soils are included in areas of Rough broken land, clayey.

All of this land is used as range. In cold winter months, the rough terrain shelters the livestock. Some grazing areas on steep slopes cannot be reached by the livestock, and these areas prevent the animals from reaching other areas. The main concerns of management are maintaining a vegetative cover and preventing overgrazing and soil blowing. The principal vegetation consists of little bluestem, sand bluestem, sideoats grama, and a few scrub cedar. (Capability unit VIIIs-2; Breaks range site; windbreak suitability group 4)



Figure 14.—Landscape of Rough broken land, clayey.

Rough Broken Land, Loamy

Rough broken land, loamy (*Ru*) consists of rugged areas where canyons cut deep into reddish sandstone. Most of this land is in broad areas of range at the western edge of the county. One of the larger areas is at the upper part of Griever Creek. Small areas of Dill soils occur on uplands adjoining this land, and some small areas of these soils are included in mapping. The canyons range from 25 to 200 feet in depth, but the average depth is 50 feet. Much soil has drifted from their steep sides. The upper slopes are mantled with deep drifts of loam and fine sandy loam. Extending from the rims are slopes ranging from 5 to 20 percent that drop 50 to 150 feet to abrupt, almost vertical walls. On these walls are exposed raw, reddish sandstone.

The floor of the canyons is 15 to 275 feet wide and is filled with loamy alluvial sediments stratified with sand and loamy sand. These deposits are as much as 3 to 10 feet deep. In some areas they rest on sandstone, but in others they are on sand that is more than 20 feet thick and is underlain by shale or sandstone. The areas along the canyon range from 150 to more than 500 feet in width and from a few hundred feet to several miles in length.

Moderate stands of nutritious grasses and some scattered sand sagebrush and cedar grow on the slopes from the rims and provide grazing suitable for livestock. In the larger areas on the floors, cover is sparse to moderate. The steep canyon walls are not accessible to livestock, and in some places they prevent livestock from moving from one area to another. Where banks of this land have a good vegetative cover, soil washing is slow, but where cover is thin or absent, areas quickly erode to raw red sandstone.

No ranch or farm in the county is made up entirely of this land, for it is grazed with smoother adjacent rangeland. Livestock are sheltered by the rough terrain and the trees in winter. Choice spots are some of the areas around the excellent spring-fed ponds.

The principal grasses on this land are sand bluestem, little bluestem, and sideoats grama. Cottonwood, elm, cedar, and redbud trees are common woody plants. Management is needed that provides a dependable source of vegetation. (Capability unit VII_s-1; Loamy Breaks range site; windbreak suitability group 4)

Sand Dunes, Lincoln Material

Sand dunes, Lincoln material (*Ss*) normally occurs in bands along the riverbanks of Major County. Large areas are on the north bank of the Cimarron River in a belt between areas of Lincoln soils on the nearly level flood plains and areas of Tivoli soils on the higher dunes farther from the stream. Slopes range from 2 to 30 percent. Small areas of the Tivoli and Lincoln soils were included with this land in mapping.

The sand dunes range from 5 to 25 feet in height but are generally 8 to 15 feet high. They are made up of sand that wind swept from the adjoining riverbed and formed into dunes. The soil material is young; it has been in place for only a short period and has not had time to develop.

The surface layer of these dunes consists of light-brown fine sand about 4 inches thick. It is underlain by loose, reddish-yellow, calcareous fine sand that extends with little change to the bottom of the deposit.

These dunes absorb water quickly, but they are droughty because the sand is porous and holds only a small amount of water. The dunes are above the areas that are normally flooded, and they are flooded only at high stages of flooding, and then only in small areas.

Because this mapping unit is droughty and highly susceptible to blowing, it is suited only to range and is used only for that purpose. Preventing overgrazing is the principal management needed and is particularly difficult in dry periods. In overgrazed areas blowouts form readily. The principal grasses are little bluestem, sand bluestem, sideoats grama, sand paspalum, sand dropseed, and blue grama. Sand plum, sand sagebrush, and skunkbush are some of the bushy plants. (Capability unit VI_e-6; Deep Sand range site; windbreak suitability group 4)

Shellabarger Series

The Shellabarger series consists of deep, nearly level to gently sloping soils that have a fine sandy loam surface layer and a friable, permeable subsoil. In Major County these soils are scattered throughout the sandy uplands. Broad areas occur near Ames in the southeastern part of the county.

The surface layer is brown to dark-brown fine sandy loam about 6 inches thick. It is friable and has granular structure. In places a thin plowpan has formed in this layer. The upper part of the subsoil consists of dark-brown heavy fine sandy loam 19 inches thick. It is friable and permeable, and it has medium granular structure.

The lower part to a depth of about 48 inches is reddish-brown light sandy clay loam. In the lower part the soil material is porous and permeable and is arranged in coarse subangular blocky peds that are friable and crush easily to granules. Below a depth of 48 inches is brown fine sandy loam mottled with reddish brown. Structure is less distinct as depth increases.

Shellabarger soils formed in deep deposits of material that range from loam to loamy sand in texture. They formed under a dense cover of mid and tall grasses. They are well drained and have moderate permeability.

The Shellabarger soils occur with the Meno, Ortello, Nobscot, Tivoli, Pratt, and Carwile soils and are less sandy than all of those soils except the Carwile. They are less clayey and less compact than the Carwile soils. Unlike the Meno soils, Shellabarger soils are not mottled in the upper part of the subsoil. They are redder and less mottled than the Carwile soils.

Typical profile of Shellabarger fine sandy loam, 0 to 3 percent slopes, 375 feet east and 555 feet north of the southwest corner of the southwest quarter of section 11, T. 20 N., R. 9 W., in a cultivated area:

- Ap—0 to 6 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) when moist; weak, medium and fine, granular structure; slightly hard when dry, very friable when moist; noncalcareous; pH 6.0; abrupt boundary.
- B1—6 to 25 inches, dark-brown (7.5YR 4/2) heavy fine sandy loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; hard when dry, friable when moist; noncalcareous; pH 6.5; gradual boundary.
- B2t—25 to 38 inches, reddish-brown (5YR 4/4) light sandy clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, granular structure and weak, coarse, subangular blocky structure; hard when dry, friable when moist; noncalcareous; pH 7.0; gradual boundary.

B22t—38 to 48 inches, reddish-brown (5YR 5/4) light sandy clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, granular structure; hard when dry, friable when moist; noncalcareous; pH 7.2; gradual boundary.

B3—48 to 60 inches +, brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) when moist; weak, medium, granular structure; soft when dry, very friable when moist; numerous fine mottles of reddish brown; noncalcareous; pH 7.6.

The A horizon ranges from about 5 to 12 inches in thickness and, when dry, from grayish brown to dark brown in color. In some small winnowed spots the top 1 to 2 inches is loam. The B2t horizons range from heavy fine sandy loam to sandy clay loam. They range from reddish brown to strong brown when dry but are a little darker when moist. A darker buried soil that ranges from clay loam to fine sandy loam occurs below a depth of 50 inches in some places.

Shellabarger fine sandy loam, 0 to 3 percent slopes (StB).—This smooth soil occurs in nearly level to gently sloping areas on the uplands. Its profile is the one described as typical of the Shellabarger series. Broad areas of this soil are near Ames in the southwestern part of Major County.

Included with this soil in the mapping were small areas of Pratt, Ortello, and Meno soils. Also included, in spots in low depressions, were areas of the Carwile soils.

This soil absorbs water readily, and its subsoil has high available moisture capacity. Runoff is not excessive, and little soil material is lost through water erosion. Although a few fields have been damaged by wind, most cultivated fields show few signs of erosion. In these eroded areas the surface layer has been winnowed and is lighter than normal in color.

About 95 percent of this soil is used for crops; the rest is mostly range. Because water-holding capacity is good, sorghums are well suited. Other well-suited crops are wheat and other small grain or forage crops common in the area. Some truck crops are grown. This soil is well suited to irrigation, but only small areas are irrigated. Soil blowing is the main concern in dryfarmed areas. (Capability unit IIe-3; Sandy Prairie range site; windbreak suitability group 1)

St. Paul Series

The St. Paul series consists of deep, dark, nearly level to moderately sloping silt loams that have a moderately permeable to slowly permeable subsoil. These soils are in smooth areas in the western part of Major County and are sometimes called hardlands.

The surface layer is dark grayish-brown silt loam about 1 foot thick. It has granular structure, is friable, and is easily tilled when the moisture content is favorable. The subsoil, about 31 inches thick, is reddish-brown silty clay loam. In the upper 9 inches of the subsoil, the soil material is arranged in coarse prisms that are very friable when moist and easily crushed to medium granules. The lower part of the subsoil contains slightly more clay than in the upper part. It is firm and has subangular blocky structure. Below a depth of 31 inches, the soil material is calcareous and structure is less pronounced. Below a depth of 43 inches is a reddish-brown, massive silty clay loam similar to the material from which these soils formed.

In some places the St. Paul soils formed in a mantle of material that was deposited by wind and water, but in other places they were derived from siltstone and silty

shale of the Permian red beds. The native vegetation was mid and tall grasses.

St. Paul soils are well drained and have moderately slow permeability. St. Paul soils occur with the Carey, Dill, LaCasa, Weymouth, and Tipton soils. St. Paul soils are more deeply leached of lime than are the LaCasa soils and are darker than the Carey or Tipton soils. They are less sandy than the Dill soils. Layers in the St. Paul soils are more distinct than those in the Weymouth soils.

Typical profile of St. Paul silt loam, 1 to 3 percent slopes, 340 feet west and 150 feet north of the northeast corner of section 23, T. 23 N., R. 16 W., on south side of road in cultivated field:

A1—0 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry, very friable when moist; noncalcareous; pH 7.2; gradual boundary.

B1—12 to 21 inches, reddish-brown (5YR 4/4) light silty clay loam, dark reddish brown (5YR 3/4) when moist; moderate, coarse, prismatic and moderate, medium, granular structure; slightly hard to hard when dry, very friable when moist; noncalcareous; pH 7.2; clear boundary.

B21t—21 to 31 inches, reddish-brown (5YR 4/4) heavy silty clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure; hard when dry, firm when moist; noncalcareous; pH 7.3; clear boundary.

B3—31 to 43 inches, reddish-brown (2.5YR 4/4) silty clay loam, dark reddish brown (2.5YR 3/4) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; calcareous; gradual boundary.

C—43 to 65 inches, reddish-brown (2.5YR 5/4) silty clay loam, reddish brown (2.5YR 4/4) when moist; massive (structureless); hard when dry, firm when moist; calcareous.

The A1 horizon ranges from about 5 to 14 inches in thickness. When dry, this layer ranges from brown to dark grayish brown. In small areas it is loam or clay loam. In places the B2t horizon is clay loam. When dry, it ranges from reddish brown to brown. The C horizon is loam or silt loam in places. When dry, this horizon ranges from reddish brown to yellowish brown. The profile ranges from neutral to mildly alkaline in the upper horizons and is calcareous in the B3 and C horizons.

St. Paul silt loam, 0 to 1 percent slopes (SpA).—This soil occurs in the western part of Major County in areas ranging from about 10 to 40 acres in size. Slopes are smooth and nearly level. Except for a surface layer that is slightly thicker in places, this soil has a profile like the one described for the St. Paul series.

Included with this soil in the mapping were small areas of Carey and Dill soils and of more sloping St. Paul soils.

Except for a few areas in native range, this fertile soil is cultivated. It is suited to many kinds of crops, and nearly all crops suited to the area are grown. Small grains, particularly wheat, and grain sorghum, are the main crops. This soil can be kept fertile under good management, but it is slightly susceptible to soil blowing and water erosion. In a few places the surface layer is slightly damaged. In cultivated areas, practices are needed to prevent surface crusting and the formation of plowpans and to offset the scarcity of moisture. Also needed is management that maintains fertility and helps to control erosion. (Capability unit IIc-1; Hardland range site; windbreak suitability group 2)

St. Paul silt loam, 1 to 3 percent slopes (SpB).—This deep soil occurs on the uplands in the western part of Ma-

for County with other St. Paul soils. It is the most extensive St. Paul soil in the county. The profile of this soil is the one described as typical of the St. Paul series.

Included with this soil in the mapping were small areas of Carey, Weymouth, and LaCasa soils.

Most of this soil is cultivated; small grains and grain sorghum are the main crops. Although erosion is not more than slight, sheet erosion gradually removes thin sheets of surface soil, and rills or shallow gullies are gouged in places after heavy rains. These shallow gullies are easily obliterated through normal tillage, but the loss of soil is not easily replaced. Surface crusts develop in areas where soil structure breaks down. If tillage depths are not varied or plowing is on soil that is too wet, a plowpan is likely to form. Management is needed for controlling erosion by both wind and water. (Capability unit IIe-1; Hardland range site; windbreak suitability group 2)

St. Paul silt loam, 3 to 5 percent slopes (SpC).—This inextensive soil is on the uplands in the western part of Major County. It occurs in strips along the upper rims of valleys and in belts among areas of the Weymouth, LaCasa, and Carey soils. Except for a surface layer that is slightly thinner, its profile is similar to the one described for the series.

Included with this soil in the mapping were some small areas of Carey, Weymouth, and LaCasa soils that total not more than 15 percent of any area mapped.

About 90 percent of this soil is cultivated; the rest is native range. Small grains and grain sorghum are the principal crops; winter wheat is the most widely grown. Because this soil is more sloping than the other St. Paul soils, management is more difficult. Erosion is generally slight, but shallow gullies or rills are quickly gouged into open fields during heavy rains, though usually the gullies can be erased by ordinary tillage. Where gullies are not controlled, however, some of them remain. Although excessive runoff is the main concern, this soil blows if its surface is not protected.

The main purposes in managing this soil are providing organic matter, maintaining soil structure, and controlling erosion. For improving the range and establishing waterways, blue grama, buffalograss, sideoats grama, and other native grasses are suited. Small amounts of tall grasses may be used. (Capability unit IIIe-2; Hardland range site; windbreak suitability group 2)

Sweetwater Series

The Sweetwater series consists of nearly level, poorly drained soils that have a water table that normally is within 3 feet of the surface. These soils are in scattered areas along the flood plains of the Cimarron and North Canadian Rivers. The surface of these areas is slightly uneven because the moist soil settles. These soils are occasionally flooded, though they are seldom damaged by the floodwater.

The surface layer is about 10 inches thick. It is generally gray when dry, and it ranges from silty clay loam to fine sandy loam in texture. This layer is friable, contains a large amount of organic matter, and has granular structure. Underlying the surface layer is strong-brown loamy fine sand that also is friable and is mottled with brown and gray. At a depth of about 32 inches, this layer grades to

pink sand that is mottled faintly and stained with brown and gray. The profile is calcareous throughout and contains some accumulations of salt.

The Sweetwater soils formed in calcareous alluvium deposited by floodwater. These young soils formed under a dense cover of water-tolerant grasses. Because the water table is high, Sweetwater soils are normally saturated with water within a depth of 3 feet, the depth depending mainly on the amount of rainfall and the distance the soils are from the stream. In dry periods, water is sometimes 40 inches from the surface.

Sweetwater soils occur with the Lincoln, Elsmere, and Leshara soils. They are more fertile, less sandy, and less droughty than the Lincoln soils. Sweetwater soils have a less uniform profile than the Elsmere soils and a more sandy subsoil than the Leshara soils.

Typical profile of a Sweetwater loam, 1,010 feet east of the southwest corner of the southeast quarter of section 18, T. 21 N., R. 10 W., on north side of road in native pasture:

- A1—0 to 10 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) when moist; weak granular structure; very hard when dry, friable when moist; calcareous; stratified with thin lenses of light brownish gray (10YR 6/2) loam in lower part of horizon; gradual boundary.
- C1—10 to 32 inches, strong-brown (7.5YR 5/6) loamy fine sand, reddish yellow (7.5YR 6/6) when moist; massive; soft when dry, very friable when moist; calcareous; faint mottling with brown and gray; gradual boundary.
- C2—32 to 50 inches +, pink (7.5YR 7/4) sand, light brown (7.5YR 6/4) when moist; single grain; calcareous; faint mottling and staining with brown and gray in very thin strata.

The A1 horizon ranges from silty clay loam to fine sandy loam. In color, this horizon ranges from gray when dry to very dark grayish brown when moist. Depth to sand ranges from 18 to 36 inches. The water table is near the surface in wet periods, but it falls to a depth of about 40 inches in dry periods. Salinity ranges from none to moderate. The accumulation of salt is greater in some places than in others.

Sweetwater soils (Sw).—These nearly level, poorly drained soils are in scattered areas along the flood plains of the Cimarron and North Canadian Rivers. Slopes range from 0 to 1 percent. This soil has a profile similar to the one described for the Sweetwater series, but texture of the surface layer varies from place to place.

Included in mapping were some small areas of Lincoln soils that do not make up more than 10 percent of any area mapped.

Sweetwater soils are not suitable for cultivation because they are wet, contain accumulated salt in places, and have a sandy subsoil. Even in drained areas, the porous, sandy subsoil and the salts make cultivation difficult. Only a few fields have been cleared for cultivation, and most of these have been returned to grass that is grazed or cut for hay.

Sweetwater soils make up some of the best rangeland in the county. Because the surface layer is fertile and available moisture supply is high, well-managed areas support abundant grasses. Among these grasses are switchgrass, indiagrass, cordgrass, eastern grama, western wheatgrass, and alkali sacaton. Also, there are some sedges. In some of the choice areas, bermudagrass has been sprigged and used as tame pasture. In excessively grazed areas, saltgrass, weeds, and other unwanted plants are dominant. Willow, tamarisk, cottonwood, and other woody plants and a few trees are scattered over the area. (Capability

unit Vw-2; Subirrigated range site; windbreak suitability group 4)

Tillman Series

The Tillman series consists of deep, dark, nearly level to moderately sloping soils below the foot slopes of the buttes and clifflike escarpments in the western part of Major County. Broad areas form the upland slopes in Cheyenne Valley. These soils are commonly called hardlands.

The surface layer consists of dark-brown clay loam about 8 inches thick. It has granular structure and is easily tilled when not too wet or too dry. The subsoil to a depth of about 38 inches is reddish-brown clay. It is very hard when dry and very firm when moist and is penetrated very slowly by water, air, and plant roots. The upper 4 inches of the subsoil is noncalcareous and has moderate, medium, angular blocky structure. The lower part is calcareous and has medium and coarse angular blocky structure. The subsoil at a depth of about 46 inches is red, massive, calcareous clay that contains a few small concretions of lime. This material is similar to the material from which these soils formed (fig. 15).

The Tillman soils formed in material derived from Permian red beds. In some places the material is shale, but in others it is clay beds of colluvial drift from the adjoining escarpments. The native vegetation was mainly short and mid grasses and a few scattered mesquite shrubs.

The Tillman soils are well drained; they have very slow permeability. In some places a plowpan has formed.

These soils occur with the Weymouth, LaCasa, Vernon, and Renfrow soils. Tillman soils contain more clay in the B horizon than the LaCasa soils. They are deeper and are leached of lime to greater depth than the Weymouth and Vernon soils. Leaching of lime is not so deep in the Tillman soils as in the Renfrow.

Typical profile of Tillman clay loam, 1 to 3 percent slopes, 1,320 feet west and 75 feet north of the southeast corner of section 30, T. 21 N., R. 12 W.:

- A1—0 to 8 inches, dark-brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/3) when moist; moderate, medium, granular structure; hard when dry, firm when moist; pH 7.5; gradual boundary.
- B21t—8 to 12 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; moderate, medium, angular blocky structure; very hard when dry, very firm when moist; pH 7.5; gradual boundary.
- B22t—12 to 38 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; moderate, medium to coarse, angular blocky structure; very hard when dry, very firm when moist; calcareous; gradual boundary.
- B31ca—38 to 46 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) when moist; weak, coarse, angular blocky structure; hard when dry; calcareous; few small concretions of lime; gradual boundary.
- B32—46 to 60 inches, +, red (2.5YR 5/6) clay, red (2.5YR 4/6) when moist; massive; very hard when dry, very firm when moist; calcareous; few small concretions of lime.

The A1 horizon ranges from 7 to 10 inches in thickness. In some places it is silt loam or silty clay loam and is as thin as 5 inches and as thick as 12 inches. When dry, this horizon ranges from dark brown to dark reddish brown. The B21t and B22t horizons range from reddish brown to red in color and are alkaline to calcareous. In small areas they are silty clay. The B3 horizons range from clay loam to clay in texture and

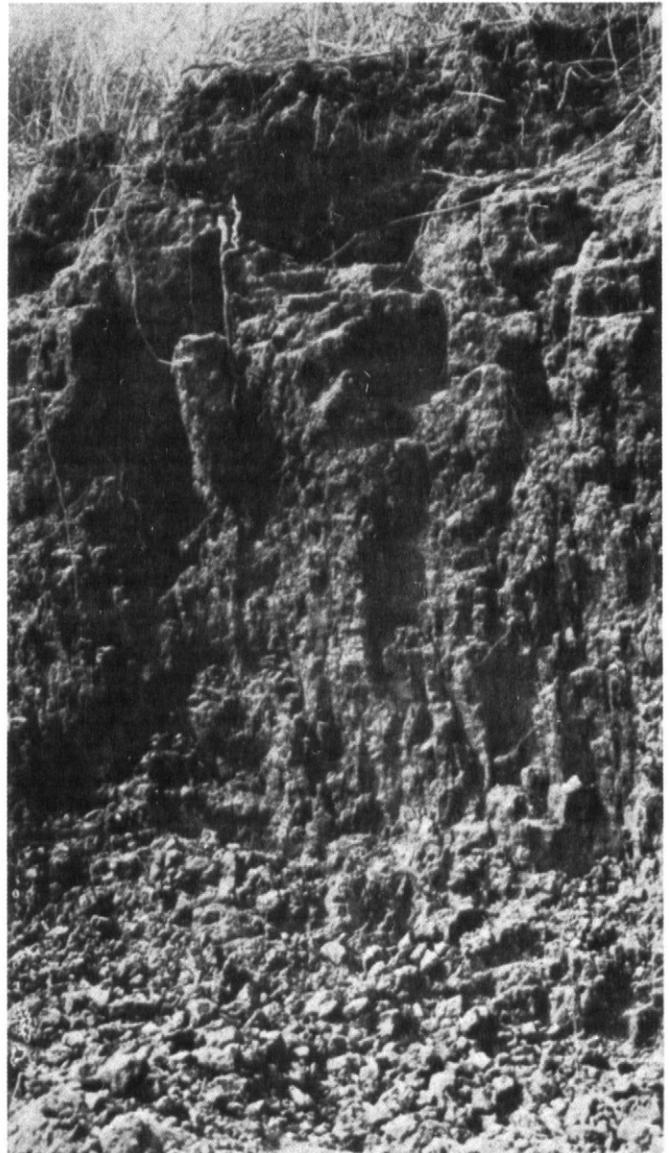


Figure 15.—Typical profile of a Tillman soil showing the blocky structure in the subsoil. Some blocks are in the foreground.

from yellowish red to red in color. In the lower B horizons, lime concretions usually make less than 5 percent of the soil mass.

Tillman clay loam, 0 to 1 percent slopes (TcA).—This nearly level soil is in smooth areas of the uplands. The surface layer is slightly thicker, but this soil otherwise has a profile similar to the one described for the series. Most of the soil occupies areas 10 to 25 acres in size that are in fields with the more sloping Tillman soils and Vernon clay loam, 0 to 3 percent slopes. Small areas of these soils were included with this soil in the mapping.

This Tillman soil is slightly droughty because its subsoil is compact clay. When the soil dries out, it cracks in places and aeration and loss of moisture are increased. Because runoff is slow, there is much time for water to enter this soil. Much water does soak into the soil if the surface layer is granular and is covered by crop residue. Water

intake is reduced, however, if this soil is plowed several times at the same depth when the soil is wet. Soil structure is weakened if the soil is plowed excessively. Then the soil puddles when it is wet and crusts when it dries, and the intake of water is further reduced.

Except for a few small areas in range, this soil is cultivated. Wheat is the main crop, but it is rotated with other small grains and sorghums. When there is not enough rain, the sorghum plants wilt, but sorghums grow well when moisture is adequate. (Capability unit IIs-1; Hardland range site; windbreak suitability group 3)

Tillman clay loam, 1 to 3 percent slopes (TcB).—This soil occurs in the valley areas below steep, rough, broken slopes on the uplands in the western part of Major County. It is on gentle slopes that gradually descend from the escarpments to the valley streams. Broad areas are in the Cheyenne Valley community. The profile of this soil is the one described as typical of the Tillman series.

Included with this soil in the mapping were areas of Tillman clay loam, 3 to 5 percent slopes, and of Vernon soils. These included areas total less than 15 percent of any area mapped. Also included are a few eroded spots.

About 90 percent of this soil is cultivated; the rest is range. Small grains are well suited and are the most widely grown crops. Sorghums and other summer crops often have reduced yields because the soil dries out in dry periods.

In cultivated areas, management is needed mainly to reduce droughtiness. Also, excessive tillage should be avoided because it pulverizes the surface layer, weakens soil structure, and increases susceptibility to soil blowing. The surface puddles if this soil is worked when it is wet. Because this soil cracks when it dries, aeration is excessive. The aeration increases droughtiness because the soil dries to a considerable depth.

On rangeland the main concern is preventing overgrazing. (Capability unit IIIe-1; Hardland range site; windbreak suitability group 3)

Tillman clay loam, 3 to 5 percent slopes (TcC).—This moderately sloping soil occurs on uplands that border the foot slopes of the escarpments and buttes in the western part of Major County. Slopes gradually descend toward the lower elevations in the valley. This soil has a profile similar to the one described for the Tillman series, but its surface layer averages about 1 inch less in thickness.

Included with this soil in the mapping were small areas of Weymouth, LaCasa, and Vernon soils. These inclusions do not exceed more than 15 percent of any area mapped. Also included are a few moderately eroded spots, generally along natural drains in plowed fields.

On this soil most erosion is a result of runoff water crossing barren fields. Runoff is less on well-managed rangeland than on cropland. Plowed fields that are not protected are cut by shallow gullies and rills during intensive rains, but most of these gullies and rills are erased by ordinary tillage. The main concern is sheet erosion that gradually carries away the surface soil. If the surface is pulverized by excessive tillage, surface crusting and puddling are increased and soil structure is worsened. Surface crusting increases runoff. Where plowpans form, the intake of water is further restricted.

About 60 percent of this soil is cropland; the rest is rangeland (fig. 16). About 15 percent was once cultivated but is now reseeded to native grasses. Wheat is the main

crop, but small acreages of other small grains and sorghums are also grown. Sorghums grow well when moisture is adequate. On rangeland, management is needed to control grazing. (Capability unit IVe-1; Hardland range site; windbreak suitability group 3)



Figure 16.—Cattle grazing on Tillman clay loam, 3 to 5 percent slopes.

Tipton Series

The Tipton series consists of deep, nearly level soils. These soils occupy broad terraces on smooth uplands above the flood plains of the rivers in the western part of the county.

The surface layer is dark-brown silt loam about 22 inches thick. It is very friable, has granular structure, and is easily tilled when the content of moisture is favorable. In places a plowpan has formed in this layer. The subsoil is yellowish-red light clay loam about 21 inches thick. It has granular structure, is friable, and is easily penetrated by plant roots. Available moisture capacity is moderate in the subsoil. Below a depth of 43 inches is friable, reddish-yellow to yellowish-red, calcareous loamy material that generally extends several feet and is similar to the material from which these soils formed. The profile of these soils is high in organic-matter content. Earthworms have been very active and have improved these soils.

The Tipton soils formed in calcareous material that probably was deposited by wind and water. The texture of this material is silt loam, loam, clay loam, and sandy clay loam. The native vegetation was mostly mid and tall grasses.

The Tipton soils are well drained and have moderate permeability.

Tipton soils occur with the Carey, St. Paul, Enterprise, and Port soils. They have less prominent, slightly less clayey horizons in the subsoil than have the Carey and St. Paul soils. Tipton soils are darker and less sandy than the Enterprise soils and are redder and leached of lime to a greater depth than the Port soils.

Typical profile of Tipton silt loam, 0 to 1 percent slopes, about 160 feet south and 105 feet east of the northwest corner of the northeast quarter of section 12, T. 23 N., R. 16 W., in a cultivated field on the south side of road:

- Ap**—0 to 8 inches, dark-brown (7.5YR 4/4) silt loam, dark brown (7.5YR 3/2) when moist; weak, medium and fine, granular structure; soft when dry, very friable when moist; noncalcareous; pH 7.2; numerous worm casts; clear boundary.
- A1**—8 to 22 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; moderate, coarse, prismatic and moderate medium and fine granular structure; soft when dry, very friable when moist; noncalcareous; pH 7.5; numerous worm casts; gradual boundary.
- B2t**—22 to 43 inches, yellowish-red (5YR 5/8) light clay loam, yellowish red (5YR 4/8) when moist; moderate, fine and medium, granular structure; hard when dry, very friable when moist; noncalcareous; pH 7.5; numerous worm casts; gradual boundary.
- C1**—43 to 51 inches, reddish-yellow (5YR 6/8) clay loam, yellowish red (5YR 5/8) when moist; weak granular structure to massive; slightly hard when dry, friable when moist; calcareous; fewer worm casts than in B2t horizon; few pebbles scattered throughout the soil mass.
- C2**—51 to 68 inches, yellowish-red (5YR 5/8) sandy clay loam, yellowish red (5YR 4/8) when moist; massive; hard when dry, friable when moist; calcareous.

The A horizon ranges from brown or dark brown to dark grayish brown. In some areas the top ½ to 1 inch has been winnowed and has a loam texture. The A horizon is neutral to mildly alkaline. The B2t horizon ranges from strong brown to yellowish red. It is neutral or calcareous. In many places darker horizons of a buried soil occur below a depth of 3 feet.

Tipton silt loam, 0 to 1 percent slopes (TpA).—This smooth, nearly level soil is on terraces bordering the flood plains along the Cimarron and North Canadian Rivers in the western part of Major County. The profile is the one described as typical of the Tipton soils.

Included with this soil in mapping were small areas of Carey, St. Paul, and Enterprise soils.

Because this soil is deep, friable, and permeable, it is desirable for cultivation, and most of it is cultivated. It is high in organic-matter content and generally is in good tilth. Winter wheat and alfalfa are the main crops. Also grown are other small grains and legumes and sorghums and cotton. Soil blowing and water erosion are hazards in some cultivated areas. In some places excessive water is received from higher areas. The productivity of this soil can be maintained by using ordinary practices of management. (Capability unit I-1; Loamy Prairie range site; windbreak suitability group 1)

Tivoli Series

The Tivoli series consists of loose, weakly developed sands in rolling areas of the sandhills where dunes and ridges range from 15 to 40 feet in height. In Major County these soils lie in irregular strips along the banks north of the Cimarron and North Canadian Rivers. The strips are about 1 mile wide.

The surface layer of these soils generally consists of yellowish-brown, loose, noncalcareous fine sand about 4 inches thick. It is underlain by reddish-yellow, loose, noncalcareous fine sand. Wind has shifted the soil material so much that there are only small differences in color throughout the profile.

The Tivoli soils formed in loose, lime-free, fine and medium sand that probably was carried by wind from the streambeds to the south. These sandy soils have not been in place long, and they do not support a grass cover

thick enough to provide much organic matter. The thin surface layer is modified by the small accumulations of organic matter from decayed plants. The native vegetation was mainly tall grasses and scattered skunkbush, sand sagebrush, wild grapes, and wild sandplum.

Tivoli soils are excessively drained and have very rapid permeability.

The Tivoli soils occur with the Shellabarger, Pratt, Nobscot, Enterprise, and Carwile soils. Tivoli soils have a thinner surface layer and a less coherent subsoil than have the Pratt soils. Structure is less distinct in the Tivoli soils than in the Enterprise, Carwile, or Shellabarger soils. In contrast with the Nobscot soils, Tivoli soils do not have a leached layer (A2 horizon) and a developed subsoil.

Typical profile of Tivoli fine sand, rolling, about 475 feet east and 50 feet south of the northeast corner of the northwest quarter of section 10, T. 20 N., R. 10 W.:

- A1**—0 to 4 inches, yellowish-brown (10YR 5/4) fine sand, dark brown (10YR 4/3) when moist; structureless (single grain); loose when dry or moist; noncalcareous; pH 7.0; clear boundary.
- C**—4 to 60 inches +, reddish-yellow (7.5YR 6/6) fine sand, strong brown (7.5YR 5/6) when moist; structureless (single grain); loose when dry or moist; noncalcareous; pH 7.2.

The A horizon ranges from dark grayish brown to yellowish brown. It is as much as 12 inches thick in some areas, but average thickness ranges from 4 to 12 inches. This layer ranges from fine sand on the steeper slopes to loamy fine sand on some of the low dunes. The C horizon ranges from reddish yellow to brownish yellow. This soil profile is generally free of lime throughout.

Tivoli fine sand, rolling (TrD).—This soil lies on the north banks of the Cimarron and North Canadian Rivers in strips that parallel those streams. In most places it no longer is shifted or blown by wind because the surface is protected by vegetation. The soil material consists of loose, sifted sand that overlies a sand subsoil. The only evidence of soil development is a thin accumulation of organic matter in the surface layer. Slopes range from 2 to 30 percent.

Included with this soil in the mapping were small areas of Pratt, Elsmere, Shellabarger, and Carwile soils in depressions between the dunes. These inclusions total less than 10 percent of any area mapped.

Because this soil is sandy and steep, it is not suited as cropland and is used as range. Soil blowing is likely, particularly during dry periods. In places, particularly at the top of dunes, in heavily grazed areas, and on pathways, the vegetation is sparse and does not control soil blowing. Blowouts develop in dry periods and spread until rainfall increases and new vegetation heals the bare areas. On this soil blowouts are few, however, and are generally less than 3 acres in size. Grazing should be deferred in these areas until they are covered with vegetation. In the depressions between the dunes, grasses are the most dense and there are a few trees.

Grazing, especially in dry periods, is limited on this soil. Protection from overgrazing is the most important management. Where management is good, the grasses are sand bluestem, sand lovegrass, big sandreed, sand paspalum, and sand dropseed. Mixed with these grasses are sand sagebrush, skunkbush, wild grapes, wild plum, and other brushy plants. (Capability unit VIIe-1; Dune range site; windbreak suitability group 4)

Treadway Series

The soils of the Treadway series are reddish, raw, compact clays that are droughty and sparsely vegetated. These nearly level soils occur on aprons, fans, and flood plains in the northwestern part of Major County.

The surface layer is reddish-brown calcareous clay about 6 inches thick. Structure is weak, thin, and platy, and in many places films of salt have accumulated in the structural seams. In bare areas a thin crust of salt forms on the surface. Beneath the surface layer is red, calcareous, compact clay 39 inches thick or more. Because this soil is very hard when dry and very firm when moist, the penetration of air, water, and roots is difficult and grass roots are scarce.

These soils have a weakly developed profile. They formed in calcareous, clay-textured alluvium that washed from exposed red shale and clay of the Permian red beds in the uplands. The plant cover was a sparse stand of short bunchgrasses and thorny mesquite shrubs.

Treadway soils are somewhat excessively drained. They have very slow permeability and are droughty.

Treadway soils occur with the Miller, Vernon, and Lincoln soils. Treadway soils are distinguished from the Miller soils by a low content of organic matter and platy structure in the surface layer. They are not so well developed as the Vernon soils, which formed in residuum of the Permian red beds. Unlike the Lincoln soils, Treadway soils are clay textured throughout the profile.

Typical profile of Treadway clay, about 1,300 feet north and 150 feet east of the southwest corner of section 22, T. 23 N., R. 15 W., on east side of road in native pasture:

- A1—0 to 6 inches, reddish-brown (2.5YR 5/4) clay, reddish brown (2.5YR 4/4) when moist; weak, thin, platy structure; calcareous; pH 8.2; few roots; gradual boundary.
- B—6 to 45 inches +, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) when moist; weak, thin, platy structure to massive; very few roots; calcareous; pH 8.2; very hard when dry, very firm when moist.

The A1 horizon, which is the surface layer, ranges from heavy clay to heavy clay loam. This soil is massive, or its structure ranges from platy to blocky. Salinity ranges from slight to strong. In some areas the profile is noncalcareous in the upper few inches. It is slightly saline in most places. In areas near the river, deposits of sand occur below a depth of 50 inches.

Treadway clay (T_w).—This soil is on nearly level aprons, fans, and flood plains at the mouths of shallow draws in the erosional red beds. This soil lies between broad, slightly higher areas of Vernon-Badland complex, 1 to 3 percent slopes, on lower areas of the flood plains along the Cimarron River. Salinity is slight. Slopes range from 0 to 1 percent. The profile of this soil is the one described as typical of the Treadway series.

Included with this soil in the mapping were small areas of Vernon, Lincoln, and Miller soils.

In some places runoff from higher areas washes in red sediments that accumulate as thin films on the surface. Other areas have shallow rills and a few small gullies that were gouged by this runoff.

Because Treadway clay is droughty and low in fertility, it is not suited as cropland and is used mostly as range. Some fields have been cultivated, but they were abandoned because yields were low, even when moisture was favorable. Much of the vegetation is tolerant of salt. Plants are

mainly vine-mesquite, alkali sacaton, western wheatgrass, sideoats grama, and some mesquite trees.

In well-managed areas, the cover of vegetation is fair. Grasses are fairly dense in areas where they are protected from livestock by thorny mesquite trees. Areas more easily reached by livestock are more heavily grazed. Vegetation is the thickest in areas where this soil is most porous. In bare areas, the soil puddles when wet and crusts when dry. Management is needed that maintains soil structure and fertility and that increases the intake of water. (Capability unit VI_s-1; Red Clay Flats range site; windbreak suitability group 4)

Vernon Series

The Vernon series consists of shallow, nearly level to steep, reddish-brown soils that developed in calcareous shale and clay beds. These soils occur in areas of escarpments and breaks in the broad upland prairies of Major County.

The surface layer is reddish-brown, calcareous clay loam about 6 inches thick. It is slightly hard when dry but is friable and crumbles easily to granules when moist. The subsoil is red, granular, calcareous clay loam that, at a depth of about 16 inches, grades to light clay containing small fragments of calcareous shale. Below a depth of 22 inches is unweathered, calcareous shale or clay beds.

The Vernon soils formed in material derived from calcareous shale and clay beds of the Permian red beds. The plant cover was mostly short and mid grasses.

These soils are well drained and have rapid runoff and very slow permeability.

The Vernon soils occur with the Weymouth, Quinlan, Renfrow, Tillman, and LaCasa soils. Vernon soils are not so deep as the Weymouth soils and have a less mature profile than the Renfrow, Tillman, and LaCasa soils.

Typical profile of Vernon clay loam, 0 to 3 percent slopes, 270 feet north and 75 feet west of the southeast corner of section 26, T. 21 N., R. 11 W.:

- A1—0 to 6 inches, reddish-brown (2.5YR 4/4) clay loam, dark reddish brown (2.5YR 3/4) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; few worm casts; calcareous; gradual boundary.
- B—6 to 16 inches, red (2.5YR 4/6) clay loam, dark red (2.5YR 3/6) when moist; moderate, medium, granular structure; hard when dry, friable when moist; calcareous; gradual boundary.
- C—16 to 22 inches, red (2.5YR 5/8) light clay, reddish brown (2.5YR 4/4) when moist; weak, fine, blocky structure; hard when dry, firm when moist; partly weathered, calcareous shale.
- R—22 to 30 inches +, reddish-brown (2.5YR 5/4), unaltered shale; few small, distinct gray spots.

The A1 horizon ranges from 3 to 10 inches in thickness and from clay loam to light clay in texture. When dry, this layer ranges from reddish brown to red. The B horizon ranges from clay loam to clay and contains small fragments of shale in places. Depth to unweathered, red-bed shale and clay beds ranges from about 10 to 20 inches. In the lower part of the profile in some places, fine concretions of lime make up 1 to 25 percent of the soil mass.

Vernon clay loam, 0 to 3 percent slopes (V_cB).—This nearly level to gently sloping soil is widely scattered throughout areas of red beds. The largest acreage lies on the valley floor between rough escarpments and the flood plains of the Cimarron River. This soil is bordered by the

Tillman soils in the western part of the county and by the Renfrow soils in the eastern part. Small areas of these associated soils were included in the mapping. The profile of this soil is the one described as typical of the Vernon series.

Rangeland shows little or no evidence of erosion. In cultivated areas, erosion is slight in most places, but in unprotected areas thin sheets of soil are gradually removed by wind and water. In plowed fields where no residue is left on the surface, runoff gouges rills or shallow gullies during intense rains.

Most of this soil is cropland. Small grains are well suited, and winter wheat is the main crop. Sorghums grow well when moisture is favorable, but they are damaged in dry, hot weather.

Management is needed, mainly for controlling soil blowing and water erosion, for this soil is moderately fertile. If terraces are used and crop residue is left on the surface, runoff is slowed and more water is absorbed. The crop residue helps to prevent surface crusting, and it reduces puddling. (Capability unit IIIe-1; Hardland range site; windbreak suitability group 4)

Vernon soils, 3 to 5 percent slopes, eroded (VeC2).—These soils are in inextensive areas in the uplands east of Fairview. Except for a few small strips, all of this mapping unit has been cultivated. The present surface layer has been thinned by erosion to the extent that, in places, part of the subsoil has been mixed with the original surface layer. The surface layer is clay loam in most places, but it ranges to light clay. This layer is lighter colored than the one described as typical of the Vernon series.

Included in the mapping were small areas of Quinlan and Renfrow soils. Also included were some narrow strips of rangeland that are only slightly eroded.

Because these soils are shallow and have low fertility, they are better suited as range than as cropland. Some areas have been cultivated with adjoining fields of other soils, and others have been reseeded to grass and left idle. In some cultivated areas, runoff has gouged shallow gullies and rills that cannot be removed by normal tillage. These gullies and rills can be crossed by farm machinery. Eventually the cultivated areas will be unsuitable as cropland unless they are well managed. A cropping system is needed for increasing the content of organic matter and maintaining soil structure. Native grasses suitable for reseeding or for establishing waterways are vine-mesquite, blue grama, and buffalograss. In severely eroded spots, sorghum is stunted because of lack of plant nutrients and the resulting chlorosis. (Capability unit IVe-4; Red Clay Prairie range site; windbreak suitability group 4)

Vernon-Badland complex, 1 to 3 percent slopes (VnB).—This complex consists of shallow Vernon soils intermingled in an irregular pattern with areas of Badland. These erosional, partly barren areas are below the blufflike escarpments in the western part of Major County. They form a dissected plain that slopes in the general direction of the Cimarron River. The Vernon soils make up 30 to 70 percent of many areas, and Badland makes up 15 to 50 percent.

The Vernon soils in this complex have a profile similar to the one described for the Vernon series, but it is more shallow over shale and clay. The Vernon soils are deeper where they occur in large areas. The vegetation on Vernon soils consists of a scanty growth of grasses, forbs, legumes, and scrubby mesquite trees.

The Badland of this mapping unit consists of almost barren areas of shale and clay beds cut by numerous gullies 1 to 10 feet deep. Low escarpments are in some areas. A few scattered annuals, sedges, and cactus plants make up most of the sparse vegetation.

This complex is not suited to crops, and its scanty vegetation provides little grazing (fig. 17). Vegetation is thickest in summer when many weeds are present. In flat drains or in level areas, 2 to 6 inches of a fresh overwash of red clay has accumulated. Some annuals grow in these deposits, but the deposits do not stay in place long enough for the annuals to get a foothold.

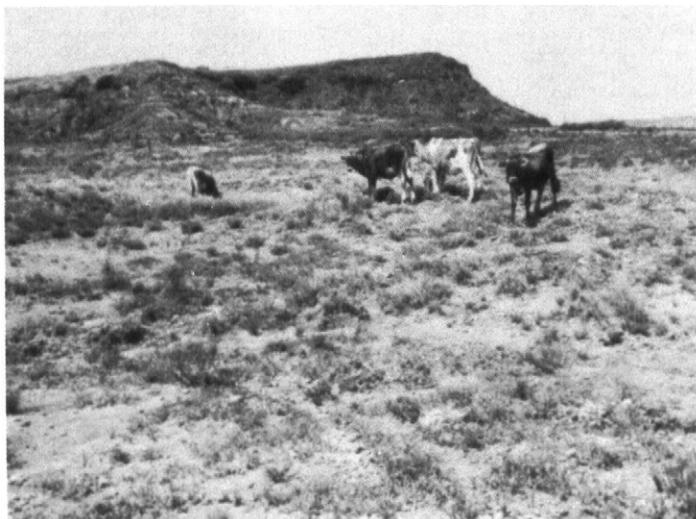


Figure 17.—Vernon-Badland complex in the foreground and Rough broken land, clayey, in the background.

Management is needed on this complex to prevent overgrazing. Because there is much runoff from the steep slopes above the complex, many ponds have been constructed to catch the excess water. In these areas it is important that the numerous fragments of gypsum are removed because the gypsum dissolves in water and leaves these soils susceptible to seepage. (Capability unit VIIs-4; Eroded Red Clay range site; windbreak suitability group 4)

Vernon-Gypsum outcrop complex (Vp).—This complex consists of the shallow Vernon soils and outcrops of gypsum. These soils and outcrops are intermingled in such an intricate pattern that it is not practical to map them separately. The complex is in the western part of the county. Slopes range from gently sloping to steep and in some of the more broken areas are more than 20 percent.

The Vernon soils developed over almost impervious red beds of Permian shale and clay, and the outcrops of gypsum are prominent in hard, whitish beds. The Vernon soils make up 25 to 40 percent of this complex, and the outcrops of gypsum make up 15 to 30 percent. Also in the complex are small areas of a shallow to very shallow soil that has a dark silt loam surface layer and makes up 15 to 30 percent of the complex. Weymouth and St. Paul soils make up less than 15 percent.

The Vernon soils in this complex are similar to the soil described for the Vernon series but are slightly more shallow. Unprotected areas of this shallow soil overlying gypsum are especially susceptible to erosion.

Broad areas of this complex are positioned on rims of mesa areas surrounded by clifflike sides dropping 50 to 75 feet. These areas are more than 100 acres in size. The blufflike slopes block livestock in some areas to the valley below, but in places the animals find pathways. Small partly barren areas that are less than 3 acres in size are at the crests of small buttes, 75 to 175 feet above the general landscape. The side slopes of these buttes are so steep and rugged that livestock seldom are able to reach the top and graze the scanty vegetation. Other areas near the rims of deep, ravinelike drainageways are 25 to 100 acres or more in size. Runoff is rapid to very rapid in most areas. It is extremely rapid in places where large amounts of gypsum crop out.

All of this mapping unit is rangeland (fig. 18). The management most needed is regulation of grazing. Erosion gradually damages these soils, especially where the vegetative cover is thin or lacking. The principal vegetation consists of sideoats grama, little bluestem, vine-mesquite, blue grama, buffalograss, and scattered cactus, forbs, and red-cedar trees.

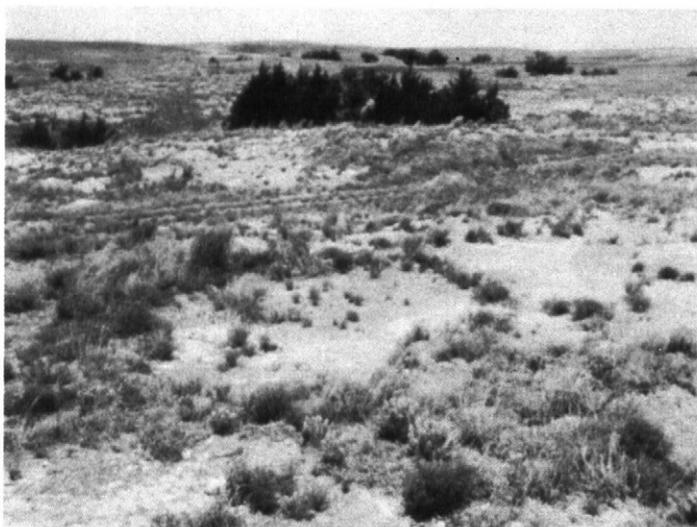


Figure 18.—Vernon-Gypsum outcrop complex. The barren areas are outcrops of gypsum.

Sites on this complex generally are not suitable for constructing ponds, because they contain a large amount of gypsum in places. Sinks are numerous in scattered areas, and water runs into them and adds to the ground water.

In the gypsum beds are many small caves called bat caves because they are inhabited by a large number of bats. Some guano has been excavated from these caves for commercial use. (Capability unit VII-3 and windbreak suitability group 4; Vernon soil is in Red Clay Prairie range site, and Gypsum outcrop is in Gyp range site.)

Weymouth Series

In the Weymouth series are gently sloping to strongly sloping soils that are moderately deep over partly weathered shale and sandstone. Broad areas of these soils occur in the western part of Major County, and smaller areas are in the northeastern part.

The surface layer consists of brown to reddish-brown, noncalcareous, granular clay loam about 7 inches thick. It is slightly hard when dry but is friable when moist. The subsoil, about 6 inches thick, is reddish-brown calcareous clay loam. It has granular structure and crumbles easily when moist. Beneath this is clay loam that is weathered less than the subsoil and breaks into medium subangular blocks. It is calcareous and contains a few fine concretions of lime. Light-red partly weathered shale and sandstone of the red beds occur at a depth of 24 inches and contain a few concretions of lime.

In some places the Weymouth soils formed in a mantle of calcareous material. In other places they formed in material weathered from the calcareous shale and clay of the Permian red beds that contain thin layers of gypsum. These soils formed under a cover of native grasses.

Weymouth soils are well drained and somewhat excessively drained. They have moderate permeability, medium available moisture capacity, and medium to rapid runoff.

Weymouth soils occur with the Nash, Grant, and Pond Creek soils in the northeastern part of the county. They are less deeply leached than the Nash soils and are not so well developed as the Grant and Pond Creek soils. Weymouth soils occur with the Vernon, Dill, Carey, St. Paul, and LaCasa soils in the western part of the county. They are not so deep as the Carey, St. Paul, or LaCasa soils but are deeper and more granular than the Vernon. Weymouth soils are less sandy than the Dill.

Typical profile of a Weymouth soil that has a clay loam surface layer and is 200 feet south and 150 feet west of the northeast corner of the northwest quarter of section 11, T. 22 N., R. 16 W., on west side of road in cultivated field:

- Ap—0 to 7 inches, reddish-brown (5YR 4/4) clay loam; dark reddish brown (5YR 3/4) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; pH 7.5; gradual boundary.
- B—7 to 13 inches, reddish-brown (2.5YR 5/4) clay loam, reddish brown (2.5YR 4/4) when moist; strong, medium, granular structure; slightly hard when dry, very friable when moist; calcareous; pH 7.5; gradual boundary.
- Cca1—13 to 24 inches, reddish-brown (2.5YR 5/4) clay loam, reddish brown (2.5YR 4/4) when moist; moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist; calcareous; few fine concretions of calcium carbonate; clear boundary.
- Cca2—24 to 38 inches, light-red (2.5YR 6/6), partly weathered sandstone and sandy shale, red (2.5YR 5/6) when moist; structureless (massive); few small concretions of lime.

In most places in the northeastern part of the county, the A horizon is loam, but in small areas it is clay loam, silt loam, and very fine sandy loam. In the western part of the county, this layer is mostly clay loam, but in small areas it is loam or silt loam. When dry, the A horizon ranges from reddish brown to dark grayish brown. The C horizon ranges from loam to clay loam, and in some places it is stratified. The profile generally is calcareous throughout, but in a few areas the upper 12 inches is noncalcareous. The C horizon contains concretions of lime that make up as much as 10 percent of the soil mass.

Weymouth loam, 1 to 3 percent slopes (WeB).—This gently sloping soil of the uplands is inextensive in Major County and occurs mostly in the northeastern part. Some of the larger areas are north of Ringwood. The profile of this soil is similar to the one described for the Weymouth series, but the surface layer is loam instead of clay loam and is about 10 inches thick. It is underlain by light-col-

ored, calcareous material that contains a few soft and hard concretions of lime. Some of these concretions, about 1 inch in diameter, are scattered in spots on cultivated fields, generally on low, rounded knolls or knobs. In most places these concretions have been brought to the surface by tillage.

Included with this soil in the mapping were small areas of moderately eroded Nash, Grant, Pond Creek, and Weymouth soils. These included areas are generally along drainageways in cultivated fields. So much soil material has been removed that the surface layer now is light-colored material that was subsoil.

About 75 percent of this soil is cultivated, mainly to winter wheat and grain sorghum. Suitable crops are small grains and sorghums. Sorghums are commonly affected by chlorosis in severely eroded spots when the soil is thin and lacking in plant nutrients.

On this soil management is needed to maintain fertility and to protect the soil from water erosion and soil blowing. (Capability unit IIe-1; Hardland range site; windbreak suitability group 4)

Weymouth loam, 3 to 5 percent slopes, eroded (WeC2).—This moderately sloping soil occurs in the uplands, mostly in the northeastern part of the county. The areas range from about 5 to 20 acres in size. Some of the most extensive areas lie on long slopes adjacent to natural drainageways and are bordered in most places by Grant and Nash soils. Small areas of these associated soils were included in the mapping. Also included were severely eroded areas of Weymouth soils that make up about 5 percent of the areas mapped.

The surface layer of the moderately eroded Weymouth soil has been thinned and is lighter colored than normal. It is loam about 4 to 6 inches thick. The subsoil is calcareous loam that contains some concretions of lime.

On this soil erosion has been most damaging at the crests of slopes. In these places wind has removed all of the original surface layer and part of the subsoil. Caliche pebbles and lime concretions are on the surface. In some sloping areas of cultivated fields, runoff has cut shallow gullies or rills that can be partly erased by ordinary tillage.

About 95 percent of this soil has been cultivated, but of this acreage 20 percent has been reseeded to grass or is idle. Small grains and sorghums are the principal crops. In scattered, eroded spots, fertility is lowered because plowing has mixed the light-colored subsoil into the surface layer. Protection is needed at all times because this soil erodes severely in periods of intense rainfall and the powdery, loose surface layer blows readily in dry periods. Chlorosis is common in grain sorghum in severely eroded areas, for these areas lack plant nutrients. Unless management is improved, this soil will be unsuitable for crops. Native grasses are suitable for seeding range, abandoned fields, or waterways. (Capability unit IVe-3; Hardland range site; windbreak suitability group 3)

Weymouth-LaCasa complex, 1 to 3 percent slopes (WIB).—These gently sloping soils are on the ridges of broad divides between drainageways of the uplands in the western part of the county. They developed in shale and clay of the Permian red beds. The Weymouth soils are so intermingled with small narrow strips of LaCasa soils that it is not practical to map either kind of soil separately.

The Weymouth soils make up 30 to 50 percent of the complex, and the LaCasa soils, 20 to 50 percent. Inclusions of St. Paul and Carey soils make up 15 percent. In the

included areas the soils normally are in shallow spots and overlie whitish gypsum. These spots are evident in cultivated fields because tillage has mixed the powdery gypsum into the surface layer.

The Weymouth soils are generally at the higher parts of the complex. Their profile is less developed than that of the LaCasa soils, and their subsoil is less prominent. The Weymouth soils are moderately deep. Their surface layer ranges from loam to clay loam and is underlain by a friable, granular subsoil. The LaCasa soils are deep. Their surface layer is mostly clay loam and is underlain by a moderately tight subsoil of heavy clay loam.

This mapping unit is almost entirely cropland. Wheat, other small grain, and sorghums grow well in years when there is enough rainfall. Production can be maintained where management is intensive and provides a suitable cropping system. Where terraces are constructed, the unstable gypsum ought to be removed. (Capability unit IIIe-1; Hardland range site; windbreak suitability group 3)

Weymouth-LaCasa complex, 3 to 5 percent slopes (WIC).—This complex occurs in fairly small areas in the rolling, dissected uplands in the western part of the county. It consists of broad areas of Weymouth soils mixed with narrow strips of LaCasa soils. These soils are so intermingled that it is not practical to map them separately. They developed in shale and clay of the Permian red beds that lie above the large outcrops of gypsum.

The Weymouth soils make up 30 to 60 percent of many areas, and the LaCasa soils make up 20 to 40 percent. The Weymouth soils are mostly at the crests of the slopes, and the LaCasa soils are mostly on the lower parts of slopes. The Weymouth soils are calcareous and are shallow to moderately deep. Their surface layer ranges from loam to clay loam and is underlain by a friable, granular subsoil. The surface layer of the deep LaCasa soils is normally clay loam. It is underlain by a moderately tight subsoil consisting of heavy clay loam.

Small inclusions of Vernon, Carey, Quinlan, Dill, and St. Paul soils are common. Also included were spots of a shallow soil that is underlain by whitish, soft to hard gypsum. These spots can be seen in clean-tilled fields because plowing has mixed the whitish gypsum into the surface layer. In some places these spots contain fragments of dolomitic gypsum.

The soils in this complex are fairly well suited as cropland and are well suited as rangeland. About 50 percent of the total acreage is range. Winter wheat is the principal crop, but other small grains and sorghums are also suitable. Water erosion is the main concern in cultivated areas, though soil blowing is also a problem. The unstable gypsum should not be mixed into the soil material when constructing terraces. On rangeland the main concern is regulation of grazing. (Capability unit IVe-1; Hardland range site; windbreak suitability group 3)

Weymouth-LaCasa complex, 3 to 5 percent slopes, eroded (WIC2).—The soils in this complex occur in broad areas in the rolling uplands in the western part of Major County. These soils have been thinned by erosion, and their surface layer is lighter colored than normal because it has been mixed with parts of the subsoil through tillage. In some spots, the surface layer consists entirely of material from the original subsoil.

The Weymouth soils make up 30 to 60 percent of this

complex, and the LaCasa soils, 20 to 40 percent. Carey, Dill, Quinlan, St. Paul, and Tillman soils, along with whitish outcrops of powdery to hard gypsum and dolomite, may make up as much as 15 percent of any area mapped. Other inclusions are small, severely eroded spots of a shallow soil that has been mixed with fragments of shale and sandstone. In a few strips of rangeland erosion is only slight.

In some fields where terraces have not been constructed, runoff has gouged a few shallow rills and gullies that cannot be removed by ordinary tillage. In places several slight rills at the crests of slopes cluster together and form a distinct rill or a shallow gully at the bottom of the drainageway.

Except for a few strips adjoining fields, all of this complex has been cultivated, mainly to winter wheat and grain sorghum. Small grains and sorghums are suitable crops, but in severely eroded spots, chlorosis develops in grain sorghum because plant nutrients are lacking. Unless management is improved, these soils will become unsuitable for crops.

The main hazard on these soils is the rapid runoff from the long, moderate slopes, but soil blowing is also likely. The soil material used to construct terraces should be free of the unstable gypsum. Suitable native grasses for vegetating waterways or for seeding fields are sidecoats grama, blue grama, buffalograss, and in small amounts, tall grasses. (Capability unit IVe-4; Hardland range site; wind-break suitability group 3)

Weymouth-Vernon complex, 5 to 12 percent slopes (WvE).—This complex occurs in the rolling dissected areas of the red beds, generally in the western part of the county. A few small areas are in the eastern part. Broad areas are above the rims of gypsum beds on the steep breaks, and some areas are on slopes that extend from the blufflike breaks to the valley floor that is below. Above the breaks is a strip of rolling rangeland between the steep rims of gypsum outcrops and the smoother Weymouth and LaCasa soils at higher elevations. The areas below the escarpments lie between the bluffs and areas of the Vernon-Badland complex on lesser slopes.

The Weymouth soils make up 60 to 80 percent of this complex, and the Vernon soils make up 20 to 40 percent. Inclusions of Tillman, Carey, and the St. Paul soils may make up 10 percent of any area mapped. Other included areas that may make up 5 to 10 percent are gypsum outcrops, exposed red beds, and clayey soils of bottom lands along the narrow drainageways.

The moderately deep Weymouth soils are in the smoother areas. The shallow Vernon soils are normally on the higher side slopes and ridges.

Because the soils in this complex are strongly sloping and rough, they are not suited as cropland. They are well suited as range (fig. 19). More than 95 percent of the acreage has a grass cover, though red beds crop out in a few barren areas. In well-managed areas, the grass cover includes sidecoats grama, little bluestem, vine-mesquite, blue grama, and buffalograss. Good ponds are in many of

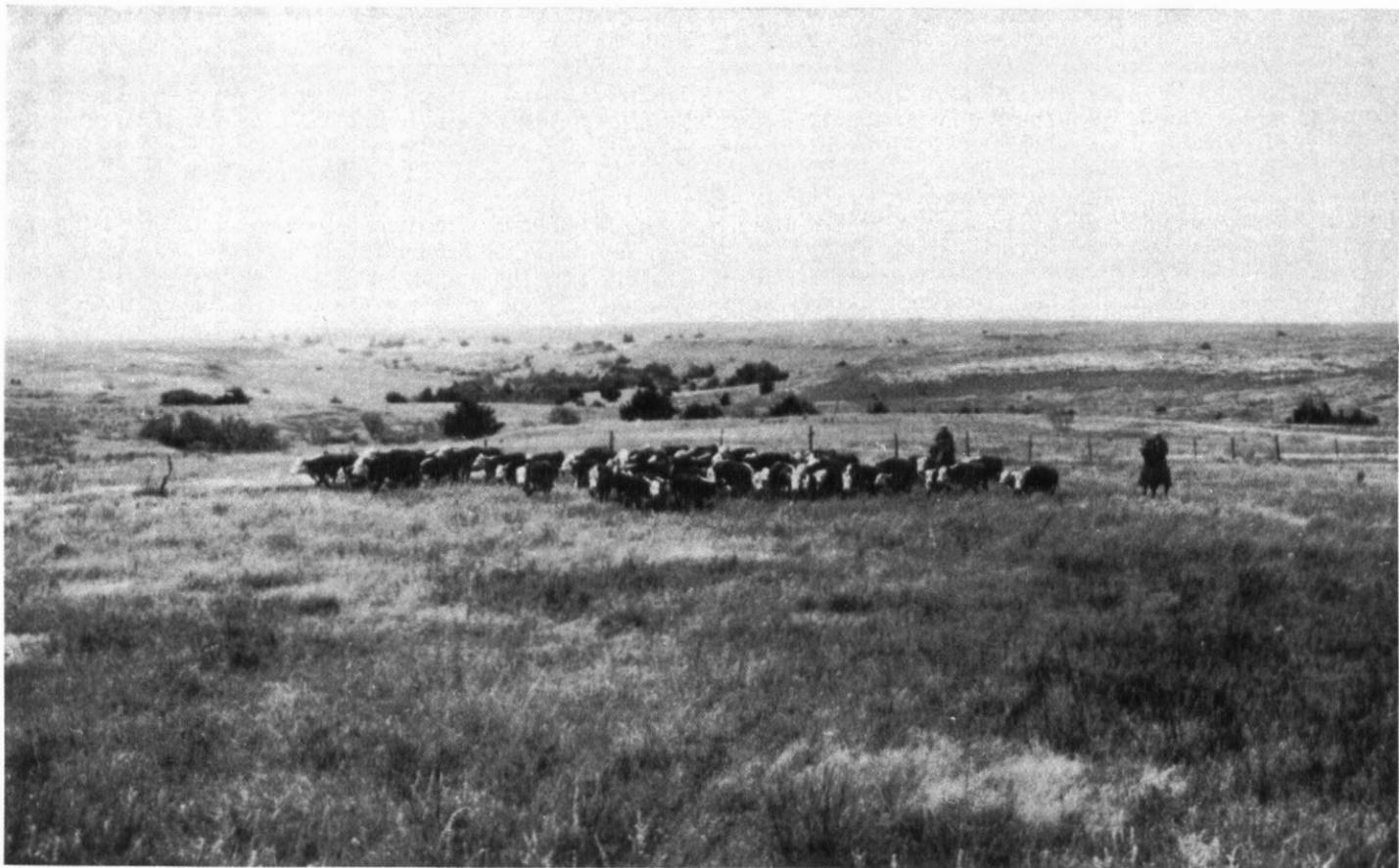


Figure 19.—Area of rangeland on Weymouth-Vernon complex, 5 to 12 percent slopes.

the drainageways, but a few ponds have developed leaks where gypsum is in the fill material. (Capability unit VIe-7 and windbreak suitability group 4; Weymouth soils are in Hardland range site, and Vernon soils are in Red Clay Prairie range site)

Yahola Series

The Yahola series consists of reddish-brown to dark reddish-brown, calcareous soils that have a fine sandy loam surface layer that is underlain by fine sandy loam stratified with loam and loamy fine sand. These smooth, nearly level soils are on broad bottom lands along the Cimarron River and on the narrow bottom lands of streams flowing from the uplands.

The surface layer is reddish-brown to dark reddish-brown, calcareous fine sandy loam about 9 inches thick. It is very friable and has medium granular structure. Underlying the surface layer is yellowish-red fine sandy loam that is stratified with loam or loamy fine sand and extends to a depth of 60 inches. This layer is very friable and easily penetrated by air, water, and roots.

The Yahola soils formed in fine sandy loam that is stratified with loamy sand. This material was sorted by water and deposited on low terraces by the floodwater from nearby streams. The native vegetation was a dense cover of mid and tall grasses.

Yahola soils occur with the Port, Lincoln, Elsmere, Leshara, Canadian, Reinach, and Enterprise soils. Yahola soils are more sandy than the Port soils and are less sandy, redder, and slightly higher than the Lincoln. Color is lighter in the Yahola soils than in the Canadian and Reinach, for lime has not been so deeply leached. Yahola soils lack the high water table of the Elsmere and Leshara soils. They are in lower positions and are more stratified in the subsoil than the Enterprise soils. Yahola soils are well drained; water penetrates them at a moderately rapid rate.

Typical profile of Yahola fine sandy loam, 1,310 feet west and 66 feet north of the southeast corner of the northeast quarter of section 36, T. 22 N., R. 16 W., on the east side of the road in a cultivated field:

- A—0 to 9 inches, reddish-brown (5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, medium, granular structure; soft when dry, very friable when moist; calcareous; gradual boundary.
- C—9 to 60 inches, yellowish-red (5YR 5/6) fine sandy loam; stratified with loam and loamy fine sand, yellowish red (5YR 4/6) when moist; weak, medium and fine, granular structure and single grain; soft to loose when dry, very friable when moist; calcareous.

The A horizon ranges from 8 to 12 inches in thickness. In small areas it is thin, winnowed loamy fine sand. The C horizon varies in texture from place to place but averages fine sandy loam to a depth of 60 inches.

Yahola fine sandy loam (0 to 2 percent slopes) (Ya).—This soil is most extensive along the flood plains of streams in the western part of the county. Many areas are subject to occasional flooding. Because the surface layer is porous, water is readily absorbed by this soil and drainage is good. The profile of this soil is the one described as typical of the Yahola series.

Included with this soil in the mapping were small areas of Port, Canadian, Reinach, and Lincoln soils totaling less than 15 percent of any area mapped. Also included

were some areas that have a surface layer of loamy fine sand or very fine sandy loam. About 85 percent of this soil is cultivated. Small grains and grain sorghum are grown in about equal acreages. Also suitable are forage crops, native grasses, and alfalfa and other legumes. Sprinklers are used for irrigation in some areas.

In cultivated fields the main concerns are maintaining soil structure, reducing soil blowing, and controlling overflow. Crops that produce a large amount of residue are grown to help reduce erosion and to maintain the organic-matter content in the surface layer. Before it is mixed into the soil, the crop residue should remain on the surface for protection during the critical period of blowing. Changing the depth of tillage helps to reduce the formation of plowpans. In places diversion terraces are needed for diverting the runoff from higher areas.

On rangeland the main concern is to prevent overgrazing. In well-managed areas, suitable grasses for pasture, range, or grassed waterways are indiangrass, big bluestem, little bluestem, switchgrass, sideoats grama, and western wheatgrass. (Capability unit IIw-1; Loamy Bottomland range site; windbreak suitability group 1)

Use and Management of Soils

The soils of Major County are used extensively for cultivated crops and native range. This section explains how the soils may be used for these main purposes and also for woodland, windbreaks, and post lots; for wildlife; and in the building of highways, farm ponds, and other engineering structures. Also given are predicted yields of the principal crops under two levels of management.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have their special requirements. The soils are classified according to degree and kind of permanent limitation, 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 major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.

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

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

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

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. (None in Major County)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated 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* shows 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 United States, shows that the chief limitation is climate that is too cold or too dry.

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

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are 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 designated by adding an Arabic numeral to the subclass symbol, for example IIe-1, or IIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph.

Management by capability units

In the following pages, the capability units in Major County are described and suggestions for the use and management of the soils are given. If only one soil is in a capability unit, the soil is named. If more than one soil is in a capability unit, the names of the soils are not given, but the names of the soil series to which the soils in the capability unit belong. The names of all the soils in any capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This capability unit consists of nearly level, deep, dark-colored soils that are well drained or moderately well

drained. These soils are in the McLain, Port, Reinach, and Tipton series. They are on bottom lands and low terraces along streams and are above the level of ordinary flooding.

These soils are high in natural fertility and have high or moderately high available moisture capacity. Some areas of the Port soils are occasionally flooded, but crops are seldom damaged.

The soils of this unit are suited to all crops commonly grown in the county. Among the most important crops are winter wheat, sorghums, and alfalfa.

These soils have only slight limitations to use, and they can be clean tilled year after year if the crops used return enough organic material. The crop residues should be shredded and left on the surface for reducing crusting and for protection against wind erosion. A plowpan can be prevented by varying the depth of tillage.

CAPABILITY UNIT I-2

Pond Creek silt loam, 0 to 1 percent slopes, is the only soil in this capability unit. It is a deep, well-drained, nearly level soil of the uplands.

This soil is high in natural fertility and available moisture capacity. It is suited to all crops commonly grown in the county. Some of the more important crops are winter wheat and other small grains, sorghums, and alfalfa.

This soil has no apparent limitations for farming, and it can be used year after year for clean-tilled crops if enough organic material is returned. Crop residue should be shredded and left on the surface so as to reduce crusting and to give some protection against soil blowing. Varying the depth of tillage helps to remove plowpans or to prevent their formation.

CAPABILITY UNIT IIe-1

This capability unit consists of deep and moderately deep, well-drained, gently sloping soils of the uplands. These soils are in the Carey, Grant, Pond Creek, St. Paul, and Weymouth series. They are easily tilled, have medium to high available moisture capacity, and are moderately high or high in natural fertility.

The soils in this unit are suited to the crops commonly grown in the county. Important crops are wheat, other small grain, and sorghums. The soils are also suited to native grasses. Cropping systems are needed that provide enough crop residue for protection against soil blowing.

Cultivated areas of these soils are susceptible to soil blowing and water erosion. Practices that are effective in reducing erosion are terracing, contour tillage, vegetating the waterways, and stubble mulching. A plowpan can be prevented or removed by varying the depth of tillage. Diversion terraces may be needed to divert water that runs in from adjacent slopes.

CAPABILITY UNIT IIe-2

This capability unit consists of soils that occur on bottom lands and low terraces. These deep, well-drained, nearly level soils are in the Canadian and Port series. They have a fine sandy loam surface layer and a friable, permeable subsoil.

The soils in this unit are easily tilled and have medium to high available moisture capacity. Runoff is slow and is in only small amounts. Flooding is occasional and is in small areas.

Among the principal crops are winter wheat, sorghums, and alfalfa. These crops should be grown in cropping systems that provide residue in amounts that control soil blowing.

Where these soils are cultivated, they are subject to soil blowing. Soil blowing can be reduced by planting crops in rows that run at right angles to the prevailing winds, by effectively managing crop residue, by vegetating the waterways, and by stubble mulching. Varying the depth of tillage is effective in helping to remove plowpans or in preventing their formation. Diversion terraces may be needed to intercept water and keep it from running in from adjacent slopes.

CAPABILITY UNIT IIc-3

This capability unit consists of deep, nearly level to gently sloping soils of the uplands. These soils have a fine sandy loam or loamy fine sand surface layer. They are in the Meno, Ortello, and Shellabarger series.

The soils in this unit absorb water readily and are easily and deeply penetrated by plant roots. They are, however, susceptible to soil blowing.

The principal crops are winter wheat and other small grains, sorghums, cowpeas, and Austrian Winter peas. Some alfalfa is also grown. These crops should be grown in cropping systems that provide residue in amounts that control soil blowing.

Effective practices are vegetating the waterways, planting crops in rows that run at right angles to prevailing winds, managing crop residue, and stubble mulching. Excessive tillage should be avoided so as to reduce damage by wind. Varying the depth of tillage helps to remove plowpans or prevent their formation.

CAPABILITY UNIT IIc-1

This capability unit consists of nearly level soils that occur on uplands. These soils are in the Kirkland, Renfrow, and Tillman series. They have a very slowly permeable subsoil that is clay or silty clay. The surface layer is silt loam, silty clay loam, or clay loam.

These soils are fairly high in content of organic matter and plant nutrients, but they are somewhat difficult to till, are very slowly permeable, and are droughty. Soil crusting prevents many of the seedlings from emerging.

These soils are suited to crops that mature early, that resist drought, or that grow well in cool seasons. Some of these crops are winter wheat, oats, and barley. Sorghums are planted when moisture is plentiful. All of these crops should be grown in cropping systems that provide residue in amounts that control soil blowing.

Practices effective in reducing erosion are contour tillage, terracing, vegetating the waterways, managing crop residue, and stubble mulching. Damage from the wind is reduced by avoiding excessive tillage. Varying the depth of tillage helps to remove plowpans or prevent their formation.

CAPABILITY UNIT IIw-1

This capability unit consists of deep, loamy, nearly level soils of the flood plains. These soils are in the Leshara and Yahola series. They are in low positions, but they are fertile and easily tilled. The Yahola soil is occasionally flooded. The Leshara soil is seldom flooded, but its water table is usually within 5 feet of the surface.

The principal crops are sorghums and small grains, and there is some cotton. Grasses are also suited. These crops



Figure 20.—Austrian Winter peas are grown on Shellabarger soils as a protective cover during winter and spring, the critical period of soil blowing.

should be grown in cropping systems that provide a protective amount of crop residue for controlling soil blowing.

The main concerns in managing these soils are excessive wetness and the occasional damage by floods. Soil blowing is a slight hazard. Crop residue should be shredded and left on the surface to reduce crusting and to give some protection against the wind. Varying the depth of tillage is effective in removing and preventing plowpans. Diversion terraces may be needed to intercept water and keep it from running in from adjacent slopes. In some places a drainage system that rapidly removes floodwater is beneficial.

CAPABILITY UNIT IIw-2

Only Carwile-Shellabarger complex, 0 to 1 percent slopes, is in this capability unit. This complex consists of soils that are in depressions of the uplands and are susceptible to occasional ponding.

Except in low areas that are ponded for several days, crop damage from excess water is only slight. The risk of soil blowing is moderate.

The principal crops on these soils are winter wheat, other small grains, and sorghums. Grasses, legumes, and other crops adapted to the area are also suited. These crops should be grown in cropping systems that provide residue in amounts that control soil blowing.

Cultivated areas of these soils are susceptible to soil blowing, and crop damage from ponded water is also a problem. A cover crop is needed in winter and spring, when soil blowing is most likely (fig. 20). Crop residue should be shredded and left on the surface to reduce crusting and to give some protection against the wind. Varying the depth of tillage helps to remove plowpans or to prevent them from forming. A drainage system is beneficial in removing ponded water.

CAPABILITY UNIT IIc-1

St. Paul silt loam, 0 to 1 percent slopes, is the only soil in this capability unit. This soil occurs on uplands and is



Figure 21.—Stubble-mulch farming where protective amounts of residue have been left on the surface. The soil is St. Paul silt loam, 0 to 1 percent slopes.

deep, dark, and nearly level. It is easily tilled and moderately permeable to air and water, but it is droughty unless moisture is conserved.

The principal crops are small grains and sorghums, though grasses and other crops adapted to the area are also suited. Alfalfa and other perennials may not survive during the long dry periods. All crops on this soil should be grown in systems that provide crop residue in amounts that control soil blowing.

Management is needed to conserve moisture and maintain fertility, and to prevent compaction and surface crusting. Practices effective in reducing erosion are contour tillage, terracing, vegetating the waterways, managing crop residue, and stubble mulching (fig. 21). Damage by wind is reduced if excessive tillage is avoided. Varying the depth of tillage helps to remove plowpans or to prevent their formation. Diversion terraces may be needed to intercept water or to break long slopes. Moisture is conserved by using terraces that impound water.

CAPABILITY UNIT IIIe-1

This capability unit consists of nearly level to gently sloping, loamy soils that occur on uplands and have a compact, moderately slowly to very slowly permeable subsoil. These soils are in the Renfrow, Tillman, Vernon, Weymouth, and LaCasa series. They absorb water slowly to very slowly and lose much of it through runoff. They are droughty and susceptible to severe erosion.

The principal crops are small grains, though sorghums and sudangrass are also grown. Native grasses are suited. Winter wheat is generally the most extensive crop. Practices are needed that help to conserve moisture and fertility. Crops on these soils should be grown in a system that provides residue in amounts that help to control soil blowing.

Both soil blowing and water erosion are likely if these soils are cultivated and are not protected by a growing crop and other means. Practices effective in reducing erosion are contour tillage, terracing, vegetating the waterways, managing crop residue, and stubble mulching. Soil blowing is reduced if excessive tillage is avoided. Varying the depth of tillage helps to remove plowpans or to prevent

their formation. Diversion terraces may be needed to intercept water that runs in from higher slopes.

CAPABILITY UNIT IIIe-2

This capability unit consists of moderately sloping, deep, loamy soils of the uplands. These soils are in the Carey, Grant, and St. Paul series. The surface layer is silt loam.

These soils are easily tilled. They have moderately high natural fertility and medium to high available moisture capacity. Water erosion is a severe hazard.

The principal crops are small grains and sorghums. Winter wheat is the most extensive crop. Also suitable are native grasses and other crops adapted to the area. Alfalfa and other perennial legumes, however, may not survive long in dry periods. All crops should be grown in systems that provide enough residue to help control erosion.

Both water erosion and soil blowing are likely in cultivated areas. Practices effective in reducing erosion are terracing, contour tillage, vegetating the waterways, and stubble mulching. Varying the depth of tillage is effective in removing plowpans or in preventing their formation.

CAPABILITY UNIT IIIe-3

Canadian fine sandy loam, 1 to 3 percent slopes, is the only soil in this capability unit. It occurs on bottom lands and is deep, gently undulating, and well drained.

This soil is friable and easily tilled. It is permeable and is easily penetrated by plant roots. Runoff is slow to moderate. Fertility is moderately high, and available moisture capacity is moderate to high. Soil blowing is a severe hazard.

On this soil, winter wheat, other small grains, and alfalfa are suited. Wheat is the most extensive crop. Grasses are also suited to this soil. Crops should be grown in a system that provides residue in amounts large enough to control soil blowing.

Cultivated areas of this soil are susceptible to erosion. Practices effective in reducing this erosion are terracing, contour tillage, vegetating the waterways, and planting crops in rows that run at right angles to the prevailing wind. Crop residue that is left on the surface and shredded reduces crusting and gives some protection against the wind. Varying the depth of tillage is effective in removing plowpans or in preventing their formation. In some places diversion terraces are needed to intercept water that runs in from adjacent slopes.

CAPABILITY UNIT IIIe-4

This capability unit consists of soils that occur on uplands and are deep or moderately deep and well drained. Only the gently sloping to moderately sloping Dill soils are in this unit. These soils have a fine sandy loam surface layer and a friable, permeable subsoil.

The soils in this unit are easily tilled. They absorb water readily and have moderate available moisture capacity. Fertility is fair, but management that maintains fertility and controls erosion is needed.

Sorghums and wheat are the main crops on these soils, but legumes and native grasses are also suited. These crops should be grown in cropping systems that provide residue in amounts that help to control erosion.

Cultivated areas of these soils are susceptible to soil blowing and water erosion. Practices effective in reducing erosion are contour tillage, terracing, stripcropping, plant-

ing crops in rows that run at right angles to prevailing wind, vegetating the waterways, managing crop residue, and stubble mulching. Avoiding excessive tillage reduces damage by the wind. Varying the depth of tillage helps in removing plowpans or in preventing their formation. In some places diversion terraces are needed to intercept water that runs in from adjacent slopes.

CAPABILITY UNIT IIIe-5

This capability unit consists of soils that occur on uplands and are well drained. Only gently sloping to moderately sloping Enterprise soils are in this unit. These soils have a fine sandy loam surface layer that is underlain by a friable fine sandy loam subsoil.

The soils of this unit are moderately fertile and easily tilled. They are readily permeable and are easily penetrated by plant roots. Available moisture is fairly high. Soil blowing is a severe hazard.

The principal crops are small grains and sorghums, but native grasses and legumes are also suited. The cropping systems should provide residue in amounts that control wind erosion.

Cultivated areas of these soils are susceptible to soil blowing. Row crops should be planted in rows that run at right angles to the prevailing wind. Crop residue left on the surface and shredded gives some protection. Varying the depth of tillage is effective in removing plowpans or in preventing their formation. In some places vegetated waterways are needed.

CAPABILITY UNIT IIIe-6

Quinlan loam, 1 to 3 percent slopes, is the only soil in this capability unit. This shallow soil of the uplands developed in weathered sandstone of the red beds.

This soil is moderate to low in fertility. Because it is shallow, it is severely damaged if it is not properly managed.

Among the principal crops are winter wheat, sudan-grass, and sorghums. Also suited are native grasses. These crops should be grown in cropping systems that provide sufficient residue for controlling soil blowing.

Cultivated areas are susceptible to water erosion. Practices effective in reducing water erosion are terracing, contour tillage, vegetating the waterways, and stubble mulching. Varying depth of tillage helps to remove plowpans and to keep them from forming. Diversion terraces may be needed to intercept water that runs in from adjacent slopes and to break up long slopes.

CAPABILITY UNIT IIIe-7

Pratt loamy fine sand, undulating, is the only soil in this capability unit. It is a deep, gently sloping soil that occurs in the sandy areas of the uplands.

The soil in this unit absorbs water readily. It has medium available moisture capacity and about medium fertility. Runoff is slight.

Well-suited crops are sorghums and wheat; sorghums grow well almost every year. Grasses, sweetclover, cowpeas and other legumes, and some cotton and watermelons are grown on this soil. The cropping systems should provide residue in amounts that control soil blowing.

Where this soil is cultivated, it is susceptible to soil blowing. Soil blowing can be controlled by planting in crop rows that run at right angles to the prevailing wind

and by returning crop residue. The residue should be shredded and left on the surface. Varying the depth of tillage is effective in helping to remove plowpans or in preventing their formation. In some places vegetated waterways are needed.

CAPABILITY UNIT IIIe-1

Miller clay, the only soil in this capability unit, is on bottom land and is deep and nearly level. It has a subsoil of very slowly permeable clay. Slick spots are in some areas of this soil.

Water runs off and percolates through this soil very slowly. Clean-tilled areas tend to puddle when wet and to crust when dry. Some plants have difficulty pushing through the crust. The slick spots require special treatment.

Wheat, oats, and barley are the principal crops. Legumes and sorghums are not generally grown, because moisture is lacking in dry weather and stands of crops are difficult to establish.

Proper use of crop residue is the most beneficial practice on this soil. The residue should be shredded and left on the surface so that crusting is reduced, the intake of water is increased, and wind erosion is controlled. A plowpan can be prevented by varying the depth of tillage.

CAPABILITY UNIT IVe-1

This capability unit consists of deep to moderately deep, moderately permeable to very slowly permeable, moderately sloping soils on uplands. These soils are in the Tillman, Weymouth, and LaCasa series. The surface layer is clay loam. Erosion and loss of needed water are likely because of the slopes and the moderate to very slow permeability.

These soils are well suited to small grains and grasses. Sorghums grow well when moisture is adequate, but they are damaged by drought in dry summers.

Cultivated areas of these soils are susceptible to severe water erosion unless runoff is controlled. Terraces, contour tillage, and shredded crop residue on the surface are effective in reducing erosion and increasing the intake of water. Varying the depth of tillage helps to remove plowpans or to prevent their formation. In some areas vegetated waterways are needed.

CAPABILITY UNIT IVe-2

Only Grant-Nash silt loams, 5 to 8 percent slopes, is in this capability unit. This complex consists of deep and moderately deep, permeable soils on sloping uplands. It loses much water as runoff, especially in areas where there is not enough protective cover or where measures have not been taken to hold the water in place.

Because preventing damage from erosion is difficult, the soils in this unit are used mostly as grassland. Some areas are used for small grains and sorghums.

Cultivated areas of these soils are susceptible to severe water erosion. Practices effective in helping to control this erosion are terracing, vegetating the waterways, contour tillage, and stubble mulching. By varying the depth of tillage, plowpans can be removed, or they can be kept from forming.

CAPABILITY UNIT IVe-3

This capability unit consists of moderately sloping to sloping, moderately eroded soils on uplands. These soils

are in the Carey, Grant, Nash, Quinlan, and Weymouth series. The surface layer is loam or silt loam.

The soils in this unit have already been damaged by erosion and will soon be unsuitable for crops unless effective measures are used to protect them against soil blowing. They are well suited to grasses in range or pasture. When there is enough moisture, legumes grow fairly well. Small grains and sorghums are suitable if management is good.

Cultivated areas of these soils are susceptible to severe erosion, but the use of terraces, contour tillage, and stubble mulching helps to control erosion. Varying the depth of tillage is effective in removing plowpans or in preventing their formation. Vegetated waterways are needed.

CAPABILITY UNIT IVe-4

In this capability unit are shallow to deep, moderately sloping, eroded soils on uplands. These soils have a loam to clay surface layer. They are in the Vernon, Weymouth, and LaCasa series.

In cultivated areas much of the water that falls is lost through runoff that causes further erosion. The growth of crops is impaired by lack of moisture, especially during droughty months in summer.

Small grains and sorghums are the principal cultivated crops. Grasses are well suited.

Cultivated areas are susceptible to severe water erosion. Practices that help reduce erosion are terracing, contour tillage, and vegetating the waterways. Crop residue should be shredded and left on the surface to reduce surface crusting, to increase the intake of water, and to reduce erosion. Varying the depth of tillage is effective in removing plowpans or preventing their formation.

CAPABILITY UNIT IVe-5

Dill fine sandy loam, 3 to 8 percent slopes, eroded, is the only soil in this capability unit. It has a fine sandy loam surface soil and a friable, permeable subsoil.

Protected areas of this soil take in water well, but unprotected areas lose a large amount through runoff that causes additional erosion.

Areas of this soil in grass are more easily managed than areas in row crops, but grain sorghum, forage sorghum, and small grains can be grown. The main crop is forage sorghum.

Both soil blowing and water erosion are likely if this soil is cultivated. Practices that help to reduce erosion are terracing, contour tillage, and vegetating the waterways. Crop residue should be shredded and left on the surface to help to control erosion, reduce crusting, and increase the intake of water. By varying the depth of tillage, plowpans can be removed or can be prevented from forming.

CAPABILITY UNIT IVe-6

This capability unit consists of deep, sandy soils that occur on hummocky uplands. These soils are in the Nobscot and Pratt series. The surface layer is fine sand or loamy fine sand.

Because the soils in this unit are sandy and loose, they are highly susceptible to soil blowing. They absorb water readily, and there is little runoff.

Well-suited crops are sorghums and rye. Cowpeas, Austrian Winter peas, and vetch mixed with rye are

suitable for improving soil tilth and providing a protective cover. Watermelons are grown on some farms in large acreages, and there are a few orchards. These soils are well suited as range.

Cultivated areas of these soils are subject to soil blowing. Soil blowing can be reduced by planting crops in rows that run at right angles to the prevailing winds and by vegetating the waterways. If crop residues are left on the surface and shredded, they help to control erosion and to increase the intake of water. Varying the depth of tillage helps to remove plowpans or to prevent their formation.

CAPABILITY UNIT IVw-1

Elsmere loamy fine sand is the only soil in this capability unit. Its use is severely limited by wetness. The water table is generally within 3 feet of the surface. In unusually dry years, the high water table benefits crops, especially those that require large amounts of water during summer. But crops generally do not grow well in excessively wet seasons nor in winter. The sandy surface of this soil blows if it is not protected.

Grain sorghum, forage sorghum, and corn are the principal crops, but cotton and alfalfa are also grown in small areas. Sorghums and grasses are the most dependable crops.

Cultivated areas of this soil are susceptible to erosion. Soil blowing can be reduced by leaving crop residues on the surface and shredding them. Drainage may be needed to remove excess water. In some places diversion terraces are needed to divert the water that runs in from adjacent slopes. Row crops should be planted at right angles to the prevailing wind.

CAPABILITY UNIT IVs-1

Lincoln loams, the only soils in this capability unit, are on nearly level bottom lands. These soils have a thin surface layer and subsoil over loose sand.

Because loose sand is near the surface, little moisture is available for shallow-rooted plants. In some places, however, the water table is generally within 4 feet of the surface and can supply moisture to deep-rooted plants.

In most areas alfalfa is grown because of its deep-root system. Nevertheless, grasses probably are more dependable than alfalfa because at times the water table falls so low.

Cultivated areas of these soils are susceptible to soil blowing, though damage is reduced by planting crops in rows that run at right angles to the prevailing winds. Crop residue that is shredded and left on the surface increases the intake of water and reduces soil blowing. Diversion terraces may be needed to intercept water and keep it from running in from adjacent slopes.

CAPABILITY UNIT Vw-1

Only Lincoln soils are in this capability unit. These soils lie in strips that are along the rivers and creeks and are subject to repeated flooding. The texture of these soils varies considerably from place to place because recurrent floods scour the soils and deposit fresh material. The water table fluctuates but generally is within 4 feet of the surface. Available moisture capacity, however, is low. These soils are not suited as cropland but are well suited as range. Soil blowing is likely unless the cover of grass is good.

CAPABILITY UNIT Vw-2

Only Sweetwater soils are in this capability unit. They lie along rivers and generally have a water table within 3 feet of the surface. The water table saturates the sand in the lower part of these soils. Plant nutrients are plentiful above a depth of 32 inches.

Some water-tolerant plants grow abundantly on these soils, but crops are not suited. If the water table were lowered, these soils would be too droughty for use as cropland. Suitable uses are range, hay meadow, and tame pasture. Bermudagrass is the principal pasture grass.

These soils are easily managed as grassland by regulating grazing. Where tame pasture is established, it can be maintained by using rotational grazing. If these soils are used as range, not more than one-half of the current growth of desirable grass should be grazed.

CAPABILITY UNIT Vw-3

Only Alluvial land is in this capability unit. This land consists of alluvial deposits along creeks, and it is subject to flooding.

Alluvial land is generally benefited by the water it receives from floods, but at extremely high stages, the channel cuts and damages vegetated areas.

This land is not suited to crops but is well suited to grass. Practices are needed for maintaining good stands. Among these practices are regulation of grazing and, when needed, reseeding or sprigging. The more desirable grasses will be maintained if not more than half the current growth is grazed.

CAPABILITY UNIT Vw-4

Only Clayey alluvial land is in this capability unit. This land consists of clay-textured alluvium that was recently deposited along creeks and draws. The areas are subject to recurrent flooding and deposition of fresh material.

This land type lies in drainageways below rough, broken escarpments in the western part of Major County. The drainage channels wind back and forth through this land, and during stages of high water, some of the vegetated areas are damaged. Except during periods of high water, the additional moisture is beneficial to the grasses.

Clayey alluvial land is not suited to crops but is well suited to grass. The main requirement is maintaining a good stand of productive grasses by regulating grazing and, in some areas, by reseeding. The more desirable grass will be maintained if not more than half of the current growth is grazed.

CAPABILITY UNIT VIe-1

Only Breaks-Alluvial land complex is in this capability unit. It consists of concave floors and moderately steep side slopes of drainageways. The side slopes are exposed banks and drift material, and the concave floors consist of alluvial soil washed in from the surrounding upland.

Breaks-Alluvial land complex is productive as pasture where grazing is regulated, but it is not suited to crops. The main concern in managing this mapping unit is maintaining a good stand of grasses for grazing and for protection against soil erosion. Grazing should be limited so as to maintain half the current growth of desirable grasses. In places diversion terraces or other structures are needed to prevent gullying.

CAPABILITY UNIT VIe-2

Only Dill fine sandy loam, 5 to 12 percent slopes, is in this capability unit. This is a deep to moderately deep soil on sloping to strongly sloping upland. It is easily penetrated by air, water, and plant roots, and it contains a fair amount of plant nutrients. Gullies form easily, since runoff is rapid from unprotected slopes. Where slopes are strong, this soil is highly susceptible to water erosion. This soil is not suited as cropland, but it is well suited as range.

CAPABILITY UNIT VIe-3

Only Eroded loamy land is in this capability unit. It consists of severely eroded soils that generally have a surface layer of silt loam, loam, or clay loam. Areas of this land were once cultivated, but they have been severely damaged by soil blowing and water erosion.

Eroded loamy land is suited only to grass. The chief concern in managing this land is maintaining an adequate cover so that the land is protected against further damage. Practices needed are seeding grasses, mowing, and regulation of grazing. The more desirable grasses are maintained if not more than half of the current growth is grazed.

CAPABILITY UNIT VIe-4

Only Nobscot fine sand, rolling, is in this capability unit. This sandy soil is sloping. It soaks up water readily but has low available moisture capacity. Soil blowing is severe if a good cover is not maintained.

This soil is not suited as cropland but is well suited as range, and it can be used for tame pasture. Abandoned fields that were once cultivated ought to be reseeded to native grasses. The scrub oak, blackjack oak, and brush that have invaded can be removed by spraying or other means. Grazing should be regulated so that half of the current growth of desirable plants is left.

CAPABILITY UNIT VIe-5

Only Nobscot-Pratt complex, duned, is in this capability unit. It consists of sloping to moderately steep, duned fine sands that absorb water readily but have low available moisture capacity. The soils in this unit are so steep and sandy that they are not suitable for cultivation. They are well suited as range.

CAPABILITY UNIT VIe-6

This capability unit consists of sandy soils in dunny relief. Only Pratt loamy fine sand, rolling, and Sand dunes, Lincoln material, are in this unit. These soils absorb water readily but have low available moisture capacity. They are highly susceptible to soil blowing and are not suited as cropland. They are suited as range if management is good. Mowing or spraying is often needed to control weeds, sand sagebrush, skunkbush, and other undesirable plants.

CAPABILITY UNIT VIe-7

Only Weymouth-Vernon complex, 5 to 12 percent slopes, is in this capability unit. This complex consists of limy soils that are shallow to deep. These soils are on sloping to strongly sloping, dissected upland. Water erosion is a severe hazard. These soils are so sloping and erodible that they are not suited as cropland. They are suited as range if management is good.

CAPABILITY UNIT VI_s-1

Treadway clay, the only soil in this capability unit, developed in material derived from alluvium. It lies in valleys that receive runoff from higher slopes. This soil is very slowly permeable and very low in fertility and content of organic matter. It is not suitable as cropland and is used mostly as range.

CAPABILITY UNIT VII_s-1

Only Rough broken land, loamy, is in this capability unit. It consists of rough, broken areas where sandstone and compacted sand are exposed. These sloping to steep canyon areas cut deeply into the red-bed sandstone. Soil material that supports grass, brush, and a few trees has drifted onto the upper slopes, but the abrupt canyon walls are mostly barren. Because soil blowing is severe, this land is not suited to crops. The upper vegetated slopes provide fair grazing if management is good.

CAPABILITY UNIT VII_s-2

Only Rough broken land, clayey, is in this capability unit. This land is in the western part of Major County and consists of gently sloping to steep, rough, broken areas of clay and shale of the red beds. Runoff occurs in large amounts in these blufflike areas, and erosion is severe. Available moisture capacity is low. This land is not suited to crops but is well suited as range if management is good.

CAPABILITY UNIT VII_s-3

Only Vernon-Gypsum outcrop complex is in this capability unit. This complex consists of shallow soils formed in shale and clay of the red beds and of very shallow soils formed in beds of gypsum. Barren gypsum is exposed in many places where the very shallow soils have been severely eroded by wind and water. Further erosion is likely unless these soils are protected by a good cover. Available moisture capacity is low. These soils are not suited as cropland but are suited as range if management is good.

CAPABILITY UNIT VII_s-4

Only Vernon-Badland complex, 1 to 3 percent slopes, is in this capability unit. This complex consists of shallow clays and clay loams intermingled with areas of barren Badland that have no protective vegetation. The Vernon soils have low available moisture capacity and low water-intake rate. Water erosion is a severe hazard. These soils are so shallow and erodible that they are best suited as range, but only small amounts of grasses can be grown, even under good management.

CAPABILITY UNIT VIII_e-1

Tivoli fine sand, rolling, is the only soil in this capability unit. This light-colored soil is deep, loose, and extremely sandy. It occupies dunes, and there is little runoff. This soil absorbs water readily, but it has low available moisture capacity. Because it is highly susceptible to soil blowing, it is not suited as cropland. This soil is suited as range, however, if management is good.

Predictions of Dryland Yields

In table 2 average acre yields of dryfarmed wheat, barley, oats, grain sorghum, forage sorghum, and alfalfa are predicted. Wheat and grain sorghum are the principal

crops grown in this county, and the main kind of farming is dryfarming. Predictions were made for the soils that normally are suitable as cropland.

The estimates in table 2 were prepared by soil scientists who questioned farmers during the survey. The farmers gave their estimates on their farms for periods of 10 to 20 years. Additional information was obtained from research on soil plots managed by staff members of the Oklahoma State University.

These predictions are the average that can be expected over a period of years. The yields may vary on the same soil from year to year. They are generally larger in years when crops receive a favorable amount of rainfall, or when the rain falls as needed. Generally, the soils that have texture of fine sandy loam or loamy fine sand need less moisture and produce higher yields in dry years than soils that have texture of clay, silt loam, clay loam, silty clay loam, or loam. Some of the highest yields, however, come from finer textured soils in wet years. Because the weather varies, the yields do not apply to any specific year. In dry years all dryfarmed soils may produce yields that are below average.

Yields in columns A are those obtained under normal management, or the management commonly practiced in the county. Under normal management, suitable crop varieties are used and seeding is at the proper time and rate. Methods of planting and harvesting are efficient, and weeds, insects, and plant diseases are controlled. Some farmers return crop residue to the soils.

Yields in columns B are those obtained under improved management. In addition to those practices named for normal management, improved management includes, where needed, stubble mulching, management of crop residue, contour farming, terracing, and grassing the waterways. The soils are tested to determine the need for lime and fertilizer, and these amendments are added if needed. Information about the use of fertilizer and lime is available from the local office of the Soil Conservation Service and from the county extension director.

Range Management ²

Slightly more than half, or about 337,500 acres of Major County is used as range. Of this acreage, about a half is in moderately rolling to steeply rolling sandy areas, and about a third is in finer textured areas of broken land in the western part of the county. The rest of the grassland is made up of gently sloping sands, upland areas of deep loams, and areas of bottom land.

The main enterprise on the ranches in the county is raising cows and calves. The herds are made up mainly of a good grade of Hereford, though there are some Black Angus and dual-purpose cattle such as Brown Swiss. In years when crops are abundant, calves may be held over to graze some of the wheatfields. Generally, however, calves are sold at weaning time and, during winter, cows are fed dry grass and a protein supplement.

Most of the problems on rangeland today are a result of grazing the land too closely in the past. If the available grass is grazed too heavily, runoff is increased, gullies form, and the grass cover deteriorates. A shortage of grass

² By JACK E. ENGLEMAN, range conservationist, Soil Conservation Service.

TABLE 2.—Predicted average yields per acre of principal dryfarmed crops under two levels of management

[Yields in columns A are those obtained under normal management, or the management commonly practiced; yields in columns B are those to be expected under improved management. Absence of yield indicates that the soil is not suited to the crop specified or that the crop is not commonly grown]

Soil	Wheat		Barley		Oats		Grain sorghum		Forage sorghum		Alfalfa	
	A	B	A	B	A	B	A	B	A	B	A	B
Canadian fine sandy loam, 0 to 1 percent slopes.....	Bu. 18	Bu. 25	Bu. 25	Bu. 35	Bu. 30	Bu. 40	Bu. 25	Bu. 37	Tons 2.2	Tons 3.2	Tons 1.4	Tons 2.6
Canadian fine sandy loam, 1 to 3 percent slopes.....	15	22	22	32	28	36	22	35	2.0	3.0	1.2	2.4
Carey silt loam, 1 to 3 percent slopes.....	14	20	22	30	24	34	22	34	2.0	2.8		
Carey silt loam, 3 to 5 percent slopes.....	12	17	18	25	20	30	19	30	1.5	2.2		
Carey silt loam, 4 to 8 percent slopes, eroded.....	8	12	13	18	14	22						
Carwile-Shellabarger complex, 0 to 1 percent slopes ¹	14	17	20	23	24	26	22	26	2.0	2.6		
Dill fine sandy loam, 1 to 3 percent slopes.....	12	18	20	26	22	30	21	28	2.0	2.6		
Dill fine sandy loam, 3 to 5 percent slopes.....	11	15	16	22	17	25	18	25	1.6	2.0		
Dill fine sandy loam, 3 to 8 percent slopes, eroded.....	8	12	12	16	14	20			1.0	1.5		
Elsmere loamy fine sand.....							13	18	1.8	2.7		
Enterprise fine sandy loam, coarse variant, 1 to 3 percent slopes.....	15	20	22	30	24	34	20	28	2.0	2.8	1.2	2.0
Enterprise fine sandy loam, coarse variant, 3 to 5 percent slopes.....	12	17	18	25	20	30	16	24	1.5	2.2		
Grant silt loam, 1 to 3 percent slopes.....	16	24	25	35	27	38	28	38	2.2	3.0	1.4	2.0
Grant silt loam, 3 to 5 percent slopes.....	14	20	18	31	22	32	22	32	1.8	2.5		
Grant-Nash silt loams, 5 to 8 percent slopes ¹	10	14	15	20	17	26			1.2	1.7		
Grant-Nash silt loams, 4 to 8 percent slopes, eroded ¹	7	12	12	17	14	22						
Kirkland silt loam, 0 to 1 percent slopes.....	16	25	25	37	30	45	22	30	2.0	3.0	1.3	2.3
Leshara loam.....	13	21	18	25	20	30	18	30	2.0	2.8		
Lincoln loams.....	9	14	14	20	18	25	15	22	1.5	2.0		
McLain silty clay loam.....	23	30	32	41	30	40	36	45	2.5	3.5	2.8	3.6
Meno loamy fine sand, 0 to 3 percent slopes.....	13	18	20	28	18	30	22	30	2.0	2.8	1.2	2.2
Miller clay.....	15	20	23	32	22	32	26	35	1.5	2.5		
Nobscot fine sand, hummocky.....							10	18	1.0	1.8		
Nobscot-Pratt complex, hummocky ¹							14	20	1.2	2.0		
Ortello fine sandy loam, undulating.....	14	19	20	30	22	34	22	30	2.0	2.8	1.2	2.0
Pond Creek silt loam, 0 to 1 percent slopes.....	20	28	30	42	36	48	30	42	2.5	3.5	1.8	2.6
Pond Creek silt loam, 1 to 3 percent slopes.....	17	24	25	36	28	40	28	38	2.2	3.0	1.5	2.2
Port fine sandy loam.....	18	25	25	35	30	40	25	38	2.2	3.5	2.5	3.2
Port silt loam.....	20	30	32	42	40	52	36	50	2.8	3.8	2.5	3.6
Pratt loamy fine sand, undulating.....	10	16	18	24	20	30	16	25	1.8	2.5		
Pratt loamy fine sand, hummocky.....			13	18	14	22	14	20	1.5	2.0		
Quinlan loam, 1 to 3 percent slopes.....	9	14	16	22	18	24	16	22	1.3	1.8		
Quinlan loam, 3 to 5 percent slopes, eroded.....	7	10	12	16	12	18						
Reinach very fine sandy loam.....	20	28	30	40	35	45	30	44	2.5	3.5	2.2	3.2
Renfrow silty clay loam, 0 to 1 percent slopes.....	14	22	25	35	30	40	21	29	1.6	2.5		
Renfrow silty clay loam, 1 to 3 percent slopes.....	13	19	20	32	25	35	15	22	1.4	2.0		
St. Paul silt loam, 0 to 1 percent slopes.....	16	23	24	34	26	38	24	36	2.2	3.0	1.2	2.2
St. Paul silt loam, 1 to 3 percent slopes.....	14	20	22	30	24	36	22	34	1.8	2.6		
St. Paul silt loam, 3 to 5 percent slopes.....	12	17	18	25	20	30	18	28	1.2	2.0		
Shellabarger fine sandy loam, 0 to 3 percent slopes.....	14	22	22	32	24	34	22	31	2.0	2.8	1.5	2.2
Tillman clay loam, 0 to 1 percent slopes.....	14	20	22	32	26	36	16	24	1.5	2.3		
Tillman clay loam, 1 to 3 percent slopes.....	12	17	18	26	20	30	13	20	1.2	1.8		
Tillman clay loam, 3 to 5 percent slopes.....	10	14	14	22	16	25						
Tipton silt loam, 0 to 1 percent slopes.....	18	26	30	40	30	42	28	40	2.5	3.5	2.0	2.8
Vernon clay loam, 0 to 3 percent slopes.....	10	14	14	22	17	25	11	16	1.0	1.5		
Vernon soils, 3 to 5 percent slopes, eroded.....	6	9	10	15	10	18						
Weymouth loam, 1 to 3 percent slopes.....	13	16	18	26	20	30	17	25	2.0	2.6		
Weymouth loam, 3 to 5 percent slopes, eroded.....	10	14	14	22	16	24	12	18				
Weymouth-LaCasa complex, 1 to 3 percent slopes ¹	13	17	18	26	20	30	14	20	1.3	2.0		
Weymouth-LaCasa complex, 3 to 5 percent slopes ¹	10	14	14	22	16	25						
Weymouth-LaCasa complex, 3 to 5 percent slopes, eroded ¹	8	12	12	18	12	20						
Yahola fine sandy loam.....	15	22	22	32	26	38	25	35	2.2	3.2	2.2	3.0

¹ Yields of each kind of soil in this complex may be different when it occurs as a single mapping unit. Yields given reflect the complimentary effect of both soils.

is especially noticeable in droughty periods because little grass is available for grazing and the range plants lose their vigor.

Range sites and condition classes

Different kinds of range produce different kinds and amounts of grasses and other forage. To manage rangeland properly, an operator should know the different kinds of land (range sites) in his holdings and the plants each site can grow. He will then be able to use the management that produces the best forage plants on each site.

Range sites are areas of rangeland that produces a significantly different kind or amount of climax, or original vegetation. A significant difference is one that is great enough to require different grazing use, or to require other management that maintains or improves the present vegetation. *Climax vegetation* is the combination of plants that originally grew on a given site. The most productive combination of forage plants on a range site is generally the climax vegetation.

The downward trend in range vegetation that is a result of heavy grazing or insufficient moisture can be expressed as range condition. Four classes of range condition are recognized, *excellent*, *good*, *fair*, and *poor*. On range in excellent condition, 76 to 100 percent of the cover is made up of the kinds of plants that grew in the original vegetation. This percentage is 51 to 76 on range in good condition, and is 26 to 50 on range in fair condition. On range in poor condition, 25 percent or less of the original, or climax, vegetation remains. If the range is in poor condition, the vegetation is mostly increasers and invaders.

On range sites, the most productive combinations of plants that will maintain themselves under natural range conditions are considered the original, or climax, vegetation. The more nutritious grasses decline most rapidly. Under heavy grazing, these choice plants, or *decreasers*, are gradually eliminated. They are replaced by less palatable plants, called *increasers*. If heavy grazing is continuous, the site eventually will be occupied by less desirable grasses and weeds called *invaders*.

Continuous heavy grazing lowers production for short periods on sites where the climax vegetation has been weakened but is not destroyed. On other range sites, overgrazing for longer periods alters the original vegetative cover and greatly reduces forage yields.

Descriptions of the range sites

In this subsection the soils in each range site are briefly described and the dominant plants on the site are named. Also given is an estimate of the annual yield of air-dry herbage where the site is in excellent condition. To find the names of the soils in each range site, refer to the "Guide to Mapping Units" at the back of this survey.

BREAKS RANGE SITE

Only Rough broken land, clayey, is in this range site. This land consists of gently sloping to steep slopes and narrow bottoms of canyons in areas underlain by the gypsumiferous red beds. The steep-walled gullies and canyons make parts of this range site inaccessible to livestock.

When this site is in excellent condition, the dominant

grasses are little bluestem, sand bluestem, sideoats grama, and many kinds of palatable forbs. If grazing is heavy, the bluestems and the better forbs are eliminated and sideoats grama and weeds increase.

Where this range site is in excellent condition, the average annual yield of air-dry herbage is 1,000 pounds per acre in years of favorable moisture and 600 pounds in years of unfavorable moisture.

CLAYPAN PRAIRIE RANGE SITE

This range site consists of nearly level and gently sloping silt loams and clay loams that have a compact, blocky clay subsoil. The compact subsoil slows internal drainage so that waterlogging is likely during rainy periods, and drought during dry periods. If the protective mulch on the surface is removed, these soils tend to seal and to take in water more slowly.

When this site is in excellent condition, the dominant grasses are big bluestem, little bluestem, indiagrass, and switchgrass. Shorter grasses are western wheatgrass, blue grama, sideoats grama, and buffalograss, and there is some vine-mesquite. If the site is heavily grazed, the taller grasses are replaced by blue grama, buffalograss, and weeds.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 2,000 pounds in years of unfavorable moisture.

DEEP SAND SAVANNAH RANGE SITE

This range site consists of deep soils on uplands that are moderately sloping to moderately steep and in places are dune. At varying depths, these soils are underlain by loamy fine sand or fine sandy loam. Blackjack oak and other woody plants grow in most places.

Sand bluestem and little bluestem are the dominant grasses when this site is in top condition. Switchgrass, sand lovegrass, and purpletop are also present. Under heavy grazing, the oaks and shrubs increase rapidly, weeds become abundant, and increasers replace the bluestems (fig. 22).

Where this range site is in excellent condition, the average annual yield of air-dry herbage is 4,200 pounds per acre in years of favorable moisture and 1,750 pounds in years of unfavorable moisture.

DEEP SAND RANGE SITE

This range site consists of deep sands on uplands. These soils are in undulating to rolling areas or are in areas of low dunes. Sand sagebrush and skunkbush are common in many places.

Sand bluestem and little bluestem are the dominant grasses when this site is in excellent condition. Under heavy grazing, sand paspalum, sand dropseed, and blue grama increase rapidly. On depleted rangeland, weeds make up a large part of the vegetative cover.



Figure 22.—Deep Sand Savannah range site. *Top*, an area heavily infested with brush; *bottom*, a vigorous growth of bluestem after brush has been controlled by spraying.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 3,500 pounds per acre in years of favorable moisture and 1,400 pounds in years of unfavorable moisture.

DUNE RANGE SITE

The only soil in this range site, Tivoli fine sand, rolling, is made up of high dunes of structureless sand. A considerable amount of woody vegetation is on this site.

When this site is in excellent condition, sand bluestem, little bluestem, sand lovegrass, and big sandreed are the dominant grasses. Under heavy grazing, sand dropseed, and sand paspalum are the principal increasers. Extreme care is needed in controlling grazing because livestock disturb the soil on the dunes and cause it to slough downhill. If practical, these areas should be fenced separately.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 2,000 pounds per acre in years of favorable moisture and 1,000 pounds in years of unfavorable moisture.

ERODED RED CLAY RANGE SITE

Only Vernon-Badland complex, 1 to 3 percent slopes, is in this range site. The site extends from the base of the Breaks site to the plain below. The soil material in this site is highly unstable. Runoff has removed practically all the topsoil, and gullying is common and difficult to control. Parts of this site are barren (fig. 23).

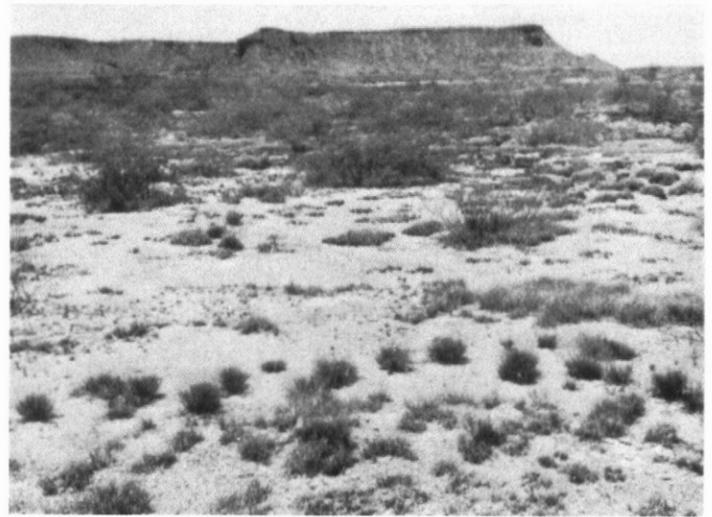


Figure 23.—Eroded Red Clay range site is in the foreground and Breaks range site is in the background.

Because this site consists largely of unstable soils, the vegetative cover varies from year to year. In well-managed areas, the better range plants are white prairie clover, fourwing saltbush, Fendler's aster, Illinois bundleflower, sideoats grama, indianguass, sand bluestem, alkali sacaton, tall dropseed, and western wheatgrass.

Where this site is in excellent condition, the average yield of air-dry herbage is 600 pounds per acre in years of favorable moisture and 200 pounds in years of unfavorable moisture.

GYP RANGE SITE

Only Gypsum outcrop, mapped in the Vernon-Gypsum outcrop complex, is in this range site. The site is an area of very shallow loam mixed with outcrops of gypsum and is one of the least productive sites in the county. It occurs mainly above the Breaks range site.

When this site is in excellent condition, little bluestem is dominant in the plant cover. Other plants common on this site are sideoats grama, hairy golden aster, pricklypear, and sand dropseed.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 1,800 pounds per acre in years of favorable moisture and 1,000 pounds in years of unfavorable moisture.

HARDLAND RANGE SITE

This range site consists of gently sloping to strongly sloping, deep to shallow silt loams and clay loams on uplands. Productivity is moderate if this site is properly managed, but the soils are likely to seal, and the rate of water intake is lowered if the protective cover is removed.

Tall and mid grasses are dominant in the climax vegetation, though blue grama, buffalograss, and other short grasses are also important. Buffalograss, sideoats grama, and blue grama increase rapidly under heavy grazing, and eventually these short grasses and weeds take over the site.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 3,000 pounds per acre in years of favorable moisture and 1,500 pounds in years of unfavorable moisture.

HEAVY BOTTOMLAND RANGE SITE

Clayey alluvial land and Miller clay, the only mapping units in this range site, consist of heavy, deep, clay-textured soils that are nearly level to moderately sloping. These soils are droughty where the vegetative cover is removed by overgrazing and the surface is compacted.

Vine-mesquite, switchgrass, sideoats grama, and western wheatgrass are the dominant plants when this site is in excellent condition. If grazing is heavy, sideoats grama, western wheatgrass, and buffalograss increase.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 4,500 pounds per acre in years of favorable moisture and 2,000 pounds in years of unfavorable moisture.

LOAMY BOTTOMLAND RANGE SITE

This range site consists of nearly level to moderately sloping, loamy soils on bottom lands along the North Canadian and Cimarron Rivers and their tributaries. These soils receive additional moisture as runoff from the slopes above and as floodwater from the streams.

Tall grasses are dominant in the plant cover when this site is in excellent condition. Among these grasses are big bluestem, switchgrass, indiagrass, and little bluestem. Willow, cottonwood, and elm trees grow in places. If this site is heavily grazed, western wheatgrass and vine-mesquite increase gradually and silver bluestem, sand dropseed, and weeds invade.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 2,500 pounds in years of unfavorable moisture.

LOAMY BREAKS RANGE SITE

Only Rough broken land, loamy, is in this range site. This land consists of gently sloping to steep slopes and narrow bottoms of canyons in areas of sandstone red beds. The steep walls of canyons make parts of the site inaccessible to livestock. Rough broken land takes in water readily.

Sand bluestem and little bluestem and some purpletop and sideoats grama grow on the slopes. Texas bluegrass, Virginia wildrye, sedges, and several kinds of muhlenbergia, grow in the shaded areas. It is essential to dispose of runoff carefully around the canyons so as to control erosion.

Where the range condition is excellent, the average annual yield of air-dry herbage is 2,000 pounds per acre in years of favorable moisture and 1,000 pounds in years of unfavorable moisture.

LOAMY PRAIRIE RANGE SITE

This range site consists of nearly level to moderately steep, loamy soils on uplands. These are among the most productive soils in Major County, and most areas are now cultivated.

On this productive range site, the dominant grasses are little bluestem, sand bluestem, and sideoats grama, and there is some blue grama. Sideoats grama and blue grama are the main increasers. Buffalograss, silver bluestem, and weeds are dominant in areas that are abused.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 2,500 pounds in years of less favorable moisture.

RED CLAY FLATS RANGE SITE

Treadway clay, a nearly level soil of the flood plains, is the only soil in this range site. Except for the surface layer, this soil is dense and blocky throughout.

When this site is in excellent condition, it has a thick cover of alkali sacaton, vine-mesquite, western wheatgrass, and sideoats grama. Some switchgrass and big bluestem grow in spots, and mesquite trees grow in many places. Continuous close grazing quickly removes the plant cover and increases sheet erosion and gullying.

Where range condition is excellent, the average annual yield of air-dry herbage is 1,400 pounds per acre in years of favorable moisture and 800 pounds in years of less favorable moisture.

RED CLAY PRAIRIE RANGE SITE

Only the Vernon soils are in this range site. These shallow soils are mapped separately and in complexes with other soils in the county. They are on rolling uplands and in broken areas that are sloping in places.

If the condition of this site is excellent, sideoats grama, little bluestem, vine-mesquite, and blue grama are dominant. Buffalograss, blue grama, sideoats grama, and perennial three-awn increase under heavy grazing.

Where range condition is excellent, the average yield of air-dry herbage is 2,200 pounds per acre in years of favorable moisture and 1,000 pounds in years of less favorable moisture.

SANDY BOTTOMLAND RANGE SITE

Only the Lincoln soils are in this range site. These soils consist of sandy alluvium on first and second bottoms

along the rivers and larger creeks in Major County. Floodwaters scour these soils and deposit sandy sediments in hummocks. Other water is received as runoff from higher areas.

Sand bluestem, little bluestem, big sandreed, and switchgrass are the dominant grasses when this site is in excellent condition (fig. 24). Sand plum and skunkbush tend to spread where the grass cover has been depleted.



Figure 24.—Sandy Bottomland range site in good condition.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 3,000 pounds per acre in years of favorable moisture and 1,800 pounds in years of unfavorable moisture.

SANDY PRAIRIE RANGE SITE

This range site consists of nearly level to strongly sloping, deep, loamy soils on uplands. These soils developed in windblown material, or they were derived from weathered sandstone. They have an open subsoil that is free of clay particles.

Sand bluestem and little bluestem make up most of the grass cover when this site is in excellent condition. The main increasers are indiagrass, switchgrass, sideoats grama, Canada wildrye, and blue grama. If close grazing is continuous, sand dropseed, weeds, and various kinds of woody plants invade.

Where range condition is excellent, the average annual yield of air-dry herbage is 4,500 pounds per acre in years of favorable moisture and 2,000 pounds in years of unfavorable moisture.

SHALLOW PRAIRIE RANGE SITE

This range site consists of gently sloping to moderately sloping, shallow soils on uplands. Depth to the underlying sandstone and sandy shale is more than 15 inches in only a few places.

Little bluestem, sideoats grama, blue grama, and hairy grama are the most dominant grasses, and sand bluestem grows in small amounts. If grazing is heavy, blue grama and sideoats grama increase, and sand dropseed and weeds invade.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 2,500 pounds per acre in years of favorable moisture and 1,300 pounds in years of unfavorable moisture.

SUBIRRIGATED RANGE SITE

This range site consists of sandy soils on bottom lands along rivers and creeks. The water table of these soils fluctuates, but normally it can be reached throughout the year by the roots of climax plants. This is the most productive range site in the county.

Important plants on this site are switchgrass, indian-grass, cordgrass, eastern gamagrass, alkali sacaton, western wheatgrass, and sedges. Under continuous heavy grazing, sedges, saltgrass, and alkali muhly increase and weeds invade.

Where this range site is in excellent condition, the average annual yield of air-dry herbage is 10,000 pounds per acre in years of favorable moisture and 6,000 pounds in years of unfavorable moisture.

Woodland, Windbreaks, and Post Lots ³

In Major County native woodland is confined to strips along the Cimarron River, the North Canadian River, other large streams, and their tributaries. In a survey in 1958, the woodland in the county was estimated at 98,000 acres.

The most common trees along the streams are cottonwood, willow, elm, and hackberry, and there are some walnut and stunted oak. Soapberry, persimmon, chittamwood, and plum grow along or adjacent to the smaller watercourses. Some tamarisk and saltcedar grow on the sandbars of the rivers. The rough broken areas along the major streams have a few redcedars. Below the breaks, mesquite bushes grow in dry areas.

Very little of this native woodland supports trees that are commercially suitable in size, quality, or species. Limited stands of native timber provide shelter for livestock, and trees are planted in windbreaks to protect and beautify farmsteads and to protect cropland. They also have esthetic value in recreational areas and are beneficial in wildlife habitats.

Farmstead windbreaks.—Many of the soils in Major County are suitable for planting trees and shrubs in farmstead windbreaks. The soil requirements are less exacting for farmstead windbreaks than for field windbreaks or post lots. In field windbreaks, the areas to be protected normally are smaller. Heavier foliage, however, generally is needed. The extra cultivation, diversion of irrigation water, and other special practices that may be needed for farmstead windbreaks generally can be justified.

Windbreaks are especially needed in winter. The use of one or more rows of evergreens in the farmstead windbreaks (and in the field windbreaks as well) is advisable because the protection of evergreen foliage is needed in winter when broad-leaved trees have no foliage. Also, evergreens add to the attractiveness of the windbreak.

Both eastern and western redcedars are well suited to many kinds of soils in the county. Ponderosa and Austrian pines are suited to most of the soils in capability classes I

³ By CHARLES P. BURKE, woodland conservationist, Soil Conservation Service.

and II. The seeding form of Chinese arborvitae may be suitable as an evergreen tree in farmstead windbreaks. Where evergreen and broad-leaved trees are used in windbreaks, they should not be planted in the same row. By leaving additional space between the rows, the overtopping of evergreens by the normally faster growing broad-leaved trees can be avoided. Care is needed to avoid the drying of the tree roots before and after planting.

In addition to protecting farmsteads, windbreaks can be used to protect schools, churches, and other public buildings.

Field windbreaks.—Trees have not been planted in field windbreaks to any great extent in Major County. Successful plantings can be made, however, if suitable trees and shrubs are selected and are planted and cared for properly.

The interval that is protected, which is the interval between the protective belts, is 15 to 20 times the height of the tall trees in the windbreak. Spacing between rows should vary according to the moisture requirements of the various soils. Also, enough space should be allowed between rows to permit the use of machines in cultivation. In only a few places does the spacing need to be more than 16 feet, and it should not be less than 10 feet. In the rows, tall trees should be spaced 6 to 10 feet apart, and shrubs and shrublike trees should be spaced about 4 to 5 feet.

Common species of tall broad-leaved trees that are suitable for windbreaks, and to the soils in the county, are cottonwood, American elm, Siberian elm, and sycamore. Shrubs suitable for planting on the windward side of the windbreak include low species of arborvitae, tamarisk, desertwillow, common lilac, and mulberry. Russian (white) mulberry is preferred to other kinds of mulberry in Major County, but it requires fairly severe top pruning if it is to be a dense barrier.

Conifers, or evergreen trees, are preferred to broad-leaved trees because they provide year-round protection for soils and crops. Also, they add to the attractiveness of the windbreak. Western yellow (ponderosa) and Austrian pines should grow well. Eastern and western redcedars are also satisfactory.

In planting conifers, special care is needed to prevent drying of the trees roots before and during planting. It is beneficial to use planted stock if it is available.

Post lots.—Soils suitable for planting in post lots in Major County are mostly along the North Canadian and Cimarron Rivers and their main tributaries. Generally, the trees in the same kinds of soils that are suitable for field crops are suitable for trees in post lots. It is not worthwhile to plant trees for posts on droughty or shallow soils or soils with very severe limitations.

Black locust, bois-d'arc (Osage-orange), red mulberry, and catalpa are the trees most commonly grown in post lots in Major County. Black locust does well on the sandier soils if depth to the material that holds water is not excessive. Bois-d'arc can stand short periods of flooding; it is adapted to soils that have a medium- or fine-textured subsoil, and it tolerates short periods of flooding. Catalpa and red mulberry require permeable, medium-textured, well-drained soils on bottom lands.

Windbreak suitability groups

Discussed in the following paragraphs are the use of soils in windbreak suitability groups and the kinds of trees

suitable for these groups. A windbreak suitability group consists of soils that are similar in their suitability for farmstead and field windbreaks and for post lots. To determine the soils in each of these groups, refer to the "Guide to Mapping Units" at the back of this survey.

WINDBREAK SUITABILITY GROUP 1

In this group are deep, nearly level to gently sloping soils of the uplands. These soils have slow runoff and high moisture-holding capacity.

The soils in this group are good to excellent for windbreaks and post lots. In this county, only the soils in this group should be used for post lots.

Tall trees suitable for windbreaks on the soils of this group are Siberian elm, cottonwood, and sycamore. The elm grows best on the loams and fine sandy loams and may attain a height of 60 to 70 feet in 20 years. Cottonwood and sycamore grow to a height of 70 to 80 feet in the same period. At 20 years of age, trees have good to excellent vigor unless they have been affected by extensive droughts.

Russian mulberry can be used in the windbreaks as a tree of intermediate height. This tree is also suitable in the shrub rows if it is spaced closely and its tops are pruned severely.

Evergreens suitable for windbreaks are Austrian pine, ponderosa pine, eastern redcedar, and some strains of the nongrafted form of Chinese arborvitae. These trees can be expected to attain heights of 20 to 30 feet at 20 years of age.

Post-lot planting should be limited to black locust, catalpa, and bois-d'arc trees. The bois-d'arc grows well on the silt loams and very fine sandy loams.

WINDBREAK SUITABILITY GROUP 2

This windbreak suitability group consists of moderately deep to deep, nearly level to rolling soils on uplands and bottom lands. These soils are medium and coarse textured and are well drained to excessively drained.

The soils of this group are generally fairly well to well suited to trees planted in farmstead and field windbreaks but are not suited to plantings in post lots. Breaks-Alluvial land complex is in this group, and parts of its breaks are unsuitable for planting trees. The Alluvial land part is well suited.

Unless the rows are planted on the contour, the soils on slopes of 3 to 5 percent should not be used extensively for field windbreaks, though short stretches can be planted to make the rows continuous. Because cultivated areas of Nobscot soils and Pratt loamy fine sands in this group are highly susceptible to soil blowing, it is desirable to protect them by using field windbreaks supported by other practices for controlling soil blowing.

Species of trees suitable for windbreaks on the soils of this group are about the same as those suitable for the soils in group 1, but the tall tree averages about 10 to 15 percent less growth and probably is less vigorous. Generally, the soils in group 2 are not so well suited to windbreaks as the soils in group 1.

WINDBREAK SUITABILITY GROUP 3

This windbreak suitability group consists of deep to moderately deep soils that are nearly level to strongly sloping. These soils are medium textured and range from permeable to very slowly permeable. Surface runoff is slow to very rapid.

The soils of this group are not suitable for post lots or field windbreaks, and extra care is needed before farmstead windbreaks can be established. Those eroded soils that have lost most of their topsoil or are gullied should not be used for farmstead windbreaks.

WINDBREAK SUITABILITY GROUP 4

The soils in this windbreak suitability group range from shallow to deep, from nearly level to steep, and from slightly acid to strongly alkaline. Erosion is slight to severe. These soils occur in rough, broken areas and on flood plains.

These soils are not suitable for tree planting. Most woody plants cannot grow on the strongly alkaline soils. Other soils are unsuitable because they are eroded, shallow, or sandy.

Wildlife⁴

Most of the wildlife areas in Major County are upland prairies, timbered uplands, escarpments, and bottom lands. The upland prairies are dominant in the Grant-Pond Creek association in the northeastern corner of the county, and in a band of the St. Paul-Carey association, generally paralleling the Cimarron River in the western part. The timbered uplands of the Nobscot-Pratt association are in the extreme southwestern and the eastern parts of the county. The escarpments occur in irregular patterns along the south side of the Cimarron River in the Weymouth-Vernon-Gypsum outcrop association and the Vernon-Tillman-Badland association. The bottom lands of the Port-Canadian-McLain-Reinach association and the Lincoln-Sweetwater association are in a narrow band along the Cimarron River and are in broad irregularly shaped areas along tributary streams south of the river.

Important kinds of wildlife in the county are bobwhite quail, mourning dove, squirrel, fox, deer, turkey, cottontail, jackrabbit, prairie dog, raccoon, mink, opossum, skunk, badger, muskrat, and beaver. Coyote, bobcat, and fox are important predatory animals, and there are several kinds of hawk and owl. Many kinds of songbirds are also in the county, and small numbers of waterfowl come in during the migration seasons. Many diamondback rattlesnakes are along the gypsum ledges and in the immediate vicinity.

Soil associations as wildlife habitat

Because wild birds and animals move from place to place, a convenient way to learn about them is by soil associations. The soil associations in Major County are shown on the general soil map at the back of this survey and are described in the section "General Soil Map."

Soil association 1.—This association is made up mainly of Weymouth soils, Vernon soils, and Gypsum outcrop, but there are also small areas of LaCasa soils interspersed. The association covers about 17 percent of the county. About 33 percent of its area is cultivated to wheat, and the rest is used as range. Areas of closely intermingled Weymouth and LaCasa soils are cultivated and provide little or no habitat for wildlife. Weymouth and Vernon soils are closely intermingled on the steeper slopes, and provide some habitat, for these soils support mid and tall grasses and a few shrubs such as sumac, skunkbush, and soapberry.

This habitat complements areas in deep ravines where there are thicker stands consisting of hackberry, soapberry, elm, cedar, and sumac. The soils in this association provide cover for rabbits, quail, furbearers, songbirds, and predatory birds and animals. The woody plants produce seed and mast that wildlife use for food. In this association, however, desirable habitat is not plentiful, and only small numbers of wildlife can be supported.

Soil association 2.—This association consists of Dill soils and Rough broken land. It covers about 6 percent of the county. About 45 percent of its area is cultivated to sorghums and small grains. Tall grass, sand sagebrush, and skunkbush grow on the steeper slopes and in canyons. In the deep canyons are blackjack oak, cedar, walnut, hackberry, plum, soapberry, cottonwood, and elm. Water from springs is generally plentiful in canyons the year round, and it is used both by wildlife and by plants. Because of this water, mast is plentiful. In the canyons live large numbers of quail, turkey, bobcat, deer, raccoon, opossum, skunk, and mink.

Soil association 3.—This association consists mostly of Vernon soils, Tillman soils, and Badland. It covers about 7 percent of the county. Nearly all areas of Tillman soils are cultivated, but only the more nearly level areas of Vernon soils are cultivated. Vegetation is sparse throughout the association, though there is some mesquite on range consisting of Tillman soils. The habitat for quail is poor, but there are some jackrabbits and coyotes. Many diamondback rattlesnakes hibernate in the crevices and caves in Gypsum outcrop. During warm weather these snakes move around in search of food. Ponds built in this association are suitable for producing fish (fig. 25). In building the ponds, however, care must be taken to use fill material that does not contain gypsum, for the structure will be weakened when the gypsum is dissolved.

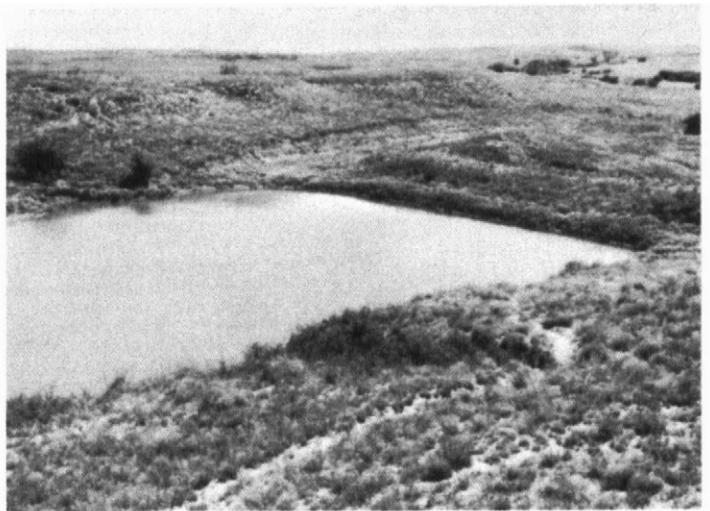


Figure 25.—A stock water pond in the Vernon-Gypsum outcrop complex.

Soil association 4.—This association consists mostly of St. Paul and Carey soils, but there are also small amounts of Enterprise and Tipton soils. The association covers about 2 percent of the county. About 75 percent of the area is cultivated to small grains and grain sorghum. The

⁴ By JEROME F. SYKORA, biologist, Soil Conservation Service.

only habitat suitable for wildlife is on the small amount of Carey soils along the larger drainageways. This habitat benefits only songbirds and doves. Ponds in this association are good producers of fish, but care must be taken not to build ponds over gypsum deposits, and not to use fill material containing gypsum in embankments.

Soil association 5.—This association consists mostly of Meno, Shellabarger, and Pratt soils, but there are also small amounts of Nobscot, Ortello, and Carwile soils. The association covers about 14 percent of the county. About 90 percent of its area is cultivated to grain sorghum, small grains, alfalfa, cowpeas, mungbeans, and some truck crops. The Pratt soils are used mostly as range but have stands of skunkbush and plum. Some of these plants grow along roads, in fence rows, and in odd areas, where they provide travel lanes and food for quail, dove, squirrel, furbearers, and songbirds.

Soil association 6.—This association consists mostly of Grant and Pond Creek soils, but small areas of Nash and Kirkland soils also occur. The association covers about 6 percent of the county. About 90 percent of its area is cultivated to small grains and grain sorghum. Little habitat suitable for wildlife remains. If the areas used as range are not heavily grazed, they provide habitat of low quality for quail, rabbit, and squirrel. Sites suitable for ponds are available, but management is needed to keep the water clear enough for the fish.

Soil association 7.—This association is made up mostly of Nobscot and Pratt soils, but there are smaller areas of Carwile and Shellabarger soils in low areas. The association covers about 24 percent of the county. About 33 percent of it is cultivated to grain sorghum, wheat, truck crops, and orchard fruit. In most places the Nobscot soils support thick stands of blackjack oak, plum, skunkbush, soapberry, hackberry, sumac, and some tall grasses, native legumes, and sagebrush (fig. 26). The less sandy Pratt soils support tall grasses and sagebrush. Areas of Pratt soils are small and irregularly shaped, and they can be used for growing plants suitable as food for wildlife. Wildlife also benefit from the small size of the cultivated fields on Pratt soils. If the range is not grazed heavily, native legumes and forbs grow well and provide excellent food for herbivorous wild-

life. The association provides good habitat for quail, deer, and turkey.

Soil association 8.—This association consists mostly of Tivoli and Pratt soils that are not suitable for cultivation and are used as range. The association covers about 5 percent of the county. Dominant vegetation consists of cottonwood, cedar, sagebrush, plum, sumac, skunkbush, hackberry, blackjack oak, tall grasses, wild legumes, and forbs. This wide variety of plants provides food and cover suitable for quail, squirrel, wild turkey, deer, and furbearers. The habitat in this association is among the best in the State for quail and turkey.

Soil association 9.—This association consists mostly of Port, Canadian, McLain, and Reinach soils. It covers about 11 percent of the county. About 90 percent of its area is cultivated to alfalfa, small grains, and grain sorghum. Some woody plants grow in narrow strips along drainageways, where there is a small amount of poor habitat for squirrel, quail, rabbit, and furbearers. Deer and quail make use of these strips where the strips border more densely wooded areas. Dove and waterfowl eat waste grain and green small grain during migration seasons. Generally, the drainageways are dry during dry seasons.

Soil association 10.—This association consists mostly of Lincoln and Sweetwater soils. It covers about 5 percent of the county and generally is not cultivated. The dominant vegetation is cottonwood, tamarisk, willow, buttonbush, plum, elm, cedar, and soapberry. Illinois bundleflower and other native legumes grow well. Tall grasses and the numerous forbs provide a good supply of food for quail, turkey, deer, and dove. Beavers build dams and live in colonies along the river where willow and cottonwood are plentiful. Turkeys roost in the tall cottonwood trees. As in soil association 3, turkey, deer, and quail find a good habitat. Because the water table is high, ponds provide adequate water. They can be stocked with bass and bluegill.

Soil association 11.—This association consists mostly of the Renfrow and Vernon soils, but there are also small amounts of Quinlan, Dill, Grant, and Pond Creek soils. The association covers about 3 percent of the county. About 90 percent of its area is cultivated to small grains and sorghums. The rougher part of this association is the only wildlife habitat of consequence. These rough areas support short and mid grasses but few or no woody plants. Jackrabbit and mourning dove get some benefit from the small amount of vegetation. Water in ponds built in Renfrow soils is too turbid for efficient production of fish. Water in ponds built in Vernon soils is less turbid.

Engineering Uses of Soils ⁵

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, structures for erosion control, drainage systems, and sewage disposal systems. The properties most important to engineers are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and reaction (pH). Depth to the water table, depth to bedrock, and topography also are important.

⁵ By WALTER HART, agricultural engineer, and WILLIAM E. HARDESTY, civil engineer, Soil Conservation Service.



Figure 26.—Area of Nobscot soils suitable for wildlife.

The information in this survey can be used by engineers to—

1. Make studies of soil and land use that will aid in selecting and developing sites for industrial, business, residential, and recreational uses.
2. Make preliminary estimates of the engineering properties of soils in the planning of agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.
3. Make preliminary evaluations of soils and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel and other material used in construction.
5. Correlate performance of engineering structures with soil mapping units and thus develop information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The Engineering interpretations in this subsection can be useful for many purposes, but 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 depths of layers here reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Some of the terms used by the soil scientists may not be familiar to the engineer, and some terms may have a special meaning in soil science. Several of these terms are defined in the Glossary at the back of this survey.

Most of the information in this subsection is in tables 3, 4, and 5, but additional information useful to engineers can be found in other sections of this soil survey, particularly "Descriptions of the Soils" and "Formation and Classification of Soils."

Engineering classification systems

Most highway engineers classify soil materials according to the AASHO system (1). In this system the soils are placed in seven basic groups, designated A-1 through A-7 (3). In group A-1 are gravelly soils of high bearing capacity, or the best soils for road subgrade. In group A-7 are the poorest soils, clays that have low strength when wet. Groups A-1, A-2, and A-7 can be further divided to indicate more precisely the nature of the soil material. Within each group, the relative engineering value of the soil material may be indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. Index numbers are shown in parentheses following the group symbol, for example, A-4(2).

In the Unified classification (8), 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 gravels (G), sands (S), silts (M), clays (C), organic (O), and highly organic (Pt). 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.

The United States Department of Agriculture classifies soils according to texture, which is determined by the proportion of sand, silt, and clay in the soil material (6). The terms "sand," "silt," and "clay" are defined in the Glossary at the back of this survey.

Estimated engineering properties of soils

Table 3 provides estimates of some of the properties of soils that affect engineering. The estimates are for a profile typical of each soil type. The thickness of each horizon can be determined from the data given in the column headed "Depth from surface."

Where test data are available, the estimates are based on test data for the modal, or typical, profile. If tests were not performed for a soil, the estimates are based on test data obtained for similar soils in this county or in other counties, and on past experience. Since the estimates are only for the modal soils, considerable variation from these estimates should be anticipated.

Because Alluvial land, Breaks-Alluvial land complex, Eroded loamy land, and Clayey alluvial land are variable, these land types are not listed in table 3.

The hydrologic soil groups referred to in table 3 are groups of soils having similar rates of infiltration, when wetted, and similar rates of water transmission within the soil. Four such groups are recognized.

Soils in group A have a high infiltration rate, even when thoroughly wetted. They have a high rate of water transmission and low runoff potential. The soils of this group are deep, are well drained or excessively drained, and consist chiefly of sand, gravel, or both.

Soils in group B have a moderate infiltration rate when thoroughly wetted. Their rate of water transmission and their runoff potential are moderate. These soils are moderately deep or deep, and moderately well drained or well drained, and are of fine to moderately coarse texture.

Soils of group C have a slow infiltration rate when thoroughly wetted. Their rate of water transmission is slow, and their potential runoff is high. These soils have a layer that impedes the downward movement of water, or they are moderately fine or fine textured and have a slow infiltration rate.

Soils of group D have a slow infiltration rate when thoroughly wetted. Their rate of water transmission is very slow, and runoff potential is very high. In this group are (1) clay soils with high shrink-swell potential; (2) soils with a permanent high water table; (3) soils with a claypan or clay layer at or near the surface; and (4) soils shallow over nearly impervious material.

Permeability, measured in inches per hour, is the rate at which water moves through undisturbed soil material. The rate depends on the texture and structure of the soil.

TABLE 3.—*Estimated*

Soil name	Hydrologic soil group	Permeability ¹	Depth from surface
Canadian (CaA, CaB)-----	B	<i>Inches per hour</i> 2.5-5.0	<i>Inches</i> 0-32 32-50
Carey (CrB, CrC, CrD2)-----	B	0.8-2.5	0-8 8-43 43-52
Carwile (CsA) (For properties of the Shellabarger soil in mapping unit CsA, refer to the Shellabarger soil series.)-----	C	0.05-0.20	0-12 12-32 32-56
Dill (DfB, DfC, DfD2, DfE)-----	B	2.5-5.0	0-40 40-50
Elsmere (Ee)-----	A	5.0-10.0	0-50 50-58
Enterprise (EnB, EnC)-----	A	2.5-5.0	0-30 30-54
Grant (GrB, GrC, GnD, GnD2)----- (For properties of the Nash soil in mapping units GnD and GnD2, refer to the Nash soil series.)	B	0.80-2.5	0-16 16-40 40-60
Kirkland (KrA)-----	D	<0.05	0-9 9-34 34-39 39-48
LaCasa-----	C	0.20-0.80	0-50
Leshara (Le)-----	B	0.20-0.80	0-38 38-47 47-56
Lincoln (Ln, Ls)-----	A	5.0-10.0	0-8 8-18 18-60
McLain (Mc)-----	C	0.20-0.80	0-30 30-40 40-60
Meno (MeB)-----	B	0.80-2.5	0-24 24-44 44-60
Miller (Mr)-----	D	<0.05	0-7 7-34 34-50
Nash-----	B	0.80-2.5	0-32 32
Nobscot (NcC, NcD, NpC, NpD)----- (For properties of the Pratt soil in mapping units NpC and NpD, refer to the Pratt series.)	A	5.0-10.0	0-17 17-60
Ortello (OrB)-----	A	2.5-5.0	0-32 32-54
Pond Creek (PcA, PcB)-----	C	0.20-0.80	0-12 12-72
Port (Pf, Pr)-----	B	0.20-0.80	0-13 13-60

See footnote at end of table.

properties of soils

Classification			Percentage passing sieve—			Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	<i>Inches per inch of soil</i> 0.14 .07	pH 6.1-8.4 7.4-8.4	Low. Low.
Loamy fine sand.....	SM	A-2	100	90-100	15-30			
Silt loam.....	ML-CL	A-4	100	100	65-85	.14	6.6-7.3	Low.
Silt loam or silty clay loam.	ML or CL	A-6 or A-4	100	100	75-90	.17	6.6-7.8	Low to moderate.
Clay loam or loam.....	CL	A-6 or A-4	100	100	65-95	.17	7.4-8.4	Moderate.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.14	6.1-6.5	Low.
Sandy clay.....	SC	A-6 or A-7	100	100	35-55	.14	7.4-7.8	Moderate.
Sandy clay loam.....	SC or CL	A-4	100	100	40-60	.14	7.4-8.4	Low.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	35-60	.12	6.1-6.5	Low.
Sandstone.....							6.6-7.3	
Loamy fine sand.....	SM	A-2	100	100	15-35	.07	7.4-8.4	Low.
Sandy clay loam.....	SC or CL	A-4	100	100	40-60	.14	7.4-8.4	Low.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.12	7.4-8.4	Low.
Loamy sand.....	SM	A-2	100	90-100	11-30	.07	7.4-8.4	Low.
Silt loam.....	ML-CL	A-4	100	100	75-90	.14	6.6-7.3	Low.
Silty clay loam.....	CL	A-6	100	100	80-95	.17	6.6-8.4	Moderate.
Loam.....	ML or CL	A-4	100	100	55-85	.14	7.4-8.4	Low.
Silt loam.....	ML or CL	A-4	100	100	75-95	.14	6.6-7.3	Low.
Silty clay.....	MH, CH, or CL	A-7	100	100	90-98	.17	6.6-8.4	High.
Clay loam.....	CL	A-6 or A-7	100	100	70-95	.17	7.4-8.4	Moderate.
Sandy clay loam.....	SC or CL	A-4 or A-6	100	100	40-60	.14	7.4-8.4	Low.
Clay loam.....	CL	A-6 or A-7	100	100	75-95	.17	6.6-8.4	Moderate.
Loam.....	ML or CL	A-4	100	100	55-85	.14	7.4-8.4	Low.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.12	7.4-8.4	Low.
Fine sand.....	SM	A-2	100	100	11-20	.05	7.4-8.4	Low.
Fine sand.....	SP-SM	A-3	100	100	5-10	.05	7.4-8.4	Low.
Loamy fine sand.....	SM	A-2	100	90-100	15-35	.07	7.4-8.4	Low.
Sand.....	SP-SM	A-3	100	70-100	5-10	.05	7.4-8.4	Low.
Silty clay loam.....	ML-CL	A-6	100	100	85-95	.17	6.6-7.3	Moderate.
Silty clay.....	ML or CL	A-7	100	100	90-98	.17	7.4-7.8	High.
Clay.....	CL or CH	A-7	100	100	90-98	.17	7.4-8.4	High.
Loamy fine sand.....	SM	A-2	100	90-100	15-35	.07	5.6-7.3	Low.
Sandy clay loam.....	SC or CL	A-4	100	100	40-60	.14	5.6-7.3	Low.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.12	5.6-7.3	Low.
Clay.....	CL or CH	A-7	100	100	90-98	.17	7.4-8.4	High.
Silty clay.....	CL or ML	A-7	100	100	90-98	.17	7.4-8.4	High.
Clay.....	CL or CH	A-7	100	100	90-98	.17	7.4-8.4	High.
Silt loam.....	ML-CL	A-4	100	100	75-95	.14	6.6-8.4	Low.
Sandstone.....								
Fine sand.....	SP-SM	A-3	100	90-100	5-10	.05	5.6-7.3	Low.
Loamy fine sand.....	SM	A-2	100	90-100	15-35	.07	5.6-6.0	Low.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-70	.12	5.6-7.3	Low.
Loamy fine sand.....	SM	A-4	100	100	36-50	.12	5.6-7.3	Low.
Silt loam.....	ML-CL	A-4	100	100	75-90	.14	6.6-7.3	Low.
Silty clay loam.....	CL	A-6	100	100	85-95	.17	6.6-7.8	Moderate.
Silt loam.....	ML-CL	A-4	100	100	75-90	.14	7.4-7.8	Low.
Clay loam.....	CL	A-6 or A-7	100	100	75-95	.17	7.4-8.4	Moderate.

TABLE 3.—*Estimated*

Soil name	Hydrologic soil group	Permeability ¹	Depth from surface
Pratt (PtB, PtC, PtD)-----	A	<i>Inches per hour</i> 2.5-5.0	<i>Inches</i> 0-54
Quinlan (QIB, QIC2)-----	B	2.5-5.0	0-60 6-16 16-30
Reinach (Ra)-----	B	0.80-2.5	0-12 12-20 20-48 48-54
Renfrow (RcA, RcB)-----	D	<0.05	0-14 14-38 38-54
St. Paul (SpA, SpB, SpC)-----	C	0.20-0.80	0-12 12-65
Shellabarger (StB)-----	B	0.80-2.5	0-25 25-48 48-60
Sweetwater (Sw)-----	D	<0.05	0-10 10-32 32-50
Tillman (TcA, TcB, TcC)-----	D	<0.05	0-8 8-60
Tipton (TpA)-----	B	0.80-2.5	0-22 22-51 51-68
Tivoli (TrD)-----	A	5.0-10.0	0-60
Treadway (Tw)-----	D	<0.05	0-45
Vernon (VcB, VeC2, VnB, Vp)-----	D	<0.05	0-16 16-22 22-30
Weymouth (WeB, WeC2, WIB, WIC, WIC2, WvE)----- (For properties of the LaCasa soil in mapping units WIB, WIC, and WIC2, and of the Vernon soil in mapping unit WvE, refer to the LaCasa and Vernon series, respectively.)	C	0.20-0.80	0-7 7-24 24-38
Yahola (Ya)-----	B	2.5-5.0	0-60

¹ Permeability is rated for the least permeable layer.

properties of soils—Continued

Classification			Percentage passing sieve—			Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
Loamy fine sand.....	SM	A-2	100	90-100	15-35	<i>Inches per inch of soil</i> 0.12	pH 6.6-7.3	Low.
Loam.....	ML or CL	A-4	100	100	55-85	.14	7.4-8.4	Low.
Very fine sandy loam.....	ML	A-4	100	100	60-80	.14	7.4-8.4	Low.
Sandstone.....								
Very fine sandy loam.....	ML	A-4	100	100	55-85	.14	6.6-7.8	Low.
Loam.....	ML or CL	A-4	100	100	55-85	.14	6.6-8.4	Low.
Very fine sandy loam.....	ML	A-4	100	100	55-85	.14	7.4-8.4	Low.
Loam.....	ML or CL	A-4	100	100	55-85	.14	7.4-8.4	Low.
Silty clay loam.....	ML-CL	A-6	100	100	85-95	.17	6.6-7.3	Moderate.
Clay.....	CL or CH	A-7	100	100	90-98	.17	6.6-8.4	High.
Clay loam.....	CL	A-6 or A-7	100	100	75-98	.17	7.4-8.4	Moderate.
Silt loam.....	ML-CL	A-4	100	100	75-95	.14	6.6-7.3	Low.
Silty clay loam.....	CL or ML	A-6 or A-7	100	100	85-95	.17	6.6-8.4	Moderate.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.14	5.6-6.6	Low.
Sandy clay loam.....	SC or CL	A-4	100	100	40-60	.14	6.1-7.3	Low.
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.14	6.1-7.8	Low.
Loam.....	ML or CL	A-4	100	100	55-85	.14	7.4-8.4	Low.
Loamy fine sand.....	SM	A-2	100	90-100	15-35	.07	7.4-8.4	Low.
Sand.....	SP-SM	A-3	100	90-100	5-10	.05	7.4-8.4	Low.
Clay loam.....	CL	A-4, A-6, or A-7	100	100	75-95	.17	7.4-7.8	Moderate.
Clay.....	CL or CH	A-7	100	100	90-98	.17	7.4-8.4	High.
Silt loam.....	ML or CL	A-4	100	100	75-90	.14	6.6-7.8	Low.
Clay loam.....	CL	A-6 or A-7	100	100	75-95	.17	7.4-8.4	Moderate.
Sandy clay loam.....	SC or CL	A-4	100	100	40-60	.14	7.4-8.4	Low.
Fine sand.....	SP-SM	A-3	100	100	5-10	.05	6.6-7.3	Low.
Clay.....	CL, CH, or ML	A-6 or A-7	100	100	90-100	.17	7.4-8.4	High.
Clay loam.....	CL	A-6 or A-7	100	100	75-95	.17	7.4-8.4	Moderate.
Clay.....	CL or CH	A-7	100	100	90-98	.17	7.4-8.4	High.
Shale.....								
Loam.....	ML or CL	A-4	100	100	55-98	.14	7.4-7.8	Low.
Clay loam.....	CL or ML	A-6 or A-7	100	100	75-98	.17	7.4-8.4	Moderate.
Sandstone and shale.....								
Fine sandy loam.....	SM or ML	A-2 or A-4	100	100	30-60	.14	7.4-8.4	Low.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		
	Topsoil	Select grading material	Subgrade
Canadian (CaA, CaB).....	Poor; easily eroded in the more sloping areas.	Good.....	Good.....
Carey (CrB, CrC, CrD2).....	Good.....	Poor; small amount of usable material.	Fair; fairly unstable material, mostly clayey.
Carwile (CsA)..... (For the Shellabarger part of the mapping unit CsA, refer to the Shellabarger series.)	Poor; easily eroded material over clayey material.	Fair; usable material to depth of 1 foot.	Fair to poor; good material to depth of 1 foot; over clay material.
Dill (DfB, DfC, DfD2, DfE).....	Poor; easily eroded in the more sloping areas.	Good.....	Good if slopes are stabilized.
Elsmere (Ee).....	Poor; easily eroded in the more sloping areas.	Poor; high water table..	Poor; high water table..
Enterprise (EnB, EnC).....	Poor; easily eroded in the more sloping areas.	Good.....	Good.....
Grant (GrB, GrC, GnD, GnD2)..... (For the Nash part of the mapping units GnD and GnD2, refer to the Nash series.)	Fair.....	Fair; elastic material....	Fair to good.....
Kirkland (KrA).....	Poor; small amount of fairly suitable material.	Poor; elastic material over clay.	Poor; mostly clay material.
LaCasa.....	Good; large amount of suitable material.	Poor; material too clayey.	Fair; fairly unstable, clayey material.
Leshara (Le).....	Fair to good; water table at depth of 2 to 3 feet.	Fair to poor; material fairly good but water table at depth of 2 to 3 feet.	Fair to poor; water table at depth of 2 to 3 feet.
Lincoln (Ln, Ls).....	Poor; easily eroded in the more sloping areas.	Good.....	Good if slopes are stabilized.
McLain (Mc).....	Fair.....	Poor; material too clayey.	Poor; profile unstable throughout.
Meno (MeB).....	Poor; easily eroded in the more sloping areas.	Good; large amounts of suitable material.	Good.....
Miller (Mr).....	Unsuitable; material too clayey.	Poor; material too clayey.	Poor; high shrink-swell potential; clayey material.
Nash.....	Poor; material easily eroded.	Fair; elastic material....	Fair to poor; sandstone at a depth of about 2½ feet.
Nobscoot (NcC, NcD, NpD, NpC)..... (For the Pratt part of the mapping units NpD and NpC, refer to the Pratt series.)	Poor; easily eroded in the more sloping areas.	Good; large amount of suitable material.	Good if slopes are stabilized.
Ortello (OrB).....	Poor; easily eroded in the more sloping areas.	Good; large amount of suitable material.	Good if slopes are stabilized.

interpretations of soils

Soil features affecting—				
Highway location	Farm ponds		Terraces and diversions	Waterways
	Reservoir area	Embankment		
Features favorable.....	Excessive seepage in places.	Erosive material; high seepage.	Nearly level to gently sloping.	Nearly level and gently sloping.
Features favorable.....	Features favorable.....	Features favorable.....	Features favorable.....	Features favorable.
Ponding during wet seasons; poorly drained.	Features favorable except on nearly level slopes.	Features favorable.....	Depressional to nearly level.	Depressional to nearly level.
Features favorable.....	High seepage.....	Erosive material; high seepage.	High permeability; soil blowing likely.	Soil blowing and deposition by wind likely.
High water table.....	Features favorable for dug ponds; high water table.	Very erosive material; high seepage.	Nearly level.....	Nearly level; high water table.
Features favorable.....	High seepage.....	Erosive material; high seepage.	High permeability; soil blowing likely.	Soil blowing and deposition by wind likely.
Features favorable.....	Features favorable.....	Features favorable.....	Features favorable.....	Features favorable.
High shrink-swell potential; clay subsoil.	Features favorable; nearly level.	Features favorable for low fills.	Very slow permeability..	Nearly level; droughty.
Features favorable.....	Features favorable.....	Features favorable for low fills.	Nearly level.....	Nearly level.
Water table at depth of 2 to 3 feet.	Features favorable for dug ponds; high water table.	Limited amount of suitable material; high water table.	Nearly level.....	Nearly level; high water table.
Flooding likely.....	High seepage.....	Erosive material; high seepage.	Nearly level slopes; rapid intake rate.	Nearly level; droughty; easily eroded.
High shrink-swell potential; substratum unstable.	Features favorable for dug ponds.	Features favorable.....	Nearly level.....	Nearly level.
Features favorable.....	High seepage.....	Erosive material; high seepage.	Slightly undulating to nearly level.	Slightly undulating to nearly level.
High shrink-swell potential; unstable clay.	Features favorable for dug ponds.	Features favorable for low fills; high fills unstable.	Nearly level.....	Nearly level; soil cracks when dry.
Features favorable.....	High seepage; sandstone at a depth of about 2½ feet.	Erosive material; small amount suitable.	Easily eroded soils; sandstone at depth of 2 to 3 feet.	Easily eroded soils.
Features favorable.....	High seepage.....	Erosive material; high seepage.	Steep dunes and hummocky areas; soil blowing likely.	Steep dunes and hummocky areas; droughty.
Features favorable.....	High seepage.....	Erosive material; high seepage.	Undulating slopes; soil blowing likely.	Undulating slopes; easily eroded.

TABLE 4.—Engineering

Soil series and map symbols	Suitability as source of—		
	Topsoil	Select grading material	Subgrade
Pond Creek (PcA, PcB).....	Good.....	Poor; 1 foot of elastic material over clayey subsoil.	Fair to poor; fairly unstable material.
Port (Pf, Pr).....	Good; large amount of suitable material.	Fair to poor; selected areas of suitable material.	Fair to poor; mostly clayey material.
Pratt (PtB, PtC, PtD).....	Poor; easily eroded in the more sloping areas.	Good.....	Good if slopes are stabilized.
Quinlan (QIB, QIC2).....	Fair to poor; fairly erosive material; small amount of suitable material.	Fair to poor; small amount of suitable material over sandstone.	Fair to poor; small amount of suitable material over sandstone.
Reinach (Ra).....	Fair; material somewhat erosive but is in large amounts.	Good; large amount of suitable material.	Good.....
Renfrow (RcA, RcB).....	Fair to poor; dense clay at depth of about 1 foot.	Poor; material too clayey.	Poor; high shrink-swell potential; clayey material.
St. Paul (SpA, SpB, SpC).....	Fair to poor; easily eroded; small amount of suitable material.	Poor; elastic and clayey material.	Fair to poor; mostly clayey material.
Shellabarger (StB).....	Poor; easily eroded in the more sloping areas.	Good; large amount of suitable material.	Good.....
Sweetwater (Sw).....	Poor; high water table..	Poor; high water table..	Poor; high water table..
Tillman (TcA, TcB, TcC).....	Poor; clay at depth of less than 1 foot.	Poor; clayey material....	Poor; high shrink-swell potential; unstable material.
Tipton (TpA).....	Fair; fairly erosive in the more sloping areas.	Fair; elastic material....	Fair; elastic, silty, and clayey material.
Tivoli (TrD).....	Poor; easily eroded in the more sloping areas.	Good.....	Good if slopes are stabilized.
Treadway (Tw).....	Poor; material too clayey.	Poor; material too clayey.	Poor; high shrink-swell potential; unstable material.
Vernon (VcB, VeC2, VnB, Vp).....	Poor; material too clayey.	Poor; material too clayey.	Poor; unstable clayey material.
Weymouth (WeB, WeC2, WIB, WIC, WIC2, WvE).... (For the LaCasa part of the mapping units WIB, WIC, and WIC2 and for the Vernon part of the unit WvE, refer to the LaCasa and Vernon series, respectively.)	Fair to poor; small amount of suitable material.	Poor; material too clayey.	Fair; small amount of material over sandstone and shale.
Yahola (Ya).....	Poor; easily eroded in the more sloping areas.	Good; large amount of suitable material.	Good.....

interpretations of soils—Continued

Soil features affecting—				
Highway location	Farm ponds		Terraces and diversions	Waterways
	Reservoir area	Embankment		
Subsoil clayey and fairly unstable.	Features favorable.....	Features favorable.....	Features favorable.....	Features favorable.
Flooding likely; fairly unstable substratum.	Features favorable except on nearly level slopes.	Features favorable.....	Nearly level.....	Nearly level.
Features favorable.....	High seepage.....	Very erosive material; high seepage.	Duned and hummocky areas; soil blowing likely.	Duned and hummocky areas; droughty.
Features favorable.....	Shallow depth to sandstone.	Limited borrow material.	Features favorable except for limited depth to sandstone.	Soils droughty and easily eroded.
Features favorable.....	High seepage likely.....	Material erosive.....	Nearly level.....	Nearly level.
High shrink-swell potential; unstable subsoil.	Features favorable.....	Features favorable for low fills.	Features favorable.....	Features favorable.
Unstable clayey subsoil.....	Features favorable.....	Features favorable.....	Features favorable.....	Features favorable.
Features favorable.....	High seepage.....	Erosive material; high seepage.	Features favorable.....	Features favorable.
High water table.....	Features favorable for dug ponds; high water table.	Very erosive material; high seepage.	Nearly level; high water table.	Nearly level; high water table.
High shrink-swell potential; unstable subsoil.	Features favorable.....	Features favorable for low fills.	Features favorable.....	Features favorable.
Features favorable if moisture is controlled.	Features favorable.....	Features favorable.....	Nearly level.....	Nearly level.
Features favorable.....	High seepage.....	Erosive material; high seepage.	Steep duned areas; high hazard of soil blowing.	Steep dunes areas; droughty.
High shrink-swell potential; unstable soil.	Features favorable.....	Unstable material for any height fill.	Nearly level slopes.....	Nearly level; droughty.
Clayey material over shale at depth of 1½ to 2½ feet.	Shale at depth of 1½ to 2½ feet.	Small amount of suitable clayey material.	Features favorable except on steeper slopes.	Droughtiness; some steep slopes.
Features favorable.....	Sandstone or shale at depth of 2 to 3 feet.	Small amount of suitable material.	Features favorable except on steeper slopes.	Features favorable.
Occasional flooding.....	High seepage.....	Erosive material; high seepage.	Nearly level slopes.....	Nearly level slopes.

TABLE 5.—Engineering

[Tests performed by the Oklahoma Department of Highways in accordance with standard procedures of American Association of State Department of Commerce,

Soil name and location	Parent material	Oklahoma report No.	Depth	Horizon	Shrinkage	
					Limit	Ratio
			<i>Inches</i>			
Carey silt loam: 1,100 feet south and 30 feet east of northwest corner of sec. 28, T. 22 N., R. 16 W. (Modal).	Permian shale and sandstone.	SO-6890	0-8	A1	20	1. 73
		SO-6891	14-26	B2t	16	1. 81
		SO-6892	30-60	C	14	1. 83
Kirkland silt loam: 1,150 feet south and 150 feet west of northeast corner of sec. 12, T. 21 N., R. 13 W. (Modal).	Permian clay and shale.	SO-6893	0-8	A	13	1. 92
		SO-6894	8-28	B2t	11	2. 01
		SO-6895	36-48	C	11	2. 01
Sweetwater soils: 2,300 feet east and 20 feet north of southwest corner of sec. 6, T. 23 N., R. 15 W. (Modal).	Alluvium.	SO-6899	0-13	A1	19	1. 76
		SO-6900	13-55	C	NP	NP
Ortello fine sandy loam: 450 feet north and 125 feet east of southwest corner of sec. 24, T. 20 N., R. 16 W. (Modal).	Eolian sandy materials.	SO-6896	0-7	A	19	1. 70
		SO-6897	7-15	B2t	20	1. 73
		SO-6898	15-50	C	17	1. 75
St. Paul silt loam: 485 feet south and 90 feet east of northwest corner of sec. 29, T. 23 N., R. 16 W. (Modal).	Permian red beds.	SO-6903	0-12	A	21	1. 69
		SO-6904	18-32	B2t	15	1. 86
		SO-6905	44-54	C	11	2. 01
Tillman clay loam: 3,525 feet west and 50 feet north of southeast corner of sec. 5, T. 22 N., R. 15 W. (Modal).	Permian clay and shale.	SO-6906	0-6	A	16	1. 84
		SO-6907	10-20	B2t	12	1. 99
		SO-6908	30-45	B3	19	1. 77
Tipton silt loam: 2,550 feet east and 30 feet south of northwest corner of sec. 12, T. 23 N., R. 16 W. (Modal).	Alluvial or eolian mantle.	SO-6909	0-14	A	18	1. 76
		SO-6910	14-36	B2t	17	1. 80
		SO-6911	36-60	C	13	1. 93
Treadway clay: 2,100 feet west and 350 feet north of southeast corner of sec. 21 T. 23 N., R. 15 W. (Modal).	Alluvium.	SO-6901	0-12	A1	16	1. 83
		SO-6902	12-48	B	16	1. 86
Weymouth loam: 1,870 feet north and 45 feet east of southwest corner of sec. 32, T. 23 N., R. 16 W. (Modal).	Clay of the Permian red beds.	SO-6912	0-5	A	17	1. 83
		SO-6913	9-30	B	19	1. 81

¹ Mechanical analyses according to AASHO Designation T 88-57 (1). Results obtained by this procedure may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses data used in this table are not suitable for use in naming textural classes of soil.

² Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing: The Classification of Soils and Soil-Aggregate Mixtures of Highway Construction Purposes, AASHO Designation M 145-49 (1). Oklahoma Department of Highways

test data

Highway Officials (AASHO) (1). The work by the highway department was performed under a cooperative agreement with the U.S. Bureau of Public Roads]

Volume change from field moisture equivalent	Mechanical analysis ¹						Liquid limit	Plasticity index	Classification	
	Percentage 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>										
12	-----	100	81	67	23	19	28	6	A-4(8)	ML-CL
22	100	99	77	65	27	22	30	9	A-4(8)	ML-CL
22	100	95	68	60	33	27	28	10	A-4(7)	CL
26	100	99	90	81	36	31	31	1	A-4(8)	ML
57	-----	100	93	89	56	49	47	22	A-7-6(14)	CL
32	100	96	71	61	35	31	33	16	A-6(10)	CL
24	100	96	72	65	25	20	32	8	A-4(7)	ML-CL
⁴ NP	100	73	7	6	5	4	⁴ NP	⁴ NP	A-3(0)	SP-SM
3	100	98	59	38	11	9	21	1	A-4(5)	ML
6	100	99	69	53	14	12	25	4	A-4(7)	ML-CL
5	100	98	46	29	11	10	20	5	A-4(2)	SM-SC
13	-----	-----	95	82	23	19	32	8	A-4(8)	ML-CL
21	-----	-----	95	84	35	31	39	15	A-6(10)	ML-CL
63	100	99	95	88	47	40	46	20	A-7-6(13)	ML-CL
26	-----	100	90	78	33	30	30	10	A-4(8)	CL
43	100	99	92	83	55	47	41	21	A-7-6(13)	CL
35	100	99	93	90	66	54	47	20	A-7-6(13)	ML-CL
8	100	95	79	56	16	14	24	3	A-4(8)	ML
15	100	94	77	69	21	18	27	7	A-4(8)	ML-CL
27	⁵ 99	89	72	64	29	26	32	14	A-6(9)	CL
23	-----	-----	94	87	56	47	36	14	A-6(10)	CL
30	-----	-----	99	96	64	54	41	17	A-7-6(11)	ML-CL
18	-----	-----	97	86	30	24	30	9	A-4(8)	ML-CL
19	-----	100	97	94	39	28	36	13	A-6(9)	ML-CL

classification procedure further subdivides the AASHO subgroup A-2-4 into the following: A-2-3 if the plasticity index shows material is nonplastic; A-2 if the plasticity index ranges from nonplastic to 5; and A-2-4 if plasticity index ranges from 5 to 10. The group index number for each of these subgroups is 0.

³ Based on the Unified Soil Classification System, Waterways Experiment Station, Corps of Engineers, March 1953 (8). Soil Conservation Service and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within 2 points of the A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are SM-SC and ML-CL.

⁴ Nonplastic.

⁵ 100 percent of material passes through No. 4 sieve.

Generally, those soils classified as A-1 in the AASHO system have the highest rate of permeability; those soils classified as fine grained in the Unified system or as A-7 in the AASHO system have the lowest rate.

Available water capacity, given in inches per inch of soil depth, is the approximate amount of capillary water in the soil when it is wetted to field capacity. The estimates in table 4 are based on the texture and structure of the soil material. Fine-grained soils have a greater available water capacity than coarse-grained soils. If the soil is air dry, or at permanent wilting point of plants, the amount of water stated in table 3 will wet the soil material to a depth of 1 inch without deeper penetration.

In the column headed "Reaction" the degree of soil acidity or alkalinity is expressed in pH values. A pH of 7.0 is neutral; lower values indicate acidity, and higher values indicate alkalinity. A soil having a pH of 4.5 to 5.0 is very strongly acid, and one having a pH of 8.5 to 9.0 is strongly alkaline.

Shrink-swell potential indicates how much the volume of soil material changes as moisture content changes. The estimates in table 3 are based primarily on the amount and type of clay material. In general, soils classified as CH and A-7 have a high shrink-swell potential, and those classified as GW or SW (coarse grained) and A-1 have a low shrink-swell potential.

Engineering interpretations of soils

In table 4 the soils of Major County are rated according to their suitability as a source of topsoil, of select grading material, and of subgrade. Also pointed out are those soil features affecting suitability as sites for highways, farm ponds, terraces and diversions, and waterways. The information in table 4 is based on the estimated engineering properties in table 3, the actual test data in table 5, and field experience with the soils.

Topsoil is fertile soil material that is used to topdress roadbanks, lawns, and gardens. Ordinarily it is rich in organic matter. The ratings in table 4 normally are for the surface layer. Suitability of soil material as topsoil depends largely on texture and thickness of the surface layer. Texture should be favorable for making a good seedbed, and thickness should be great enough to permit economical removal of material.

The suitability of select grading material depends primarily on the grain size and the content of silt and clay. Soils that are primarily sand are good grading material if a binder is added to increase cohesion. In contrast, clay soils are poor grading material, because they compress under load but rebound when unloaded.

All kinds of soil material are used as road subgrade. Sandy clays and sandy clay loams are easy to place and to compact. Clays having high shrink-swell potential, however, require special methods of compaction and close control of moisture both during and after construction. Sands compact well but are difficult to confine in a fill.

Commercial sand in Major County is obtained primarily from Canadian fine sandy loam; Enterprise fine sandy loam, coarse variant; Lincoln loams; Lincoln soils; Nobscot fine sand; Nobscot-Pratt complex; Ortello fine sandy loam; Pratt loamy fine sand; Reinach very fine sandy loam; Sand dunes, Lincoln material; Yahola fine sandy loam; and Tivoli fine sand. Lincoln soils and the Lincoln loams are the major sources of commercial gravel.

Engineering test data

Table 5 contains the test data for soil samples collected from selected soils and tested by the Oklahoma Department of Highways. The tests were made for the purpose of determining shrinkage, volume change, liquid limit, and plasticity index.

As moisture is removed, the volume of a soil decreases, in direct proportion to the loss of moisture, until equilibrium, called the *shrinkage limit*, is reached. Beyond the shrinkage limit, more moisture may be removed, but the volume of the soil does not change. In general, the lower the number-listed in table 5 for the shrinkage limit, the higher the content of clay.

The shrinkage ratio is the volume change, expressed as a percentage of the volume of dry soil material, divided by the loss of moisture caused by drying. The ratio is expressed numerically. The volume change used in computing shrinkage ratio is the change in volume that will take place in a soil when it dries from a given moisture content to the point where no further shrinkage takes place.

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 field moisture equivalent is the volume change, expressed as a percentage of the dry volume, of the soil mass when the moisture content is reduced from the field moisture equivalent (FME) to the shrinkage limit.

In mechanical analysis, the soil components are sorted by particle size. Sand and other granular material are retained on the No. 200 sieve. Silt-clay materials are those soil particles smaller than the openings in a No. 200 sieve. Clay is the fraction smaller than 0.002 millimeter in diameter. The material intermediate in size between that held on the No. 200 sieve and that having a diameter of 0.002 millimeter is called silt.

Liquid limit and plastic limit indicate the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases 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 at which the soil material passes from a semisolid to plastic state. The liquid limit is the moisture content at which the material changes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Geology

The soils in Major County formed largely in materials deposited during the Permian and Quaternary geologic periods. Geologic formations at or near the surface are shown in figure 27. In the Permian period, about 200 million years ago, sediments that formed the red beds were deposited. Permian red beds can be distinguished by the reddish color of iron oxides that formed in the prevailing arid climate.

At times during the Permian period, shallow seas covered what is now Major County. The land was sometimes above and sometimes below water. When the inland seas dried up, vast deposits of gypsum and salts were left. Strata of these deposits can be seen in Dog Creek shale, Flowerpot shale, and the Blaine formation. Figure 28.

shows these and other important formations laid down in the Permian and Quaternary periods.

The crossbedding in Rush Springs sandstone and the Marlow formation indicates that desert conditions prevailed when the land was not covered with water. Well drilling has shown that the Permian red beds and gypsum

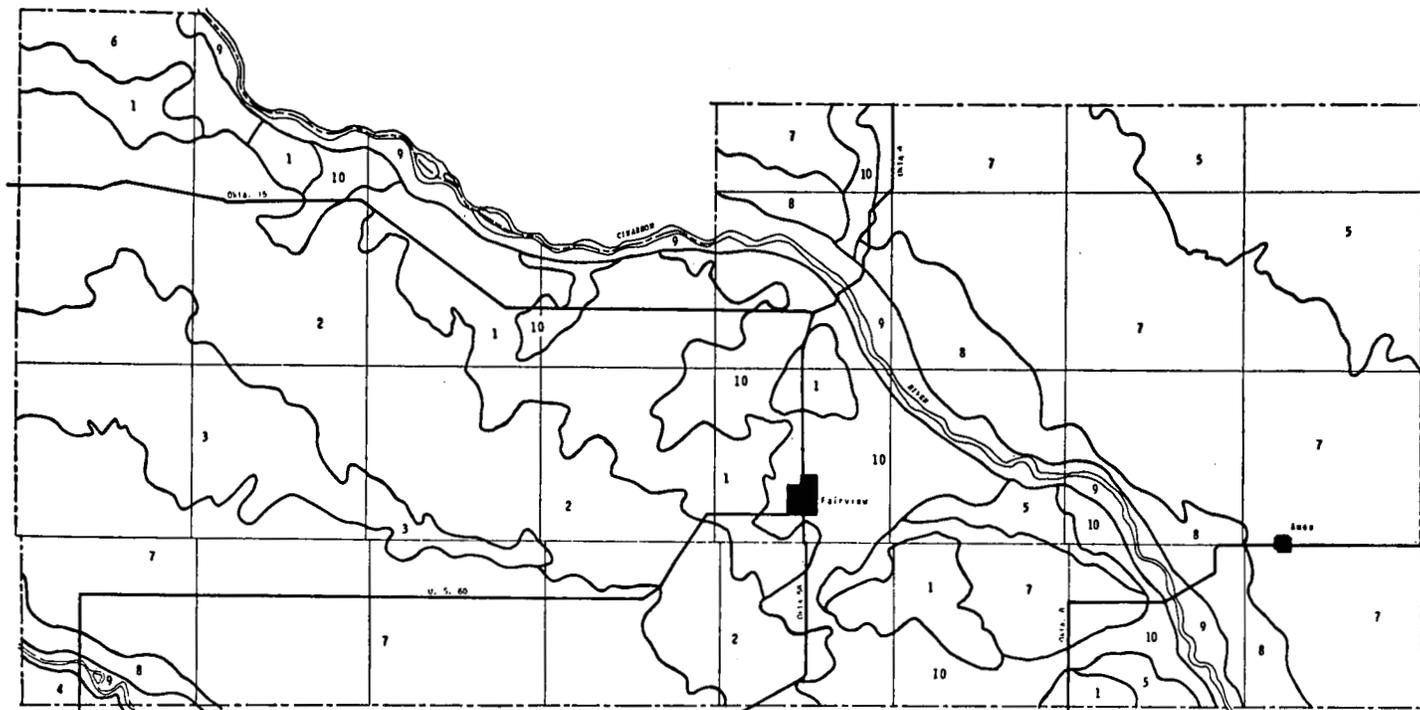


Figure 27.—Generalized geology of Major County: (1) Flowerpot shale; (2) Blaine formation and Dog Creek shale; (3) Marlow formation and Rush Springs sandstone; (4) Rush Springs sandstone; (5) loamy mantle and outcrops of Cedar Hills sandstone; (6) loamy mantle and outcrops of Flowerpot shale; (7) Quaternary sands, wind-worked alluvium; (8) Quaternary sands, recent wind-deposited dunes; (9) recent alluvial deposits; (10) alluvial deposits consisting of former streambeds and recent alluvium.

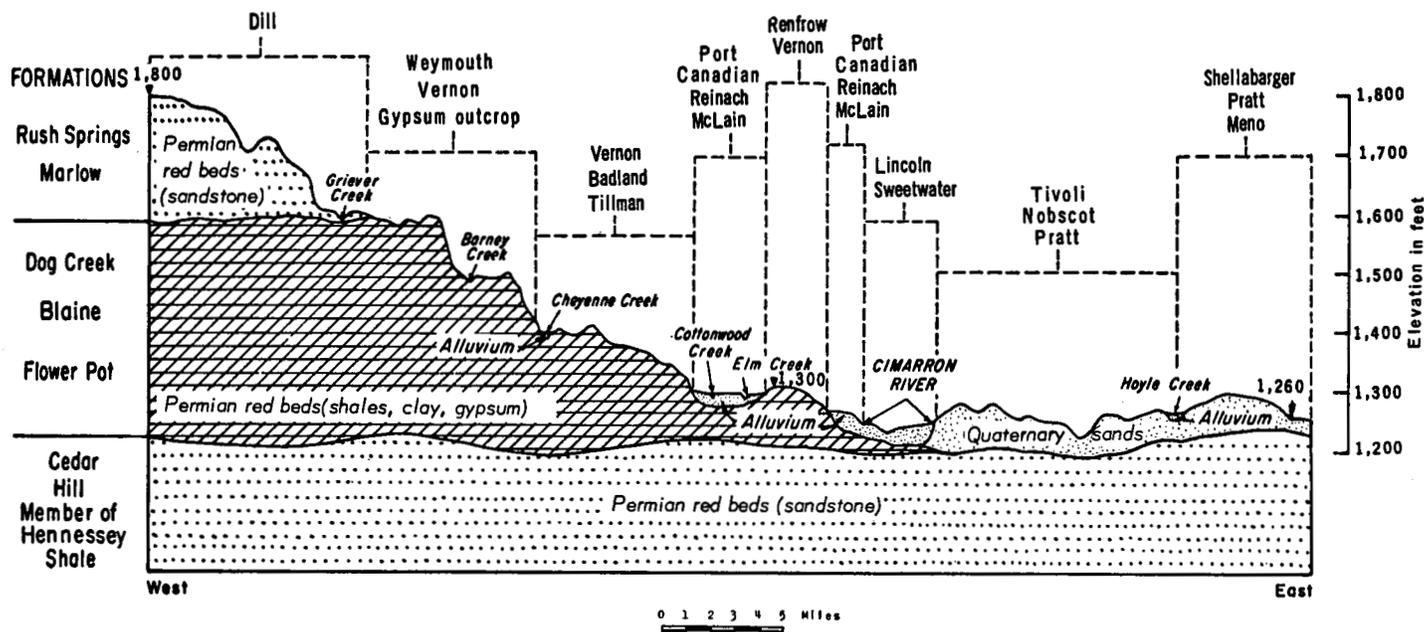


Figure 28.—Cross section along a line extending across the middle of the county from the western to the eastern boundary.

beds are well over a thousand feet thick in Major County. The Permian red beds are more prominent in the western half of the county than in the eastern half. Nearly 600 feet of red earths and evaporites are exposed in the western half of Major County. Evaporites are sediments deposited from aqueous solution when the solvent evaporates.

Two groups of formations in Permian red beds are exposed in the western part of the county. Of these groups, the El Reno is below the Whitehorse. Flowerpot shale, the lowest formation of the El Reno group, is the oldest Permian formation in the western half of the county. In ascending order above this shale are the Blaine formation and Dog Creek shale. Above the Dog Creek shale are the Marlow formation and Rush Springs sandstone, which make up the Whitehorse group.

Flowerpot shale is at the surface in an erosional plain adjacent to the Cimarron River, but several miles south of the river, some drains that have cut deeply into the uplands expose this formation. The parts of Flowerpot shale exposed in the county are about 200 feet thick. In Major County the principal soils associated with this formation are in the Tillman and Vernon series. In many areas the Vernon soils are intermingled with areas of Badland.

The Blaine formation lies above Flowerpot shale and below Dog Creek shale. An abundance of gypsum is the outstanding characteristic of the Blaine formation in the western part of the county. This gypsum can be seen in a stratum that caps the buttes and blufflike escarpments throughout the western part of the county (fig. 29).

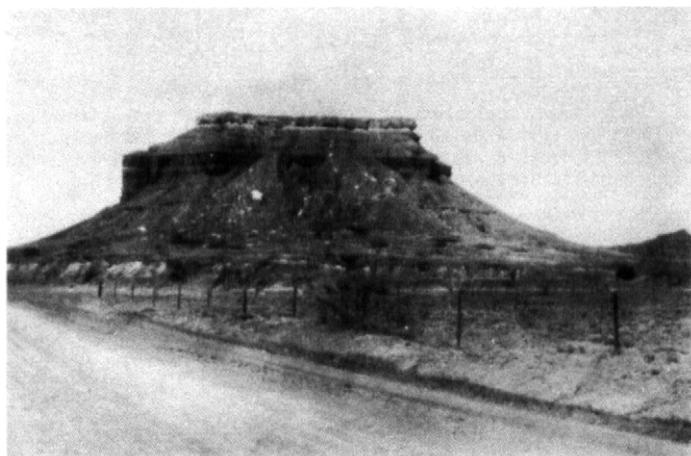


Figure 29.—A small butte showing an exposure of Flowerpot shale capped by gypsum of the Blaine formation.

A large part of the gypsum deposits of the Blaine formation are exposed in the Vernon-Gypsum outcrop complex. Some Vernon soils developed in the shale deposits of this formation. Many caves and sinkholes occur where water has dissolved and removed the soluble gypsum. Many of these caves are summer homes for bats. Several tons of guano have been removed from the caves for use as commercial fertilizer.

Dog Creek shale is the uppermost formation of the El Reno group. It consists of reddish and bluish silty shale and reddish siltstone containing some clay. In a few places, there are beds of gypsum, gypsiferous siltstone, sandstone, and silty dolomite. Dog Creek shale ranges from about 40

to 120 feet in thickness. This shale is exposed in the western part of the county. Soils associated with this formation are in the Weymouth, LaCasa, Carey, St. Paul, and Vernon series.

In the Whitehorse group, Rush Springs sandstone lies above the Marlow formation. The Marlow formation rests on Dog Creek shale. The Marlow formation is red to reddish-brown, fine-grained sandstone. In local areas it is noncalcareous to weakly calcareous and in places is cross-bedded. It ranges from about 40 to 90 feet in thickness. Dill soils developed from materials weathered from the Marlow formation.

Rush Springs sandstone rests on the Marlow formation in the southwestern part of the county and in spots in the west-central part. It consists of reddish, calcareous, fine-grained sandstone that is about 10 to 130 feet thick. It is somewhat harder than the underlying Marlow formation. A few wells that supply water of good quality have been dug into these sandstone formations. The supply of water is low but is adequate for home use. The Dill and Carey soils are associated with Rush Springs sandstone.

In the eastern part of the county, Flowerpot shale is the uppermost Permian formation. On this shale the Renfrow and Vernon soils developed. Also exposed in the eastern part of the county is the Cedar Hills member of Hennessey shale. Erosion has removed the Flowerpot shale and has exposed the Hennessey shale. A small amount of ground water of good quality is in the Hennessey shale. The Cedar Hills member consists of brownish-red, fine-grained sandstone and silty sandstone separated by silty shale and siltstone containing some clay. The Cedar Hills member is about 130 feet thick. Except in a few places where it is exposed at the surface, it is covered with a mantle. The Weymouth, Nash, and Quinlan soils have formed in this red-bed deposit.

The Pleistocene epoch of the Quaternary period contributed to the development of the surface of Major County. This epoch began about one million years ago. In the Pleistocene epoch much material was deposited in a broad belt along the streams in the county.

Southerly winds caused the formation of sand dunes and their migration northward. Evidence of this process is the broad belt of sandy deposits north of the Cimarron and North Canadian Rivers. Some of the soils that developed in this belt are in the Pratt, Nobscot, Ortello, Shellabarger, Carwile, and Meno series. These soils formed in fine-grained material that was reworked in places by wind. The sandhills on the north bank of the rivers are fairly recent deposits of the Quaternary period. Wind shaped the deposits into dunes that range from 10 to 50 feet in height. The area of duned-shaped sands is about 1 mile wide. The dunes consist of loose sand that probably came from the streambed to the south. Because the materials have been winnowed, they contain little silt or clay. In older, deeper deposits made by water, the particles range from clay to gravel in size. Also present are a few broken shells that were washed in. In these deposits, it is fairly easy to locate a good source of water, some in quantities large enough for irrigation. The water-bearing zone is just above the line where the sand deposits and the red beds are in contact.

Erosional forces began shaping the surface of the county in the Quaternary period, and geologic erosion is continuing. The gypsum ledge marks the boundary be-

tween the formations to the west consisting of less dissolved materials and the formation to the east where there is a more eroded plain. Erosional forces of water determined the courses of the Cimarron and North Canadian Rivers, and like all young streams, these rivers gradually cut their streambeds. Evidently, the Cimarron River once flowed through the valley in which the town of Fairview is located. The stream circled south across the southern edge of the county and then turned eastward to its present channel. The former streambed is now a valley of fertile soils.

Mantles of material, some young and some old, occur in the county and have textures of silt loam, fine sandy loam, loam, very fine sandy loam, and clay loam. The older mantles, which indicate mature development of soils in place, are in areas of Flowerpot shale and the Cedar Hills member of Hennessey shale in the south-central and northeastern parts of the county. The mantles range from 1 to 20 feet in thickness. In them the Pond Creek, Kirkland, and Grant soils developed. Younger mantles blanket Flowerpot shale on the south bank of the Cimarron River and blanket Rush Springs sandstone south of the North Canadian River. Tipton and Enterprise soils formed in these areas.

In Major County, the alluvial deposits of the Recent epoch consist of sand, gravel, and mud. Areas of these deposits are called bottom land, valley wash, or flood plains. The character of the deposit depends largely on the area drained by the stream that deposited them. If the stream runs through a silty or clayey area, most of the alluvium is of silt or clay texture. If the stream runs through a sandy area, the alluvium is mostly sand. The speed of the water and the distance the materials are carried also affect the kind of deposit. Generally, only the heavier particles of sand and gravel are dropped by swift streams. Silt and clay are deposited by slow-moving backwaters, and the soils that develop in these deposits are generally fertile. Materials deposited by swift streams are coarse, and the soils formed in these materials are sandy.

Most of the alluvium in Major County occurs along the valleys of the Cimarron and North Canadian Rivers in strips 1 to 2 miles wide. Other areas, however, are in the valley around Fairview and along the smaller streams of the county. The main soils that developed in this alluvium are in the Port, Yahola, Canadian, Leshara, Elsmere, McLain, Reinach, Sweetwater, Miller, and Lincoln series. The water-deposited sand and gravel underlying the Lincoln soils are sources of sand and gravel for commercial use. Ground water of fair quality underlies the sandy soils near streams. On bottom land, the finer textured soils generally supply little ground water of good quality.

Formation and Classification of Soils

This section deals with the environment in which the soils formed, and with classification of the soils. Physical and chemical data are limited for these soils, and the discussion of soil genesis is correspondingly incomplete.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on the materials deposited or accumulated by geologic processes.

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 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 genesis. They act on the parent material that has 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 kind of profile that forms, and in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for the differentiation of soil horizons. Generally, a long time is required for the development of 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.

Parent material

The parent material of the soils in Major County was derived from (1) Permian red beds; (2) Quaternary sand; (3) a Quaternary loamy mantle; and (4) alluvium. The geologic materials from which the soils formed are discussed in the subsection "Geology."

Two kinds of beds make up the Permian red beds. One kind is in a large total acreage and consists of shale, clay, siltstone, and gypsum. The other is in a smaller but fairly extensive area and consists of sandstone and pack sand.

The beds consisting of shale, clay, siltstone, and gypsum weather slowly, and many of the soils formed in these beds are shallow. The depth to which these soils have developed, however, depend on the lay of the land and the length of time that weathering has taken place. The Vernon soils are examples of shallow soils that formed in resistant red beds. Tillman and Renfrow soils also formed in this kind of material, but they are deep because the processes of soil development have been going on for a long time.

The sandstone and pack sand in the Permian red beds are less resistant to weathering than the shale and siltstone, and less time is required for soil development. Soils developed from weathered sandstone and pack sand have a fine sandy loam texture, and they reflect the reddish color of the parent material. Dill, Carey, Quinlan, and Nash soils have developed in these formations.

Eolian sands laid down in the Quaternary period do not contain coarse fragments. Particles of sand have been reduced by bombardment caused by wind, though the sand, mostly feldspar and quartz, resists weathering. In the older deposits weathering is deeper, and the soils are fairly fertile. Soils in the deeper deposits are in the Pratt, Shellbarger, Ortello, Meno, Nobscot, and Enterprise series. The Tivoli soils on sand dunes north of the Cimarron and North Canadian Rivers are young and are still receiving sand that is fine and is blown from the riverbed to the south.

The Quaternary loamy mantle was laid down by wind. This mantle flanks the broad tableland near Meno, in the

northeastern part of the county, and is in an upland area southeast of Fairview. The mantle is thick. It was deposited on the red beds before large masses of sand were deposited, as is indicated in places by deposits of sand covering the loamy deposits. This mantle has a fairly high content of silt. Pond Creek and Kirkland are examples of soils that formed in this thick mantle. The Grant soils are thinner over red beds because they formed on slopes.

A younger mantle of loam material occurs in places on high terraces bordering the south banks of the Cimarron and North Canadian Rivers. Soils formed in this material are friable and have a high content of silt. They reflect the characteristics of the silty parent material.

The soils that formed in alluvium are relatively young, for the alluvium has been in place for only a short period. McLain, Port, Reinach, and Canadian soils are among those that formed in the older alluvium. The Lincoln, Sweetwater, Leshara, and Miller soils formed in the younger alluvium.

Plant and animal life

Plant and animal life contribute to the development of soils. Plants begin to grow after the parent material is weathered enough to supply nutrients. As the first plants die, they are decomposed by living organisms, and organic matter is added to the soil. Micro-organisms take nitrogen from the air and assist in combining it with other elements in the formation of compounds that nourish plants and encourage their growth. Acids are produced when organic material decays, and these acids help to decompose particles of rocks and to extract from them mineral substances that are valuable as plant food. Also, plants influence the temperature in the soils by providing shade in the warm seasons and by helping to retain moisture. As the soil formation takes place, the amount of biological activity increases.

Along with micro-organisms, the population of earthworms, spiders, beetles, and rodents helps to convert nutrients to a form available to plants. By mixing the organic residue and minerals in the soil, and by thickening accumulations of organic matter, many earthworms and small burrowing animals contribute to the development of soil.

Where trees are abundant, the soils are more acid than they are under grass and they contain a small amount of organic matter. Leaves and twigs accumulate on the surface as litter. Acids are released from this litter by fungi activity and are washed downward by rainwater as the soil is leached. The upper few inches of soil is generally darkened by organic residue, but the content of organic matter is low because much of its organic matter is lost through oxidation. Beneath the thin, dark surface layer is a light-colored layer from which leaching has removed fine soil particles and basic elements, which are deposited in a lower layer.

Nobscot soils formed mainly under a cover of blackjack oak and a few scattered cedars that had an undergrowth of mid and tall grasses. Other soils in the county formed mostly under native grass.

Short grasses are dense and matted. Tall grasses are less dense but contribute large amounts of residue to the soils. The kinds of grasses depend on the nature of the soils. In general, the finer textured soils developed under short and

mid grasses, and sandy soils developed under mid and tall grasses.

During soil development in areas of permanent grass, plants returned large amounts of organic matter to the surface. Then water carried the bases downward. In this way enough calcium was returned to the surface layer to prevent loss of bases and dispersion of soil colloids. Plants also contributed organic matter to the surface layer. As a result of the direct and indirect effects of the grasses, most of the soils in Major County are highly fertile.

Climate

Climate affects the formation of the soils in several ways. As an initial step in soil formation, the action of rain, snow, and ice, as well as variations in temperature, disintegrates rocks and the debris on the soil surface. Temperature and moisture affect the kinds and amounts of plants that grow and therefore influence the kinds and amount of organic matter in the soil. Also affected by temperature is the rate that organic matter decomposes, the growth of micro-organisms, and the speed of chemical reaction. Freezing and thawing affect soil structure. The amount of water that percolates through the soil determines the rate at which minerals are leached and the downward movement of fine particles.

The climate of Major County is much the same today as it was when the soils developed. The climate is continental and is characterized by rapid changes and extremes in temperature. Precipitation averages about 28 inches annually and is slightly higher in the western part of the county than in the eastern. Winters are rather short and mild, and summers are rather long and mild. The average growing season is 200 days.

Because precipitation is low in all seasons and evaporation is high, elements are not leached rapidly from the soils in Major County. As a result, large amounts of elements are in the soil and calcium carbonates generally occur in the upper part of the substratum, or C horizon. Because rainfall is heavier in the eastern part of the county, lime is leached to a greater depth. In many soils, the presence of a lime zone indicates the depth of leaching. Many of the sandy soils do not have a lime zone, but lime may be at or near the surface in sloping soils developed in calcareous material that contains a large amount of clay. Lime may be leached to a depth of several feet in nearly level soils. The downward movement of fine particles is greater in the nearly level soils because more water percolates.

The strong winds that blow across the county in summer increase evaporation. Also, these winds decrease fertility by winnowing fine particles from the surface layer in unprotected areas. Some soils under grass, however, may be enriched by additions of fine soil particles.

Earthworms, bacteria, and other living organisms important in soil formation are favored in spring and fall by warm temperature and more than normal moisture.

Relief

Relief influences the formation of soils through its effect on drainage, erosion, soil temperature, and plant cover. In Major County the degree of soil development depends to a large extent on the average amount of water in the soil. Steep slopes absorb less moisture and produce less

vegetation than nearly level soils, and normally their profile is less developed. Also, erosion may carry away the soil material that does form on steep slopes.

The effects of relief are modified by the thickness of vegetation, the texture of soil material, and the age of the deposit. The deeper and better developed soils in Major County generally occupy nearly level relief. Most of the moisture from rainfall penetrates those soils, and their vegetation is more abundant. This vegetation tends to hold the soils in place and adds to the organic matter.

Soil profiles generally become thinner toward the upper limits of the slope, and there is more runoff lost from the steeper areas. Where runoff is excessive, little water enters the soils. Consequently, there is less clay movement downward from the A horizon to form a B_{2t} horizon. Because lime is leached to less depth in steep areas, many soils formed in limy deposits are calcareous throughout.

Time

The length of time necessary for a soil to develop depends upon the other factors of soil formation. If the other factors have not operated long enough for definite genetic horizons to form, the soil is considered young, or immature. Mature soils have approached equilibrium with their environment and tend to have well-defined horizons.

The soils in Major County range from young to old, and their age is indicated by the degree of development. Renfrow soils are examples of the older soils in the county. Renfrow soils have deep, well-expressed profiles, even though they formed in shale and clay that weather slowly. Not only is the profile thick but an A horizon and a B_{2t} horizon have formed. Relief is level to gently sloping.

Vernon soils occur with Renfrow soils and developed in the same kind of shale and clay, but these soils lack a B horizon, and they are shallow over the unweathered shale and clay. Free carbonates are at or near the surface in the Vernon soils but are leached to a depth below the subsoil in the Renfrow soils.

Tivoli soils are among the youngest soils in Major County. They developed on the sand dunes north of the Cimarron and North Canadian Rivers. These soils are immature because only a short period has elapsed since their parent material was deposited and because they developed on loose, porous sandhills where vegetation is sparse.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First, through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (2) and later revised (5). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (4, 7). Therefore, readers interested in developments of this system should search the latest literature available. In this subsection some of the classes in the current system and the great soil groups of the older system are given for each soil series in table 6. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation. The suborder is not shown in table 6 for the current classification system.

GREAT GROUP: Soil suborders are separated into great groups on basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans interfering with growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 6, because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils where used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

General Nature of the Area

This section was written primarily for those not familiar with Major County. It describes the physiography, climate, natural resources, and agriculture of the county.

TABLE 6.—*Soil series classified according to the current system and the 1938 system*

Soil series	Current system ¹			1938 system
	Family	Subgroup	Order	Great soil groups
Canadian.....	Coarse loamy, mixed, thermic.....	Udic Haplustolls.....	Mollisols.....	Alluvial soils.
Carey.....	Fine silty, mixed, thermic.....	Typic Argiustolls.....	Mollisols.....	Reddish Chestnut soils.
Carwile.....	Fine, mixed, noncalcareous, thermic.	Typic Argiaquolls.....	Mollisols.....	Planosols.
Dill.....	Coarse loamy, mixed thermic.....	Typic Ustochrepts.....	Inceptisols.....	Reddish Chestnut soils.
Elsmere.....	Sandy, mixed, mesic.....	Aquic Haplustolls.....	Mollisols.....	Alluvial soils.
Enterprise.....	Coarse silty, mixed, thermic.....	Typic Ustochrepts.....	Inceptisols.....	Regosols.
Grant.....	Fine silty, mixed, thermic.....	Udic Argiustolls.....	Mollisols.....	Reddish Prairie soils.
Kirkland.....	Fine, mixed, thermic.....	Abruptic Paleustolls.....	Mollisols.....	Reddish Prairie soils.
LaCasa.....	Fine, mixed, thermic.....	Typic Argiustolls.....	Mollisols.....	Reddish Chestnut soils.
Leshara.....	Fine silty, mixed, mesic.....	Aquic Fluventic Haplu- stolls.	Ustolls.....	Alluvial soils.
Lincoln.....	Sandy, mixed, thermic.....	Typic Ustifluvents.....	Entisols.....	Alluvial soils.
McLain.....	Fine, mixed, thermic.....	Pachic Argiustolls.....	Mollisols.....	Alluvial soils.
Meno.....	Loamy, mixed, thermic.....	Aquic Arenic Haplustalfs.....	Alfisols.....	Prairie soils.
Miller.....	Fine, mixed, thermic.....	Vertic Haplustolls.....	Mollisols.....	Alluvial soils.
Nash.....	Coarse silty, mixed, thermic.....	Udic Haplustolls.....	Mollisols.....	Regosols.
Nobscot.....	Loamy, mixed, thermic.....	Arenic Haplustalfs.....	Alfisols.....	Red-Yellow Podzolic soils.
Ortello.....	Coarse loamy, mixed, mesic.....	Udic Haplustolls.....	Mollisols.....	Prairie soils.
Pond Creek.....	Fine silty, mixed, thermic.....	Pachic Argiustolls.....	Mollisols.....	Reddish Prairie soils.
Port.....	Fine silty, mixed, thermic.....	Cumulic Haplustolls.....	Mollisols.....	Alluvial soils.
Pratt.....	Sandy, mixed, thermic.....	Psammentic Haplustalfs.....	Alfisols.....	Chestnut soils.
Quinlan.....	Loamy, mixed, thermic, shallow.....	Typic Ustochrepts.....	Inceptisols.....	Regosols.
Reinach.....	Coarse, silty, mixed, thermic.....	Pachic Haplustolls.....	Mollisols.....	Alluvial soils.
Renfrow.....	Fine, mixed, thermic.....	Udertic Paleustolls.....	Mollisols.....	Reddish Prairie soils.
St. Paul.....	Fine, silty, mixed, thermic.....	Typic Argiustolls.....	Mollisols.....	Reddish Chestnut soils.
Shellabarger.....	Fine loamy, mixed, thermic.....	Udic Argiustolls.....	Mollisols.....	Reddish Prairie soils.
Sweetwater.....	Sandy, mixed, calcareous, thermic.	Typic Haplaquolls.....	Mollisols.....	Alluvial soils.
Tillman.....	Fine, montmorillonitic, thermic.....	Vertic, Paleustolls.....	Mollisols.....	Reddish Chestnut soils.
Tipton.....	Fine, loamy, mixed, thermic.....	Typic Argiustolls.....	Mollisols.....	Reddish Chestnut soils.
Tivoli.....	Mixed, thermic.....	Typic Ustipsamments.....	Entisols.....	Regosols.
Treadway.....	Fine, mixed, thermic.....	Ustertic Camborthids.....	Aridisols.....	Alluvial soils.
Vernon.....	Fine, mixed, thermic.....	Ustollic Camborthids.....	Aridisols.....	Lithosols.
Weymouth.....	Fine loamy, mixed, thermic.....	Typic Ustochrepts.....	Inceptisols.....	Calcisols.
Yahola.....	Coarse, loamy, mixed, calcareous, thermic.	Typic Ustifluvents.....	Entisols.....	Alluvial soils.

¹ Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Physiography

Major County consists of erosional uplands, valleys, breaks, and sand dunes. In the largest valleys in the county are the North Canadian and Cimarron Rivers. The North Canadian River crosses the southwestern corner of the county. In the uplands south of this river are soils that developed in the Permian red beds. North of the river is a sandy strip that averages about 8 miles in width. This strip is dunelike, hummocky, and undulating.

The western rim of the valley of the Cimarron River is an escarpment extending southeasterly from the northwestern part of the county to the south-central part. This escarpment is as much as 175 feet above the valley floor. The foot slopes of the escarpment are so severely eroded in places that raw Permian red beds are exposed and present a badland appearance. In some areas, however, the soils are deep and productive. The strip of erosional upland immediately west of the escarpment consists of soils that developed in the Permian red beds. This area is smooth and gently rolling, but it is dissected by tributaries of the Cimarron River.

The broad valley of the Cimarron River contains

smooth, nearly level soils on the bottom land. Another broad valley, and its bottom land, curves southward through the center of the county and then turns eastward and joins the river bottom. This valley does not contain a flowing river. By all indications, it was once the entrenchment of the Cimarron River that now cuts across the northern and east-central part of the county. Except for the alluvial material deposited, there is little trace of the stream that once flowed but that now is covered by fertile soils. Like the North Canadian River, the Cimarron River is flanked on the north by a broad belt of sandy soils. This duned, hummocky, undulating strip parallels the river and averages about 8 miles in width. Northeast of this belt, the soils developed in a deep, loamy mantle. This area is a tableland that is dissected by shallow, erosional drainageways.

The highest elevation, about 1,820 feet, is in the western part of the county, and from here the general slope is southeasterly. The lowest elevation is in the southeastern part and is 1,100 feet. As the Cimarron River flows south-eastward, its gradient drops about 6 feet per mile. The elevation at Fairview is 1,292 feet.

Climate⁶

Major County has a warm, temperate, subhumid climate typical of regions in the central part of the northwestern quarter of Oklahoma. Masses of warm, moist air from the Gulf of Mexico dominate the area, but significant changes in weather take place when cooler, moist air moves in from the West Coast or colder, dry air pushes south from the Arctic Circle. These storms often result in rapid changes in cloudiness, temperature, wind, and precipitation.

Normally, the seasons are extremely variable, as is illustrated by the climate data from Fairview in table 7. Changes between the seasons are usually gradual enough for the farmers to complete activities delayed by severe wet or dry spells. Bright sunshine and southerly winds help to ease the discomfort in moderately cold winters, except when northers bring periods of cold and snow that normally last only 3 to 5 days.

Spring is the most variable season because precipitation is heaviest and there are severe storms and a few tornadoes. Precipitation is second heaviest in summer and occurs mainly as local showers. During long, warm periods the gentle breezes, low humidity, and cool nights give relief. In fall the mild, sunny days alternate with periods of moderate to heavy rains.

Available records from Fairview show an average annual temperature of 61.6° F. for Major County. The average monthly temperature ranges from 38.2° in January to 83.5° in July. The wide range in daily temperatures (25.5°) can be seen by studying table 7. Since 1940, extreme temperatures ranged from 113° on July 14, 1954 to -7° on January 4, 1959.

From late October through early May, temperatures

⁶ By STANLEY G. HOLBROOK, State climatologist, U.S. Weather Bureau.

may be expected to reach freezing on 82 days. Daily temperatures will reach above freezing on only 7 of those days. Since 1941, the temperature was 0°, or below, on 11 days in 7 of the last 21 years, but only during the months of January, February, and March. January 1949 was the coldest month on record; temperatures averaged 29.7° daily, and the average minimum reading was 19.2°.

Probabilities of last freezing temperatures in spring and first in fall are given in table 8. The data are based on available records from Fairview for the period 1940-63. The freeze-free period, when most crops can be grown, averages 200 days along the bottom lands of the Cimarron River, and 213 days at higher elevations. Freezing temperatures have varied from March 10, 1946 to May 3, 1954 in spring, and from October 7, 1952 to November 18, 1958 in fall.

During the long, warm season between March and November, the temperature climbs to 90° on an average of 96 days. Since 1940, maximum temperatures were 100° or more, from May through October, on an average of 31 days.

As shown in table 7, the annual average precipitation at Fairview is 27.99 inches. From Fairview, the amount increases eastward across Major County. Rainfall ranged from 11.67 inches in 1956 to 49.22 inches in 1957. In 6 of the 32 years since 1931, less than 19 inches of precipitation fell, and the three driest years occurred between 1952 and 1956. In 1948 a total of 43.88 inches fell in a wet period; slightly more (45.95 inches) fell in 1949. On the average, about two-thirds of the annual precipitation comes in equal amounts in spring and summer, 23 percent in fall, and 11 percent in winter. May is the wettest month; it receives 17 percent of the total annual precipitation. The greatest monthly total (17.46 inches) fell in May 1957. January is the driest month, and November is the next driest. The most rain recorded in a 24-hour period was 7.85 inches in May 1957.

TABLE 7.—Temperature and precipitation at Fairview

Month	Temperature ¹				Precipitation ²				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average monthly total	One year in 10 will have—		Days with snow cover 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—		
	° F.	° F.	° F.	° F.	Inches	Inches	Inches	Number	Inches
January.....	50.2	26.1	69	7	0.94	(³)	1.8	2	2
February.....	55.4	30.5	74	15	1.25	0.1	2.5	2	3
March.....	62.9	36.0	81	18	2.00	.1	3.9	1	3
April.....	74.4	47.9	90	34	2.51	.6	6.3	(⁴)	2
May.....	82.4	57.1	95	43	4.71	1.2	11.1	-----	-----
June.....	92.4	67.5	103	57	3.76	1.1	7.4	-----	-----
July.....	96.2	71.3	105	64	2.51	.2	6.0	-----	-----
August.....	96.5	70.5	107	61	2.77	.2	5.8	-----	-----
September.....	88.3	61.8	99	47	2.95	.1	7.1	-----	-----
October.....	77.3	50.7	92	36	2.17	.3	5.1	-----	-----
November.....	62.9	36.9	77	22	1.29	(³)	3.7	(⁴)	2
December.....	52.7	29.1	68	14	1.13	.1	2.3	1	2
Year.....	74.3	48.8	⁵ 108	⁶ 3	27.99	16.4	43.9	6	2

¹ Period 1940-62.

² Period 1932-62.

³ Trace, amount less than 0.05.

⁴ Less than half a day.

⁵ Average annual highest maximum.

⁶ Average annual lowest minimum.

TABLE 8.—Probabilities of last freezing temperatures in spring and first in fall.

Probability	Dates for given probability and at temperature level shown				
	16° F.	20° F.	24° F.	28° F.	32° F.
Spring:					
1 year in 10, later than	Mar. 21	Mar. 23	Mar. 26	Apr. 7	Apr. 22
2 years in 10, later than	Mar. 12	Mar. 16	Mar. 21	Apr. 1	Apr. 16
5 years in 10, later than	Feb. 22	Mar. 3	Mar. 11	Mar. 22	Apr. 4
Fall:					
1 year in 10, earlier than	Nov. 22	Nov. 12	Nov. 6	Oct. 31	Oct. 20
2 years in 10, earlier than	Nov. 29	Nov. 20	Nov. 12	Nov. 3	Oct. 24
5 years in 10, earlier than	Dec. 12	Dec. 3	Nov. 22	Nov. 10	Nov. 1

Annual snowfall in Major County averages 10.2 inches but has ranged from 0.2 inches in 1934-35 to 34.4 in 1947-48. Eleven winters had more than 15 inches of snow, and four winters had 20 inches. Only one-third of the winters will receive less than 5 inches. Snow has occurred in this county as early as September 26 in 1949 and as late as April 11 in 1900 and 1951. During January 1949 the greatest monthly snowfall at Fairview was 16.2 inches. In 1 year out of every 6, more than 10 inches is expected each month. The greatest snowfall was 10 inches on February 16, 1940. In 2 years out of every 3, the daily snow cover will be 3 inches; 5 inches, in 1 year out of 4; 7 inches, in 1 year out of 7.

The prevailing wind direction is southerly, but during midwinter the northerly winds predominate. Average hourly windspeed is about 13 miles per hour, but March and April average about 15 miles per hour.

Annual evaporation from lakes in Major County averages about 63 inches, of which 70 percent is from May through October. This loss of moisture through evaporation is greatest during July and August, when water lost each month at nearby Canton Reservoir averages nearly 8 inches. About one-third of this loss is offset by precipitation. Evaporation from lakes has ranged from 5.3 inches in August 1950 to 12.3 inches in August 1956.

Natural Resources

One of the most valuable natural resources in the county is ground water because it can be used to irrigate farmland, to supply livestock, and for domestic purposes. Some of the wells produce 1,110 gallons per minute. In 1964, between 70 and 80 irrigation wells, most of them east of the Cimarron River, operated in the county.

Oil and gas industries have grown rapidly in Major County since 1944. After an early discovery near Ringwood, oil and gas production began at the Ringwood field. At present this oilfield contains many wells spaced 160 acres apart in an area that covers 20,000 acres. A large field in Cheyenne Valley produces mostly gas.

One of the main sources of roadbuilding material in Major County is crushed gypsum available for commercial mining. Also mined commercially are sand and gravel deposits in a few pits along the major rivers. Other sources of gravel are the old stream deposits, generally associated with the Enterprise and Pratt soils.

Agriculture

The early days of settlement in Major County were marked by rivalry between ranchers and farmers. The cattlemen arrived first and built up large herds of cattle. Farmers came later and came in large numbers after the establishment of railroads. The ranchers suffered losses caused by the severe winters and a big range fire in 1890. The size of the ranches was reduced, but today much of Major County still remains as rangeland. The trend for farms is toward an increase in acreage.

The main crops grown are wheat, barley, oats, and other small grains. Table 9 shows the acreage in principal crops grown in selected years, as reported in the United States Census of Agriculture.

TABLE 9.—Acreage of principal crops

Crop	1959	1964
Sorghum for all purposes except sirup	19,368	14,545
Harvested for grain or seed	8,223	6,210
Cut for silage	2,802	1,012
Hogged or grazed or cut for dry forage or hay	8,343	7,323
Small grains harvested:		
Wheat	131,482	124,388
Oats	8,888	4,719
Barley	19,842	10,662
Alfalfa and alfalfa mixtures cut for hay	3,575	7,243

Wheat, the most important cash crop, is raised on more than 70 percent of the farms in the county. The most favorable yields are grown on deep loamy soils on bottom lands and loamy soils in nearly level uplands.

Sorghums are the next most important crop in the county. Sorghums are grown as a cash crop and as feed for livestock. Although yields of sorghums fluctuate, they are more dependable on the better sandy soils than on the hardlands. In years having favorable moisture, the highest yields are obtained on the hardlands.

The acreage in oats fluctuates considerably but is not extensive. The acreage in barley declined from 1939 to 1949, and in recent years has shown a marked decrease. Since 1929, the acreage in field corn and broomcorn has decreased considerably.

As shown in table 9, in 1964 sorghums and alfalfa were the most extensive hay crops in the county. Most of the alfalfa is dryfarmed on the Port, Reinach, McLain and Canadian soils; only a small acreage is irrigated. Alfalfa is marketed mostly to dairies, though a small amount is cut for cattle feed.

Tons of watermelons are harvested nearly every year from a few sandy fields in the county. Most of these melons are shipped to outside markets in all parts of the United States. Grown on small acreages for local markets are peaches, apples, and other fruits and sweetpotatoes, tomatoes, peppers, onions, Irish potatoes, and other truck crops.

Cotton is grown in a few sandy areas of the county. Because there are no cotton gins in Major County, the farmers haul their crops some distance for sale.

Rye and vetch are the main cover crops used to protect sandy soils against blowing and to furnish grazing for livestock.

Beef cattle are numerous in Major County, but other livestock are also raised. Table 10 gives the number of livestock in the county in 1959 and 1964, according to the United States Census of Agriculture.

TABLE 10.—*Number of livestock in stated years*

Livestock	1959	1964
All cattle and calves.....	38, 617	50, 454
Milk cows.....	4, 001	3, 271
Hogs and pigs.....	3, 741	2, 848
Sheep and lambs.....	3, 711	1, 138
Horses and mules.....	¹ 625	⁽²⁾
Turkeys, sold.....	79, 968	81, 522
Chickens.....	³ 53, 522	³ 25, 707

¹ More than 3 months old.
² Not reported.
³ More than 4 months old.

Hereford and Aberdeen Angus are the main breeds of beef cattle, but there are a few Shorthorns. The largest amounts of beef are produced on the ranches in the western part of the county. The ranchers have mostly cow-calf herds, and a basic herd is maintained the year round.

The size of herds of dairy cattle has increased in the past few years, though the number of dairy cattle has slightly decreased. Generally, the trend is to keep large herds in dairies rather than small herds for selling cream. The Holstein is the breed favored by the local dairies, but there are a few herds of Ayrshires, Guernseys, and Jerseys.

Hogs are raised in small numbers in the county. Chester Whites, Hampshires, and some Berkshires are most commonly raised for home use.

The lard-type hog has been replaced by the meaty type through crossbreeding. Among farmers, it is popular to cross Poland China or Duroc breeds with the Yorkshire breed.

Only a few herds of sheep, mainly Hampshires, Southdowns, or Dorset Horns, are in Major County. Rambouillet and Corriedale breeds are the commonly known western sheep.

Turkeys provide a major source of income to some farmers in the county. Since 1950, the flocks of turkeys have steadily increased in size. In 1964 some of the largest flocks consisted of 50,000 birds. These flocks were raised in pens and buildings having small range areas (fig. 30). The Broad Breasted Bronze and the White Holland have meaty carcasses and are the two most popular breeds. Because these are popular breeds, the turkey raisers profit from the side-line business of selling turkey eggs for hatching.

Most flocks of chickens are small and are kept for home use.



Figure 30.—One of the large pens of turkeys in Major County.

Literature Cited

- (1) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. 1961. STANDARD SPECIFICATION FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 v., illus.
- (2) BALDWIN, M., KELLOGG, C. E., AND THORP, J. 1938. SOIL CLASSIFICATION. U.S. Dept. Agr. Ybk. 1938: 978-1001.
- (3) PORTLAND CEMENT ASSOCIATION. 1956. PCA SOIL PRIMER. 86 pp., illus. Chicago, Ill.
- (4) SIMONSON, ROY W. 1962. SOIL CLASSIFICATION IN THE UNITED STATES. 137: 1027-1034.
- (5) THORP, JAMES AND SMITH, GUY D. 1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUP. Soil Sci. 67: 117-126.
- (6) UNITED STATES DEPARTMENT OF AGRICULTURE. 1951. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handb. 18, 503 pp., illus.
- (7) _____ 1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM. U.S. Dept. Agr., 265 pp., illus. [Supplement issued in March 1967]
- (8) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS. 1953. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. 3-357, 2 v. and appendix.

Glossary

Alluvium. Fine material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Chlorosis. A yellowing between veins on upper foliage that results from chlorophyll deficiency. Many factors, including heredity, cause chlorosis.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds that cement the soil grains together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; will not hold together in a mass.

Compact.—Dense and firm but not cemented.

Friable.—When moist, crushes easily under pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

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.

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; tends to stretch somewhat and pull apart, rather than pull free from other material.

Cemented.—Hard and brittle; little affected by moistening.

Diversion. 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 the runoff.

Eolian soil material. Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, covered by grass for protection against erosion; used to conduct surface water away from cropland.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and it is therefore marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon; the B horizon also has (1) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. This layer, commonly called the soil parent material, is presumed to be like that from which the overlying horizons were formed in most soils. If the underlying material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loess. Geological deposit of fairly uniform fine material, mostly silt, presumably transported by wind.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are: *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.

Permeability. That quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See also Horizon, soil.

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. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		pH
Extremely acid	Below 4.5	Mildly alkaline	7.4–7.8
Very strongly acid	4.5–5.0	Moderately alkaline	7.9–8.4
Strongly acid	5.1–5.5	Strongly alkaline	8.5–9.0
Medium acid	5.6–6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1–6.5		
Neutral	6.6–7.3		

Sand. Individual rock or mineral fragments that are from 0.05 to 2.0 millimeters in diameter. Sand grains are generally quartz, but they may be of other mineral composition. Sand, as a textural class name of any soil, contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil 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 soil textural class, it is 80 percent or more silt and less than 12 percent clay.

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 parent material.

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.

Substratum. Any layer beneath the solum, either conforming (C or R) or unconforming.

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 runoff so that it may soak into the soil or flow slowly to a prepared outlet. 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 (see also Clay, Sand, and Silt). The basic textural classes, in order of increasing proportions of fine particles, are as follows: 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."

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.

Wilting point. The moisture content of soil at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at <http://offices.sc.egov.usda.gov/locator/app>.

Nondiscrimination Statement

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (<http://directives.sc.egov.usda.gov/33081.wba>) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for

program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (<http://directives.sc.egov.usda.gov/33085.wba>).

All Other Inquiries

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (<http://directives.sc.egov.usda.gov/33086.wba>).