

Issued November 1968

# SOIL SURVEY

## Washington 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 1962-65. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station; it is part of the technical assistance furnished to the Caney Valley Soil and Water Conservation District.

## HOW TO USE THIS SOIL SURVEY

**T**HIS SOIL SURVEY contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, and other structures; and in appraising the suitability of tracts of land for agriculture, industry, and recreation.

### Locating Soils

All of the soils of Washington County are shown on the detailed map at the back of this survey. This map consists of many sheets that were 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 and gives the capability classification, the range site classification, and the windbreak and post-lot classification of each soil. It also shows the page where each range site and each windbreak and post-lot group is described.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suit-

ability 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 ranchers, and those who work with them,* can learn about use and management of the soils from the soil descriptions and from the discussions of the range sites.

*Game managers, sportsmen, and others* can find information about soils and wildlife in the section "Wildlife."

*Ranchers and others interested in range* can find, under "Use of the Soils as Range," groupings of the soils according to their suitability for range and a description of the vegetation on each range site.

*Community planners and others concerned with nonfarm uses of soils* can find pertinent information in the section "Non-farm Uses of the Soils."

*Engineers and builders* can find under "Engineering Uses of the Soils," tables that give test data, estimates of soil properties, and information about 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 the Soils."

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

### COVER PICTURE

Typical landscape in Washington County. Collinsville and Talihina soils, in native range.

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# SOIL SURVEY OF WASHINGTON COUNTY, OKLAHOMA

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

WASHINGTON COUNTY is in the northeastern part of Oklahoma (fig. 1). It is about 10½ miles wide and 40 miles long. The total area is 425 square miles, or 272,000 acres. Bartlesville, the county seat, is located in the west-central part.

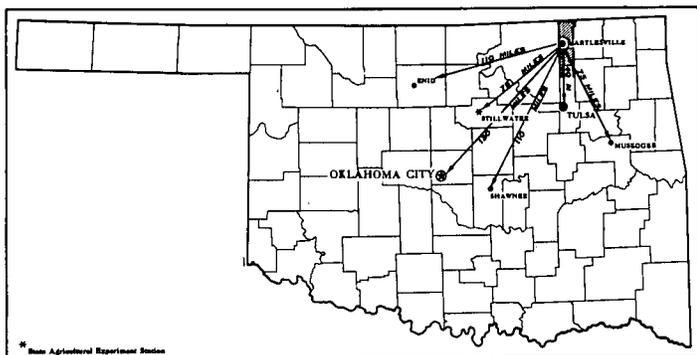


Figure 1.—Location of Washington County in Oklahoma.

Mainly, the soils are deep to moderately deep and nearly level to gently sloping. The native vegetation was mainly tall prairie grass. Most of the acreage is now used as native range. The range is in good to excellent condition. Cattle ranching is the major agricultural enterprise. Oil deposits have been developed into a major industry.

## How This Survey Was Made

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

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those

in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this 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 of 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. Verdigris and Eram, 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 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 the 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. Verdigris silt loam and Verdigris clay loam are two soil types in the Verdigris series. The difference in the texture of their surface layer is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Eram clay loam, 2 to 5 percent slopes, is one of two phases of Eram clay loam, a soil type that has a slope range of 2 to 15 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, and other details that help in drawing boundaries accurately. The soil map in the back of this survey was prepared from 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 or occur in such small individual tracts that it is not practical to show them separately on the map. Such an area is shown as one mapping unit and is called a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Bates-Collinsville complex, 2 to 6 percent slopes.

Most surveys include areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it 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 Oil-waste land or Rough stony land, and are called land types.

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

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

## General Soil Map

The general soil map at the back of this publication shows, in color, the soil associations in Washington County. A soil association is a landscape that has a distinctive proportional 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 associations is useful to people who want a general idea of the soils of 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 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 five soil associations in Washington County are discussed in the following pages.

### 1. *Dennis-Okemah-Parsons association*

*Nearly level and gently sloping, deep soils on prairie uplands*

This association consists mainly of nearly level and gently sloping valleys, but it includes a few ridges and breaks. It occupies 37 percent of the county. The pattern of the major soils is shown in figure 2.

Dennis soils make up 45 percent of this association, Okemah soils 20 percent, and Parsons soils 20 percent. Dennis soils are very gently and gently sloping, well drained, and deep. They have a surface layer of dark grayish-brown silt loam. The major part of the subsoil is yellowish-brown clay loam. Okemah soils are nearly level and very gently sloping and are moderately well drained. The surface layer is dark-gray silt loam. It grades to grayish-brown silty clay at a depth of 20 inches. Parsons soils are level and are somewhat poorly drained. They have a surface layer of grayish-brown silt loam and, at a depth of 11 inches, a subsoil of very slowly permeable clay.

Bates, Eram, and Dwight soils are minor components of the association. On the ridges and breaks are some areas of the shallow and very shallow Collinsville and Talihina soils.

Except for those on the ridges and breaks, the soils in this association are suitable for pasture, range, and crops. Protection from erosion and maintenance of soil structure and fertility are major problems in cultivated areas.

### 2. *Collinsville-Talihina-Bates association*

*Gently sloping to hilly, very shallow to deep soils on prairie uplands*

This soil association consists mainly of gently sloping to hilly prairies, but it includes a few gently sloping ridges (see fig. 2). It occupies about 28 percent of the county.

Collinsville soils make up 40 percent of this association, Talihina soils 25 percent, and Bates soils 20 percent. Collinsville and Talihina soils are in a complex mapping unit. They are shallow and very shallow, sloping and moderately steep soils. Collinsville soils have a loam or sandy loam surface layer about 10 inches thick over sandstone bedrock. Talihina soils have a surface layer of brown clay loam. Below this is a layer of clay, which rests on beds of shale and siltstone at a depth of 10 inches. Bates soils are moderately deep and deep, loamy, dark grayish brown, gently sloping, and well drained.

Dennis and Eram soils, minor components of the association, are similar to Bates soils. They are deep to moderately deep, gently sloping to moderately steep, and well drained.

The soils of this association are suitable for native grass pasture and range.

### 3. *Summit-Sogn association*

*Very gently sloping to moderately steep, deep, moderately deep, and very shallow soils on prairie uplands*

This association consists mainly of very gently sloping to moderately steep valleys, but it includes a few breaks and ridges. It occupies about 11 percent of the county.

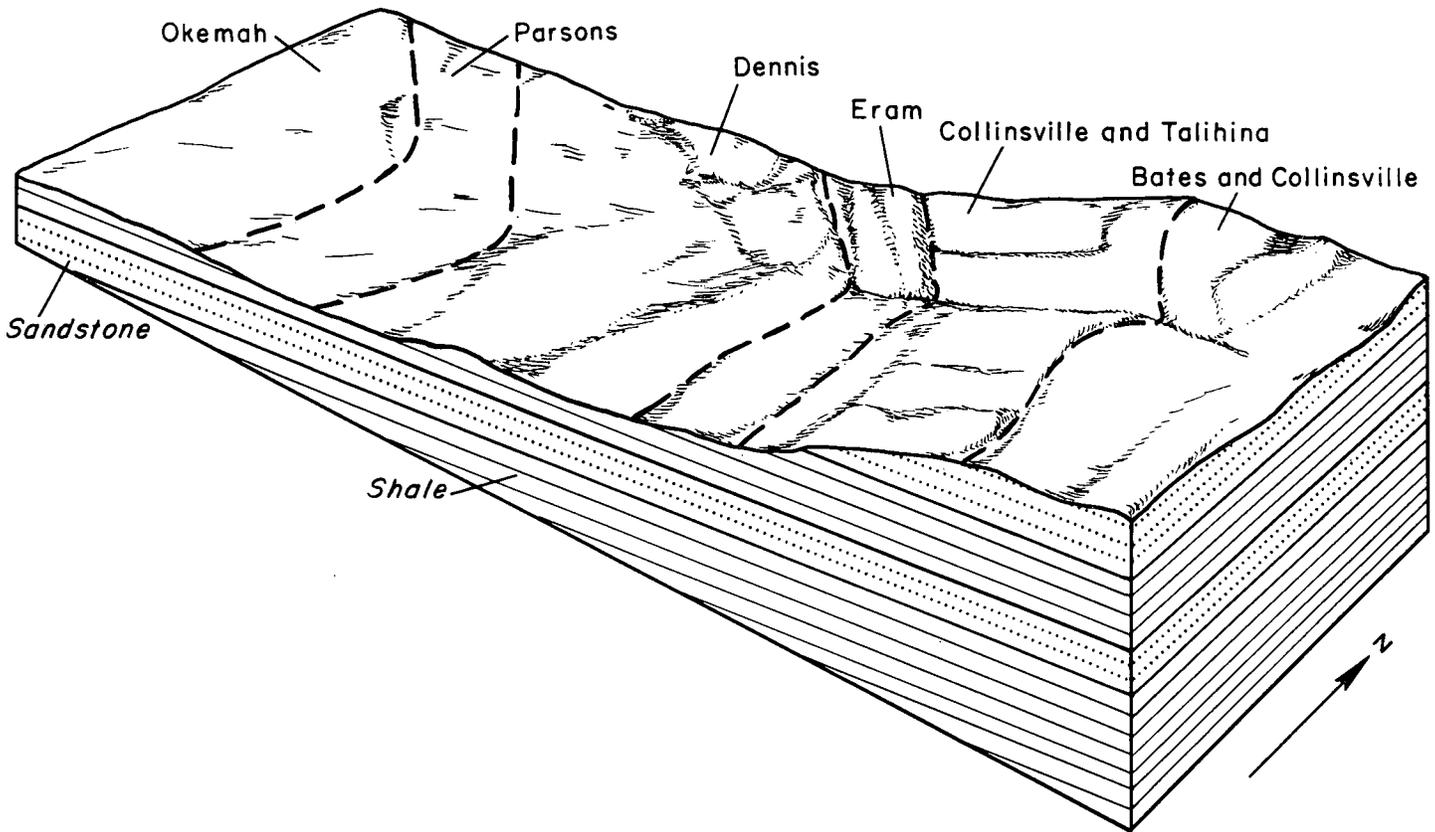


Figure 2.—Major soil series in soil associations 1 and 2, and their relation to the landscape.

Summit soils make up 43 percent of this association, and Sogn soils 40 percent. Summit soils are deep and moderately deep, dark colored, very gently sloping and gently sloping, and moderately well drained. Sogn soils are very shallow, stony, dark colored, very gently sloping to moderately steep, and moderately well drained.

The minor soils, the Newtonia, Okemah, and Dennis, are similar to Summit soils but are less clayey, have mottles in the subsoil, and are reddish in color.

Summit soils are suitable for pasture, range, and crops. Sogn soils are suitable for range and pasture. Controlling erosion and maintaining soil structure and fertility are the chief management problems in the cultivated areas. Pasture and range plants respond to good management.

#### 4. Osage-Verdigris association

*Nearly level, deep soils on bottom lands*

This association consists mainly of nearly level bottom lands along the Caney River and other streams. It occupies about 20 percent of the county.

Osage soils make up about 50 percent of this association, and Verdigris soils about 50 percent. Osage soils are deep, clayey, dark colored, nearly level, and somewhat poorly drained (fig. 3). Verdigris soils are deep, loamy, dark grayish brown, nearly level, and moderately well drained. Nearly half the acreage of Verdigris soils is on low bottoms and in stream channels and is frequently flooded.

Unless drained, Osage soils are suitable only for pasture and meadow. Verdigris soils are suitable for pasture and crops. Verdigris soils, broken, are suitable for woods,

pasture, or wildlife cover. Drainage, flood protection, and maintenance of soil structure and fertility are the chief management needs in the cultivated areas.

#### 5. Darnell-Stephenville association

*Gently sloping to steep, very shallow to deep soils on forested uplands*

This association consists of gently sloping to steep ridges occurring mainly along the western side of the county. It occupies about 4 percent of the county (see fig. 3).

Darnell soils make up about 60 percent of this association, and Stephenville soils 35 percent. Darnell soils are shallow and very shallow, loamy, stony, grayish brown, and gently sloping to steep. Stephenville soils are deep and moderately deep, loamy, grayish brown, and gently sloping.

Rough stony land, a minor part of this association, occurs as very steep breaks. It is stony and excessively drained.

This association is used mainly as pasture.

### Descriptions of the Soils

In this section the soils of Washington County are described in detail. The procedure is to describe first a soil series and then the mapping units in that series. The description of each soil series includes a description of a profile that is considered representative of all the soils

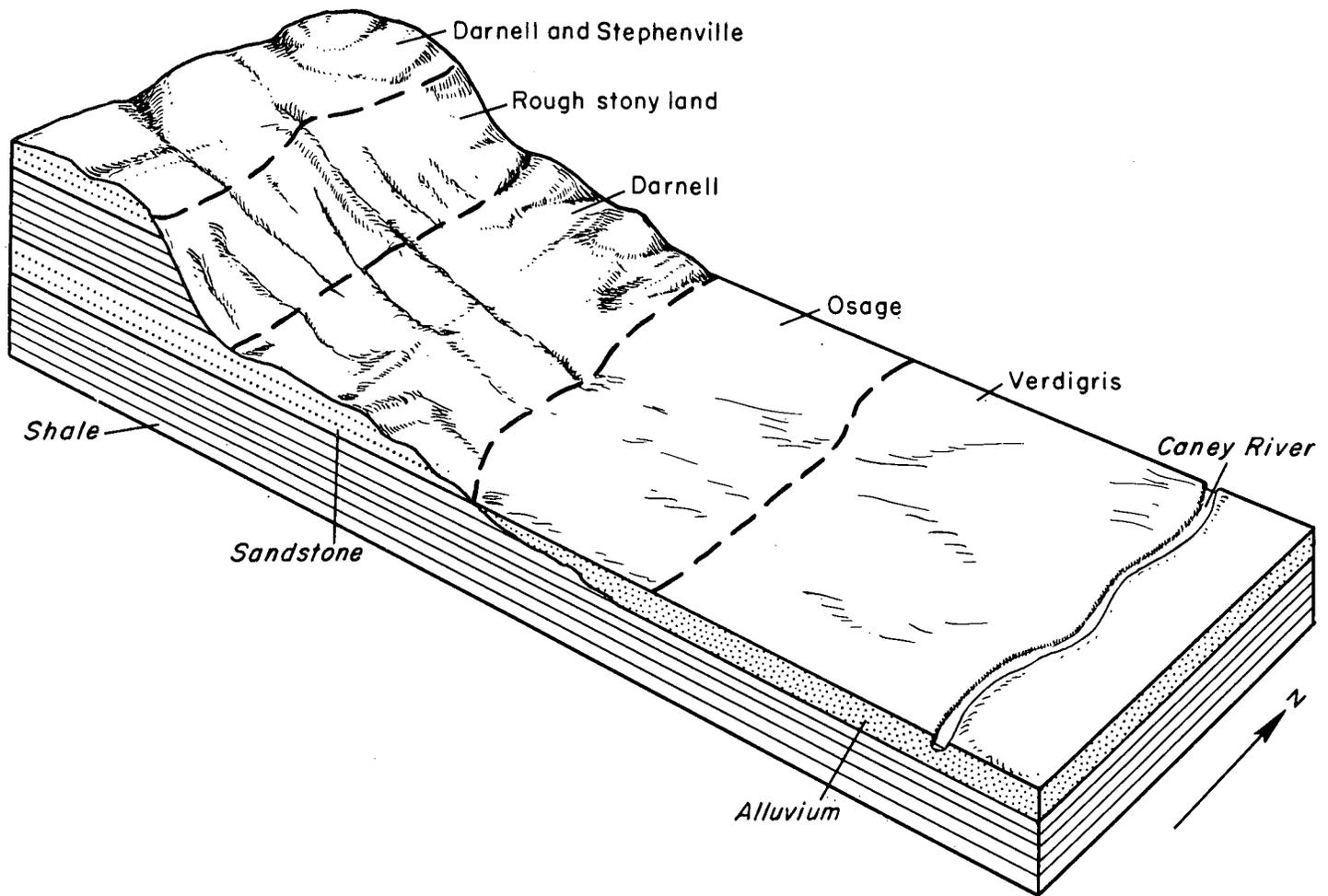


Figure 3.—Major soil series in soil associations 4 and 5, and their relation to the landscape.

of the series. If the profile of a given mapping unit differs from this typical profile, the differences are stated in the description of the mapping unit, unless they are apparent from the name of the mapping unit. To get full information on any one mapping unit, it is necessary to read both the description of that unit and the description of the soil series to which the unit belongs.

As explained in the section "How This Survey Was Made," a few of the mapping units, Borrow pits and Oil-waste land, for example, are land types, and are not part of any soil series. Nevertheless, they are listed in alphabetic order along with the soil series.

The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many terms used in describing soil series and mapping units are defined in the Glossary, and some are defined in the section "How This Survey Was Made." At the back of this publication is the "Guide to Mapping Units," which lists all the mapping units in the county and shows the capability unit, range site, and windbreak and post-lot group each unit is in.

### Bates Series

This series consists of moderately deep and deep, friable, dark-colored, gently sloping soils on uplands. These soils

developed in material weathered from noncalcareous sandstone under tall prairie grasses.

The surface layer consists of about 12 inches of dark grayish-brown fine sandy loam, generally medium acid and of medium granular structure. The upper part of the subsoil is brown, slightly acid light sandy clay loam. It has moderate, medium, subangular blocky structure. The lower part is yellowish-brown to light yellowish-brown, slightly acid sandy clay loam with some strong-brown and yellow mottles. It has medium prismatic structure. At a depth of about 34 inches is yellowish-brown sandstone.

Bates soils are well drained. They have medium internal drainage and moderate permeability. They are susceptible to water erosion. The natural fertility is high. In cultivated areas a plowpan is common.

Typical profile of Bates fine sandy loam (native grass meadow, 4 percent slope, 1,500 feet north of the southeast corner of sec. 19, T. 28 N., R. 14 E.):

- A1—0 to 12 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable when moist, hard when dry; roots abundant; medium acid; clear boundary.
- B1—12 to 20 inches, brown (10YR 5/3) light sandy clay loam, dark brown (10YR 3/3) when moist; moderate, medium, subangular blocky structure; crushes to moderate to strong, medium, granular; friable when moist,

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

Soil	Acres	Per- cent	Soil	Acres	Per- cent
Bates fine sandy loam, 3 to 5 percent slopes	1,090	0.4	Oil-waste land	2,180	0.8
Bates-Collinsville complex, 2 to 6 percent slopes	25,840	9.5	Okemah silt loam, 0 to 1 percent slopes	13,600	5.0
Borrow pits	270	.1	Okemah silt loam, 1 to 3 percent slopes	1,360	.5
Breaks-Alluvial land complex	10,720	3.9	Okemah silt loam, 1 to 3 percent slopes, eroded	270	.1
Collinsville-Talihina complex, 5 to 20 percent slopes	21,390	7.9	Osage clay	23,940	8.8
Darnell stony sandy loam, 5 to 30 percent slopes	7,620	2.8	Parsons silt loam, 0 to 1 percent slopes	8,700	3.2
Darnell-Stephenville fine sandy loams, 2 to 6 percent slopes	1,900	.7	Rough stony land	3,260	1.2
Dennis silt loam, 1 to 3 percent slopes	46,510	17.1	Sogn soils, 1 to 20 percent slopes	19,310	7.1
Dennis silt loam, 3 to 5 percent slopes	8,430	3.1	Summit silty clay loam, 1 to 3 percent slopes	16,860	6.2
Dennis silt loam, 3 to 5 percent slopes, eroded	3,270	1.2	Summit silty clay loam, 3 to 5 percent slopes	7,340	2.7
Dwight-Parsons silt loams, 0 to 1 percent slopes	1,360	.5	Summit silty clay loam, 1 to 5 percent slopes, eroded	270	.1
Eram clay loam, 2 to 5 percent slopes	2,720	1.0	Verdigris clay loam	17,680	6.5
Eram clay loam, 5 to 15 percent slopes	3,640	1.3	Verdigris silt loam	6,700	2.5
Mason silt loam	1,900	.7	Verdigris soils, broken	10,610	3.9
Newtonia silt loam, 0 to 1 percent slopes	540	.2	Total	272,000	100.0
Newtonia silt loam, 1 to 3 percent slopes	2,720	1.0			

hard when dry; roots abundant; slightly acid; gradual boundary.

B2t—20 to 28 inches, yellowish-brown (10YR 5/4) sandy clay loam, dark yellowish brown (10YR 4/4) when moist; common, fine, distinct mottles of strong brown; moderate, medium, prismatic structure; firm when moist, hard when dry; roots abundant; clay films on ped surfaces; slightly acid; gradual boundary.

B3—28 to 34 inches, light yellowish-brown (10YR 6/4) sandy clay loam, yellowish brown (10YR 5/4) when moist; few, fine, distinct mottles of strong brown and yellow; weak, medium, prismatic structure; firm when moist, hard when dry; slightly acid; gradual boundary.

R—34 inches +, yellowish-brown sandstone.

The texture of the A horizon in most places is fine sandy loam, but in some it is loam. The color of the A horizon ranges from dark grayish brown to brown. The texture of the B horizon is sandy clay loam in most places but ranges from heavy loam to light clay loam. The depth to sandstone bedrock ranges from 20 to 50 inches.

Bates soils are coarser textured and more permeable than Dennis soils, and they have a thicker surface layer and a more fully developed profile than Collinsville soils.

**Bates fine sandy loam, 3 to 5 percent slopes (BcC).**—This soil occurs as small areas on uplands, near areas of Collinsville and Dennis soils. It has the profile described as typical for the Bates series (fig. 4). Included in mapping were spots of Collinsville and Dennis soils.

Most of this soil is used for pasture, but some is used for crops, mainly small grain, soybeans, and sorghum. Practically all crops common in the county grow well if adequately fertilized. An example of a suitable cropping system is corn or grain sorghum for 2 years, then small grain and a legume for 1 year.

Erosion, loss of fertility, and formation of a plowpan are the chief hazards. If row crops are grown, terracing and contour farming are needed to break up concentrations of water. Terracing is not necessary if only close-growing crops are grown. (Capability unit IIIe-1; Loamy Prairie range site; group 1 for windbreaks and post lots).

**Bates-Collinsville complex, 2 to 6 percent slopes (BcC).**—The composition of this complex is as follows: Bates fine sandy loam, 70 to 80 percent; Collinsville fine sandy loam, 15 to 25 percent; Dennis silt loam, 5 percent.

The complex is very extensive, and the individual areas are large.

The Bates soil in this complex is generally moderately deep; sandstone is at a depth of 20 to 26 inches. The Collinsville soil is generally deeper than the typical soils of the Collinsville series; the depth to bedrock is 12 to 20

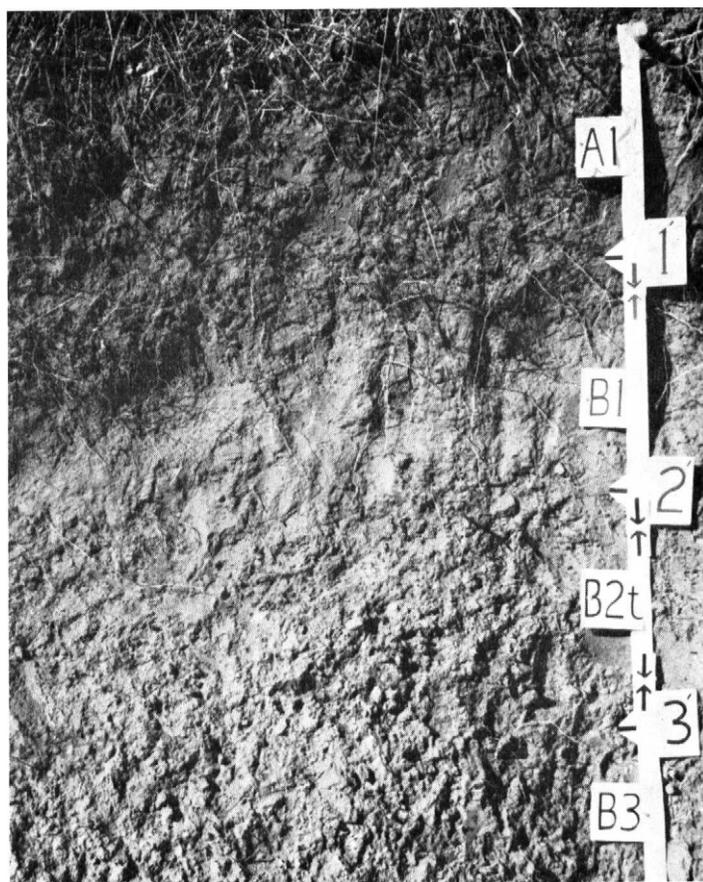


Figure 4.—Profile of Bates fine sandy loam.

inches. Dennis silt loam has a profile similar to that described as typical of the Dennis series.

Most of this complex is used for pasture or range. Only a small part is cultivated. Small grain, sown or drilled sorghum, sericea lespedeza, and tame pasture plants are the common crops grown. Because of a serious hazard of water erosion, growing of row crops is not advisable.

Erosion, deterioration of structure, and rapid loss of fertility are the chief hazards. Erosion can be partly controlled by contour tillage, use of sown or close-growing crops, and use of cover crops. Terracing is difficult in some areas because of the limited depth to bedrock. (Capability unit IVE-1; Bates part is in Loamy Prairie range site and in group 1 for windbreaks and post lots; Collinsville part is in Shallow Prairie range site and in group 3 for windbreaks and post lots)

### Borrow Pits

Borrow pits (Bp) are areas where soil has been excavated for use in fills and roads or for other construction work. They are of limited use other than as wildlife habitat or as water areas. (Capability unit VIIIs-1; group 3 for windbreaks and post lots; not in a range site)

### Breaks-Alluvial Land

Breaks-Alluvial land complex (Bk) is on the floors and sides of small valleys along the upper reaches of intermittent streams on uplands. It is frequently flooded. The drainage is somewhat poor to somewhat excessive. The slope range is 0 to 12 percent. The individual areas are 75 to 600 feet wide.

The soils on the valley sides are mostly loamy in the surface layer and loamy to clayey in the subsoil and substratum. They range in color from grayish brown and dark brown to reddish brown. The depth to beds of sandstone or shale ranges from about 10 inches to about 5 feet and is generally more than 3 feet. The soils on the valley floor are loamy in texture and brown to grayish brown in color. The vegetation is mostly tall grasses, but there are a few trees.

Because of frequent flooding, irregular slopes, and susceptibility to severe erosion, this complex is not suitable for cultivated crops, but it can be used for range, for tame pasture, or for wildlife habitat. Most of it is now used as range. The potential for wildlife habitat is excellent. Pasture management requirements depend upon the slope, the intensity of damaging floods, and the size of the area. Most areas in tame pasture are used with adjoining soils that are in other capability units.

The main problems are controlling erosion and providing protection from flooding. (Capability unit VIe-1; group 1 for windbreaks and post lots; Breaks part is in Loamy Prairie range site, and Alluvial land part is in Loamy Bottomland range site)

### Collinsville Series

This series consists of very shallow and shallow, dark-colored, gently sloping to moderately steep soils on uplands. These soils formed in material weathered from noncalcareous sandstone.

The surface layer consists of 6 inches of dark grayish-brown light loam, generally medium acid, and of moderate, medium, granular structure. Below this is about 4 inches of brown, medium acid sandy loam over sandstone.

Collinsville soils are well drained and somewhat excessively drained. They have medium internal drainage and moderately rapid permeability. They are susceptible to water erosion.

In Washington County, Collinsville soils are not mapped separately. They occur as complexes with Bates and with Talihina soils.

Typical profile of Collinsville loam (native grass pasture, 12 percent slope, at the southeast corner of sec. 21, T. 25 N., R. 13 E.) :

- A1—0 to 6 inches, dark grayish-brown (10YR 4/2) light loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable when moist; few small sandstone fragments; roots abundant; medium acid; clear boundary.
- C—6 to 10 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; about 90 percent sandstone fragments; medium acid; abrupt boundary.
- R—10 inches +, sandstone bedrock.

The color of the A horizon ranges from very dark grayish brown to brown, and the texture from loam to stony sandy loam. The depth to bedrock ranges from 4 to 20 inches. Stones cover from 2 to 8 percent of the surface where the slope is near the upper limit of the range.

Collinsville soils have a thinner surface layer than Bates soils and are shallower over sandstone. They are coarser textured than Talihina soils, and they are underlain by sandstone instead of shale.

**Collinsville-Talihina complex, 5 to 20 percent slopes (CtE).**—The composition of this complex is as follows: Collinsville soils, 50 to 70 percent; Talihina soils, 20 to 30 percent; and Bates soils, 5 to 10 percent. Minor areas of Dennis and Eram soils are included. The complex is extensive, and the individual areas are large.

The Collinsville soils in this complex have a profile similar to that described as typical of the Collinsville series. The depth to sandstone bedrock is 4 to 20 inches, and there are a few outcrops. The Talihina soils have a profile like the one described for the Talihina series. The Bates soils have a profile like the one described for the Bates series, except that they are generally 20 to 26 inches deep over sandstone.

This complex is suited to native grass and is used largely as range. Moderately steep slopes, shallowness, and susceptibility to water erosion are the main limitations. (Capability unit VIIs-1; Shallow Prairie range site; group 3 for windbreaks and post lots)

### Darnell Series

This series consists of very shallow and shallow, friable, brownish, gently sloping to steep soils on uplands. These soils developed in material weathered from coarse-grained sandstone, under a cover of tall native grasses.

The surface layer consists of about 5 inches of medium acid fine sandy loam. It is grayish brown and has weak, fine, granular structure. The subsoil is light yellowish brown, has weak, fine, granular structure, and contains a few sandstone fragments and dark-colored concretions. Beneath this is reddish-yellow sandstone.

Darnell soils are well drained and somewhat excessively drained. They have medium internal drainage and moder-

ately rapid permeability. They are susceptible to water erosion.

Typical profile of Darnell fine sandy loam (wooded pasture, 2 percent slope, 500 feet north of the southeast corner of the NE $\frac{1}{4}$  sec. 26, T. 28 N., R. 13 E.) :

A1—0 to 5 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few dark-colored concretions; medium acid; clear boundary.

B—5 to 15 inches, light yellowish-brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few small sandstone fragments and dark-colored concretions; medium acid; abrupt boundary.

R—15 inches +, reddish-yellow sandstone.

The color of the A1 horizon ranges from grayish brown to brown, and the thickness from 3 to 6 inches. The depth to sandstone ranges from about 5 to 20 inches.

Darnell soils have a thinner A horizon and a less fully developed profile than Stephenville soils.

**Darnell stony sandy loam, 5 to 30 percent slopes (DcF).**—Except for the texture of the surface layer, the profile of this somewhat excessively drained soil is like that described as typical of the Darnell series. The sub-surface layer is 4 to 14 inches thick. The depth to the sandstone bedrock is 5 to 20 inches. A few small areas of Stephenville soils, Talihina soils, and rock outcrop were included in mapping.

This soil is not suited to cultivated crops but can be used for native grasses and for wildlife food and cover. Steep slopes, shallowness, stoniness, and susceptibility to erosion are the main limitations. Brush control is a problem. (Capability unit VIIIs-1; Shallow Savannah range site; group 3 for windbreaks and post lots)

**Darnell-Stephenville fine sandy loams, 2 to 6 percent slopes (DcC).**—This complex consists of shallow and moderately deep soils. The composition of the complex is as follows: Darnell fine sandy loam, 50 to 80 percent; Stephenville fine sandy loam, 15 to 30 percent; and Darnell stony fine sandy loam, 5 to 15 percent. The complex is not very extensive, but the individual areas are large.

The Darnell soils in this complex have the profile described as typical of the series. Darnell stony fine sandy loam has somewhat stronger slopes than Darnell fine sandy loam. The Stephenville soil has a profile like the one described for the Stephenville series, except that the depth to sandstone is slightly less.

This complex is used mainly as tame pasture or woodland pasture. Tame pasture needs periodic applications of fertilizer and lime. Only a small acreage is now cultivated. The common crops are small grain, sudangrass, sericea lespedeza, Korean lespedeza, vetch, and corn. Small grain can be grown year after year if the residue is used for soil improvement. Shallowness and susceptibility to erosion limit suitability for row crops.

Control of erosion, control of brush, and maintenance of fertility are the main management problems.

Erosion can be partly controlled by contour tillage, use of sown or close-growing crops, and use of crop residue. Cover crops are helpful if crop residue and close-growing crops do not give adequate protection. If row crops are included in the cropping system, terraces are useful. In some areas, constructing terraces is difficult because bedrock is near the surface. Grassed waterways are generally needed, particularly as outlets for terraces. The natural

fertility generally is moderately high, but it is advantageous to apply fertilizer and lime where the soils have been depleted by intensive farming. (Capability unit IVE-2; Darnell part is in Shallow Savannah range site and in group 3 for windbreaks and post lots; Stephenville part is in Sandy Savannah range site and in group 1 for windbreaks and post lots)

## Dennis Series

This series consists of deep, friable, dark-colored, very gently sloping and gently sloping soils on uplands. These soils developed under tall prairie grasses, largely from noncalcareous silty or sandy shale.

The surface layer consists of about 10 inches of dark grayish-brown silt loam, is generally slightly acid, and has moderate, medium, granular structure. The upper part of the subsoil is dark grayish-brown, very strongly acid light clay loam that contains few dark-colored concretions. It has moderate, medium, granular structure. The lower part of the subsoil is yellowish-brown, medium acid heavy clay loam with common red and light-gray mottles. It has moderate, medium, subangular blocky to blocky structure. The substratum is yellowish-brown, medium acid clay loam over shale.

Dennis soils are well drained. They have slow internal drainage and slow permeability. They are susceptible to water erosion.

Typical profile of Dennis silt loam (native pasture, 2 percent slope, 100 feet west of northeast corner of sec. 31, T. 28 N., R. 14 E.) :

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; mildly alkaline (profile located near enough to cement plant to be affected by limestone dust); clear boundary.

B1—10 to 15 inches, dark grayish-brown (10YR 4/2) light clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; few dark-colored concretions; very strongly acid; clear boundary.

B21t—15 to 28 inches, yellowish-brown (10YR 5/4) heavy clay loam, dark yellowish brown (10YR 4/4) when moist; many, medium, distinct mottles of yellowish red and brownish yellow when dry; moderate, medium, subangular blocky structure; firm when moist, hard when dry; few dark-colored concretions; medium acid; gradual boundary.

B22t—28 to 40 inches, yellowish-brown (10YR 5/4) heavy clay loam, dark yellowish brown (10YR 4/4) when moist; many, coarse, distinct mottles of light gray and red when dry; moderate, medium, blocky structure; very firm when moist, very hard when dry; many dark-colored concretions and few fragments of shale; medium acid; gradual boundary.

B3—40 to 52 inches, yellowish-brown (10YR 5/4) clay loam, dark yellowish brown (10YR 4/4) when moist; common, medium, distinct mottles of light gray and red; weak, medium, blocky structure; very firm when moist, very hard when dry; many dark-colored concretions and many fragments of sandy shale; medium acid.

The color of the A horizon ranges from grayish brown to dark brown. The thickness of this horizon ranges from 8 to 16 inches but is commonly about 10 inches. Where affected by limestone dust from a cement plant, the surface layer is medium acid to mildly alkaline. The texture of the B horizon ranges from heavy clay loam to light clay. The depth to shale ranges from 36 to 72 inches.

Dennis soils are finer textured and less permeable than Bates soils. They have a thicker surface layer and a more fully de-

veloped profile than Talihina soils, and they are less clayey. They are coarser textured and deeper to shale than Eram soils. They are more permeable than Parsons soils and lack the claypan subsoil that is typical of Parsons soils. They are more acid and slightly less dark colored than Okemah soils, and are less clayey in the subsoil.

**Dennis silt loam, 1 to 3 percent slopes (DtB).**—This soil has the profile described as typical for the Dennis series (fig. 5). Included in mapping were a few small areas of Bates, Eram, Okemah, and Parsons soils.

Some of this soil is used for pasture, and some for crops. Small grain, sorghum, alfalfa, and soybeans are the main cultivated crops. An example of a suitable cropping system is a row crop, such as grain sorghum, for 3 years, then a sown crop, such as small grain and vetch, for 2 years.

Runoff, erosion, deterioration of soil structure, and loss of fertility are the chief hazards. Terracing and contour farming are needed if row crops are grown. Perennial vegetation should be established in terrace outlets. (Capability unit IIe-1; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Dennis silt loam, 3 to 5 percent slopes (DtC).**—This soil has a profile similar to the one described for the Dennis series. Included in mapping were a few small areas of Bates and Eram soils.

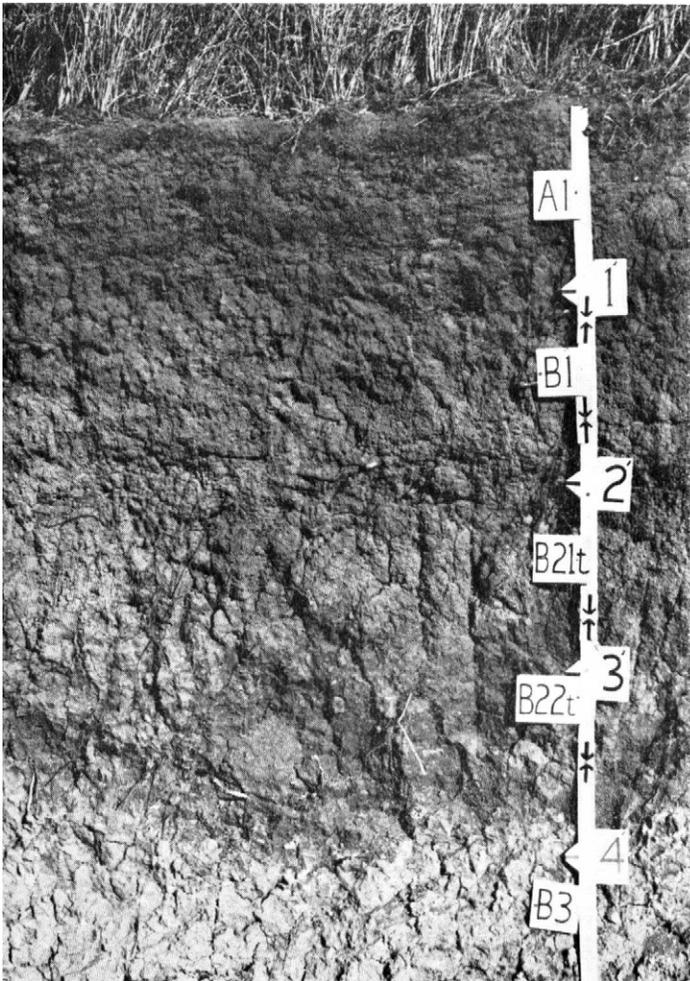


Figure 5.—Profile of Dennis silt loam with native grass cover.

This soil is used for tame pasture and cultivated crops. The common cultivated crops are small grain, soybeans, and sorghum. An example of a good cropping system is corn or grain sorghum for 2 years, then small grain and a legume for 1 year.

Severe erosion, deterioration of soil structure, loss of fertility, and development of plowpans are hazards. Terracing and contour farming are generally needed if row crops are grown. Terraces ought to have adequate outlets, and these should be protected from erosion with perennial vegetation. If close-growing crops are grown every year, terracing is not necessary. (Capability unit IIIe-2; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Dennis silt loam, 3 to 5 percent slopes, eroded (DtC2).**—This soil usually occurs as areas of about 15 acres or less within larger tracts of Dennis silt loam. A few areas are more than 15 acres in size.

Erosion has removed about 25 to 75 percent of the original surface layer, and the surface layer is now about 6 inches thick. The subsoil is exposed in many rills, small gullies, and thin spots.

Included in mapping were areas of uneroded Dennis silt loam, less than 5 acres in size, and also a few small spots of Bates fine sandy loam and Okemah silt loam.

This soil is used largely for pasture and hay. Suitable cultivated crops include grain sorghum and small grain. Small grain can be grown continuously if the residue is used for soil improvement.

Terracing and contour farming are generally needed if clean-cultivated crops are grown. Perennial vegetation should be established in terrace outlets and may be needed in drainageways of unterraced fields. Fertilizer is needed for most crops.

Control of erosion and maintenance of soil structure and fertility are the main management problems. (Capability unit IIIe-4; Loamy Prairie range site; group 2 for windbreaks and post lots)

## Dwight Series

This series consists of deep, gray, nearly level soils on uplands. These soils developed under mixed prairie grasses in material weathered from clayey shale.

The surface layer consists of about 5 inches of gray silt loam, is generally medium acid, and has weak, fine, granular structure. The upper part of the claypan subsoil is very dark grayish-brown, slightly acid clay that has weak, medium, blocky structure. The lower part, to a depth of about 50 inches, is dark grayish-brown, moderately alkaline, massive clay mottled with yellowish brown. The subsoil is high in exchangeable sodium.

Dwight soils are somewhat poorly drained. They have very slow internal drainage and very slow permeability. They are used mainly as pasture.

In Washington County, Dwight soils were mapped only as part of a complex with Parsons soils.

Typical profile of Dwight silt loam (tame pasture, 0 to 1 percent slopes, 1,980 feet west of the northeast corner of sec. 18, T. 29 N., R. 14 E.):

A1—0 to 5 inches, gray (10YR 5/1) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; medium acid; abrupt boundary.

B21t—5 to 24 inches, very dark grayish-brown (10YR 3/2) clay, very dark brown (10YR 2/2) when moist; weak, medium, blocky structure; extremely firm when moist, extremely hard when dry; slightly acid; gradual boundary.

B22t—24 to 50 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; common, medium, distinct, gray and yellowish-brown mottles; massive; extremely firm when moist, extremely hard when dry; few nests of white crystals; few dark-colored concretions; moderately alkaline.

The thickness of the A horizon ranges from 3 to 7 inches, and the color ranges from gray to dark grayish brown. The B2t horizon ranges in color from very dark grayish brown to very dark gray.

Dwight soils have a thinner surface layer and a darker colored subsoil than Parsons soils. They have a much lighter colored and thinner surface layer and are more slowly permeable than Okemah soils.

**Dwight-Parsons silt loams, 0 to 1 percent slopes (DwA).**—This complex consists of deep, somewhat poorly drained and moderately well drained soils with claypan subsoils. The composition of this complex is as follows: Dwight silt loam, 50 to 70 percent; Parsons silt loam, 20 to 40 percent; and Okemah silt loam, 5 to 10 percent. This complex generally occurs in large bodies but is not very extensive in total acreage.

The Dwight soils in this complex have the profile described as typical for the series (fig. 6). The Parsons soils have a profile similar to that described for the Parsons series. They are somewhat poorly drained. Their silt loam surface layer, 8 to 16 inches thick, is mainly grayish brown in the upper part and light brownish gray in the lower part and is strongly acid. The Okemah soils in this complex have a profile similar to that described for the Okemah series.

Most of this complex is used for range. Tame pasture plants and fall-sown small grain can be grown. Very little acreage is cultivated. Droughtiness is a limitation. Maintenance of soil structure and fertility is the major management problem. Some areas need surface drainage. Terracing and contour farming are generally not needed. (Capability unit IVs-1; Dwight part is in Shallow Claypan range site, and Parsons part is in Claypan Prairie range site; group 3 for windbreaks and post lots)

## Eram Series

This series consists of moderately deep, friable, dark-colored, gently sloping to moderately steep soils on uplands. These soils developed under tall prairie grasses, in material weathered from noncalcareous shale.

The surface layer consists of about 9 inches of grayish-brown clay loam, generally medium acid. It has moderate, medium, granular structure and contains common, small fragments of sandstone and shale. The subsoil is about 13 inches of grayish-brown, slightly acid clay mottled with yellowish brown and pale brown. It has weak, coarse, blocky structure. Below this are beds of shale.

Eram soils are well drained. They have slow internal drainage and slow permeability. They are susceptible to water erosion.

Typical profile of Eram clay loam (native grass pasture, 3 percent slope, 1,320 feet east of the northwest corner of sec. 35, T. 23 N., R. 13 E.) :

A1—0 to 9 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moder-

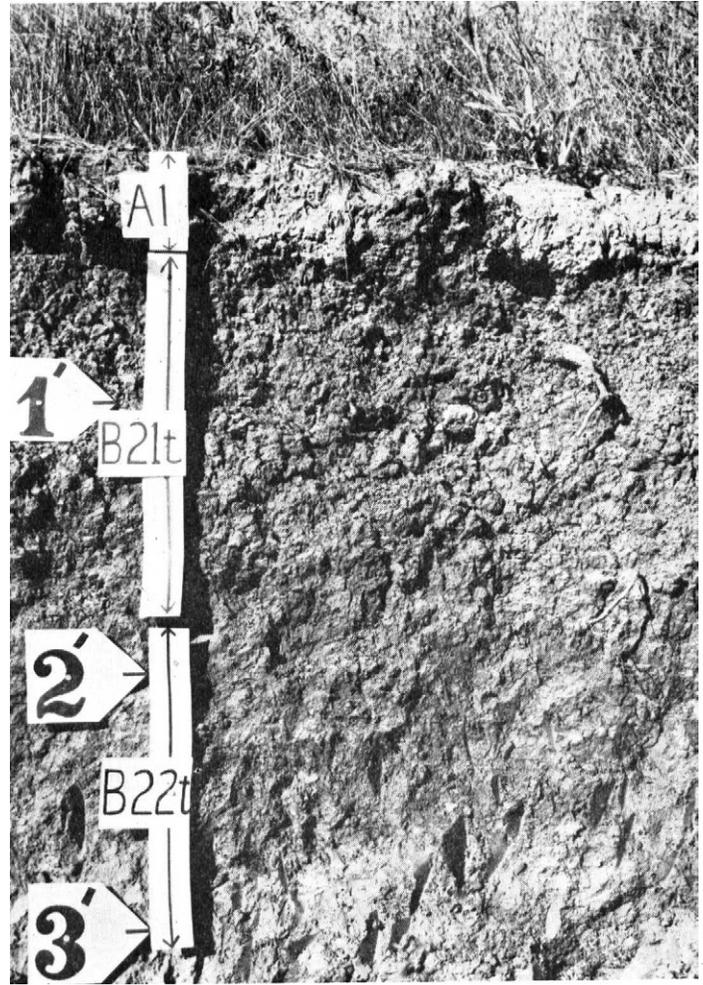


Figure 6.—Profile of Dwight silt loam, showing the shallow surface layer (A1) and the claypan subsoil (B21t, B22t).

ate, medium, granular structure; friable when moist, hard when dry; common, small fragments of sandstone and shale; medium acid; gradual boundary.

B2t—9 to 22 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; few, fine, faint mottles of yellowish brown and pale brown; weak, coarse, blocky structure; very firm when moist, very hard when dry; clay films on ped surfaces; slightly acid; diffuse boundary.

R—22 inches +, beds of shale.

The thickness of the horizons varies widely. The depth to shale ranges from 20 to 40 inches. Fragments of sandstone are scattered on the surface where the slope is near the upper limit of the range.

Eram soils have a thicker surface layer than Talihina soils, and they have a B horizon, which Talihina soils lack. They are finer textured and less deep to shale than Dennis soils. They have thinner horizons and are less well developed than Okemah soils.

**Eram clay loam, 2 to 5 percent slopes (EcC).**—This is a moderately deep, well-drained soil on prairie uplands. Small acreages of Dennis and Talihina soils were included in mapping. This soil has the profile described as typical of the series.

This soil is suitable for pasture and meadow and is used mostly for pasture. Only a small acreage is cultivated.

The common crops are small grain, sorghum, sericea lespedeza, and tame pasture. Small grain can be grown year after year if the residue is used for soil improvement.

If cultivated, this soil is susceptible to erosion, loss of fertility, and deterioration of structure. Erosion can be partly controlled by contour tillage, use of sown or close-growing crops, and use of cover crops. Terraces are needed if clean-cultivated crops are grown. Regular use of residue and cover crops helps to preserve structure and also adds organic matter and increases the water-intake rate. Fertilizer and lime are needed where the soil has been depleted by intensive farming. (Capability unit IVe-3; Loamy Prairie range site; group 3 for windbreaks and post lots)

**Eram clay loam, 5 to 15 percent slopes (EcD).**—This is a moderately deep, well-drained soil on prairie uplands. It occurs as large areas, mainly in the western part of the county. From 1 to 5 percent of the surface is covered with stones and cobbles. The horizons are thinner than those in the profile described as typical of the series. Included in mapping were small areas of Collinsville, Dennis, and Talihina soils.

This soil is used for native grass range. The erosion hazard, the surface stones, and the slope make it unsuitable for cultivation. (Capability unit VIe-2; Loamy Prairie range site; group 3 for windbreaks and post lots)

## Mason Series

This series consists of deep, friable, dark-colored, nearly level soils on bottom lands. These soils developed under tall prairie grass in alluvium washed from prairie soils. They occur along the larger streams, on high bottoms above overflow.

The surface layer consists of about 14 inches of dark grayish-brown, slightly acid silt loam. It has weak, fine, granular structure. The subsoil is about 16 inches of dark-brown, medium acid to slightly acid silty clay loam. It has strong, medium, granular to weak blocky structure. The substratum, beginning at a depth of 30 inches, is yellowish-brown, medium acid clay loam. It has moderate, medium, granular structure.

Mason soils are well drained. They have medium internal drainage and moderately slow permeability. They are used mainly for cultivated crops and tame pasture.

Typical profile of Mason silt loam (cultivated field, 0.5 percent slope, 1,290 feet east and 200 feet north of the southwest corner of sec. 16, T. 26 N., R. 14 E.):

- A1—0 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid; gradual boundary.
- B21t—14 to 22 inches, dark-brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) when moist; strong, medium, granular structure; slightly hard when dry, friable when moist; clay films on ped surfaces; slightly acid; gradual boundary.
- B22t—22 to 30 inches, dark-brown (10YR 4/3) silty clay loam, dark yellowish brown (10YR 4/4) when moist; massive to weak blocky structure; very hard when dry, very firm when moist; clay films on ped surfaces; few dark-colored concretions; medium acid; gradual boundary.
- C—30 to 48 inches, yellowish-brown (10YR 5/4) clay loam, dark yellowish brown (10YR 4/4) when moist; moderate, medium, granular structure; hard when dry, firm when moist; medium acid.

The texture of the surface layer is dominantly silt loam but ranges to loam, and the color is grayish brown to dark brown. The texture of the B2 horizon is silty clay loam or light clay loam.

Mason soils have a more fully developed profile than Verdigris soils.

**Mason silt loam (0 to 1 percent slopes) (Mc).**—This soil usually occurs as large areas on high bottoms along the larger streams. Though the individual areas are large, the soil is not very extensive. Included in mapping were small areas of Verdigris and Okemah soils. This soil has the profile described as typical of the Mason series.

This soil is fertile and is permeable to moisture and roots. It is not subject to overflow. Cultivated crops and tame pasture are the main uses. Corn, grain sorghum, soybeans, and small grain are the chief crops. High-residue crops can be grown continuously if the residue is used for soil improvement. Maintaining fertility and preserving soil structure are the principal management problems. Minimum tillage and use of crop residue help to protect soil structure. (Capability unit I-1; Loamy Bottomland range site; group 1 for windbreaks and post lots)

## Newtonia Series

This series consists of deep and moderately deep, dark-brown, nearly level and very gently sloping soils on uplands. These soils developed under tall prairie grasses in material weathered from limestone.

The surface layer consists of about 10 inches of dark-brown silt loam, generally slightly acid. It has strong, medium, granular structure. The upper part of the subsoil is reddish-brown, medium acid light silty clay loam. It has strong, medium, granular structure. The lower part is red to reddish-brown, medium acid to neutral silty clay loam. It has medium, subangular blocky or blocky structure. At a depth of about 42 inches is limestone bedrock.

Newtonia soils are well drained. They have medium internal drainage and moderate permeability. They are susceptible to water erosion. Most of the acreage is in cultivation.

Typical profile of Newtonia silt loam (native grass pasture, 2 percent slope, 1,280 feet north of the southeast corner of sec. 15, T. 29 N., R. 13 E.):

- A1—0 to 10 inches, dark-brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/2) when moist; strong, medium, granular structure; friable when moist, slightly hard when dry; slightly acid; diffuse boundary.
- B1—10 to 22 inches, reddish-brown (5YR 4/3) light silty clay loam, dark reddish brown (5YR 3/3) when moist; strong, medium, granular structure; friable when moist, hard when dry; medium acid; gradual boundary.
- B2t—22 to 34 inches, red (2.5YR 4/6) silty clay loam, dark red (2.5YR 3/6) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; few dark-colored concretions; clay films on ped surfaces, medium acid; clear boundary.
- B3—34 to 42 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) when moist; common, fine, distinct mottles of reddish yellow, red, and light brown; weak, medium, blocky structure; firm when moist, hard when dry; many dark-colored concretions; neutral.
- R—42 inches, limestone bedrock.

The color of the A horizon ranges from dark brown to reddish brown, and that of the B horizon from dark reddish brown

to red. The depth to limestone ranges from 20 to 60 inches but is commonly about 42 inches, which is less than is typical for Newtonia soils.

Newtonia soils occur in association with Summit and Sogn soils. They have a redder and more friable subsoil than that of Summit soils. They are deeper than Sogn soils.

**Newtonia silt loam, 0 to 1 percent slopes (NeA).**—This is a moderately deep and deep, well-drained soil on prairie uplands. It has a profile like the one described for the Newtonia series. It occurs mainly as small areas in the central and northern parts of the county. Small acreages of Summit and Sogn soils were included in mapping.

This soil is used mainly for cultivated crops and pasture. The principal crops are corn, small grain, alfalfa, grain sorghum, soybeans, and tame pasture. An example of a suitable cropping system is small grain for 2 years, then corn or grain sorghum for 3 years. Corn, grain sorghum, soybeans, or small grain can be grown continuously if the residue is managed for soil improvement.

The main management problems are maintenance of fertility and maintenance of structure. Diversion terraces may be needed to break up concentrations of water on long slopes. (Capability unit I-2; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Newtonia silt loam, 1 to 3 percent slopes (NeB).**—This is a moderately deep and deep, well-drained soil on prairie uplands. It has the profile described as typical for the Newtonia series. Though the individual areas are large, this soil is not extensive in total acreage. Small acreages of Sogn, Summit, and Dennis soils were included in mapping.

This soil is used mainly for cultivated crops and tame pasture. The principal crops are small grain, sorghum, corn, soybeans, alfalfa, and tame pasture. Corn, grain sorghum, or small grain can be grown continuously if the residue is managed for soil improvement.

Control of erosion and maintenance of structure and fertility are the main management problems. Terracing and contour farming are generally needed for control of erosion if row crops are grown. Perennial vegetation should be established in terrace outlets and other drainageways. (Capability unit IIe-2; Loamy Prairie range site; group 1 for windbreaks and post lots)

## Oil-Waste Land

Oil-waste land (Od) consists of areas where liquid wastes, principally oil and salt water, have accumulated (fig. 7). It includes slush pits and adjacent uplands and bottom lands. It is in all parts of the county where oil drilling or refining operations are going on. The areas are usually about 3 acres in size but range from half an acre to 70 acres. The slope range is 0 to 5 percent. Surface runoff is rapid, and erosion is a severe hazard.

Oil-waste land is unsuitable for farming. Some of it could be reclaimed, but the cost would be high. Diversion of surface drainage from higher areas would be necessary. Rainwater could be impounded to help leach out soluble salts. A mulch of hay or straw would reduce evaporation and thus help prevent accumulation of salts on the surface.

Very little vegetation grows on these areas at present. Salt-tolerant pasture plants could be grown if seeded in the middle of the rainy season, when the salt accumulations



Figure 7.—Oil-waste land.

on the surface are reduced. (Capability unit VIIIs-2; group 3 for windbreaks and post lots; not in a range site)

## Okemah Series

This series consists of deep, friable, dark-colored, nearly level and very gently sloping soils on uplands. These soils developed in material weathered from noncalcareous shale, under a cover of tall prairie grasses.

The surface layer is about 16 inches thick. The upper part is dark-gray silt loam that has medium granular structure. The lower part is gray heavy silt loam with a few dark-brown mottles. It has strong, coarse, granular structure. The upper part of the 44-inch subsoil is dark grayish-brown, moderately alkaline silty clay loam with a few yellowish-brown mottles. It has moderate, medium, subangular blocky structure. The lower part is grayish-brown to light yellowish-brown, moderately alkaline silty clay, with common or few very dark grayish-brown mottles. It has weak, medium, blocky structure. The substratum is mottled clayey material over shale or sandstone.

Okemah soils are moderately well drained. They have slow internal drainage and slow permeability. They are susceptible to water erosion. A large part of the acreage is used for cultivated crops and tame pasture.

Typical profile of Okemah silt loam (native grass pasture, 0.5 percent slope, 970 feet north of the southwest corner of sec. 20, T. 27 N., R. 13 E.) :

- A1—0 to 12 inches, dark-gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) when moist; moderate, fine and medium, granular structure; hard when dry, friable when moist; roots abundant; mildly alkaline (sample located near enough to cement plant to be affected by limestone dust); clear boundary.
- A3—12 to 16 inches, gray (10YR 5/1) heavy silt loam, very dark brown (10YR 2/2) when moist; few, fine, faint mottles of dark brown; thin gray coatings on surface of peds; strong, coarse, granular structure; hard when dry, friable when moist; neutral; clear boundary.
- B1—16 to 20 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of yellowish brown; compound structure—moderate, medium, subangular blocky and moderate, medium, granular; very hard when dry, firm when moist; few, small, dark concretions; moderately alkaline, noncalcareous; clear boundary.

B21t—20 to 40 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; common, fine, faint mottles of very dark grayish brown; weak, medium, blocky structure; very hard when dry, very firm when moist; clay films on ped surfaces; few dark-colored concretions; moderately alkaline, noncalcareous; gradual boundary.

B22t—40 to 60 inches, light yellowish-brown (2.5Y 6/4) silty clay, light olive brown (2.5Y 5/4) when moist; few, fine, faint mottles of very dark grayish brown; weak, medium, blocky structure; few clay films on ped surfaces; few dark-colored concretions; moderately alkaline, noncalcareous.

The color of the A horizon ranges from gray to very dark grayish brown. Gypsum crystals occur in the lower part of the profile in some areas. The depth to shale ranges from 36 to 84 inches and is commonly about 60 inches.

Okemah soils are darker colored and more permeable than Parsons soils, and they lack the claypan subsoil of Parsons soils. They have thicker horizons and a more fully developed profile than Eram soils. Okemah soils are darker colored and have a more alkaline subsoil than Dennis soils. They have a thicker surface layer and a more permeable subsoil than Dwight soils.

**Okemah silt loam, 0 to 1 percent slopes (OkA).**—This is a deep, moderately well drained soil on prairie uplands. It has the profile described as typical for the Okemah series. It occurs as large areas throughout the county. Minor areas of Parsons, Summit, and Dennis soils were included in mapping.

This soil is used for cultivated crops and tame pasture. It is suitable for intensive use. Corn, small grain, alfalfa, grain sorghum, soybeans, and tame pasture are the principal crops. An example of a suitable cropping system is 2 years of small grain, then 3 years of corn or grain sorghum. Small grain, grain sorghum, corn, or soybeans can be grown continuously if the residue is managed for soil improvement.

Maintenance of fertility and structure is the principal management problem. Diversion terraces are needed to break up concentrations of water on long slopes. (Capability unit I-2; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Okemah silt loam, 1 to 3 percent slopes (OkB).**—This is a deep, moderately well drained soil on prairie uplands. The profile is similar to the one described for the Okemah series. The total acreage is not large, and the individual areas are small and scattered. Small areas of Dennis and Summit soils were included in mapping.

This soil is used for cultivated crops and tame pasture. The principal crops are small grain, sorghum, alfalfa, soybeans, and tame pasture. A suitable cropping system is a row crop, such as grain sorghum, for 3 years, then a sown crop, such as small grain and vetch, for 2 years.

Control of runoff, protection from erosion, and maintenance of soil structure and fertility are problems in use and management. Terracing and contour farming are needed if row crops are grown. Perennial vegetation should be established in drainageways and terrace outlet channels. (Capability unit IIe-1; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Okemah silt loam, 1 to 3 percent slopes, eroded (OkB2).**—Individual areas of this soil are generally about 20 acres in size, but a few large areas were mapped. Small areas of uneroded Okemah silt loam and of Parsons and Dennis soils were included in mapping. Except for a thinner surface layer, the profile of this soil is like the one described as typical of the series.

About 25 to 75 percent of the surface layer has been removed by erosion. The present surface layer consists of about 7 inches of heavy silt loam, and there are many gullies, rills, and thin spots where the subsoil is exposed. The gullies are 100 to 200 feet apart, and most are crossable with machinery. The thin spots are much lighter colored when the soil is very dry.

This soil is used largely for tame pasture or hay crops, but some is used for grain sorghum, sericea lespedeza, and small grain. A suitable cropping system is 2 years of grain sorghum, then 3 years of small grain. Residue should be managed for soil improvement.

Control of erosion and maintenance of structure and fertility are the chief management problems. Terracing and contour farming are generally needed for control of erosion if row crops are grown. Perennial vegetation should be established in terrace outlets and may be needed in drainageways of unterraced fields. Fertilizer is needed for most crops. (Capability unit IIIe-5; Loamy Prairie range site; group 2 for windbreaks and post lots)

## Osage Series

This series consists of deep, dark-colored, clayey, nearly level soils on bottom lands along the major streams. These soils developed in recent alluvium washed from prairie soils, under a cover of scattered trees and tall prairie grasses.

The surface layer consists of about 22 inches of dark-gray, generally slightly acid clay. It has moderate, medium, subangular blocky structure. The substratum is 28 inches or more of dark-gray, neutral clay mottled with strong brown. It is massive and has a few dark-colored concretions.

Osage soils are somewhat poorly drained. They have slow internal drainage and very slow permeability. Flooding is a hazard. A complete drainage system is needed. Most of the acreage is used as wooded pasture, native grass pasture, or meadow.

Typical profile of Osage clay (wooded bottom land, nearly level, 100 feet west of the center of the north side of sec. 17, T. 25 N., R. 13 E.):

- A1—0 to 22 inches, dark-gray (10YR 4/1) clay, very dark gray (10YR 3/1) when moist; moderate, medium, subangular blocky structure; very firm when moist, very hard when dry; slightly acid; gradual boundary.
- C—22 to 50 inches, dark-gray (10YR 4/1) clay, very dark gray (10YR 3/1) when moist; few, fine, distinct mottles of strong brown when dry; massive; few, small, dark-colored concretions; neutral.

The thickness of the A horizon ranges from 10 to 28 inches, and the color ranges from dark gray to black. The number of mottles in the C horizon varies greatly.

Osage soils are finer textured and less permeable than Verdigris and Mason soils.

**Osage clay (0 to 1 percent slopes) (Os).**—This soil is deep and somewhat poorly drained. It has the profile described as typical for the series. It occurs as large areas and is very extensive on the bottom lands along the major streams. Included in mapping were small areas of Verdigris soil.

This soil is used mainly as wooded pasture or native grass meadow. It is suitable for crops if drained. Tame pasture, pecans, small grain, and grain sorghum are the main crops. Small grain can be grown year after year if

the residue is used for soil improvement. Good stands of native pecan trees exist in most wooded areas.

This soil is high in natural fertility, but it is poorly aerated and is difficult to till. Poor drainage, the flood



Figure 8.—A newly constructed field drainage ditch in a large field of Osage clay.

hazard, and a tendency to puddle when wet and crust when dry are the principal limitations. A complete drainage system is needed (fig. 8). (Capability unit IIIw-1; Heavy Bottomland range site; group 1 for windbreaks and post lots)

## Parsons Series

This series consists of grayish-brown, nearly level soils on uplands. These soils developed in material weathered from shale, under tall prairie grasses.

The surface layer is about 11 inches thick. The upper part is grayish-brown, strongly acid silt loam that has weak, fine, granular structure. The lower part is light brownish-gray, strongly acid silt loam that has weak, fine, granular structure. The upper part of the subsoil is slightly acid, grayish-brown clay with many reddish-brown and grayish-brown mottles. It has weak, medium, blocky structure and prominent clay films on the surface of peds. The lower part is slightly acid, brown clay that has weak, medium, blocky structure. The substratum at a depth of about 38 inches is moderately alkaline, mottled brown, yellowish-brown, and gray clay.

Parsons soils are somewhat poorly drained. They have very slow internal drainage and very slow permeability. They are used mainly for cultivated crops and tame pasture.

Typical profile of Parsons silt loam (native grass meadow, 0.5 percent slope, 1,650 feet east and 100 feet south of the northwest corner of sec. 31, T. 28 N., R. 14 E.):

- A1—0 to 9 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; many roots; strongly acid; clear boundary.
- A2—9 to 11 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; strongly acid; abrupt boundary.
- B21t—11 to 24 inches, grayish-brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) when moist; many, medium, distinct mottles of reddish brown and gray-

ish brown; weak, medium, blocky structure; very firm when moist, extremely hard when dry; prominent clay films; slightly acid; gradual boundary.

B22t—24 to 38 inches, brown (10YR 5/3) clay, dark brown (10YR 4/3) when moist; weak, medium, blocky structure; very firm when moist, extremely hard when dry; slightly acid; gradual boundary.

C—38 to 50 inches, mottled brown, yellowish-brown, and gray clay; few black concretions; massive; moderately alkaline.

The thickness of the A horizon ranges from 8 to 16 inches and is most commonly about 11 inches. The color ranges from light brownish gray to dark grayish brown. The depth to shale ranges from 36 to 84 inches but is commonly about 60 inches.

Parsons soils have a thicker surface layer than Dwight soils, and they have a light-colored A2 horizon, which Dwight soils lack. They have a lighter colored surface layer and a more slowly permeable subsoil than Okemah and Dennis soils.

**Parsons silt loam, 0 to 1 percent slopes (PaA).**—This is a deep, somewhat poorly drained soil on prairie uplands. It has the profile described as typical for the series (fig. 9). The individual areas are large. Small acreages of Dwight, Dennis, and Okemah soils were included in mapping.

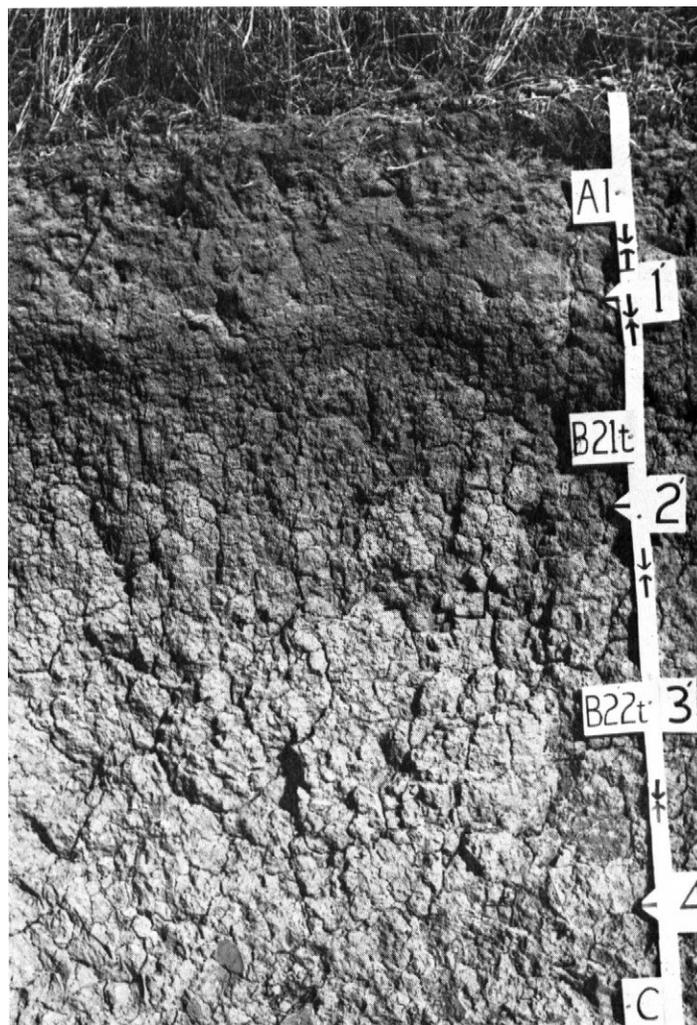


Figure 9.—Profile of Parsons silt loam. The claypan subsoil, at a depth of about 13 inches, is very slowly permeable to roots and water.

This soil is used mainly for cultivated crops and tame pasture. The common crops are small grain, grain sorghum, and soybeans. An example of a suitable cropping system is a row crop, such as grain sorghum, for 3 years, then a small grain-legume mixture for 2 years.

Loss of fertility, impairment of structure, and development of a plowpan are the main hazards. Runoff is slow, and permeability is very slow. Terracing is not generally needed, but row direction for drainage is beneficial. (Capability unit IIs-1; Claypan Prairie range site; group 3 for windbreaks and post lots)

## Rough Stony Land

Rough stony land (Ro) consists of narrow breaks near areas of Darnell soils. It includes sandstone outcrops and areas of very shallow to moderately deep, very stony soil material. The slope range is 30 to 60 percent. Most of the acreage is covered with a thick growth of scrubby oak and elm trees and a very sparse understory of native grass.

This land type is not suitable for cultivation. It is used mainly as wooded range. It also offers food and cover for wildlife. (Capability unit VIIs-2; Savannah Breaks range site; group 3 for windbreaks and post lots)

## Sogn Series

This series consists of very shallow, stony, dark-colored, very gently sloping to moderately steep soils on uplands. These soils occur in a broad band that extends from the northeast corner to the southwest corner of the county. They developed under prairie grasses in material weathered from limestone.

The surface layer consists of very dark grayish-brown silty clay loam, generally mildly alkaline. It has moderate, medium, granular structure and contains many limestone rocks and fragments. This layer is about 8 inches deep over limestone bedrock.

Sogn soils are excessively drained. They have medium internal drainage and moderately slow permeability. They are used mainly for range.

Typical profile of a Sogn soil (native grass pasture, 3 percent slope, in the northeast corner of sec. 24, T. 27 N., R. 13 E.):

A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; friable when moist, hard when dry; few limestone rocks and fragments; numerous roots; mildly alkaline.

R—8 inches +, limestone bedrock.

The color of the surface layer ranges from very dark grayish brown to grayish brown. The depth to bedrock ranges from 4 to 15 inches and is commonly about 8 inches. Stones cover 1 to 30 percent of the surface, most commonly about 15 percent.

Sogn soils have a much thinner, less fully developed profile than Summit soils. They are much darker colored than Newtonia soils and have a less fully developed profile.

**Sogn soils, 1 to 20 percent slopes (SoE).**—These are very shallow, dark-colored, stony, excessively drained, loamy soils on prairie uplands. The profile is similar to the one described for the Sogn series. These soils occur in a broad band extending from the southwest corner to the northeast part of the county. The individual areas are

large. Small acreages of Newtonia and Summit soils were included in mapping.

These soils are used as native range. They are too droughty, too shallow, and too stony to be suitable for other uses. (Capability unit VIIs-3; Very Shallow range site; group 3 for windbreaks and post lots)

## Stephenville Series

This series consists of deep and moderately deep, friable, grayish-brown, gently sloping, timbered soils on uplands. These soils occur mainly in the western and northern parts of the county. They developed in material weathered from sandstone, under a cover of scattered scrub oak trees and tall native grasses.

The surface layer is about 12 inches thick. The upper part is grayish-brown, medium acid fine sandy loam that has weak, fine, granular structure. The lower part is light yellowish-brown, strongly acid fine sandy loam. It is massive and contains a few dark-colored concretions. The subsoil is about 28 inches thick. The upper part is yellowish-red, strongly acid sandy clay loam that has weak, medium, subangular blocky structure. The lower part is red, very strongly acid sandy clay loam. It is massive and contains many sandstone fragments. Beneath this are beds of reddish-yellow sandstone.

Stephenville soils are well drained. They have medium internal drainage and moderate permeability. They are susceptible to water erosion. These soils are used mainly as woodland range.

In Washington County, Stephenville soils were mapped only as part of a complex with Darnell soils.

Typical profile of Stephenville fine sandy loam (2 percent slope, 500 feet north and 340 feet west of the southeast corner of the northeast quarter of sec. 26, T. 28 N., R. 13 E.):

A1—0 to 5 inches, grayish-brown (10YR 5/2) fine sandy loam, dark brown (10YR 3/3) when moist; weak, fine granular structure; soft when dry, very friable when moist; many roots; medium acid; clear boundary.

A2—5 to 12 inches, light yellowish-brown (10YR 6/4) fine sandy loam, dark yellowish brown (10YR 4/4) when moist; massive; soft when dry, very friable when moist; few dark-colored concretions; many roots; strongly acid; clear boundary.

B21t—12 to 28 inches, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; few clay films on ped surfaces; few dark-colored concretions; many roots; strongly acid; clear boundary.

B22t—28 to 40 inches, red (2.5YR 5/8) sandy clay loam, red (2.5YR 4/8) when moist; massive; many sandstone fragments; very strongly acid; abrupt boundary.

R—40 inches +, beds of reddish-yellow sandstone.

The texture of the A horizon is dominantly fine sandy loam, and the color ranges from grayish brown to brown. The texture of the B21t horizon ranges from sandy clay loam to heavy sandy loam, and the color ranges from yellowish red to reddish yellow. The depth to sandstone ranges from about 20 to 50 inches.

Stephenville soils have thicker horizons and a more fully developed profile than Darnell soils.

## Summit Series

This series consists of deep and moderately deep, dark-colored, very gently sloping and gently sloping soils on uplands. These soils occur in a broad band that extends

across the county from the northeast corner to the southwest corner. They developed in material weathered from limestone and soft calcareous shale, under a cover of tall grasses.

The surface layer is about 8 inches of very dark gray silty clay loam, generally slightly acid. It has strong, fine, granular structure. The upper part of the 26-inch subsoil is very dark gray, medium acid heavy silty clay loam. It has strong, medium, granular structure and has clay films on the peds. The lower part is very dark grayish-brown, medium acid to slightly acid clay, with many olive and reddish-brown mottles. It has weak, fine, blocky structure and a few dark-colored concretions. The substratum consists of about 28 inches or more of light olive-brown, mildly alkaline clay over beds of limestone or shale. It has many olive-yellow and yellowish-brown mottles and a few dark-colored concretions.

Summit soils are moderately well drained. They have slow internal drainage and slow permeability. They are susceptible to water erosion. These soils are used mainly for cultivated crops and tame pasture.

Typical profile of Summit silty clay loam (native grass meadow, 3 percent slope, 400 feet west of the northeast corner of sec. 24, T. 26 N., R. 13 E.) :

- A1—0 to 8 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; strong, fine, granular structure; friable when moist, hard when dry; roots abundant; slightly acid; gradual boundary.
- B1—8 to 16 inches, very dark gray (10YR 3/1) heavy silty clay loam, black (10YR 2/1) when moist; strong, medium, granular structure; firm when moist, very hard when dry; many roots; medium acid; gradual boundary.
- B21t—16 to 24 inches, very dark grayish-brown (10YR 3/2) clay, very dark brown (10YR 2/2) when moist; moderate, fine, blocky structure; very firm when moist, very hard when dry; thin, continuous clay films; medium acid; gradual boundary.
- B22t—24 to 34 inches, dark grayish-brown (2.5Y 4/2) clay, very dark grayish brown (2.5Y 3/2) when moist; many, fine, faint mottles of olive and reddish brown; weak, fine, blocky structure; extremely firm when moist, extremely hard when dry; few dark-colored concretions; slightly acid; gradual boundary.
- C—34 to 62 inches, light olive-brown (2.5Y 5/4) clay, olive brown (2.5Y 4/4) when moist; many mottles of olive yellow and yellowish brown; massive; extremely firm when moist, extremely hard when dry; few dark-colored concretions; few fine CaCO<sub>3</sub> concretions; mildly alkaline.

The thickness of the A horizon ranges from 7 to 14 inches. The depth to bedrock ranges from 30 to 72 inches. In some places the B horizon has some strong-brown mottles.

Summit soils have a much thicker and more fully developed profile than the very shallow Sogn soils. They are much darker colored and are less permeable than Newtonia soils.

#### **Summit silty clay loam, 1 to 3 percent slopes (SuB).—**

This is a moderately deep and deep, moderately well drained, very gently sloping soil on prairie uplands. The profile is like the one described for the series. The areas are large, and the total acreage is extensive. Small areas of Okemah, Sogn, and Newtonia soils were included in mapping.

This soil is used mainly for cultivated crops and tame pasture. The principal crops are small grain, sorghum, alfalfa, soybeans, and tame pasture. An example of a suitable cropping system is a row crop, such as grain sorghum, for 3 years, then a sown crop, such as a small grain-vetch mixture, for 2 years.

Control of runoff, protection from erosion, and maintenance of structure and fertility are problems in use and management. Terracing and contour farming are needed if row crops are grown. Perennial vegetation should be established in drainageways and terrace outlet channels. (Capability unit IIe-1; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Summit silty clay loam, 3 to 5 percent slopes (SuC).—** This is a moderately deep and deep, moderately well drained, gently sloping soil on prairie uplands. It has the profile described as typical for the Summit series. It occurs as large areas near Sogn and Newtonia soils and is extensive in the county. Small acreages of Eram, Newtonia, and Sogn soils were included in mapping.

This soil is used mainly for cultivated crops and tame pasture. The principal crops are small grain, sorghum, and tame pasture. Small grain can be grown continuously if the residue is used for soil improvement.

Protection from severe erosion and maintenance of structure and fertility are the major problems. If row crops are grown, terracing and contour farming are generally needed to break up concentrations of water. Terraces are not needed if only high-residue, close-growing grass and legume crops are grown and the residue is used for soil improvement. Perennial vegetation should be established in drainageways and terrace outlet channels. Although the natural fertility is high, applications of fertilizer are needed in areas that have been depleted by cropping. (Capability unit IIIe-3; Loamy Prairie range site; group 1 for windbreaks and post lots)

**Summit silty clay loam, 1 to 5 percent slopes, eroded (SuC2).—** Most areas of this soil are about 30 acres in size, but some are large. Included in mapping were small areas of noneroded Summit silty clay loam and of Eram and Dennis soils. The surface layer is thinner than the one in the profile described as typical of the Summit series.

Erosion has removed about 25 to 75 percent of the surface layer. The present surface layer is about 5 inches thick, but there are many gullies, rills, and thin spots where the subsoil is exposed. The gullies are 100 to 200 feet apart, and most are crossable with machinery.

This soil is used mainly for tame pasture or hay crops. Tame pasture, sorghum, sericea lespedeza, and small grain are suitable crops. An example of a suitable cropping system is grain sorghum for 2 years, then small grain for 3 years. All residue from the grain crop should be used for soil improvement.

Protection from erosion and maintenance of structure and fertility are the main management problems. Terracing and contour farming are usually needed when clean-cultivated crops are grown. Perennial vegetation should be established in terrace outlet channels and in drainageways of unterraced fields. Fertilizer is needed for most crops. (Capability unit IIIe-5; Loamy Prairie range site; group 2 for windbreaks and post lots)

## **Talihina Series**

This series consists of very shallow and shallow, dark-colored, gently sloping to moderately steep soils on uplands. These soils occur in all parts of the county. They developed in material weathered from noncalcareous olive and gray shale, under a cover of tall grasses.

The surface layer is about 6 inches of brown clay loam, generally medium acid. It has moderate, fine, granular structure and contains numerous small fragments of shale and siltstone. The substratum is about 4 inches thick. It is about 50 percent fragments of weathered shale. The soil material in the substratum is light olive-brown, medium acid light clay. At a depth of 10 inches are beds of pale-olive shale and siltstone.

Talihina soils are somewhat excessively drained. They have slow internal drainage and slow permeability. They are susceptible to water erosion.

In Washington County, Talihina soils were mapped only as part of a complex with Collinsville soils.

Typical profile of Talihina clay loam (native grass pasture, 15 percent slope, 1,980 feet west of the southeast corner of sec. 2, T. 23 N., R. 13 E.):

A1—0 to 6 inches, brown (10YR 5/3) clay loam, dark brown (10YR 3/3) when moist; moderate, fine, granular structure; hard when dry, firm when moist; numerous small fragments of shale and siltstone; medium acid; clear boundary.

C—6 to 10 inches, light olive-brown (2.5Y 5/4) light clay, olive brown (2.5Y 4/4) when moist; about 50 percent fragments of slightly weathered shale; medium acid; abrupt boundary.

R—10 inches +, beds of pale-olive shale and siltstone; neutral.

The color of the A horizon ranges from brown and grayish brown to dark grayish brown, and the texture ranges from dominantly clay loam to clay. The depth to shale, siltstone, or beds of clay ranges from 4 to 20 inches. The slope range is 5 to 20 percent.

Talihina soils have thinner and less developed layers than Eram and Dennis soils. They are finer textured than Collinsville soils, which overlie sandstone rather than shale.

## Verdigris Series

This series consists of deep, friable, dark-colored, loamy, nearly level soils on flood plains. These soils developed in recent alluvium washed mainly from prairie soils.

The surface layer is dark grayish-brown, slightly acid silt loam that has moderate, medium, granular structure. It is about 22 inches thick. Below it is 38 inches or more of dark grayish-brown and grayish-brown, slightly acid and medium acid silt loam with a few yellowish-brown mottles. This material has moderate, medium, granular structure.

Verdigris soils are moderately well drained. They have medium internal drainage and moderately slow permeability. They are subject to flooding in wet seasons. Surface runoff is medium. These soils are used mostly for cultivated crops and tame pasture.

Typical profile of Verdigris silt loam (tame pasture, 0.5 percent slope, 400 feet west of the southeast corner of the SW $\frac{1}{4}$  sec. 7, T. 25 N., R. 13 E.):

A1—0 to 22 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; slightly acid; gradual boundary.

AC—22 to 36 inches, dark grayish-brown (10YR 4/2) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of yellowish brown when dry; moderate, medium, granular structure; friable when moist, slightly hard when dry; slightly acid; gradual boundary.

C—36 to 60 inches +, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; few,

fine, faint mottles of yellowish brown when dry; moderate, medium, granular structure; friable when moist, slightly hard when dry; medium acid.

The texture of the surface layer and the underlying layers is silt loam or clay loam. In places the substratum is more mottled, and the mottles are darker shades of brown and gray.

Verdigris soils are coarser textured and more permeable than Osage soils. They have a less fully developed profile than Mason soils.

**Verdigris clay loam** (0 to 1 percent slopes) (Vc).—This soil occurs as large areas on flood plains throughout the county. It is near Osage clay and Verdigris silt loam, and small acreages of those soils were included in mapping.

This soil has a 22-inch surface layer of clay loam. The substratum is 50 inches or more of clay loam that has a weak, fine, subangular blocky structure.

This soil is fertile and is readily penetrated by plant roots and moisture. It is used for cultivated crops and tame pasture. The principal crops are corn, alfalfa, soybeans, sorghum, small grain, pecans, and tame pasture. A common cropping system is alfalfa for 3 or 4 years, then corn or grain sorghum for 2 years. Native pecan trees, originally part of the hardwood forest, have been left for pecan groves. The trees are 40 to 80 feet apart. These groves are generally used for tame pasture also (fig. 10).

Some of this soil is irrigated. Much of the irrigation water is pumped from streams.

Maintenance of fertility and structure is the principal problem. Drainage of some small areas and control of seasonal flooding would be beneficial. (Capability unit IIw-1 or, if flooding is controlled, I-1; Loamy Bottomland range site; group 1 for windbreaks and post lots)

**Verdigris silt loam** (0 to 1 percent slopes) (Vd).—This soil occurs as large areas on the flood plains along major streams. It has the profile described as typical for the series. Included in mapping were small acreages of Verdigris clay loam and Osage clay. This soil is readily penetrated by plant roots and moisture. It is used mainly for cultivated crops and tame pasture. The principal crops are corn, alfalfa, soybeans, sorghum, small grain, pecans, and tame pasture. A commonly used cropping system is alfalfa for 3 or 4 years, then corn or grain sorghum for 2



Figure 10.—Bermudagrass pasture and pecan trees on Verdigris clay loam.

years. Native pecan trees, originally part of the hardwood forest, have been left for pecan groves. The trees are 40 to 80 feet apart. These groves are generally used for tame pasture also.

Some of this soil is irrigated. Much of the irrigation water is pumped from streams.

Maintenance of fertility and structure is the principal problem in managing this soil. Drainage in some places and control of flooding would be beneficial. (Capability unit IIw-1 or, if flooding is controlled, I-1; Loamy Bottomland range site; group 1 for windbreaks and post lots)

**Verdigris soils, broken** (0 to 20 percent slopes) (Vs).—These soils occur as narrow areas along the major streams of the county. They are flooded frequently. Most of the acreage is covered with hardwood trees and an understory of tall grasses. The profile is similar to the one described for the Verdigris series.

These soils are not suitable for cultivation. Little of the acreage has been cleared of timber. The soils can be used for range, for post lots, for pecan groves, for woodland, and for wildlife habitat. Tame pasture can be established in some areas.

Frequent flooding and irregular slopes are the main limitations. (Capability unit Vw-1; Loamy Bottomland range site; group 1 for windbreaks and post lots)

## Use of the Soils for Crops and Pasture

This section explains the system of classifying soils according to relative suitability for crops and pasture, describes some of the management practices generally applicable, and provides estimates of yields of the principal cultivated crops and pasture crops under defined levels of management.

The suitability of each soil for use as cropland and pasture, and the management needs of each soil when so used, are discussed in the descriptions of the individual soils (pages 4 through 17).

## The Capability Classification System

The capability classification is a grouping that shows, in a general way, how suitable soils are for the common field crops and pasture plants. It is a practical grouping based on the 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 special requirements.

In this system all the soils are grouped at three levels: the capability class, the subclass, and the unit. The eight capability classes, the broadest groupings, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage. In class VIII are soils and landforms so rough, so shallow, or otherwise so limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate the kinds of limitations within the classes. Within most of the classes there can be as many as three subclasses. The subclass is indicated by adding a small letter, *e*, *w*, or *s*, to the numeral that identifies the class, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); and *s* shows that the soil is limited mainly because it is shallow, droughty, or stony.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, and *s*, because the soils in it are subject to little or no erosion but have other limitations that restrict their use.

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

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations, without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil, and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system and the capability subclasses and units in this county are described in the list that follows. The "Guide to Mapping Units" shows the capability classification of each soil in the county.

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

Unit I-1. Deep, nearly level, well-drained alluvial soils on bottom lands.

Unit I-2. Deep, nearly level, moderately well drained and well drained soils on uplands.

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

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

Unit IIe-1. Deep and moderately deep, very gently sloping, moderately well drained and well drained soils on uplands.

Unit IIe-2. Moderately deep and deep, very gently sloping, well-drained soils on uplands.

Subclass IIw. Soils that have moderate limitations because of seasonal overflow.

Unit IIw-1. Deep, moderately well drained soils on bottom lands.

Subclass IIs. Soils that have moderate limitations because of a claypan.

Unit IIs-1. Deep, nearly level, somewhat poorly drained soils on uplands.

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

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

Unit IIIe-1. Moderately deep and deep, gently sloping, well-drained soils on uplands.

Unit IIIe-2. Deep, gently sloping, well-drained soils on uplands.

Unit IIIe-3. Moderately deep and deep, gently sloping, moderately well drained soils on uplands.

Unit IIIe-4. Deep, gently sloping, eroded soils on uplands.

Unit IIIe-5. Moderately deep and deep, very gently sloping and gently sloping, eroded soils on uplands.

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

Unit IIIw-1. Deep, clayey, nearly level, somewhat poorly drained soils on bottom lands.

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

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

Unit IVe-1. Shallow and moderately deep, gently sloping, well-drained soils on uplands.

Unit IVe-2. Shallow and moderately deep, gently sloping, well-drained soils on uplands.

Unit IVe-3. Moderately deep, gently sloping, well-drained soils on uplands.

Subclass IVs. Soils that have very severe limitations because of a claypan.

Unit IVs-1. Deep, nearly level, somewhat poorly drained soils on uplands.

**Class V.** Soils that 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 habitat.

Subclass Vw. Soils subject to frequent flooding.

Unit Vw-1. Deep soils on bottom lands.

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

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

Unit VIe-1. Nearly level to moderately steep, somewhat poorly drained to somewhat excessively drained, frequently flooded soils on floors and sides of valleys.

Unit VIe-2. Moderately deep, sloping to moderately steep, moderately well drained soils on uplands.

Subclass VIi. Soils generally unsuitable for cultivation and limited for other uses by low moisture-holding capacity, shallowness, stones, or other soil characteristics.

Unit VIi-1. Shallow and very shallow, sloping to moderately steep, somewhat excessively drained soils on uplands.

**Class VII.** Soils that have very severe limitations that make them unsuitable for cultivation and restrict their use to range, woodland, or wildlife habitat.

Subclass VIIi. Soils very severely limited by low moisture-holding capacity, shallowness, stones, or other soil characteristics.

Unit VIIi-1. Shallow and very shallow, stony, sloping to steep, somewhat excessively drained soils on uplands.

Unit VIIi-2. Very shallow, stony, steep and very steep, excessively drained soils on uplands.

Unit VIIi-3. Very shallow, stony, very gently sloping to moderately steep, excessively drained soils on uplands.

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

Subclass VIIIi. Soils extremely limited by low moisture-holding capacity, shallowness, high toxicity, or other soil characteristics.

Unit VIIIi-1. Borrow pits.

Unit VIIIi-2. Oil-waste land.

## General Management Practices <sup>1</sup>

Practices beneficial to most of the cultivated soils of this county include minimum and timely tillage, maximum use of soil-improving crops and minimum use of soil-depleting crops, and utilization of crop residue.

Minimum tillage reduces the likelihood of crusting and increases the rate of water intake. Excessive tillage of such soils as those of the Parsons, Osage, and Summit series causes compaction and surface crusting. Tilling only when the moisture content of the soils is favorable is important, too. If the Osage soils, for example, are tilled when too wet or too dry, the soil structure breaks down, the surface puddles and crusts, and, as a result, the capacity of the soil to absorb and store water is impaired. Tilling constantly to the same depth results in the formation of a plowpan in some soils, among them the Bates (fig. 11), Dennis, Mason, Parsons, and Stephenville. Varying the depth of tillage and growing deep-rooted legumes and grasses help both to prevent formation of a pan and to break up existing pans.

A soil-improving cropping system includes crops that leave large amounts of residue. Alfalfa, grain sorghum, and wheat are among the soil-improving crops grown on gently sloping upland soils, such as those of the Dennis, Newtonia, Okemah, and Bates series. Alfalfa is grown as a soil-improving crop on Verdigris and Mason soils. Grain sorghum residue and wheat straw provide some protection against erosion and supply organic matter, but if large amounts of this nonleguminous residue have been used, it may be necessary to apply nitrogen to prevent a shortage of this nutrient for the succeeding crop.

Clean-tilled crops and hay crops are soil depleting if cut low for silage, bundle feed, or hay. Deterioration of soil structure and reduction of organic-matter content result if such crops are grown on the eroded phases of Dennis and Okemah soils. Minimum use of such crops is advisable for all the soils of the county.

<sup>1</sup> By E. O. HILL, conservation agronomist, and KENNETH BLAN, work unit conservationist, SCS.

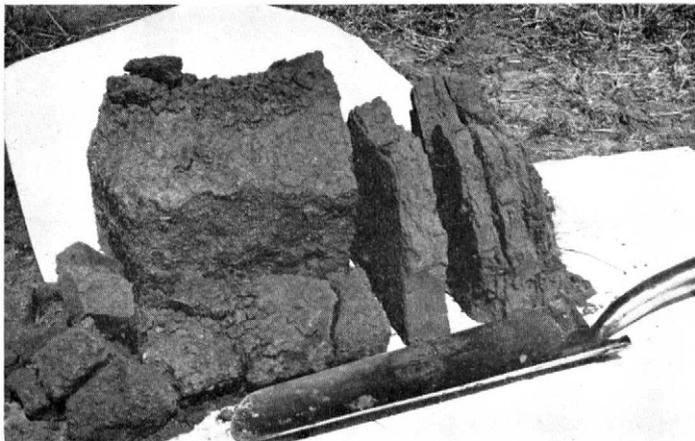


Figure 11.—Fragments of plowpan, removed from Bates fine sandy loam.

Crop residue left on the surface during winter and spring is effective in controlling erosion of the gently sloping soils of the Bates, Stephenville, Dennis, and Newtonia series. Crop residue also adds organic matter, which improves tilth, increases the capacity to absorb and store water, and helps to prevent crusting.

About 20 percent of the acreage of arable soils in Washington County is used for tame pasture. Most of this acreage consists of Verdigris, Mason, Dennis, Bates, Stephenville, Newtonia, and Okemah soils.

Bermudagrass is a suitable pasture plant for use on Mason, Verdigris, Newtonia, Bates, and Dennis soils. Fescue is suitable for somewhat poorly drained soils, such as those of the Osage series. It can be grown on upland soils, such as those of the Dennis and Summit series, but needs good management to survive through dry years. Fescue overseeded with Ladino clover or other cool-season legumes makes excellent pasture on well drained and moderately well drained soils, such as those of the Mason and Verdigris series. Bromegrass is suitable for pasture on medium-textured and moderately fine textured soils. Mixed with legumes, it provides highly palatable forage. Winter rye, winter oats, and winter wheat can be grown on all cultivated soils, alone or mixed with vetch, to provide supplemental pasture for use in winter and early in spring (fig 12).



Figure 12.—Fall-seeded annual winter rye grown for grazing on Dennis silt loam.



Figure 13.—Bermudagrass and clover mixture on Dennis silt loam. This mixture provides excellent forage and protects the soil.

Bermudagrass is usually established from roots or sprigs, the other pasture plants from seed. Brush control, weed control, fertilization, and regulation of grazing help to make pasture stands productive and long lived. A good stand of pasture plants provides protection against wind erosion and water erosion (fig. 13).

### Predicted Yields

Predicted long-term average yields of the important crops, including pasture crops, under two levels of management, are given in table 2. Columns A represent customary management, and columns B improved management. No predictions are given for soils not ordinarily considered suitable for crops. Crop failures were considered in estimating average yields.

Customary management, or the level of management practiced by a large number of farmers in the county, includes (1) proper rates of seeding, proper rates of planting, and efficient methods of harvesting; (2) control of weeds, insects, and diseases sufficient to insure good growth of plants; (3) terracing and contour farming where necessary; and (4) use of lime and fertilizer in small amounts.

Improved management includes the first three of the practices included in customary management, and in addition (1) use of lime and fertilizer in amounts indicated by soil tests; (2) use of adapted and improved varieties of crops; (3) surface drainage where needed; (4) residue management; (5) tillage by methods that help to control erosion, maintain structure, increase infiltration, and encourage the emergence of seedlings; (6) choice of a cropping sequence fitted to the operator's goals and the specific needs of the specific soils; and (7) pasture management that includes uniform grazing, deferment or rotation of grazing, and brush control.

The yield predictions were formulated by the soil scientists who made the soil survey and are based on consultation with farmers and on observations made during the progress of the survey. They have been corroborated by personnel of Oklahoma State University, from research information.

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

[The figures in columns A indicate yields expected under customary management; those in columns B indicate yields expected under improved management. Absence of a figure indicates that the crop is not commonly grown on the particular soil, that the crop is not suited to the soil, or that the soil is not arable]

Soil	Wheat		Oats <sup>1</sup>		Barley		Corn		Grain sorghum		Alfalfa		Soybeans		Tame pasture			
															Common bermuda-grass		Improved bermuda-grass	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Bates fine sandy loam, 3 to 5 percent slopes	Bu. 17	Bu. 25	Bu. 23	Bu. 39	Bu. 22	Bu. 36	Bu. 23	Bu. 34	Bu. 24	Bu. 41	Tons	Tons	Bu. 12	Bu. 19	AUM <sup>2</sup> 3.5	AUM <sup>2</sup> 5.5	AUM <sup>2</sup> 4.0	AUM <sup>2</sup> 6.5
Bates-Collinsville complex, 2 to 6 percent slopes <sup>3</sup>	13	18	20	30	18	28			21	32					2.4	4.0	3.0	4.5
Borrow pits																		
Breaks-Alluvial land complex															2.2	4.5	2.5	5.0
Collinsville-Talihina complex, 5 to 20 percent slopes <sup>3</sup>																		
Darnell stony sandy loam, 5 to 30 percent slopes																		
Darnell-Stephenville fine sandy loams, 2 to 6 percent slopes			15	25	15	24			12	20					2.2	4.5	2.5	4.5
Dennis silt loam, 1 to 3 percent slopes	21	32	30	44	30	42	32	46	36	50	2.0	3.0	15	23	4.0	6.0	5.5	7.5
Dennis silt loam, 3 to 5 percent slopes	17	25	24	38	26	36	22	35	32	44			10	16	3.5	5.5	4.0	7.0
Dennis silt loam, 3 to 5 percent slopes, eroded	14	20	20	34	22	32			24	38					3.0	4.6	4.0	6.0
Dwight-Parsons silt loams, 0 to 1 percent slopes <sup>3</sup>	10	18	14	24	10	20			13	21								
Eram clay loam, 2 to 5 percent slopes	10	16	20	30	18	28			20	28					2.0	3.5	3.0	4.0
Eram clay loam, 5 to 15 percent slopes	23	34	35	50	32	45	35	50	40	55	2.4	3.5	20	26	5.0	6.0	6.0	8.0
Mason silt loam	23	34	34	48	32	45	35	50	40	55	2.3	3.3	18	24	4.5	6.0	6.0	7.5
Newtonia silt loam, 0 to 1 percent slopes	21	31	30	44	30	42	30	45	36	50	2.0	3.0	15	22	4.0	6.0	5.5	7.0
Newtonia silt loam, 1 to 3 percent slopes	23	34	34	48	32	45	35	50	40	55	2.0	3.0	18	24	4.0	6.0	5.5	7.0
Oil-waste land																		
Okemah silt loam, 0 to 1 percent slopes	23	34	34	48	32	45	35	50	40	55	2.0	3.0	18	24	4.0	6.0	5.5	7.0
Okemah silt loam, 1 to 3 percent slopes	21	32	34	46	30	42	30	45	36	50	2.0	2.8	15	23	4.0	6.0	5.5	7.0
Okemah silt loam, 1 to 3 percent slopes, eroded	16	25	24	36	24	36	18	25	24	38			14	20	3.0	4.5	4.0	5.5
Osage clay	12	15	22	32	20	30	20	30	28	40					2.9	4.2	3.5	5.7
Parsons silt loam, 0 to 1 percent slopes	21	33	30	40	27	38	22	37	27	44			13	21	2.9	4.2	3.5	5.7
Rough stony land																		
Sogn soils, 1 to 20 percent slopes																		
Summit silty clay loam, 1 to 3 percent slopes	22	32	30	42	26	36	27	40	36	48	2.0	2.8	16	23	4.0	6.0	5.5	7.0
Summit silty clay loam, 3 to 5 percent slopes	19	26	24	36	24	34	23	36	30	44			12	20	4.0	5.5	4.5	7.5
Summit silty clay loam, 1 to 5 percent slopes, eroded	15	24	20	32	18	28			24	37					2.5	4.0	2.5	5.0
Verdigris clay loam	28	38	36	54	34	50	52	74	52	74	3.0	4.5	26	34	5.0	7.0	6.5	8.0
Verdigris silt loam	28	38	36	54	34	50	52	74	52	74	3.0	4.5	26	34	5.0	7.0	6.5	8.0
Verdigris soils, broken																		

<sup>1</sup> If winter oats varieties are used exclusively, yield may increase by approximately 25 percent.

<sup>2</sup> Animal-unit-months. The figures represent the number of months that 1 acre will provide grazing for 1 animal (1,000 pounds live weight), or the number of months the pasture can be grazed multiplied by the number of animal units an acre will support. For

example, 1 acre of Verdigris silt loam in an improved pasture of bermudagrass under improved management will provide grazing for 4 animals for 2 months, so it has a rating of 8 animal-unit-months.

<sup>3</sup> Yields will not be the same as yields for the components of the complex.

## Use of the Soils as Range<sup>2</sup>

Nearly 80 percent of Washington County, or approximately 215,500 acres, is used for livestock production. A few ranchers graze steers exclusively, but most keep herds of cows and market weaned calves in the fall. Some maintain both a basic herd of cows and a smaller herd of steers. Angus and Hereford are the dominant breeds. Most of the herds consist of registered or good grade animals. The sale of livestock and livestock products accounts for about 85 percent of the annual farm and ranch income. Major markets are located at Dewey, Collinsville, and Tulsa, and at Caney and Coffeyville in Kansas. The livestock industry depends for feed mainly on the native range but utilizes cropland and tame pasture for supplemental feed.

### Range Sites and Condition Classes

Effective range management requires knowledge of the capabilities of the various soils, the combinations of plants that can be produced, and the effects of grazing on the different kinds of plants. It also requires the ability to recognize signs of improvement or deterioration of the range vegetation. A system for inventorying and evaluating rangeland resources is discussed in the following paragraphs.

Range sites are distinctive areas of rangeland that, because of their particular combination of soils, climate, and topography, differ from each other in ability to produce native vegetation. Since there are no significant differences in climate and elevation within the county, differences in soil characteristics, such as depth and texture, or differences in topography are the bases for grouping soils into range sites. Each range site produces a characteristic type of climax vegetation, and usually each needs a particular system of management to keep it productive.

In this soil survey, the term climax vegetation refers to the original cover of vegetation that prevailed over the county at the time of settlement. The plants that make up the climax vegetation are generally adapted to the climate and will withstand drought, flood, and insects. They are usually the most productive and the most palatable plants that will grow on a particular site.

Livestock graze selectively, seeking the more palatable and nutritious plants. Unless grazing is regulated, the better plants are weakened and gradually decrease in abundance. Consequently, this group of plants is referred to as *decreasers*. *Increasesers* are plants that begin to spread when the decreasers begin to decline. These plants are commonly shorter, less productive, and less palatable for grazing purposes. If the increasesers are grazed heavily for several years, they become weakened and may decline and be replaced by *invaders*. These invading plants, not normally present in the climax vegetation, include brush, undesirable grasses, and weeds.

As the vegetation of a range site changes from predominantly decreaser to increaser and invader plants, the productivity and general health of the range decline. To indi-

cate the degree to which a range has deteriorated from its potential, the following four classes of range condition are recognized:

*Excellent condition*—76 to 100 percent of the present vegetation is of the same composition as the original vegetation. Decreaser plants dominate, and forage production is near the maximum for the site. The plant cover and mulch encourage intake of moisture and provide protection against erosion.

*Good condition*—51 to 75 percent of the present vegetation is of the same composition as the original vegetation. A few of the decreaser plants have been grazed out and replaced by increaser plants, but the general productivity of the site is still good.

*Fair condition*—26 to 50 percent of the present vegetation is of the same composition as the original vegetation. With increaser plants dominant and weedy plants invading, production of palatable forage is unsatisfactory. Litter and cover are usually inadequate to protect the soil against compaction and erosion.

*Poor condition*—Less than 25 percent of the present vegetation is of the same composition as the original vegetation. Invaders are abundant and very few decreasers and increasesers remain. Production is unsatisfactory, and the plant cover and litter are inadequate.

Good range management requires recognition of the range site and determination of range condition. Range condition classes may be determined at any time. Range condition class guides, which catalog the plants commonly found on each range site, are kept current in the work unit office of the Soil Conservation Service.

Forage production depends on the nature of the site, the condition and vigor of the vegetation, and precipitation. Management should be flexible enough to allow for variations in precipitation. Stocker cattle might be added during periods of favorable rainfall when forage production is high. During extended droughts, a reduction in the number of livestock might be necessary.

Short summer droughts are common in this section of Oklahoma. During these periods, the deep-rooted climax grasses in pasture that is in good or excellent condition continue to grow, but shallow-rooted plants in pasture that is in fair or poor condition become more or less dormant. Many operators maintain feed reserves, mostly hay, for use in dry periods.

### Descriptions of Range Sites

The soils of Washington County have been grouped into 10 range sites. Soils that produce similar kinds and amounts of climax vegetation and that require and respond to approximately the same management have been grouped together. Descriptions of these sites, including estimates of potential yields, follow. The range site classification of each individual soil is shown in the "Guide to Mapping Units." Borrow pits and Oil-waste land are not in any range site.

<sup>2</sup>This section prepared by HARLAND DIETZ, range conservationist, Soil Conservation Service.

### ***Loamy Bottomland range site***

This site consists of the Alluvial land part of Breaks-Alluvial land complex and soils of the Mason and Verdigris series. It is on the bottom lands of the Caney River and other streams. The slope ranges from nearly level to gently sloping. The soils have excellent capacity for root growth and moisture storage.

Tall warm-season grasses, chiefly big bluestem, indian-grass, eastern gama, prairie cordgrass, and switchgrass, are the dominant decreaseers in the climax vegetation. Tall dropseed, meadow dropseed, purpletop, knotroot bristlegrass, and longspike tridens are the principal increaseers. Broomsedge, ironweed, giant ragweed, seacoast sumpweed, white snakeroot, and coralberry are the most common invaders.

A few elm, sycamore, walnut, pecan, chinquapin oak, and hackberry trees grow naturally, mainly on streambanks and in areas that are flooded frequently. The trees increase in number if the site is overgrazed for a long time. Under the trees grow shade-tolerant, cool-season plants, including Canada wildrye, Virginia wildrye, and sedges.

This is the most productive site in the county. An acre produces about 11,500 pounds of herbage (air-dry weight) in a year of favorable rainfall, and about 8,000 pounds in a year of unfavorable rainfall.

### ***Heavy Bottomland range site***

This unit consists of Osage clay, a deep, nearly level soil on the wide bottom lands along the Caney River and other large streams (fig. 14). This soil takes in water very slowly, is somewhat poorly drained, and is subject to flooding. When dry, it hardens and cracks. The slope range is 0 to 1 percent.

On the better drained areas, the dominant decreaseers in the climax vegetation are tall grasses, including eastern gama, switchgrass, big bluestem, indiangrass, Florida paspalum, Virginia wildrye, and Canada wildrye. On the more poorly drained areas, a nearly pure stand of prairie cordgrass is the common decreaseer. Important forbs on this site are Maximillian sunflower and wholeleaf rosinweed. Tall dropseed, meadow dropseed, knotroot bristlegrass, western wheatgrass, and various sedges are the dominant increaseers. Woody plants, such as elm, hack-



**Figure 14.**—Heavy Bottomland range site in excellent condition. The grass, which is predominantly prairie cordgrass, has been mowed for hay. Unmowed part represents 1 year's growth.

berry, pecan, and walnut, are also common increaseers. The principal invaders are coralberry, ironweed, common broomweed, seacoast sumpweed, western ragweed, and giant ragweed.

This site produces about 8,000 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 5,000 pounds per acre in a year of unfavorable rainfall.

### ***Loamy Prairie range site***

This range site, the most extensive in the county, consists of soils of the Bates, Dennis, Eram, Newtonia, Okemah, and Summit series and the Breaks part of the Breaks-Alluvial land complex. These soils are moderately deep to deep. They have a loamy surface layer and a slowly permeable or moderately permeable subsoil. The slope ranges from nearly level to moderately steep.

Tall grasses, including big bluestem, indiangrass, little bluestem, and switchgrass, generally make up 80 to 90 percent of the climax vegetation. Eastern gama occurs on this site, mainly on the lower slopes of Summit soils. Decreaser legumes and forbs, including leadplant, catclaw sensitivebrier, Illinois bundleflower, compassplant, and perennial sunflower, usually grow on the better managed ranges. Meadow dropseed, Scribner panicum, side-oats grama, knotroot bristlegrass, heath aster, Missouri goldenrod, and prairie sagewort are the principal increaseers. Splitbeard bluestem, broomsedge bluestem, bitter sneezeweed, ironweed, lanceleaf ragweed, silver bluestem, oldfield three-awn, common broomweed, and western ragweed are the chief invaders.

This site produces about 7,000 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 5,000 pounds per acre in a year of unfavorable rainfall.

### ***Claypan Prairie range site***

This site consists of the Parsons soil in Dwight-Parsons silt loams, 0 to 1 percent slopes, and Parsons silt loam, 0 to 1 percent slopes. A heavy claypan subsoil, at a depth of 8 to 16 inches, slows the absorption of water and restricts the growth of plant roots. The surface layer stays wet in a rainy season but is droughty when rainfall is below normal. Even when in excellent condition, this site is only moderately productive.

Big bluestem, little bluestem, switchgrass, and indiangrass are the dominant decreaseers in the climax vegetation. Overgrazing, especially during a prolonged drought, causes rapid depletion of the more palatable vegetation. Among the increaseers are meadow dropseed, tall dropseed, silver bluestem, knotroot bristlegrass, dotted gayfeather, and heath aster. The principal invaders are common broomweed, western ragweed, lanceleaf ragweed, seacoast sumpweed, bitter sneezeweed, ironweed, oldfield three-awn, Japanese brome, and broomsedge bluestem.

This site produces about 5,000 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 2,500 pounds per acre in a year of unfavorable rainfall.

### ***Shallow Prairie range site***

This site consists of Collinsville-Talihina complex, 5 to 20 percent slopes, and the Collinsville soil in Bates-

Collinsville complex, 2 to 6 percent slopes. These soils are on uplands. They are shallow or very shallow.

When this site is in excellent condition, the most abundant decreaser plants are little bluestem, big bluestem, indiagrass, switchgrass, leadplant, catclaw sensitivebrier, Virginia tephrosia, slender lespedeza, and ashy sunflower. The more common increasers are tall dropseed, Scribner panicum, purpletop, purple lovegrass, heath aster, and goldenrod. Invaders include broomsedge bluestem, splitbeard bluestem, ironweed, lanceleaf ragweed, western ragweed, and bitter sneezeweed. Woody plants, such as blackberry, coralberry, sumac, hawthorn, and persimmon, are common, and they thicken if overgrazing continues. It often becomes necessary to spray for brush control in order to speed recovery of the better native plants.

This site produces about 4,200 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 2,500 pounds per acre in a year of unfavorable rainfall.

#### ***Shallow Claypan range site***

This site consists of the Dwight soil in Dwight-Parsons silt loams, 0 to 1 percent slopes. It usually is associated with the Claypan Prairie site. The dense, compact clay subsoil, which is at a depth of 3 to 7 inches, is nearly impervious to moisture and roots.

When this site is in excellent condition, the vegetation is approximately 60 percent decreaseers and 40 percent increasers. The dominant decreaseers are little bluestem, switchgrass, big bluestem, and Illinois bundleflower. The principal increasers are meadow dropseed, silver bluestem, blue grama, fall witchgrass, buffalograss, heath aster, and dotted gayfeather. Invader plants include western ragweed, bitter sneezeweed, oneseed croton, common broomweed, pricklypear, tumblegrass, windmillgrass, and oldfield three-awn.

This is the least productive site in the county. It produces about 2,500 pounds per acre of herbage (air-dry weight) in a year of favorable rainfall, and about 1,200 pounds per acre in a year of unfavorable rainfall.

#### ***Very Shallow range site***

This site consists of Sogn soils, 1 to 20 percent slopes, which are very shallow, stony soils, usually 10 inches or less in depth over limestone bedrock. The space for moisture storage and for root growth is very limited.

Short grasses dominate on this site. They include hairy grama, side-oats grama, and small amounts of little bluestem. Blue grama occurs occasionally along the western edge of the county but is unusual in the eastern part. Among the numerous native legumes that grow on this site are catclaw sensitivebrier, prairie acacia, Illinois bundleflower, wild alfalfa, roundhead prairie-clover, white prairie-clover, and purple prairie-clover. Increasers include buffalograss, tumble windmillgrass, silver bluestem, dotted gayfeather, noseburn, pricklypear, and various annual plants. Spots of deep soils like those in the Loamy Prairie range site occur in crevices and pockets in the limestone rock. These soils support taller grasses, mainly big bluestem, indiagrass, switchgrass, and little bluestem.

This site produces about 3,000 pounds (air-dry weight) per acre in a year of favorable rainfall, and about 1,000 pounds per acre in a year of unfavorable rainfall.

#### ***Sandy Savannah range site***

This site consists of the Stephenville soil in Darnell-Stephenville fine sandy loams, 2 to 6 percent slopes. It occurs in association with the Shallow Savannah site along the western edge of the county. The acreage is small. The soil is moderately deep and deep and is well drained.

The original vegetation consisted of tall grasses and scattered trees. Little bluestem, big bluestem, indiagrass, switchgrass, and wildrye are the dominant decreaseers. The trees are mainly post oak, blackjack oak, and hickory. They thicken if the site is overgrazed continually. Heath aster, goldenrod, purpletop, purple lovegrass, tall dropseed, and Scribner panicum are the principal increasers. Broomsedge bluestem, splitbeard bluestem, ironweed, maretail, coralberry, and persimmon are the chief invaders. Brush control is usually necessary to speed recovery of the better grasses.

This site produces about 5,000 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 3,000 pounds per acre in a year of unfavorable rainfall.

#### ***Shallow Savannah range site***

This site consists of Darnell stony sandy loam, 5 to 30 percent slopes, and the Darnell soil in Darnell-Stephenville fine sandy loams, 2 to 6 percent slopes. The major part of the site is on uplands along the western edge of the county. The soils are typically shallow or very shallow and stony. The loamy surface layer takes in moisture readily, but the soils are so shallow that space for moisture storage and root development are limited.

The climax vegetation on this site consists of an open stand of post oak, blackjack oak, and hickory and a ground cover of tall grasses. The most abundant decreaser grass on the site is little bluestem. Other decreaser plants include big bluestem, indiagrass, switchgrass, slender lespedeza, Stuves lespedeza, Illinois tickclover, and hairy sunflower.

On much of this site, the stands of trees have gradually thickened as a result of heavy grazing and annual burning in past years. Some areas have a dense stand of brush, which limits production severely. The principal increaser grasses are purpletop, Scribner panicum, tall dropseed, and purple lovegrass. The dominant invader plants are broomsedge bluestem, splitbeard bluestem, ironweed, maretail, ragweed, and coralberry. Brush control followed by deferment of grazing is usually necessary for improvement of areas that are in fair or poor condition (fig. 15).

This site produces about 3,800 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 1,800 pounds per acre in a year of unfavorable rainfall.

#### ***Savannah Breaks range site***

This site consists of Rough stony land, which is characterized by large boulders and outcrops of sandstone. The slope is 30 to 60 percent, and runoff is excessive.

The vegetation consists of an open stand of post oak, blackjack oak, and hickory and a ground cover of little bluestem, big bluestem, indiagrass, and wildrye. The increaser plants are post oak, blackjack oak, and associated woody plants, hairy grama, purpletop, green muhly, Scribner panicum, and sedges. The common invaders are



**Figure 15.**—Shallow Savannah range site in excellent condition. The soil is Darnell stony sandy loam, 5 to 30 percent slopes. Control of brush and deferment of grazing for 2 years have increased forage production. In far right background is an area that has not been treated for brush control.

broomsedge bluestem, splitbeard bluestem, marestalk, blackeyed susan, and ragweed.

This site produces about 2,000 pounds of herbage (air-dry weight) per acre in a year of favorable rainfall, and about 800 pounds in a year of unfavorable rainfall.

### **Woodland, Windbreaks, and Post Lots**<sup>3</sup>

Little timber of commercial value remains in Washington County, but some of the soils are suitable for windbreak and post-lot plantings.

#### **Native Woodland**

The native woodland in Washington County is mostly along the Caney River and its principal tributaries. The soils are Osage clay, Verdigris soils, broken, Verdigris clay loam, Verdigris silt loam, and Breaks-Alluvial land complex. The best of the remaining native timber is on the Verdigris soils. Scrub trees and cull trees grow on soils of the Darnell and Stephenville series.

The better native trees on the bottom lands include pecan, cottonwood, sycamore, water oak, bur oak, hackberry, elm, black walnut, and ash. Inferior trees in the rough or rocky areas include blackjack oak, which is predominant, and post oak. Scattered redcedars grow on the shallow or rocky soils.

In the past, a few stands of timber on the bottom lands furnished some lumber and building material used locally. Even yet, small amounts of sawtimber are cut intermittently, but, except for pecan trees, little remains in the way of trees of commercial size and quality. The soils on which such trees grow, such as the Verdigris and Mason soils, are among the best in the county for crops, tame pasture, and meadow, and they are fast being cleared.

The remaining stands of trees have some value as wildlife food and cover, as recreation areas, and to some extent as sources of fuel and fenceposts. Pecan and black wal-

<sup>3</sup> By CHARLES P. BURKE, woodland conservationist, Soil Conservation Service.

nut provide a harvest of nuts and are superior species for furniture wood. Walnut is used for gun stocks. White ash, which grows on clay soils of the bottom lands, is used to some extent for handle blocks.

#### **Windbreaks**

There is no great need for field windbreaks in Washington County, but farmsteads and livestock feeding areas on the open prairie benefit from the shelter provided by windbreaks. Through the Soil and Water Conservation District, ranchers and farmers can obtain technical help in planning, establishing, and maintaining windbreaks.

#### **Post-Lot Plantings**

Posts cut from most of the native trees are not durable and have to be replaced frequently, but trees suitable for posts can be grown on some of the soils. Black locust, catalpa, and Osage-orange are suitable species. If planted with ordinary care on suitable soils and properly managed, trees of these species grow to adequate size within a reasonable time, and repeated crops can be obtained at intervals of 5 to 7 years. Cultivation during the first growing season contributes to the survival and growth of the seedlings. Protection from fire and grazing is necessary.

#### **Windbreak and Post-Lot Groups**

The soils of Washington County have been placed in three groups according to their suitability for windbreak and post-lot plantings. Each group consists of soils that have about the same potential for producing the same kinds of trees under similar management. The "Guide to Mapping Units" shows which group each individual soil is in.

##### **Group 1**

Group 1 consists of soils of the Bates, Dennis, Mason, Newtonia, Okemah, Osage, Stephenville, Summit, and Verdigris series, and the land type Breaks-Alluvial land. These are moderately deep and deep, loamy and clayey, nearly level to strongly sloping soils on bottom lands and uplands. They are somewhat poorly drained to well drained. The soils of this group are the best in the county for post lots and farmstead windbreaks. (Farmstead windbreaks include windbreaks for livestock protection.)

Black locust, catalpa, and Osage-orange are suitable species for post-lot plantings. Catalpa should be planted only on the better areas of the Breaks-Alluvial land complex. Osage-orange does well on Osage clay and Verdigris clay loam. Black locust is suitable for any of the soils in the group. Broadleaf trees suitable for windbreaks include American elm, Siberian elm, cottonwood, pecan, sycamore, and black walnut. Suitable evergreens include eastern redcedar and Arizona cypress (winter-hardy variety).

Trees of commercial value grow on Verdigris clay loam, Verdigris silt loam, and Osage clay.

##### **Group 2**

Group 2 consists of the soils of the Dennis, Okemah, and Summit series. These are moderately deep and deep, loamy, very gently sloping and gently sloping, eroded, moderately well drained and well drained soils on uplands.

They have high to moderate moisture-storage capacity. These soils are not well suited to post-lot plantings. Windbreaks are difficult to establish, and they require extra effort in care and maintenance. Redcedar and Siberian elm are the species best suited.

### Group 3

Group 3 consists of soils of the Collinsville, Darnell, Dwight, Eram, Parsons, Talihina, and Sogn series and the land types Borrow pits, Oil-waste land, and Rough stony land. These are very shallow to deep, loamy, nearly level to very steep soils on uplands. They are somewhat poorly drained to excessively drained. Because of shallowness, droughtiness, very steep slopes, clayey subsoils, and toxic conditions, the soils in this group are not suitable for post lots or windbreaks. There are no native woodlands of commercial value on these soils.

## Wildlife

The important kinds of wildlife in Washington County are quail, greater prairie chicken, mourning dove, fox squirrel, rabbit, raccoon, mink, opossum, skunk, muskrat, and beaver. There are small flocks of wild turkey and a small population of deer. The predatory mammals are coyote, bobcat, and red and gray fox. The predatory birds include numerous species of hawks and owls. Songbirds of many kinds are common. Some waterfowl utilize ponds and impoundments during the migration season.

The availability of food and cover for wildlife coincides in a general way with the soil associations. Descriptions of the associations are in the section "General Soil Map."

The Dennis-Okemah-Parsons association has a low to moderate potential as a habitat for quail, deer, furbearers, and rabbit. The potential for squirrel is low because of a lack of mast and den trees. The better habitat for quail and rabbit occurs in the wooded sections along the prairie drainageways. The potential for prairie chicken is high because there are areas of native grassland interspersed with cultivated fields. The potential for fish production is moderate. The watersheds are well vegetated, and turbidity is only a minor problem.

The Collinsville-Talihina-Bates association is composed mainly of native grassland and has a low potential for deer, furbearers, squirrel, and turkey. Because of lack of woody cover, the potential for quail, rabbit, and dove is only moderate, but some cover suitable for these species is present along streams and drainageways. Lack of cultivated fields limits the food supply. The potential for prairie chicken is moderate.

The Summit-Sogn association is composed of grassland dissected with wooded stream courses. It has a low to moderate potential for prairie chicken, rabbit, quail, and dove. Cultivation is generally not practical, so the opportunity to provide food is limited. Some woody cover occurs along drainageways and creeks. The Summit soils, where they occur adjacent to woody cover, will support plantings for wildlife. Small grain, sorghum, corn, and alfalfa would add to the food supply. Ponds built in Summit soils have a moderate potential for fish production.

The Osage-Verdigris association is composed of soils on bottom lands. The vegetation on the Osage soils con-

sists of thick stands of pecan, walnut, ash, elm, and sycamore trees. The Verdigris soils are intensively cultivated. The habitat is favorable for squirrel, deer, turkey, rabbit, and furbearers. The potential for quail is low because of inadequate surface drainage of Osage soils. The potential for development of marshy duck habitat is good on Osage soils. The potential for production of fish is low because of lack of suitable sites for ponds and the frequency of flooding.

The Darnell-Stephenville association supports a woody cover and an understory of grass. The potential for quail, deer, turkey, dove, and rabbit is good. The Darnell soil is not well suited to wildlife plantings, because of slopes and stoniness. The Stephenville soils have a moderate potential for wildlife plantings. Ponds built in Stephenville soils have a low to moderate potential for fish production. Darnell soils do not have suitable sites for ponds.

## Engineering Uses of the Soils <sup>4</sup>

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to engineers are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, and reaction (pH). Depth to the water table, depth to bedrock, and relief are also important.

Information in this survey can be used to—

1. Make studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of soil properties that are significant in the planning of agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.
3. Make preliminary evaluations of soil 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 construction materials.
5. Correlate performance of engineering structures with soils, to develop information for overall planning that will be useful in designing and maintaining engineering structures.
6. Determine the suitability of the soils for cross-country movement of vehicles and construction equipment.
7. Supplement 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.

With the use of the soil map for identification, the engineering interpretations reported here can be useful for

<sup>4</sup>Prepared by FREDERICK E. KEETER and WILLIAM E. HARDESTY, civil engineers, Soil Conservation Service.

many purposes. It should be emphasized that they may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Some of the terms used by soil scientists may not be familiar to engineers, and some terms may have a special meaning in soil science. These and other special terms are defined in the Glossary.

## Engineering Classification Systems

Two systems of classifying soils for engineering purposes are in general use: the AASHO system<sup>5</sup> and the Unified system.<sup>6</sup>

The AASHO system is used by highway engineers to group soils according to engineering properties as de-

<sup>5</sup> AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 v., illus. 1961.

<sup>6</sup> WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3-357, v. 1, illus. 1953.

termined by field performance of the soils in highways. In this system, soils are placed in seven principal groups. The groups range from A-1, consisting of gravelly soils of high bearing capacity, to A-7, consisting of clayey soils that have low strength when wet. Within each group, the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest.

In the Unified classification system, the soils are grouped on the basis of texture, plasticity, and performance as material for engineering structures. The soil materials are identified as coarse grained, which are gravels (G) and sands (S); fine grained, which are silts (M) and clays (C); and highly organic soils (O). In this system, clean sands are identified by the symbols SW and SP; sands that contain fines of silt and clay, by the symbols SM and SC; silts and clays that have a low liquid limit, by the symbols ML and CL; and silts and clays that have a high liquid limit, by the symbols MH and CH.

Agricultural scientists of the U.S. Department of Agriculture classify soils according to texture.<sup>7</sup> In this system,

<sup>7</sup> UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL SURVEY MANUAL. Agr. Handbook No. 18, 503 pp., illus. 1951.

TABLE 3.—*Estimated engi-*

Series and map symbols	Depth to bedrock	Hydro-logic soil group	Depth from surface
Bates (BaC, BcC) ----- For the Collinsville part of unit BcC, see the Collinsville series in this table.	<i>Feet</i> 2-4	B	<i>Inches</i> 0-12 12-34 34
Borrow pits (Bp). Properties variable.			
Breaks-Alluvial land (Bk). Properties variable.			
Collinsville (CtE) ----- For the Talihina part of this unit, see the Talihina series in this table.	1	C	0-6 6-10 10
Darnell (DaF, DsC) ----- For the Stephenville part of DsC, see the Stephenville series in this table.	1	C	0-15 15
Dennis (DtB, DtC, DtC2) -----	3-6	C	0-10 10-15 15-52
Dwight (DwA) ----- For the Parsons part of this unit, see the Parsons series in this table.	3-7	D	0-5 5-50
Eram (EcC, EcD) -----	2-4	D	0-9 9-22 22
Mason (Ma) -----	10+	B	0-14 14-30 30-48

See footnote at end of table.

texture depends on the proportional amount of the mineral particles of different sizes. The soil materials are designated as cobbles, gravel, sand, silt, and clay. Rarely is a soil made up of particles of only one size, but a particle size may be dominant in a soil so that the soil exhibits the characteristics of material composed of that particle size. For example, a soil that is 40 percent clay is called clay. It feels slick, sticky, and plastic when wet. Texture is closely associated with workability, fertility, permeability, erodibility, and other important soil characteristics. Representative groups, from finest to coarsest, are: (1) fine-textured soils (clay, silty clay, and sandy clay); (2) medium-textured soils (very fine sandy loam to silt); and (3) coarse-textured soils (loamy sand and sand).

**Engineering Interpretations of the Soils**

To make the best use of the soil maps and the soil survey, an engineer should know the properties of the soil materials and the condition of the soil in place. Table 3 gives estimates of soil properties significant in engineering, and table 4 (p. 30) gives some interpretations based on these properties. Table 5 (p. 34) gives the results of laboratory tests of selected soils.

The estimated properties shown in table 3 are based on

typical profiles. If test data are available, the data shown are for the modal, or most nearly typical, profile. If tests were not made, the estimates shown are based on test data obtained from similar soils in this county and other counties nearby or on past experience in engineering work.

For the hydrologic soil group, the entire thickness of the soil profile shown in the table is considered. The soils are classified in four hydrologic groups—A, B, C, and D. The basis of the grouping is intake of water at the end of a long-duration storm, after prior wetting and opportunity for swelling, without consideration of the protective effect of vegetation. Group A consists mostly of sandy soils that have the lowest runoff potential. None of the soils of Washington County is in group A. Group D consists mostly of clays that have the highest runoff potential.

Permeability refers to the movement of water downward through undisturbed soil material. The estimates are for the soil in place. They are based on soil structure and porosity, without consideration of plowpans, surface crusts, or other artificial restrictions.

Available water, in inches per inch of soil depth, is the approximate amount of capillary water in a soil when that soil is wet to field capacity. When the soil is air dry, this amount of water will wet the soil material to a depth of 1 inch without deeper percolation.

*Engineering properties of the soils*

Classification			Percentage passing sieve—		Permeability of least permeable layer	Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
Fine sandy loam..... Sandy clay loam..... Sandstone.	ML CL	A-4 A-6, A-7	100 100	50-70 60-80	<i>Inches per hour</i> 0.8-2.5	<i>Inches per inch of soil</i> 0.12 .14	pH 5.6-6.5 5.6-6.5	Low. Low to moderate.
Loam..... Sandy loam..... Sandstone.	ML-CL SM	A-4 A-2, A-4	100 100	55-75 30-50	2.5-5.0	.14 .12	5.6-6.5 5.6-6.5	Low. Low.
Fine sandy loam..... Sandstone.	SM, ML	A-2, A-4	100	30-60	2.5-5.0	.12	5.6-6.5	Low.
Silt loam..... Clay loam..... Clay loam.....	ML ML, CL CL	A-4 A-4, A-6 A-6, A-7	100 100 100	75-90 75-95 75-95	----- ----- 0.05-0.2	.14 .17 .17	5.6-7.8 4.5-6.0 5.6-6.5	Low. Moderate. Moderate.
Silt loam..... Clay.....	ML-CL MH, CH	A-4 A-7	100 100	75-90 90-95	----- <0.05	.14 .17	5.1-6.0 6.1-8.4	Low. High.
Clay loam..... Clay..... Shale beds.	CL CH	A-6 A-7	100 100	85-95 85-95	----- 0.5-0.2	.17 .17	5.6-6.5 6.1-7.0	Moderate. High.
Silt loam..... Silty clay loam..... Clay loam.....	ML CL, ML CL	A-4 A-6 A-6	100 100 100	70-95 85-95 85-95	----- 0.2-0.8 -----	.14 .17 .17	6.1-7.0 5.6-6.5 5.6-6.5	Low Moderate. Moderate.

TABLE 3.—*Estimated engineering*

Series and map symbols	Depth to bedrock	Hydrologic soil group	Depth from surface
Newtonia (NeA, NeB)-----	<i>Feet</i> 2-5	C	<i>Inches</i> 0-10 10-22 22-42 42
Oil-waste land (Od). Properties variable.			
Okemah (OkA, OkB, OkB2)-----	3-7	C	0-16 16-20 20-60
Osage (Os)-----	10+	D	0-50
Parsons (PaA)-----	3-7	D	0-11 11-50
Rough stony land (Ro). Properties similar to those of Darnell soils.			
Sogn (SoE)-----	( <sup>1</sup> )	D	0-8 8
Stephenville-----	2-4	B	0-12 12-40 40
Summit (SuB, SuC, SuC2)-----	2-6	C	0-16 16-62
Talihina-----	1	D	0-6 6-10 10
Verdigris (Vc, Vd, Vs)-----	10+	B	0-60

<sup>1</sup> Less than 1 foot.

Reaction refers to the degree of acidity or alkalinity of the soil. Terms used to express each range are described under "Reaction" in the Glossary.

Shrink-swell potential indicates the change in volume to be expected when the moisture content of the soil material changes. It is based on tests for volume change or on observance of other physical properties of the soils. For example, Osage clay is very sticky when wet, and it shrinks extensively when dry. Hence, it has high shrink-swell potential. In contrast, the A horizon of Darnell fine sandy loam is nonplastic and has a low shrink-swell potential.

In table 4, ratings showing the suitability of the soils as sources of material for various uses are given, and some features that affect the use of the soils for specified purposes are listed. These features affect the selection of a site, the design of a structure, or the application of practices for land treatment. The data in this table are evaluated on the basis of the estimated data in table 3, on actual test data in table 5, and on field experience.

For topsoil, normally only the surface layer of a soil is rated. The suitability of this layer depends largely on its texture and depth. Material is suitable for topsoil only if it can be worked into a good seedbed, but it must be clayey enough to resist erosion on steep slopes.

The suitability of soil material for select grading material depends mainly on the grain size of the particles and on the amount of silt and clay. Soils that are predominantly sand are good if a binder is added for cohesion. Clays are not suitable, because they compress under a load and rebound when unloaded.

Suitability of soil material for road subgrade depends on compaction characteristics, plasticity, and erodibility. Gravelly, coarse-textured soils generally are best for subgrade. Highly plastic clays are poor.

Table 5 shows data obtained by laboratory tests of soil samples collected during the survey of Washington County and analyzed by the State Highway Department. Test data for some of the other soils have been published in soil surveys for other counties in Oklahoma.

*properties of the soils—Continued*

Classification			Percentage passing sieve—		Permeability of least permeable layer	Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
Silt loam.....	ML, CL	A-4	100	70-95	<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	Low. Moderate. Moderate.
Silty clay loam.....	ML, CL	A-6, A-7	100	85-95	-----	. 14	6. 1-6. 5	
Silty clay loam.....	MH	A-7	100	90-98	0. 8-2. 5	. 17	5. 6-6. 5	
Limestone.						. 17	5. 6-7. 3	
Silt loam.....	ML	A-4	100	80-95	-----	. 14	6. 1-7. 8	Low. Moderate. Moderate to high.
Silty clay loam.....	CL, ML	A-6, A-7	100	80-95	-----	. 14	7. 4-8. 4	
Silty clay.....	CL, CH	A-7	100	80-95	0. 05-0. 2	. 17	7. 4-8. 4	
Clay.....	CH	A-7	100	75-90	< 0. 05	. 17	6. 1-7. 3	High.
Silt loam.....	ML	A-4	100	70-90	-----	. 14	5. 1-6. 0	Low. High.
Clay.....	CH-MH	A-7	100	85-95	< 0. 05	. 17	6. 1-8. 4	
Silty clay loam.....	ML, CL	A-4, A-6	100	85-95	0. 2-0. 8	. 17	6. 6-8. 4	Moderate.
Limestone.								
Fine sandy loam.....	SM, ML	A-4	100	40-60	-----	. 14	5. 1-6. 0	Low. Low to moderate.
Sandy clay loam.....	SC, CL	A-4	100	40-60	0. 8-2. 5	. 14	4. 5-5. 5	
Sandstone.								
Silty clay loam.....	CL, MH	A-6, A-7	100	85-95	-----	. 17	5. 6-6. 5	Moderate. High.
Clay.....	CH, MH	A-7	100	90-98	0. 05-0. 2	. 17	5. 6-8. 4	
Clay loam.....	CL	A-6	100	75-90	-----	. 17	5. 6-6. 5	Moderate. Moderate.
Clay.....	CH, CL	A-7	100	75-95	0. 05-0. 2	. 17	5. 6-6. 5	
Shale and siltstone.								
Clay loam or silt loam.....	CL or ML	A-4 or A-6	100	75-95	0. 2-0. 8	. 17	5. 6-6. 5	Low to moderate.

**Nonfarm Uses of the Soils**

Table 6 (p. 36) shows the degree and nature of limitations of each soil for the following uses: septic tank filter fields; sewage lagoons; sanitary land fill; sites for low buildings; lawns, trees, and shrubs; small farms and gardens; golf fairways; picnic areas; intensive play areas; paths and trails; and parks. This information can be of use to metropolitan planning commissions, city and county governments, realtors, oil companies, contractors, and developers and users of recreational facilities.

**Formation and Classification of the Soils**

In this section, the formation of the soils of Washington County and the classification of the soils by higher categories are discussed.

Soil is the product of the interaction of five major factors of soil formation: climate, living organisms (especially vegetation), parent material, relief, and time.

**Climate**

The present climate of Washington County is warm and moist. Presumably the climate that existed when the soils were forming was similar. This kind of climate promotes rapid soil development. Although its effect is modified locally by runoff, the climate is uniform throughout the county. Therefore, differences among the soils of the county are not due to differences in climate.

**Living organisms**

Plants, animals, insects, bacteria, and fungi are important in the formation of soils. Gains in organic matter and nitrogen, gains or losses in plant nutrients, and altera-

**Factors of Soil Formation**

TABLE 4.—*Interpretations of engineering properties*

Soils and map symbols	Suitability as source of—			Soil features affecting—			
	Topsoil	Select grading material	Subgrade	Highway location	Farm ponds		Agricultural drainage
					Reservoir area	Embankment	
Bates (BaC)-----	Fair to good if soil material is mixed.	Fair to good--	Good-----	Lateral internal seepage.	Limited depth to bedrock; variable seepage.	Features favorable.	Not needed; good natural drainage.
Bates-Collinsville complex (BcC).	Poor; Collinsville part shallow over rock.	Poor to fair---	Good-----	Lateral internal seepage; bedrock at depth of 1 to 2 feet.	Bedrock at depth of 1 to 2 feet; high seepage.	Borrow material limited.	Not needed; good natural drainage.
Borrow pits (Bp) Properties variable-----							
Breaks-Alluvial land complex (Bk).	Poor; limited in quantity.	Unsuitable; too clayey.	Poor; broken topography; limited in quantity.	Rough, broken topography; bedrock at depth of 1 to 5 feet.	Low seepage; good natural impoundment sites.	Features favorable; borrow material limited in some places.	Nonarable.
Collinsville-Talihina complex (CtE).	Poor; limited in quantity.	Collinsville part fair to good if crushed.	Good-----	Seepage along shale beds; steep slopes subject to slides.	Moderately steep slopes; bedrock or shale at depth of 1 foot.	Borrow material limited; steep slopes.	Nonarable.
Darnell (DaF)-----	Poor; limited in quantity and generally stony.	Fair to good if crushed.	Good; limited in quantity; sandstone at depth of about 1 foot.	Seepage along shale beds; bedrock at depth of about 1 foot; steep slopes.	Steep slopes; bed rock at depth of about 1 foot.	Borrow material limited; steep slopes.	Nonarable.
Darnell-Stephenville (DsC).	Poor; Darnell part shallow over rock.	Fair to good--	Good-----	Features favorable.	Variable seepage; limited depth to soft bedrock.	Borrow material limited.	Not needed; good natural drainage.
Dennis (DtB, DtC, DtC2).	Good to fair in uppermost 15 inches.	Unsuitable---	Poor; low density; difficult to compact; unstable when wet.	Plastic below a depth of 15 inches; lateral internal seepage.	Features favorable.	Features favorable.	Not needed; good natural drainage.
Dwight-Parsons (DwA).	Poor; shallow over dense clay.	Unsuitable---	Very poor; highly plastic; high shrink-swell potential.	Highly plastic; poor internal drainage; seasonal high water table.	Turbid water; other features favorable.	Hazard of severe cracking; low stability.	Seasonal high water table; poor internal drainage; nearly level topography.

TABLE 4.—*Interpretations of engineering properties*—Continued

Soils and map symbols	Suitability as source of—			Soil features affecting—			
	Topsoil	Select grading material	Subgrade	Highway location	Farm ponds		Agricultural drainage
					Reservoir area	Embankment	
Eram (EcC, EcD)-----	Poor; shallow over dense clay.	Unsuitable; too clayey.	Very poor; high shrink-swell potential; unstable.	Highly plastic; poor internal drainage; cuts unstable.	Shale at depth of 2 feet; some stones; moderately steep slopes.	Hazard of severe cracking; low stability.	Not needed; good natural drainage.
Mason (Ma)-----	Good-----	Poor; plastic; subsurface material too clayey.	Poor; low density; difficult to compact; fast capillary action.	Plastic below a depth of about 1 foot.	Features favorable.	Nearly level relief.	Not needed; good natural drainage.
Newtonia (NeA, NeB)--	Good-----	Unsuitable; too elastic and clayey.	Poor; low density; difficult to compact; limestone at depth of 2 to 5 feet.	Plastic; limestone at depth of 2 to 5 feet.	High seepage; limestone at depth of 2 to 5 feet.	Compaction of granular clay material difficult; high seepage.	Not needed; good natural drainage.
Oil-waste land (Od). Properties variable.							
Okemah (OkA, OkB, OkB2).	Poor to fair in uppermost 16 inches.	Unsuitable----	Poor; low density; difficult to compact; unstable when wet.	Plastic below a depth of about 1 foot.	Features favorable.	Nearly level topography.	Slow internal drainage.
Osage (Os)-----	Unsuitable; too clayey.	Unsuitable----	Very poor; highly plastic; high shrink-swell potential.	Highly plastic; poor drainage; subject to flooding.	Features favorable for dug ponds.	Hazard of severe cracking; low stability.	Slow internal drainage; subject to flooding; surface drainage needed.
Parsons (PaA)-----	Poor; shallow over dense clay.	Unsuitable----	Very poor; highly plastic; high shrink-swell potential.	Highly plastic; poor drainage; seasonal high water table.	Turbid water; other features favorable.	Hazard of severe cracking; low stability.	Seasonal high water table; very slow internal drainage.
Rough stony land (Ro)-	Unsuitable; limited in quantity; steep.	Fair to good if crushed.	Fair to good except on steep slopes; large boulders.	Steep slopes; large boulders; subject to slides.	Steep slopes---	Steep slopes---	Nonarable.
Sogn (SoE)-----	Unsuitable; very shallow and rocky.	Unsuitable----	Very poor; mostly rock.	Very shallow to limestone bedrock; very gentle to moderately steep slopes.	Very shallow to limestone bedrock.	Borrow material limited; low stability.	Nonarable.

TABLE 4.—*Interpretations of engineering properties*—Continued

Soils and map symbols	Suitability as source of—			Soil features affecting—			
	Topsoil	Select grading material	Subgrade	Highway location	Farm ponds		Agricultural drainage
					Reservoir area	Embankment	
Summit (SuB, SuC, SuC2).	Fair to poor; generally too clayey.	Unsuitable....	Poor; highly plastic; high shrink-swell potential.	Highly plastic; seasonal seepage; slow internal drainage.	Shale or limestone at depth of 2 to 6 feet; other features favorable.	Hazard of cracking when dry; low shear strength.	Not needed; good natural drainage.
Verdigris (Vc, Vd, Vs)---	Good-----	Clay loam unsuitable; silt loam fair to poor; elastic.	Fair to poor; unstable when wet.	Flooding hazard; unstable when wet.	Features favorable for dug ponds.	Nearly level topography.	Medium internal drainage; occasional flooding; level topography.

tions in structure and porosity are among the changes caused by living organisms.

Vegetation has affected soil formation in this county more than other living organisms. The upland soils that developed under prairie grass vegetation are generally deeper, darker colored in the surface layer, and higher in organic-matter content than the soils that developed under trees.

#### Parent material

Parent material is the unconsolidated mass from which a soil forms. It determines the limits of the chemical and mineralogical composition of the soil.

The soils on the uplands of Washington County formed from material weathered from sandstone, limestone, and shale laid down during the Pennsylvanian geologic period. Bates, Collinsville, Darnell, and Stephenville soils are examples of soils that formed from material weathered from sandstone. Sogn, Summit, and Newtonia soils are examples of soils that formed from material weathered from limestone. Eram, Dennis, Okemah, and Talihina soils are examples of soils that formed from material weathered from shale.

The soils along the Caney River and other streams consist of alluvial material deposited during the Recent geologic epoch. Verdigris soils formed from the silt and sand dropped near the streambed when these streams overflowed. These soils are moderately well drained and moderately slowly permeable. Osage soils formed from the clay and silt that were dropped from slow-moving water at the outer edges of the flood plains. Osage soils are somewhat poorly drained and very slowly permeable.

#### Relief

Relief modifies the effects of climate and vegetation on soil formation. In Washington County, the range in relief is from nearly level to very steep. The soils that have strongly developed horizons are those that are nearly level

or gently sloping. More strongly sloping soils generally do not develop a prominent B horizon.

#### Time

Time, usually a long time, is required for the formation of distinct horizons in soils. Differences in the length of time that parent materials have been in place are commonly reflected in the degree of development of the soil profile. Young soils have very little profile development, and older soils have well-expressed horizons.

Collinsville soils are young soils that lack development. Except for darkening of their surface layer, Collinsville soils retain most of the characteristics of their parent material. Bates soils are older and have better developed horizons. Bates soils formed from parent materials similar to those of the Collinsville soils, but they now have a sandy clay loam subsoil that bears little resemblance to the original parent material.

#### Processes of Soil Formation

The processes that have most markedly influenced soil formation in Washington County are accumulation of organic matter, leaching of calcium carbonate and bases, reduction and transfer of iron, and translocation of silicate clay minerals.

The accumulation of organic matter in the surface layer of the soils that formed under prairie grass gives that layer a dark color and a granular structure. The Mason soils are examples of such soils. They typically have a dark grayish-brown A1 horizon, about 14 inches thick, that is high in organic-matter content. In soils that formed under trees, the surface layer has accumulated less organic matter and is lighter colored. The Stephenville soils are examples of such soils. They typically have a grayish-brown A1 horizon 5 inches thick over a light yellowish-brown A2 horizon 7 inches thick.

Calcium carbonate has been leached completely out of the

profile of many of the soils, among them the Darnell and Stephenville soils. In the Stephenville soils, the A2 horizon is leached of bases, and the B horizon is leached to the extent that base saturation is moderately low. In the Okemah soils, bases have accumulated in the lower part of the B horizon, and this part of the profile is moderately alkaline. These accumulations indicate the depth to which water percolates.

Reduction and transfer of iron, a process called gleying, is slightly evident in the somewhat poorly drained Parsons soils. The grayish color of the subsoil indicates reduction and loss of iron. Reddish-brown mottles and concretions result from the segregation of iron.

Translocation of silicate clay minerals has contributed to soil development in some soils of this county. In soils affected by this process—the Stephenville soils, for example—the eluviated A2 horizon is usually lighter colored and lower in clay content than the B horizon, and clay in the form of films in pores or on ped surfaces has accumulated in the B horizon. Probably these soils had been leached of carbonates and soluble salts before the translocation of silicate clays occurred.

Horizon differentiation is also affected by some factors that retard the soil-forming processes. For instance, grass brings bases to the surface, and this recycling of bases prevents complete leaching and retards the formation of an A2 horizon. Loss of soil through geologic erosion hampers the formation of horizons in sloping soils, for example, the Sogn and Collinsville soils. In other soils, the Verdigris, for example, frequent deposition of new sediments prevents the development of distinct horizons.

## Classification of the Soils

Soils are classified so that we may more easily remember their significant characteristics, assemble knowledge about them, see their relationships to each other and to the environment, and develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through the use of soil maps, we can apply our knowledge of soils to specific tracts of land.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938<sup>8</sup> and revised later.<sup>9</sup> The system currently used was adopted by the National Cooperative Soil Survey in 1965. This current system is under constant study. Readers interested in the development of the system should refer to the latest literature available.<sup>10 11</sup>

In the current system, classes are defined in terms of observable or measurable properties of soils. The properties that are considered have been so selected that the result is the grouping of soils of similar genesis. The

system has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. Table 7 (p. 38) shows the classification of the soils of the county according to these categories. It also shows the classification according to one category—the great soil group—of the 1938 system.

Following are brief descriptions of each of the categories in the current system.

*Order.*—The properties used to differentiate between orders are those that tend to give broad climatic groupings of soils. Three soil orders are recognized in Washington County: Inceptisols, Mollisols, and Alfisols. Inceptisols most commonly occur on young but not recent land surfaces. Mollisols are mineral soils that have a soft, dark-colored surface layer. Alfisols are soils that have a clay enriched B horizon that is high in base saturation.

*Suborder.*—Each order is divided into suborders, mainly on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The climatic range is narrower than that permitted in the order. The soil properties considered reflect mainly either (1) the presence or absence of waterlogging, or (2) differences resulting from the climate or vegetation.

*Great group.*—Each suborder is divided into great groups on the basis of uniformity in the nature of the major soil horizons and their sequence in the profile. The horizons considered are those in which clay, iron, or humus have accumulated or those that have pans that interfere with the growth of roots or the movement of water. The soil features considered are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly in content of calcium, magnesium, sodium, and potassium), and the like.

*Subgroup.*—Each great group is divided into subgroups, one representing the central (typic) segment of the great group, and others, called intergrades, having properties of one great group and also one or more properties of another great group, suborder, or order.

*Family.*—Families are established within a subgroup mainly on the basis of properties important to the growth of plants or to the behavior of soils when used in engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

*Series.*—Series are groups of soils in which the major horizons are similar in important characteristics, except for the texture of the surface layer, and in arrangement in the profile. (See the section "How This Survey Was Made.")

## General Facts About the County

The area that is now Washington County was a part of the Louisiana Purchase of 1803 that was set aside for the Cherokee Indians. The county was established in 1907, when Oklahoma became a State.

Bartlesville, which was organized in 1897, became the county seat. In 1907 the population of the county was 12,813. In 1960 it was 42,347. The city of Bartlesville had

<sup>8</sup> BALDWIN, MARK; KELLOGG, CHARLES E.; and THORP, JAMES. SOIL CLASSIFICATION. U.S. Dept. Agr. Ybk. pp. 979-1001. 1938.

<sup>9</sup> THORP, JAMES, and SMITH, GUY D. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUP. Soil Sci. 67: 117-126. 1949.

<sup>10</sup> SIMONSON, ROY W. SOIL CLASSIFICATION IN THE UNITED STATES. Science, v. 137, No. 3535, pp. 1027-1049, illus. 1962.

<sup>11</sup> UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. 1960. [Supplement issued in March 1967]

TABLE 5.—*Engineering*

[Tests performed by the Oklahoma Department of Highways in accordance with standard

Soil name and location of sample	Parent material	Oklahoma report No.	Depth	Horizon	Shrinkage		Volume change from field moisture equivalent
					Limit	Ratio	
			<i>Inches</i>				<i>Percent</i>
Bates fine sandy loam: 1,500 feet N. of SE. corner of sec. 19, T. 28 N., R. 14 E. (Modal profile)	Sandstone and shale.	SO-9427	0-12	A1	23	1.59	7
		SO-9428	20-28	B2t	15	1.85	27
		SO-9429	28-34	B3	16	1.86	26
Dwight silt loam: NW. corner of SW $\frac{1}{4}$ sec. 29, T. 28 N., R. 14 E. (Modal profile)	Shale.	SO-9430	0-6	A1	24	1.57	5
		SO-9431	6-30	B2t	12	1.92	55
Mason silt loam: 1,290 feet E. and 200 feet N. of SW. corner of sec. 16, T. 26 N., R. 14 E. (Modal profile)	Old alluvium.	SO-9422	0-7	A1	20	1.72	4
		SO-9423	24-54	B2, B2t	18	1.82	24
Newtonia silt loam: 300 feet W. of NE. corner of SE $\frac{1}{4}$ sec. 9, T. 26 N., R. 14 E. (Modal profile)	Limestone.	SO-9424	0-16	A1	20	1.76	24
		SO-9425	24-36	B2t	18	1.83	49
		SO-9426	36-42	C	14	1.91	83
Okemah silt loam: 970 feet N. of SW. corner of sec. 20, T. 27 N., R. 13 E. (Modal profile)	Shale.	SO-9435	0-12	A1	20	1.75	14
		SO-9436	16-26	B21t	12	1.98	64
		SO-9437	26-40	B22t	10	2.02	59
Parsons silt loam: 1,650 feet E. and 100 feet S. of NW. corner of sec. 31, T. 28 N., R. 14 E. (Modal profile)	Shale.	SO-9432	0-9	A1	24	1.59	9
		SO-9433	13-24	B21t	11	1.98	57
		SO-9434	24-38	B22t	10	2.03	74
Summit silty clay loam: 400 feet W. of NE. corner of sec. 24, T. 26 N., R. 13 E. (Modal profile)	Limestone and shale.	SO-9419	0-8	A1	22	1.64	46
		SO-9420	16-24	B21t	15	1.91	74
		SO-9421	24-34	B22t	12	1.91	70

<sup>1</sup> According to Designation: T 88-57, "Mechanical Analysis of Soils," in "Standard Specifications for Highway Materials and Methods of Sampling and Testing," pt. 2, Ed. 8 (1961), published by AASHTO. Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO 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

a population of 27,878 in 1960. Next in size was the city of Dewey, which had a population of 3,994. Other towns are Copan (population 617), Ramona (546), Ochelata (312), and Vera (125).

In 1897, the first commercial oil well was completed near Bartlesville. The oil industry has been a major force in the economy of the county.

## Relief and Drainage

The relief of Washington County is generally rolling. East of the Caney River is a prairie plain that ranges in elevation from 700 to 860 feet. West of the Caney River the slopes are stronger. Along the western border of the county, an escarpment, 150 to 200 feet high and mainly wooded, rises above the plain.

The Caney River, the major stream of the county, flows in a southeasterly direction. Caney Creek and Cotton Creek drain into the Caney River in the northern part of the county. Coon Creek and Hogshooter Creek drain into the Caney River in the west-central part of the county. Double Creek drains into the Caney River in the southern part of the county.

## Climate<sup>12</sup>

Washington County has a warm-temperate, continental climate. Changes between seasons are gradual, but seasonal characteristics are well defined. Winters are open and sunny. Cold, blustery weather occurs, but long periods of in-

<sup>12</sup> By STANLEY G. HOLBROOK, state climatologist, Weather Bureau.

## test data

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis <sup>1</sup>						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—					AASHO	Unified <sup>2</sup>
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.				
-----	100	66	44	20	15	31	6	A-4(6)	ML
100	99	77	62	40	35	43	18	A-7-6(12)	ML-CL
100	98	67	58	36	31	41	16	A-7-6(9)	ML-CL
-----	100	89	79	24	16	32	8	A-4(8)	ML-CL
100	99	91	85	44	38	53	24	A-7-6(16)	MH-CH
-----	100	91	77	21	16	26	1	A-4(8)	ML
-----	100	91	77	30	25	33	11	A-6(8)	ML-CL
-----	100	95	85	35	28	35	8	A-4(8)	ML
<sup>3</sup> 98	91	85	80	47	39	46	13	A-7-5(10)	ML
100	99	96	94	75	67	69	25	A-7-5(18)	MH
-----	100	91	83	26	20	32	9	A-4(8)	ML-CL
-----	100	95	83	49	44	50	23	A-7-6(15)	ML-CL
100	99	94	87	50	45	54	29	A-7-6(18)	CH
-----	100	83	69	20	15	31	6	A-4(8)	ML
100	99	89	81	46	40	54	28	A-7-6(18)	CH
100	99	91	82	53	48	62	32	A-7-5(20)	MH-CH
-----	100	93	85	38	27	54	14	A-7-5(12)	MH
100	97	93	88	56	50	59	22	A-7-5(17)	MH
100	99	96	92	62	54	68	37	A-7-5(20)	MH-CH

2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

<sup>2</sup> SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are ML-CL and MH-CH.

<sup>3</sup> For sample No. SO-9425, 100 percent passed the No. 4 sieve.

tense cold and heavy snow are not common. Spring is a season of variable weather that brings the greatest amounts and intensities of precipitation and the most frequent occurrences of severe local storms. The heavy rains at this time sometimes necessitate replanting of crops, but they are beneficial because they fill farm ponds and provide adequate moisture for initial growth of plants and a reserve of moisture for the somewhat drier months of summer, when crops are maturing. Summers are hot, but the hot weather is modified by cool nights, breezes, and occasional showers or thunderstorms. Fall is a transition period during which mostly sunny weather is interrupted by a few days of moderate to heavy soaking rain.

Table 8 (p. 39) gives temperature and precipitation data based on records kept at the Weather Bureau at Bartlesville. The mean annual temperature, based on the Bartles-

ville records, is 59.7° F. Mean monthly temperatures range from 36.4°, for January, to 81.8°, for July. The daily range of temperature averages 25°. The lowest temperature of record, which occurred on January 22, 1930, is -25°; the highest, which occurred on July 14, 1954, is 115°. Temperatures of 90° or above occur on an average of 81 days a year, and temperatures of 100° or above on 16 days in 5 out of 6 years. In about 1 year out of 10 the temperature reaches 110°. Freezing temperatures occur on an average of 95 days a year. Subzero temperatures occur in 1 year out of 2, and temperatures of -10° or below in 1 year out of 9.

Table 9 (p. 40) shows average dates of specified low temperatures, based on Bartlesville records. The average dates vary somewhat from one part of the county to another. The last freeze in spring has occurred as early as

TABLE 6.—Limitations of

Soil series and map symbols	Degree of limitation for—				
	Septic tank filter fields	Sewage lagoons	Sanitary land fill	Sites for low buildings	Lawns, trees, and shrubs
Bates (BaC)-----	Severe: rock at 2 to 4 feet.	Severe: rock at 2 to 4 feet; variable seepage.	Severe: rock at 2 to 4 feet.	Slight-----	Slight-----
Bates-Collinsville complex (BcC).	Severe: rock at 1 to 2 feet.	Severe: rock at 1 to 2 feet.	Severe: rock at 1 to 2 feet.	Slight-----	Severe: droughty; rock at 1 to 2 feet.
Borrow pits (Bp) Properties variable-----					
Breaks-Alluvial land complex (Bk).	Severe: rock at 1 to 5 feet; Alluvial land subject to flooding.	Severe: Breaks have 12 percent slopes; Alluvial land subject to flooding.	Severe: limited area; Alluvial land subject to flooding.	Severe: limited area; Alluvial land subject to flooding.	Severe: Breaks shallow and droughty; Alluvial land subject to flooding.
Collinsville-Talihina complex (CtE).	Severe: moderately steep slopes; rock or shale at 1 foot.	Severe: moderately steep slopes; rock or shale at 1 foot.	Severe: moderately steep slopes; rock or shale at 1 foot.	Severe: moderately steep slopes.	Severe: droughty; shallow; moderately steep slopes.
Darnell (DaF)-----	Severe: steep slopes; rock at about 1 foot.	Severe: steep slopes; rock at about 1 foot.	Severe: steep slopes; rock at about 1 foot.	Severe: steep slopes.	Severe: droughty; shallow; steep slopes.
Darnell-Stephenville (DsC)-----	Severe: rock at 1 to 4 feet.	Severe: high seepage; rock at 1 to 4 feet.	Severe: rock at 1 to 4 feet.	Moderate: rock at 1 to 4 feet.	Slight-----
Dennis (DtB, DtC, DtC2)-----	Severe: percolation rate slow.	Slight-----	Moderate: difficult to excavate when wet.	Moderate: moderate shrink-swell potential.	Slight-----
Dwight-Parsons (DwA)-----	Severe: percolation rate very slow.	Slight-----	Severe: difficult to excavate.	Severe: high shrink-swell potential; poor internal drainage.	Severe: droughty; poor internal drainage; crusting.
Eram (EcC, EcD)-----	Severe: percolation rate slow.	Slight to severe: some moderately steep slopes.	Severe: difficult to excavate; some steep slopes.	Severe: high shrink-swell potential.	Moderate: droughty; depth to shale 2 to 5 feet; slow internal drainage.
Mason (Ma)-----	Moderate: percolation rate slow.	Slight-----	Slight-----	Moderate: moderate shrink-swell potential.	Slight-----
Newtonia (NeA, NeB)-----	Severe: rock at 2 to 5 feet.	Severe: fragmented limestone at 2 to 5 feet; variable seepage.	Moderate: fragmented limestone at 2 to 5 feet.	Slight-----	Slight-----
Oil-waste land (Od)-----	Severe: percolation rate very slow; high corrosion potential.	Severe: highly saline; properties variable.	Severe: properties variable.	Severe: properties variable.	Severe: highly saline; barren.
Okemah (OkA, OkB, OkB2)-----	Severe: percolation rate slow.	Slight-----	Moderate: difficult to excavate when wet.	Moderate: moderate to high shrink-swell potential.	Slight-----

soils for selected nonfarm uses

Degree of limitation for—Continued					
Small farms and gardens	Golf fairways	Picnic areas	Intensive play areas	Paths and trails	Parks
Slight.....	Slight.....	Slight.....	Moderate: gentle slopes; rock at 2 to 4 feet.	Slight.....	Slight.
Severe: droughty; rock at 1 to 2 feet.	Moderate: low productivity; coarse fragments.	Moderate: rock at 1 to 2 feet.	Moderate: gentle slopes; rock at 1 to 2 feet.	Slight.....	Moderate: rock at 1 to 2 feet.
Severe: Breaks shallow and droughty; Alluvial land subject to flooding.	Severe: broken relief; Alluvial land subject to flooding.	Severe: broken relief; Alluvial land subject to flooding.	Severe: limited area; Alluvial land subject to flooding.	Moderate: broken relief; Alluvial land subject to flooding.	Severe: few trees; Alluvial land subject to flooding.
Severe: droughty; shallow; moderately steep slopes.	Severe: moderately steep slopes; stony; droughty.	Severe: treeless; moderately steep slopes.	Severe: moderately steep slopes; rock or shale at 1 foot.	Moderate: treeless; rock or shale at 1 foot.	Severe: moderately steep; rock or shale at 1 foot.
Severe: droughty; shallow; steep slopes.	Severe: steep slopes; stony.	Severe: steep slopes.	Severe: steep slopes; rock at about 1 foot.	Moderate: steep slopes.	Severe: steep slopes.
Severe: rock at 1 to 4 feet; low water-holding capacity.	Slight.....	Slight.....	Severe: rock at 1 to 4 feet.	Slight.....	Slight.
Slight.....	Slight.....	Slight.....	Slight.....	Slight.....	Slight.
Severe: droughty; poor internal drainage; crusting.	Moderate: droughty; somewhat poorly drained.	Moderate: treeless; somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: treeless; somewhat poorly drained.	Moderate: treeless; somewhat poorly drained.
Severe: droughty; slow internal drainage.	Slight to severe: rocks; some steep slopes.	Slight.....	Severe: too steep in most places.	Slight.....	Moderate: treeless; some steep slopes.
Slight.....	Slight.....	Slight.....	Slight.....	Slight.....	Slight.
Slight.....	Slight.....	Slight.....	Slight.....	Slight.....	Slight.
Severe: highly saline; barren.	Severe: barren.....	Severe: barren; properties variable.	Severe: barren; properties variable.	Severe: barren; properties variable.	Severe: barren; properties variable.
Slight.....	Slight.....	Slight.....	Slight.....	Slight.....	Slight.

Table 6.—Limitations of

Soil series and map symbols	Degree of limitation for—Continued				
	Septic tank filter fields	Sewage lagoons	Sanitary land fill	Sites for low buildings	Lawns, trees, and shrubs
Osage (Os)-----	Severe: percolation rate very slow; flooding.	Severe: flooding.	Severe: flooding; difficult to excavate.	Severe: flooding; high shrink-swell potential.	Severe: flooding; droughty; somewhat poorly drained.
Parsons (PaA)-----	Severe: percolation rate very slow.	Slight-----	Severe: difficult to excavate.	Severe: high shrink-swell potential; somewhat poorly drained.	Severe: droughty; poor internal drainage; crusting.
Rough stony land (Ro)-----	Severe: steep slopes.	Severe: steep slopes.	Severe: steep slopes.	Severe: steep slopes.	Severe: steep slopes; shallow.
Sogn (SoE)-----	Severe: rock at 1 foot or less.	Severe: rock at 1 foot or less.	Severe: rock at 1 foot or less.	Severe: rock at 1 foot or less.	Severe: droughty; rock at 1 foot or less.
Summit (SuB, SuC, SuC2)-----	Severe: percolation rate very slow.	Slight-----	Moderate: rock at 2 to 6 feet.	Severe: high shrink-swell potential.	Slight-----
Verdigris (Vc, Vd, Vs)-----	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Slight: flooding.

TABLE 7.—Classification of soil series

Series	Current classification			1938 classification by great soil groups
	Family	Subgroup	Order	
Bates-----	Fine-loamy, mixed, thermic-----	Typic Argiudolls-----	Mollisols-----	Prairie soils.
Collinsville-----	Loamy, mixed, thermic-----	Lithic Hapludolls-----	Mollisols-----	Lithosols.
Darnell-----	Loamy, siliceous, thermic, shallow-----	Typic Ustochrepts-----	Inceptisols-----	Lithosols.
Dennis-----	Fine, mixed, thermic-----	Aquic Paleudolls-----	Mollisols-----	Prairie soils.
Dwight-----	Fine, montmorillonitic, mesic-----	Typic Natrustolls-----	Mollisols-----	Planosols.
Eram-----	Fine, mixed, thermic-----	Aquic Argiudolls-----	Mollisols-----	Prairie soils.
Mason-----	Fine-silty, mixed, thermic-----	Typic Argiudolls-----	Mollisols-----	Alluvial soils.
Newtonia-----	Fine-silty, mixed, thermic-----	Typic Paleudolls-----	Mollisols-----	Reddish Prairie soils.
Okemah-----	Fine, mixed, thermic-----	Aquic Paleudolls-----	Mollisols-----	Prairie soils.
Osage-----	Fine, montmorillonitic, noncalcareous, thermic-----	Vertic Haplaquolls-----	Mollisols-----	Alluvial soils.
Parsons-----	Fine, mixed, thermic-----	Mollic Albaqualfs-----	Alfisols-----	Planosols.
Sogn-----	Loamy, mixed, mesic-----	Lithic Haplustolls-----	Mollisols-----	Lithosols.
Stephenville-----	Fine-loamy, siliceous, thermic-----	Ultic Haplustalfs-----	Alfisols-----	Red-Yellow Podzolic soils.
Summit-----	Fine, montmorillonitic, thermic-----	Vertic Argiudolls-----	Mollisols-----	Prairie soils.
Talihina-----	Fine, mixed, thermic, shallow-----	Typic Hapludolls-----	Mollisols-----	Lithosols.
Verdigris-----	Fine-silty, mixed, thermic-----	Cumulic Hapludolls-----	Mollisols-----	Alluvial soils.

February 28 and as late as May 4. The first freeze in fall has occurred as early as October 1 and as late as November 2. The average length of the freeze-free season ranges from 200 days in the northern part of the county to 210 days in the southern part.

The mean annual precipitation ranges from 35.5 inches at Bartlesville to 37 inches in the southern part of the county and 38.5 inches in the northeastern corner. At Bartlesville, annual precipitation totals over the past 55 years

have ranged from 19.84 inches, in 1963, to 67.64 inches, in 1915. Maximum monthly rainfall has ranged from 5.69 inches, in February 1915, to 17.87 inches, in May 1943. Once in about every 2 years, as much as 3.5 to 6 inches of rain falls in a day, most commonly in June or September. Seasonal distribution of rainfall is as follows: 31 percent in spring, 30 percent in summer, 26 percent in fall, and 13 percent in winter. The driest part of the year runs from the first of October through March.

soils for selected nonfarm uses—Continued

Degree of limitation for—Continued					
Small farms and gardens	Golf fairways	Picnic areas	Intensive play areas	Paths and trails	Parks
Severe: flooding; somewhat poorly drained; difficult to work.	Severe: flooding; clayey surface; somewhat poorly drained.	Severe: flooding; clayey surface; somewhat poorly drained.	Severe: flooding; clayey surface; somewhat poorly drained.	Severe: clayey surface; somewhat poorly drained.	Severe: clayey surface; somewhat poorly drained.
Severe: droughty; poor internal drainage; crusting.	Moderate: droughty; somewhat poorly drained.	Moderate: treeless; somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: treeless; somewhat poorly drained.	Moderate: treeless; somewhat poorly drained.
Severe: steep slopes; shallow.	Severe: steep slopes; rocky.	Severe: steep slopes.	Severe: steep slopes.	Moderate: steep slopes.	Severe: steep slopes.
Severe: droughty; rock at 1 foot or less.	Severe: rocky surface.	Severe: treeless	Severe: rock at 1 foot or less.	Moderate: rock at 1 foot or less.	Severe: treeless; rock at 1 foot or less.
Slight	Slight	Moderate: slow permeability.	Slight	Slight	Moderate: treeless; high shrink-swell potential.
Moderate: flooding	Severe: flooding	Moderate: flooding	Severe: flooding	Slight	Moderate: flooding.

TABLE 8.—Temperature and precipitation

[All data from Bartlesville, Okla. Period of record 1931–1960]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	48.0	24.7	67	5	1.56	0.5	3.6	3	2
February	53.0	28.2	72	13	1.56	.7	2.0	2	2
March	61.4	35.2	82	20	2.25	.5	4.5	1	2
April	72.3	47.1	87	32	3.55	1.0	6.6	(1)	4
May	79.9	56.3	90	43	5.20	1.9	9.4		
June	88.9	65.7	99	55	4.62	1.5	9.2		
July	94.2	69.3	103	59	3.29	.4	8.7		
August	94.2	68.1	106	57	2.68	.6	6.0		
September	86.8	59.3	99	45	4.21	.3	7.9		
October	76.1	48.1	91	34	3.14	.3	7.1		
November	60.9	34.9	78	19	2.02	.2	5.4	(1)	2
December	51.0	27.8	68	13	1.47	.3	2.9	1	2
Year	72.2	47.1	<sup>2</sup> 104	<sup>3</sup> 0	35.55	26.5	49.2	7	2

<sup>1</sup> Less than 0.5 day.

<sup>2</sup> Average annual highest maximum.

<sup>3</sup> Average annual lowest minimum.

TABLE 9.—Probabilities of last freezing temperatures in spring and first in fall

[All data from Bartlesville, Okla. Period of record 1921–1950]

Probability	Dates for given probability and temperature				
	16°F.	20°F.	24°F.	28°F.	32°F.
Spring:					
1 year in 10 later than.....	March 13.....	March 27.....	April 3.....	April 9.....	April 17.
2 years in 10 later than.....	March 7.....	March 21.....	March 28.....	April 5.....	April 12.
5 years in 10 later than.....	February 23.....	March 11.....	March 17.....	March 27.....	April 2.
Fall:					
1 year in 10 earlier than.....	November 17.....	November 11.....	October 29.....	October 22.....	October 13.
2 years in 10 earlier than.....	November 25.....	November 17.....	November 3.....	October 27.....	October 18.
5 years in 10 earlier than.....	December 9.....	November 28.....	November 16.....	November 4.....	October 28.

Between October and April, an average of 8.9 inches of snow falls. In one winter out of eight, there is more than 15 inches of snow, and in one out of fifteen, more than 20 inches. In only one out of four winters is the total snowfall 3 inches or less. The greatest total for a month was 16.5 inches, in February 1913, and the heaviest fall in a day was 9.6 inches, on December 29, 1954. A record depth of 11 inches has been recorded twice, most recently in December 1954. Even the heavier snowfalls usually melt within 2 to 6 days.

Windspeed averages 12 miles an hour over the year. The average for a month ranges from 13 miles per hour, in March, to 9 miles per hour, in August. Northerly winds prevail in January and February, and southerly winds the rest of the year. The relative humidity averages near 60 percent in the afternoon and 80 percent at night in winter, and near 46 percent in the afternoon and 84 percent at night in summer. Skies are clear during the daylight hours on 126 days of the year. Lake evaporation averages 53 inches a year, and 72 percent of this total takes place between the first of May and the end of October. (Records on wind velocity, relative humidity, sunshine, and evaporation have not been kept at Bartlesville. Interpolations have been made from records kept at nearby stations.)

In the past 91 years, 15 tornadoes have struck in the county. Only eight affected towns, and none resulted in any deaths. The most destructive one was on April 5, 1965.

Hailstorms severe enough to damage roofs, crops, and automobiles occur once in 4 years. Hailstones as much as 3 inches in diameter have been observed.

## Glossary

**Alkali soil.** A soil that has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of total exchangeable bases), or both, that the growth of most crop plants is reduced.

**Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

**Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

**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.

**Claypan.** A compact, slowly permeable soil horizon that contains more clay than the horizons above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

**Complex, soil.** A mapping unit consisting of two or more kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on the soil map.

**Concretions.** Grains, pellets, or nodules, of various sizes, shapes, and colors, consisting of concentrations of compounds or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

**Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

*Loose.*—Noncoherent; will not hold together in a mass.

*Friable.*—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed into a lump.

*Firm.*—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

*Plastic.*—When wet, is 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 to pull free from other material.

*Hard.*—When dry, is moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

*Soft.*—When dry, breaks into powder or individual grains under slight pressure.

*Cemented.*—Hard and brittle; little affected by moistening.

**Cover crop.** A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

**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 such runoff.

**Drainage, natural.** Refers to the conditions that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural drainage are recognized.

*Excessively drained* soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

*Somewhat excessively drained* soils are also very permeable and are free from mottling throughout their profile.

*Well-drained* soils are nearly free from mottling and are commonly of intermediate texture.

*Moderately well drained* soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and C horizons.

*Somewhat poorly drained* soils are wet for significant periods but not all the time, and commonly have mottling below 6 to 16 inches in the lower A horizon and in the B and C horizons.

*Poorly drained* soils are wet for long periods and are light gray and generally mottled from the surface downward, though mottling may be absent or nearly so in some soils.

*Very poorly drained* soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has characteristics produced by soil-forming processes.

**Humus.** The well-decomposed, more or less stable part of the organic matter in mineral soils.

**Infiltration.** The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

**Internal soil drainage.** The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid, and very rapid.*

**Liquid limit (soil engineering).** The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

**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 these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

**Munsell notation.** A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

**Permeability, soil.** The quality of a soil horizon that enables water or air to move through it. Terms used to describe rates of permeability, and their equivalent in inches per hour, are as follows: *Very slow* (less than 0.05), *slow* (0.05 to 0.20), *moderately slow* (0.20 to 0.80), *moderate* (0.80 to 2.50), *moderately rapid* (2.50 to 5.00), *rapid* (5.00 to 10.00), and *very rapid* (over 10.00).

**Phase, soil.** A subdivision of a soil type, series, or other unit in the soil classification system, made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects management.

**Plastic limit (soil engineering).** The moisture content at which a soil changes from a semisolid to a plastic state.

**Plasticity index (soil engineering).** The numerical difference between the liquid limit and the plastic limit; the range in moisture content within which the soil remains plastic.

**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 and alkalinity are expressed thus:

	pH		pH
Extremely acid---	Below 4.5	Neutral-----	6.6 to 7.3
Very strongly acid-----	4.5 to 5.0	Mildly alkaline--	7.4 to 7.8
Strongly acid-----	5.1 to 5.5	Moderately alkaline-----	7.9 to 8.4
Medium acid-----	5.6 to 6.0	Strongly alkaline--	8.5 to 9.0
Slightly acid-----	6.1 to 6.5	Very strongly alkaline-----	9.1 and higher

**Relief.** The elevations or inequalities of the land surface, considered collectively.

**Sand.** As a soil separate, individual rock or mineral fragments ranging from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

**Silt.** As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

**Slope, soil.** The amount of rise or fall in feet for each 100 feet of horizontal distance. It is normally expressed in percent. The slope terms and their numerical equivalents used in this survey are—

	Percent
Level and nearly level-----	0 to 1
Very gently sloping-----	1 to 3
Gently sloping-----	3 to 5
Sloping-----	5 to 8
Strongly sloping-----	8 to 12
Moderately steep-----	12 to 20
Steep-----	20+

**Soil.** A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a 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. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular.* *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together 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, or true soil; the C or R horizon.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace.** An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it either soaks into the soil or flows slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is in permanent sod.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

**Tilth, soil.** The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

**Topsoil.** A presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. The capability units are not discussed separately. For a discussion of the suitability of a given soil for crops and pasture and of the management needed, see the discussion of the mapping unit. For a discussion of windbreak and post-lot groups, see pages 24 and 25. Other information is given in tables as follows:

Acreeage and extent, table 1, page 5. Engineering uses of the soils, tables 3, 4, and Predicted yields, table 2, page 20. 5, pages 26, 30, and 34, respectively.  
Nonfarm uses of the soils, table 6, page 36.

Map symbol	Mapping unit	De-scribed on page	Capability unit	Range site	Page	Windbreak and post-lot group Number
BaC	Bates fine sandy loam, 3 to 5 percent slopes-----	5	IIIe-1	Loamy Prairie	22	1
BcC	Bates-Collinsville complex, 2 to 6 percent slopes-----	5				
	Bates-----	--	IVe-1	Loamy Prairie	22	1
	Collinsville-----	--	IVe-1	Shallow Prairie	22	3
Bp	Borrow pits-----	6	VIIIIs-1	-----	--	3
Bk	Breaks-Alluvial land complex-----	6				
	Breaks-----	--	VIe-1	Loamy Prairie	22	1
	Alluvial land-----	--	VIe-1	Loamy Bottomland	22	1
CtE	Collinsville-Talihina complex, 5 to 20 percent slopes-----	6	VIIs-1	Shallow Prairie	22	3
DaF	Darnell stony sandy loam, 5 to 30 percent slopes--	7	VIIIs-1	Shallow Savannah	23	3
DsC	Darnell-Stephenville fine sandy loams, 2 to 6 percent slopes-----	7				
	Darnell-----	--	IVe-2	Shallow Savannah	23	3
	Stephenville-----	--	IVe-2	Sandy Savannah	23	1
DtB	Dennis silt loam, 1 to 3 percent slopes-----	8	IIe-1	Loamy Prairie	22	1
DtC	Dennis silt loam, 3 to 5 percent slopes-----	8	IIIe-2	Loamy Prairie	22	1
DtC2	Dennis silt loam, 3 to 5 percent slopes, eroded---	8	IIIe-4	Loamy Prairie	22	2
DwA	Dwight-Parsons silt loams, 0 to 1 percent slopes--	9				
	Dwight-----	--	IVs-1	Shallow Claypan	23	3
	Parsons-----	--	IVs-1	Claypan Prairie	22	3
EcC	Eram clay loam, 2 to 5 percent slopes-----	9	IVe-3	Loamy Prairie	22	3
EcD	Eram clay loam, 5 to 15 percent slopes-----	10	VIe-2	Loamy Prairie	22	3
Ma	Mason silt loam-----	10	I-1	Loamy Bottomland	22	1
NeA	Newtonia silt loam, 0 to 1 percent slopes-----	11	I-2	Loamy Prairie	22	1
NeB	Newtonia silt loam, 1 to 3 percent slopes-----	11	IIe-2	Loamy Prairie	22	1
Od	Oil-waste land-----	11	VIIIIs-2	-----	--	3
OkA	Okemah silt loam, 0 to 1 percent slopes-----	12	I-2	Loamy Prairie	22	1
OkB	Okemah silt loam, 1 to 3 percent slopes-----	12	IIe-1	Loamy Prairie	22	1
OkB2	Okemah silt loam, 1 to 3 percent slopes, eroded---	12	IIIe-5	Loamy Prairie	22	2
Os	Osage clay-----	12	IIIw-1	Heavy Bottomland	22	1
PaA	Parsons silt loam, 0 to 1 percent slopes-----	13	IIIs-1	Claypan Prairie	22	3
Ro	Rough stony land-----	14	VIIIs-2	Savannah Breaks	23	3
SoE	Sogn soils, 1 to 20 percent slopes-----	14	VIIIs-3	Very Shallow	23	3
SuB	Summit silty clay loam, 1 to 3 percent slopes----	15	IIe-1	Loamy Prairie	22	1
SuC	Summit silty clay loam, 3 to 5 percent slopes----	15	IIIe-3	Loamy Prairie	22	1
SuC2	Summit silty clay loam, 1 to 5 percent slopes, eroded-----	15	IIIe-5	Loamy Prairie	22	2
Vc	Verdigris clay loam-----	16	IIw-1	Loamy Bottomland	22	1
Vd	Verdigris silt loam-----	16	IIw-1	Loamy Bottomland	22	1
Vs	Verdigris soils, broken-----	17	Vw-1	Loamy Bottomland	22	1

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