Issued August 1968

SOIL SURVEY
Deaf Smith County, Texas

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
in cooperation with
Texas Agricultural Experiment Station

Major fieldwork for this soil survey was done in the period 1956–63. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the Texas Agricultural Experiment Station; it is part of the technical assistance furnished to the Tierra Blanca Soil Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Deaf Smith County, Texas, contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

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

On each sheet of the detailed map, soil areas are outlined and identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

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

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 suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

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

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the subsection "Use of Soils for Wildlife."

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

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

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

Newcomers in Deaf Smith 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 Nature of the County."

Cover picture: Irrigated lettuce on Ulysses clay loam, 0 to 1 percent slopes. City of Hereford is in the background.

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Contents

NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

Issued August 1968

EXPLANATION

Series Year and Series Number

Series year and number were dropped from all soil surveys sent to the printer after December 31, 1965. Many surveys, however, were then at such advanced stage of printing that it was not feasible to remove series year and number. Consequently, the last issues bearing series year and number will be as follows:

Series 1957, No. 23, Las Vegas and Eldorado Valleys Area, Nev.
Series 1958, No. 34, Grand Traverse County, Mich.
Series 1959, No. 42, Judith Basin Area, Mont.
Series 1960, No. 31, Elbert County, Colo. (Eastern Part)
Series 1961, No. 42, Camden County, N.J.
Series 1962, No. 13, Chicot County, Ark.
Series 1963, No. 1, Tippah County, Miss.

Series numbers will be consecutive in each series year, up to and including the numbers shown in the foregoing list. The soil survey for Tippah County, Miss., will be the last to have a series year and series number.

SOIL SURVEY OF DEAF SMITH COUNTY, TEXAS

BY LUTHER C. GEIGER, HERBERT E. BRUNS, AND BILLY R. CHANCE, SOIL CONSERVATION SERVICE[1]

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH TEXAS AGRICULTURAL EXPERIMENT STATION

DEAF SMITH COUNTY is in the western part of the Panhandle of Texas (fig. 1). The county consists of 964,480 acres, or about 1,500 square miles. It is rectangular and about 50 miles long and 30 miles wide. Elevations range from about 4,450 feet on the western edge of the county to about 3,650 feet along Tierra Blanca Creek.

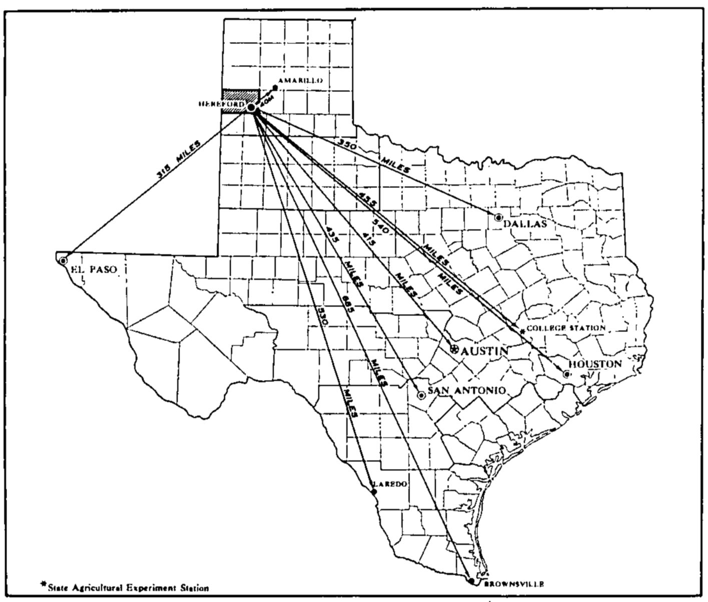

***Figure 1.*—Location of Deaf Smith County in Texas.**

Wheat and grain sorghum are dryfarmed and are also the main irrigated crops. Significant acreages of irrigated vegetables and sugarbeets are grown. Beef production is important. Most of the northwestern part of the county consists of ranches. Several thousand cattle are fattened each year in feedlots, where vegetable byproducts, silage, and locally grown grains are used as feed.

The climate of Deaf Smith County is semiarid. During periods of droughts dryland crops produce little or no harvest. These droughts are followed by years when rainfall is sufficient for favorable yields.

Deaf Smith County is in the southern part of the Great Plains, which extend from Texas into Canada. Most of the county is on a smooth tableland called the High Plains. About 95 percent of it is a nearly level tableland. The rest, about 60,000 acres, is in the Canadian breaks. Geologically, the High Plains formed from Rocky Mountain outwash and an overlying loess mantle. The Canadian breaks formed in material washed from older, low-lying Triassic and Permian red-bed deposits.

The High Plains tableland is nearly level but tilted to the east at an average grade of about 10 feet per mile. Except for a few low rises and many playas, or depressions, the main surface is smooth. Slopes are even, not concave nor convex. Runoff water flows into the playas from the nearly level areas. These playas are dish shaped and range from less than 1 acre to several hundred acres in size. They consist of a central basin in which runoff is held, a higher nearly level bench or terrace, and an outer rim that slopes to the main surface.

In Deaf Smith County the High Plains is dissected by three moderate-sized streams, which have cut down through the upper part of the High Plains deposits. The largest stream is Tierra Blanca Creek. It heads in New Mexico, runs eastward across the southern part of the county, and empties farther on into the drainage system of the Red River. Palo Duro Creek and North Palo Duro Creek head in the northeastern part of the county and, likewise, drain eastward into the Red River system.

In the northwestern part of the county are the Canadian breaks. Here, headwater erosion by the drainage system of the Canadian River has eroded deposits from the High Plains. This erosion has lowered the landscape and exposed, in places, the underlying Triassic red bed. The main plain of the Canadian breaks, however, consists of outwash from the red bed. Since the underlying Triassic red bed slopes to the southeast and, toward the Canadian River, the surface drainage system is to the northwest, an obsequent stream pattern has developed in this area. An obsequent stream is one that flows in a direction opposite that of the consequent drainage. This condition has prevented rapid downcutting into resistant rock. It has formed by the streams and resulted in a gently rolling plain that is interspersed with flats and valley fills.

Several other landforms are in the Canadian breaks. Rough broken land along the escarpment is the most prominent. Below the escarpment is a narrow area of strong foot slopes and steep hills and ridges. Adjoining

[1] Assisting with the fieldwork were LOUIS JACQUOT and DONNIE SMITH, Soil Conservation Service.

these to the west, there are the gently rolling areas in the Canadian breaks that include a few scattered mesas, hills, and interspersed flats and valley fills. On the western side of the Canadian breaks near the New Mexico-Texas line, is a small windblown area consisting of hummocks and dunes.

Deaf Smith County is in a mixed prairie region. The High Plains is almost treeless, though there are a few scattered mesquite and a few groves of cottonwood along the creeks. Scattered juniper, cholla, cactus, and mesquite grow in the Canadian breaks.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Deaf Smith 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 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. Pullman and Ulysses, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Quay clay loam and Quay fine sandy loam are two soil types in the Quay series. The difference in texture of their surface layers is apparent from their names.

Some types vary so much in slope, degree of erosion, depth to gravel, 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, Mansker clay loam, 0 to 1 percent slopes, is one of several phases of Mansker clay loam, a soil type that ranges from nearly level to sloping.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this survey was prepared from the aerial photographs.

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

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Kimbrough-Lea complex. The soil scientist may also show as one mapping unit two or more soils that are mapped as one unit because their differences are not great enough to require that the soils be shown as separate units on the map. Such a mapping unit is called an undifferentiated soil group, of which an example is Spur and Bippus soils. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be classified by soil series. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Rough broken 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 a way that it is 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 surveys. On basis of the yield and practice tables and other data, the soil scientists set up trial groups, and then test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

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

The eight soil associations in Deaf Smith County are described in the following pages.

1. Kimbrough-Lea Association

Gently sloping loamy soils very shallow to moderately deep over indurated caliche

This association is a gently rolling upland plain made up of low convex knolls or ridges and shallow concave vales. This plain has a slightly knobby and pitted surface because it overlies a rock stratum that dips and rises. The two areas of this association are near the southeastern corner of the county. They measure about 8,000 acres, or less than 1 percent of the county.

The Kimbrough and the Lea soils each make up about 45 percent of this association. The rest is mainly Potter and Mansker soils.

The Kimbrough soils are on convex knobs and are very shallow over indurated caliche. The somewhat deeper Lea soils are in vales. These two kinds of soils are intermingled in a complex pattern. Most pure areas of either kind of soil are less than 3 acres in size.

The Kimbrough soils consist of 4 to 12 inches of calcareous loam over indurated caliche. Lea soils have a dark grayish-brown, calcareous loam surface layer and a light-brown, friable clay loam subsoil. They are 12 to 25 inches deep to a layer containing a high proportion of indurated caliche. The caliche underlying both the Kimbrough and Lea soils consists of white to light-gray, limestonelike slabs, plates, and fragments. This layer is difficult to dig through with hand tools, and it cannot be worked with the ordinary farm machines. In some places the caliche is quarried and then crushed to gravel size for local use as base material for roads.

Almost all of this association is range, which is in short grasses. The Lea soils are arable, but most areas are so small that cultivation is not practical.

2. Mansker-Potter-Bippus Association

Sloping to steep clay loams or gravelly loams shallow or very shallow over caliche; and on bottom lands, nearly level, deep, loamy soils

This association consists of bottom lands and sloping areas in strips along the North Palo Duro, Palo Duro, Tierra Blanca, and Frio Creeks. These creeks cut the High Plains as they flow generally eastward. The strips along them range from ½ to 1 mile in width. This association covers about 40,000 acres, or about 4 percent of the county.

The Mansker soils make up about 60 percent of this association. Most of the rest is made up of about equal acreages of Potter and Bippus soils, but there are small areas of Spur, Ulysses, and Mobeetie soils.

The Mansker, Potter, and Bippus soils occur in a moderately uniform pattern. The Potter soils are in a band 200 to 400 feet wide, just below the nearly level High Plains. Below the Potter soils are the Mansker soils, in bands 200 to 800 feet wide. These bands parallel the smooth, generally treeless bottom lands, which are occupied by the Bippus soils.

The Mansker soils are calcareous clay loams shallow to soft or gravelly caliche. Potter soils are gravelly and are very shallow to thick beds of weakly cemented caliche. Bippus soils are deep, dark, noncalcareous clay loams that formed in alluvium and are some of the most fertile soils in the county.

This association is all range except for a few small areas of Bippus and Mansker soils that are dryfarmed. Odd-shaped areas and the hazard of erosion limit cultivation. Although some of the best rangeland in the county is in this association, ranching alone is carried out on only a few farms. On most farm units ranching and farming are mixed because the farms extend into areas of the adjacent Pullman association, which is largely cultivated.

3. Mobeetie Association

Undulating to hummocky, deep, brown to reddish-brown fine sandy loams of the uplands

This association of the undulating to hummocky uplands is in one area in the northern corner of the Canadian breaks near Glenrio. It adjoins the Quay-Montoya-Vernon association (fig. 2). The Mobeetie association covers only about 5,000 acres, or less than 1 percent of the county.

Mobeetie soils make up almost all of the association, and small areas of Springer, Quay, and Zita soils make up the rest.

Mobeetie soils are brown to reddish-brown fine sandy loams that developed in material that was derived from red beds and deposited by the wind. These soils are deep and have a friable, granular subsoil. Because water is taken into the soils readily, there is little runoff.

The soils in this association are used for range on which the plants are mainly sideoats grama, little bluestem, sand bluestem, and other mid and tall grasses. In overgrazed areas these grasses are generally replaced by sagebrush, yucca, weeds, and other invaders.

If management is good, this association is one of the most productive areas in the county for grazing livestock. It is also a favorite grazing area for the herds of antelope that roam the Canadian breaks. The soils are poorly suited to cultivation because the hazard of soil blowing is severe and natural fertility is moderately low.

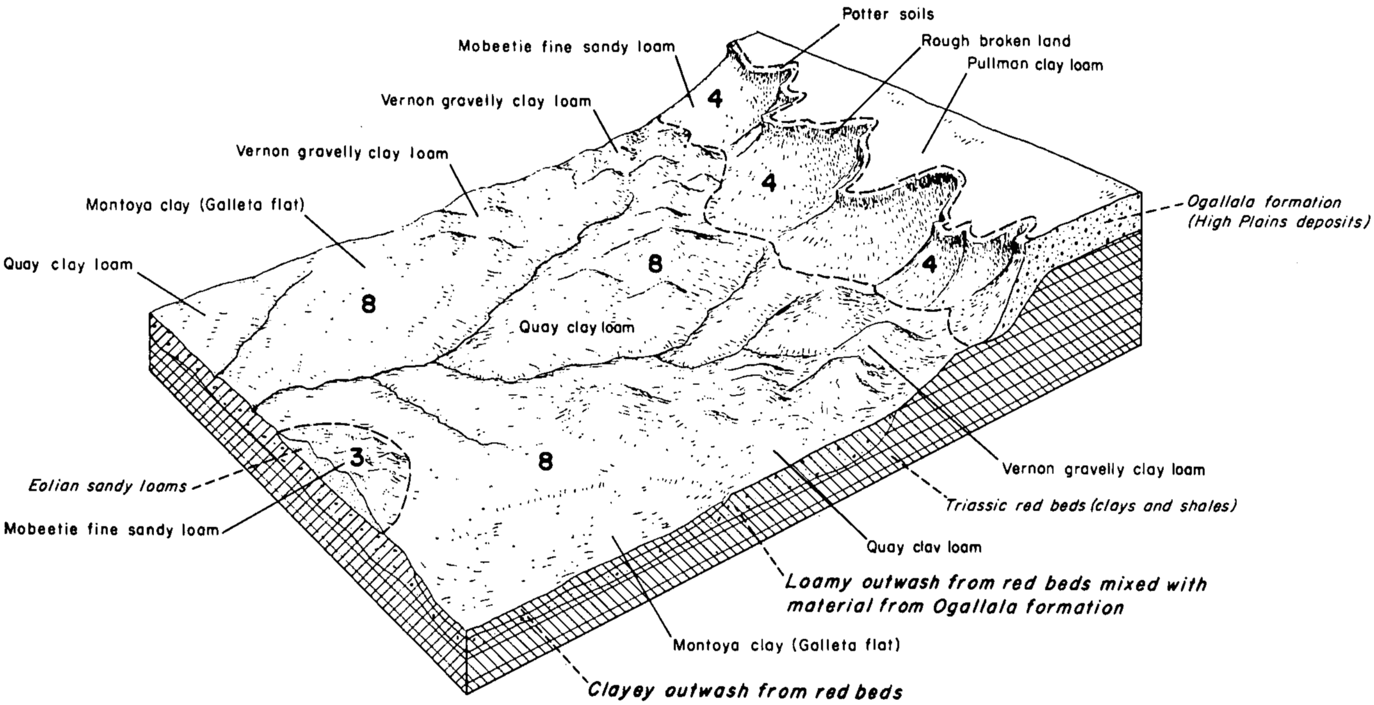

Figure 2.—**Topography and underlying material of the Mobeetie (3); Quay-Montoya-Vernon (8); and Mobeetie-Potter-Rough broken land (4) associations.**

4. Mobeetie-Potter-Rough Broken Land Association

Sloping, deep fine sandy loams; steep loams very shallow over caliche; and Rough broken land

This association is made up of an escarpment and adjoining steep slopes. It extends northeastward across the northwestern corner of the county in a long band about one-half mile wide. The association is one of the most scenic areas of the county. It is between the smoother tableland to the east and the low-lying Canadian breaks to the west (see fig. 2). Elevation differences between the upper and lower parts range from 200 to 400 feet. The association covers about 20,000 acres, or about 2 percent of the county.

Mobeetie soils make up about 45 percent of this association; Rough broken land, 25 percent; Potter soils, 25 percent; and small areas of minor soils, the rest. The minor soils are in the Mansker, Bippus, Vernon, and Quay series.

The deep Mobeetie soils are fine sandy loams. They are on foot slopes between the higher Rough broken land and the lower plains of the Canadian breaks. Rough broken land makes up the escarpment and is the most conspicuous area in the association. This land consists of nearly vertical, buff-colored cliffs and steep, gravelly slopes. The Potter soils are gravelly loams that are very shallow to weakly cemented caliche. They occur in small areas and are intermingled with Rough broken land.

Because the soils in this association are sloping to steep and some have a shallow root zone, they are not suited to cultivation. Grazing is only fair. Forage grows in moderately large quantities on the Mobeetie soils but is in only small quantities on Rough broken land and the Potter soils. A few areas of Rough broken land are barren, and the Potter soils support only a thin cover of mid and short grasses. Grazing is difficult in the sloping to steep areas, but some shelter is provided for deer and other wildlife.

5. Olton-Zita Association

Nearly level or gently sloping, deep, dark-colored loamy soils on smooth upland plains

This association occurs throughout the tableland of the High Plains in scattered areas that range from 2,000 to 8,000 acres in size. These areas are smooth and nearly level in most places, but in a few they are gently sloping. In most places they are adjoined, surrounded, or almost surrounded by the broad expanses of the Pullman association. The Olton-Zita association amounts to about 25,000 acres, or nearly 3 percent of the county.

Olton soils make up about 75 percent of the association; Zita soils, 20 percent; and small areas of minor soils the remaining 5 percent. The minor soils are in the Mansker, Pullman, and Ulysses series.

The Olton soils surround the Zita soils. The Zita soils are generally on low, gentle, convex rises. The Olton soils have a dark-brown, friable clay loam surface layer and a blocky clay loam subsoil that is moderately slow in permeability. The Zita soils have a brown, friable clay loam surface layer and a moderately permeable, friable clay loam subsoil. Both Zita and Olton soils are 3 to 6 feet deep to pinkish-white caliche.

This association is mostly dryfarmed or used for range. The soils provide some of the most productive cropland in the county. Grain sorghum and wheat are grown in a few irrigated areas. The hazard of soil blowing is slight to moderate, but erosion can be controlled by leaving moderate amounts of stalks and straw on the surface.

6. Ulysses-Pullman Association

Nearly level to gently sloping loamy soils moderately deep or deep over soft caliche, on smooth upland plains

This association is mostly on the nearly level parts of the High Plains, but a few areas are on gentle side slopes of draws at the upper reaches of Palo Duro and Tierra Blanca Creeks. This association covers about 226,000 acres, or 24 percent of the county.

Ulysses soils make up about 70 percent of the association; Pullman soils, 20 percent; and minor soils, the remaining 10 percent. The minor soils are in the Mansker, Randall, Church, and Olton series.

The dark-colored Pullman soils generally occur as irregularly shaped areas within larger areas of the limy, lighter colored Ulysses soils. These soils are intermingled in a complex pattern.

Ulysses soils have a dark-brown clay loam surface layer and a granular, friable clay loam subsoil that is moderately permeable. They are calcareous throughout. A layer of soft caliche underlies these soils at a depth between 20 and 30 inches. Pullman soils are deep. They have a dark grayish-brown, friable clay loam surface layer. The subsoil is clayey and dense, has blocky structure, and takes in water slowly.

Most of this soil association is cultivated. The dry-farmed acreage about equals the irrigated acreage. Wheat and grain sorghum are the chief crops, though smaller amounts of vegetables, silage, and forage sorghum are grown. Tracts of range about 50 to 1,500 acres in size make up the rest of this association. Most farms have dryland, irrigated land, and some rangeland.

7. Pullman Association

Nearly level to gently sloping, deep, dark grayish-brown loamy soils on smooth upland plains

This association covers most of the tableland of the High Plains; its smooth, nearly level expanses extend across the county. Prominent features are lacking, except for a few low rises and many round, dish-shaped depressions. These depressions, which are generally Randall clay at the bottom, catch most of the water running off the Pullman soils (fig. 3), and the rest runs into the drainageways and creeks that cut the plain. This association amounts to about 610,000 acres, or 63 percent of the county.

Pullman soils cover about 90 percent of the association, and the rest consists of small areas of Randall, Church, Ulysses, Mansker, Olton, and Zita soils. The soils in this association are locally called hardlands or wheatlands.

The Pullman soils have a clay loam surface layer and a dense, blocky, compact, clayey subsoil that is slowly permeable. These soils are 3 to 6 feet deep to pinkish-white, soft caliche. They are somewhat droughty but are moderately high in natural fertility. Although the surface layer takes in much water from summer showers, this water quickly evaporates. These soils are completely wetted only after extended rains or heavy irrigations.

This is the most important soil association in Deaf Smith County. It is extensive and contains most of the dryfarmed and irrigated cropland in the county. The principal crops are grain sorghum, wheat, alfalfa, vegetables, and sugarbeets. The soils are well suited to surface irrigation because they are smooth and nearly level.

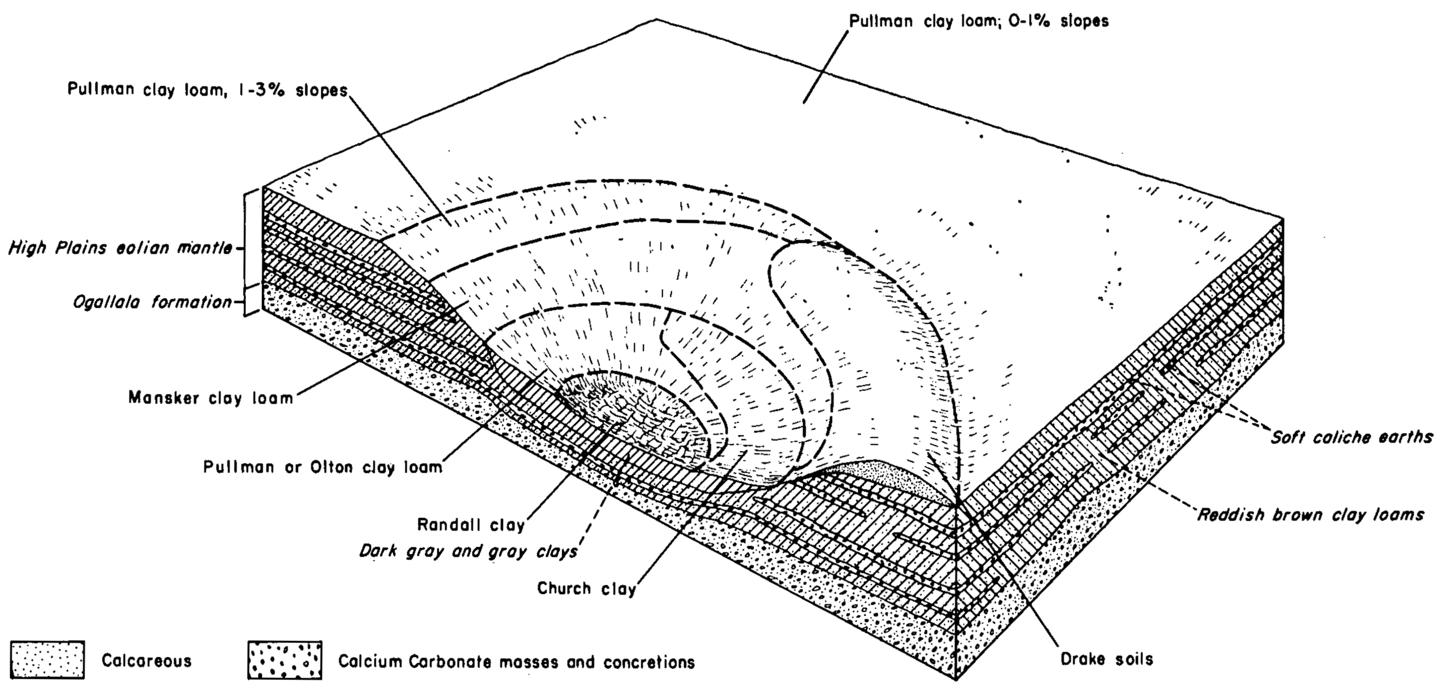

***Figure 3.*—Patterns of soils around a playa on the High Plains.**

Little or no land leveling is needed. A typical farm is between 1,000 and 2,000 acres, about 80 percent of which is Pullman clay loams. Most of these areas are under cultivation. The rest consists of playa basins and their adjoining sloping areas. The sloping areas are used for grazing, but the basins are generally fenced off.

8. Quay-Montoya-Vernon Association

Nearly level and gently rolling to hilly, calcareous, reddish-brown clay loams, clays, and gravelly clay loams

Most of this association is a broad belt that extends through the Canadian breaks in the northwestern part of the county. A narrow belt surrounds Garcia Lake, northeast of Bootleg. In the Canadian breaks, the topography ranges from steep rolling hills and ridges near the escarpment to gently and moderately rolling plains and alluvial flats to the west. The total area of this association is about 30,000 acres, or nearly 3 percent of the county.

About 50 percent of this association consists of Quay soils. Most of the rest is in about equal acreages of Vernon and Montoya soils. In addition, there are small areas of Zita, Mobeetie, and Potter soils.

The Quay soils have a clay loam surface layer and subsoil. These soils are limy throughout. They support good stands of short grasses. The Montoya soils are tight and clayey. They support a dense cover consisting mostly of galleta and are locally called Galleta flats. The Vernon soils have a gravelly surface layer and are very shallow to shaly clay. They support a sparse cover consisting mostly of mid and short grasses and some woody plants.

All of this association is in range, most of which is in four large ranches that cover much of the Canadian breaks. Because nutritious forage is abundant and the range is open, this association is a favorite habitat of antelope. Cultivation is limited by a lack of irrigation water and moderately low natural fertility.

Descriptions of the Soils

This section describes the soil series, groups of similar soils, and the single soils, or mapping units, of Deaf Smith County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure in this section is first to describe the soil series and then the mapping units in the series. Thus to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How This Survey Was Made," not all mapping units are of a soil series. For example, Rough broken land is a miscellaneous land type and does not belong to a soil series; nevertheless, this land is listed in alphabetic order along with the series.

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

Soil scientists, engineers, students, and others who want detailed descriptions of the soil series should turn to the section "Genesis, Classification, and Morphology of Soils." Many terms used in the soil descriptions and other sections are defined in the Glossary and in the "Soil Survey Manual" (*6*).[2]

Bippus Series

The Bippus series consists of deep, dark-colored, loamy soils that occupy gently sloping to nearly level valley fills and alluvial fans along the main creeks and draws in the High Plains. These soils developed in loamy sediments that washed from areas of higher lying Pullman, Ulysses, and Mansker soils.

The surface layer extends to an average depth of 18 inches and consists of dark-grayish brown clay loam. It has a coarse prismatic structure that breaks to fine subangular blocky and granular. Roots are abundant, and worm casts are common. This layer is friable, mellow, and easy to work.

The subsoil is a grayish-brown to dark grayish-brown, friable clay loam that extends to an average depth of about 30 inches. This layer is generally lighter colored and more limy than the surface layer and contains slightly more clay. It has subangular blocky and granular structure. Roots and worm casts are common. A few rounded pebbles of caliche generally are scattered throughout this layer.

The substratum consists of limy clay loam, silty clay loam, or silty clay alluvial sediments that are light brownish gray, light brown, or brown. Old root channels and pores are common in this alluvium, and roots are common in the upper part.

The Bippus soils have moderately high natural fertility. They developed under a dense cover of native grasses that received extra runoff from the adjoining, more sloping soils. Humus from decaying roots and leaves is present in moderately high amounts. Water is absorbed readily and moves easily through the subsoil. These soils are easy to work and manage, but bare areas are susceptible to soil blowing during dry, windy periods.

Most areas of these soils are rangeland on which stands of short grasses are dense. Wheat and grain sorghum are well suited.

Bippus clay loam (Br) is a dark-colored, loamy soil that is deep, friable, and high in natural fertility. It is along Tierra Blanca and Palo Duro Creeks in valley fills and on high bottom lands that are seldom flooded. Typically, this soil parallels the stream channel in long strips about 700 feet wide. In most places it lies between Mansker clay loam, 3 to 5 percent slopes, on the higher lying slopes of the drainageways, and Spur and Bippus soils, along the stream channel.

Included with this soil in mapping were areas that have a silty clay loam or loam surface layer. Also included were narrow areas of Spur, Bippus, and Mansker soils.

[2] Italic numbers in parentheses refer to Literature Cited, p. 61.

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

Soil	Cropland		Range	Total area	Total extent
	Dryland	Irrigated			
	Acres	*Acres*	*Acres*	*Acres*	*Percent*
Bippus clay loam	20	(2)	2, 040	2, 060	0. 2
Church clay	40	420	5, 135	5, 595	. 6
Drake soils, 3 to 5 percent slopes	125	140	1, 065	1, 330	. 1
Drake soils, 5 to 8 percent slopes	10	20	955	985	. 1
Kimbrough-Lea complex	35	45	7, 440	7, 520	. 8
Lincoln soils	(2)	(2)	1, 045	1, 045	. 1
Mansker clay loam, 0 to 1 percent slopes	35	115	890	1, 040	. 1
Mansker clay loam, 1 to 3 percent slopes	310	30	2, 970	3, 310	. 3
Mansker clay loam, 3 to 5 percent slopes	1, 400	760	25, 110	27, 270	2. 9
Mansker clay loam, 5 to 8 percent slopes	975	10	6, 645	7, 630	. 8
Mansker-Potter complex, 2 to 8 percent slopes	(2)	(2)	1, 990	1, 990	. 2
Mobeetie fine sandy loam, 3 to 5 percent slopes	15	(2)	6, 395	6, 410	. 7
Mobeetie fine sandy loam, 5 to 8 percent slopes	(2)	(2)	4, 285	4, 285	. 4
Montoya clay	(2)	(2)	3, 700	3, 700	. 4
Olton clay loam, 0 to 1 percent slopes	7, 000	3, 900	19, 625	30, 525	3. 2
Olton clay loam, 1 to 3 percent slopes	2, 500	995	8, 445	11, 940	1. 2
Potter soils	(2)	(2)	9, 870	9, 870	1. 0
Pullman clay loam, 0 to 1 percent slopes	214, 355	207, 200	113, 265	534, 820	55. 4
Pullman clay loam, 1 to 3 percent slopes	18, 250	15, 800	21, 000	55, 050	5. 7
Pullman clay loam, 1 to 3 percent slopes, eroded	580	30	125	735	. 1
Pullman-Ulysses complex, 0 to 1 percent slopes	1, 450	2, 800	14, 485	18, 735	2. 0
Pullman-Ulysses complex, 1 to 3 percent slopes	1, 560	855	2, 540	4, 955	. 5
Quay clay loam, 0 to 1 percent slopes	(2)	(2)	2, 330	2, 330	. 2
Quay clay loam, 1 to 3 percent slopes	(2)	(2)	6, 310	6, 310	. 7
Quay clay loam, 3 to 5 percent slopes	(2)	(2)	1, 925	1, 925	. 2
Quay fine sandy loam, 1 to 5 percent slopes	(2)	(2)	2, 905	2, 905	. 3
Randall clay	475	125	13, 895	14, 495	1. 5
Rough broken land	(2)	(2)	5, 400	5, 400	. 6
Springer fine sandy loam, 1 to 3 percent slopes	(2)	(2)	2, 390	2, 390	. 2
Spur and Bippus soils	105	65	9, 440	9, 610	1. 0
Ulysses clay loam, 0 to 1 percent slopes	25, 000	19, 500	27, 695	72, 195	7. 5
Ulysses clay loam, 1 to 3 percent slopes	25, 120	14, 700	55, 610	95, 430	9. 9
Vernon-Quay complex	(2)	(2)	5, 635	5, 635	. 6
Zita clay loam, 0 to 1 percent slopes	760	20	940	1, 720	. 2
Zita clay loam, 1 to 3 percent slopes	400	65	2, 870	3, 335	. 3
Total	300, 520	267, 595	396, 365	964, 480	100. 0

[1] Land use acreages were recorded by the survey party as the fieldwork was being done (1956–63), and the above figures are totals from these records.

[2] No acreage given.

The surface layer of Bippus clay loam is dark grayish brown to very dark grayish brown. It is about 18 inches thick and has fine subangular blocky and granular structure. In some places the substratum below a depth of 30 inches consists of water-laid sand or gravel.

This soil is high in natural fertility. It is friable, mellow, and easy to till. Runoff is slow to medium.

Because areas of this soil are narrow, only small patches are farmed, though natural fertility is ample enough for dryfarming. Irrigation is also practical. The main concern of management is in diverting runoff from the higher lying slopes. Well-suited crops are wheat and grain sorghum. (Capability unit IIIe–2, dryland, and IIe–1, irrigated; Deep Hardland range site)

Church Series

The Church series consists of dark-colored, calcareous, clayey soils that are moderately well drained and have compact layers. These soils are moderately extensive in the county.

The surface layer is dark-gray, calcareous clay, generally about 15 inches thick, but it ranges from 10 to 20 inches in thickness. The structure in areas of native grass is fine subangular blocky; aggregates are slightly rounded and blocklike. If these soils are tilled, however, large extremely hard clods are likely to form. Where cultivation continues, the clods break into fine, powdery granules that blow away readily. During dry periods the surface layer cracks in many places, and most cracks extend below the surface layer.

Underlying the surface layer is gray, extremely hard clay that extends to a depth of 2 to 5 feet. It breaks into coarse blocks. This layer generally contains a few concretions of whitish lime that are the size of sand. It is very slowly penetrated by water and air when it is dry. Large cracks extend into this layer when it is dry, and they are rapidly filled with water when the soil is again wetted. These cracks quickly seal before the bulk of the soil mass is wet. After the sealing, water moves very slowly through this layer.

The substratum is also gray clay that contains a few lime concretions. It is calcareous. Only a few roots penetrate into this layer.

The Church soils are moderately high in natural fertility. They formed under a dense cover of mid and short grasses. They have high capacity for storing water and plant nutrients. Because these soils are clayey, they slowly give up water to plants and are droughty under dryfarming. They are susceptible to soil blowing where the surface is bare, but this blowing can be controlled by leaving moderate amounts of stalks or straw on the surface.

Church soils are used for dryfarming, irrigated farming, and range. Wheat, cotton, and grain sorghum are moderately well suited to irrigated areas.

Church clay (Ch) is a dark, limy soil on broad, level benches of the playa basins in the High Plains. Most areas of this soil are crescent shaped and partly encircle areas of Randall clay on the playa bottoms. A few areas occupy all of the playa bench and completely enclose the playa. The adjoining soils are Randall clay, Pullman clay loam, Olton clay loam, Drake soils, and Mansker clay loam. Areas of Church clay range from about 20 to 200 acres in size. Slopes are generally concave or plane and range from 0 to 1 percent, but in a few narrow strips, on the fringes of the playas, slopes are as much as 2 percent.

Included with this soil in mapping were small areas of Ulysses clay loam and of Olton clay loam.

Church clay is moderately productive. It is moderately easy to work throughout a wide range of moisture content, but it tends to be very sticky when moisture is near field capacity. If the soil is plowed when dry, extremely hard clods may form.

Under both dryland and irrigated farming, this soil is well suited to wheat and grain sorghum. It is also well suited to irrigated alfalfa and cotton. (Capability unit IVes–1, dryland, and IIIes–1, irrigated; High Lime range site)

Drake Series

The Drake series consists of light-colored, grayish, loamy soils that are high in lime. These soils are on the eastern slopes of the larger playa basins in the High Plains.

The surface layer typically is grayish-brown, moderately alkaline clay loam about 9 inches thick, but it is only 7 inches thick in places and ranges to loam or fine sandy loam. Structure is granular, but in cultivated fields the soil material is powdery, loose, and susceptible to severe soil blowing.

The subsoil is a light-gray loam to clay loam that extends to an average depth of 15 inches. This layer, when dry, breaks into prisms 6 to 10 inches across, and the prisms break into fine granules. In this layer worm casts are abundant, and threads or veins of whitish lime are numerous.

The substratum is light-gray silty clay loam. Roots are common in the upper part, but they decrease rapidly with increasing depth.

The water from rain readily soaks into the surface of Drake soils. Permeability and moisture-supplying capacity are moderate, but natural fertility is moderately low. Because the content of lime is high, some nutrients are not available to plants. This lack of nutrients causes chlorosis, as is indicated by the yellowing of the leaves of grain sorghum.

Most areas of these soils are range, but grain sorghum is grown in a few irrigated fields. The less sloping areas are moderately well suited to irrigated grain sorghum, cotton, and alfalfa.

Drake soils, 3 to 5 percent slopes (DrC) are grayish-brown, limy clay loams. They are widely distributed through the High Plains, but their total acreage in the county is small. Areas average about 40 acres in size. These soils occur on the eastern slopes of the larger playa basins. Typically, Drake soils are adjoined by the Pullman and Ulysses soils on the upper slopes and, at their lower edges, by the Church, Pullman, and Olton soils on the playa benches.

Included in the mapping were small spots of Mansker loam and of Ulysses clay loam.

Drake soils are moderately low in natural fertility. The high content of lime tends to make much of the iron, phosphorus, and other essential elements unavailable to plants. These soils are highly susceptible to soil blowing and to water erosion.

Most areas of these soils are range, but a few small areas are irrigated. Well-suited dryland crops are grain and forage sorghums. In irrigated areas alfalfa and cotton grow well. (Capability unit VIe–3, dryland, and IVe–4, irrigated; High Lime range site)

Drake soils, 5 to 8 percent slopes (DrD) are light brownish-gray, limy clay loams that are scattered in small areas throughout the High Plains. These soils are on the eastern slopes of the larger playa basins. They are adjoined, at their upper edges, by Pullman and Ulysses soils and, at their lower edges, by Church and Pullman soils on the playa benches. Areas of Drake soils range from 20 to about 100 acres in size. The surface layer is 7 to 8 inches thick. It is clay loam in most places but ranges to loam or fine sandy loam.

Included in mapping were small areas of Mansker clay loam. All of the acreage is range. The hazard of soil blowing is high because these soils contain much lime. A good cover is needed at all times because overgrazing makes the surface layer powdery and loose. Runoff flowing from old cattle trails has gouged out small gullies in a few areas. (Capability unit VIe–3 dryland; High Lime range site)

Kimbrough Series

In the Kimbrough series are dark, grayish-brown, loamy soils that are very shallow over indurated caliche. These soils are on the High Plains.

The surface layer is calcareous, dark grayish-brown, grayish-brown, or dark-brown loam. It is generally about 9 inches thick, but it ranges from 4 to 12 inches in thickness. Structure is subangular blocky and granular. Angular fragments, chips, and pebbles of hard caliche are common throughout this layer.

The substratum directly underlies the surface layer and consists of indurated, overlapping plates and fragments of caliche that are a few inches to several feet across. The plates are so hard that they cannot be dug through with a hand shovel, but most of them can be pried loose and removed with a crowbar. In the upper 1 to 1½ feet of this horizon, brownish limy material is among the plates and fragments. Some roots grow in this material. This layer of indurated caliche plates is 5 to 15 feet thick, and it grades into soft caliche.

All of the acreage of Kimbrough soils is range consisting of sparse stands of short grasses and only traces of mid grasses. Mainly because these soils are very shallow, they are droughty, low in fertility, and not suitable for cultivation.

Kimbrough-Lea complex (Kl) consists of moderately deep, loamy soils that are very shallow to rocklike caliche. The largest areas are in the southeastern part of the county near Dawn, but a few small areas are scattered throughout the High Plains. The landscape, on which there are some mounds, is gently rolling.

Included in mapping were small spots of rock outcrops, mostly within areas of Kimbrough soils, and on the outer edges of the complex, a few areas of Ulysses clay loam.

Kimbrough and Lea soils are intermingled in such a complex pattern that they cannot be shown separately on the soil map. The Kimbrough soils are in the convex areas, and the Lea soils are on the concave to even lower slopes. An average area of this complex is about 50 percent Kimbrough loam and about 50 percent Lea loam. A pure area of either soil more than 3 acres in size occurs in only a few places.

The Kimbrough soils consist of about 9 inches of dark-colored, calcareous, friable loam on indurated caliche. The Lea soils are also dark colored and loamy, but depth to indurated caliche averages about 20 inches.

This complex is mostly rangeland, but a few small areas are cultivated. Stands of blue grama, buffalograss, and other short grasses are on each kind of soil, but the stands are dense on the Lea soils and are thin on the Kimbrough soils. The hard caliche underlying the soils limits the use of farm machinery. The thicker deposits are crushed and used locally for building roads. (Capability unit VIIs–1, dryland; Very Shallow range site).

Lea Series

The Lea series consists of dark grayish-brown, loamy soils that are shallow to moderately deep over indurated caliche. These soils are on the High Plains.

The surface layer is calcareous, dark grayish-brown, friable, and mellow loam about 13 inches thick. When this layer is dry, its structure breaks into a mixture consisting of slightly hard, fine blocks that have partly rounded edges and very fine, soft granules and crumbs.

The subsoil is brown, moderately limy clay loam about 7 inches thick. Its structure is similar to that of the surface layer. Worm casts and pores are common. In most places the subsoil contains a few hard fragments and pebbles of lime. The lower boundary is wavy or broken. It is underlain by indurated caliche.

The substratum ranges from 5 to 15 feet in thickness. It consists of white, overlapping plates or indurated caliche and smaller fragments. The plates range from 2 to 10 inches in thickness and from a few inches to several feet across. They cannot be dug through with a shovel, but with some difficulty they can be pried loose with a crowbar. Light-brown or grayish-brown, limy material is among the rocks and fragments in the upper 1 to 1½ feet of this layer. Some roots grow in this material. In the lower part, soft caliche material is between the plates. The substratum grades into soft caliche.

All of the acreage of the Lea soils is range that has a good cover of short grasses. Although moderately fertile, these soils have a limited capacity for storing water and plant nutrients. Also, the rock outcrops make tillage difficult.

In this county Lea soils are mapped only in a complex with Kimbrough soils.

Lincoln Series

In the Lincoln series are deep, brown, sandy soils that occur along the flood plains of some of the larger creeks in the Canadian breaks. These soils have a loose substratum.

The surface layer is generally brown loamy fine sand about 10 inches thick, but it ranges from 8 to 15 inches in thickness. It is calcareous and has weak granular structure or is single grained. When dry, the material in this layer is barely coherent.

The substratum directly underlies the surface layer. It is light-brown loamy fine sand to a depth of 60 inches or more.

All of the acreage is range on which the dominant plants are sand sagebrush, dropseed, and sand bluestem. These soils are severely susceptible to soil blowing and are not suitable for cultivation.

Lincoln soils (Ln) consist of deep, loose, light-colored loamy fine sands that occur on the sandy bottom lands in the Canadian breaks. These nearly level soils have been cut by a winding, ditchlike stream channel that is 3 to 10 feet deep and 10 to 40 feet wide. The channel carries all the runoff from ordinary rains, but it overflows when rains are of high intensity. Most areas are flooded at least once every 1 to 3 years. Some areas have been reworked by the wind and are seldom flooded. They are undulating or have mounds on their surface.

Lincoln soils are low in natural fertility and have low water-holding capacity. They are subject to severe soil blowing.

All of the acreage is range. Most areas are overgrazed, but these soils support switchgrass, indiangrass, sand bluestem, and other tall grasses if grazing is properly regulated. (Capability unit Vw–2, dryland; Sandy Bottom Land range site)

Mansker Series

In the Mansker series are dark-colored, limy, loamy soils that are shallow over soft or gravelly caliche.

The surface layer is dark grayish-brown to grayish-brown or light-brown, granular clay loam. It is generally about 10 inches thick, but thickness ranges from 4 to 12 inches. This layer contains a moderate amount of free lime in the form of white veins and threads. In most places a few hard pebbles of lime are in the surface layer. This layer is easily worked throughout a wide range of moisture content.

The subsoil, about 8 inches thick, is a light-brown, friable clay loam that is limy and porous and contains many worm casts. It is slightly more limy than the surface layer.

A layer of lime accumulation extends from a depth of nearly 18 inches to about 36 inches. The lime is in the form of soft pink caliche. This layer is a mixture of about equal amounts of brown to light-brown clay loam and of white soft lime in masses. Roots grow in the top few inches of this layer, but below that the available supply of water and of plant nutrients is limited. This layer ranges from a few inches to about 3 feet in thickness and is underlain by layers consisting of reddish-brown to reddish-yellow limy material that has clay loam texture.

Water enters the Mansker soils readily and moves easily through them. The content of organic matter is fairly high in undisturbed areas, but in most cultivated areas productivity has been reduced because of intensive cropping and subsequent erosion. Also, the content of lime increases susceptibility to soil blowing because the surface layer in cultivated areas is powdery and loose. The lime also causes chlorosis, or a yellowing of the leaves, in grain sorghum.

The less sloping Mansker soils are fairly well suited to wheat and grain sorghum. A few areas are irrigated.

Mansker clay loam, 0 to 1 percent slopes (MkA) is in irregularly shaped spots and patches that generally adjoin large areas of Ulysses soils. A few areas are near the Pullman, Zita, and Olton soils. This soil is scattered throughout all the High Plains in this county, but its total acreage is small.

Included with this soil in mapping were small areas of Ulysses clay loam.

The surface layer of this Mansker soil is about 10 inches thick. In some areas the uppermost 1 to 3 inches has been lost through soil blowing. Pebbles of caliche are generally scattered on the surface. Average depth to the layer of caliche is about 18 inches.

Most of this soil is range that supports stands of blue grama and sideoats grama. Grain and forage sorghums are suitable for dryfarming, and alfalfa is suitable for irrigated farming. Productivity is moderately low, and this soil blows readily if the surface is bare. (Capability unit IVe–9, dryland, and IIIe–10, irrigated; Hardland Slopes range site)

Mansker clay loam, 1 to 3 percent slopes (MkB) is in areas around playas and along draws of the High Plains. Typically, on its upper slopes this soil merges with nearly level Pullman or Ulysses soils, and on its lower slopes it merges with the more sloping Mansker soils. Areas of this soil range from 5 to about 50 acres in size.

Included with this soil in mapping were small areas of Ulysses clay loam and a few spots of Potter gravelly loam.

In undisturbed areas the surface layer is 6 to 8 inches thick, but in slightly eroded cultivated fields, this layer is 4 to 6 inches thick. Depth to caliche ranges from 12 to 20 inches.

Most areas of this soil are range that supports stands of blue grama and sideoats grama. The soil blows easily in cultivated areas, but a good litter of crop residue on the surface helps to control this blowing. Alfalfa grows well in irrigated areas. (Capability unit IVe–9, dryland, and IIIe–10, irrigated; Hardland Slopes range site)

Mansker clay loam, 3 to 5 percent slopes (MkC) is in areas around playas and along streams. Typically, these areas are long and narrow and average about 50 acres in size. Included with this soil in mapping were a few areas of Potter soils. This soil is slightly more red and contains more clay in the subsoil than the one described as typical of the Mansker series. In a few places, mainly along cattle trails, shallow gullies occur.

Most of this soil is range, but a few areas are cultivated with the adjoining, more fertile soils so that the shape of irregular fields is improved to make the fields better for mechanized farming. This soil should be cultivated only under the most careful management. Water erosion and soil blowing are severe hazards. Dryfarmed forage and grain sorghums are well suited. If irrigated, alfalfa also is well suited. (Capability unit IVe–2, dryland, and IVe–6, irrigated; Hardland Slopes range site)

Mansker clay loam, 5 to 8 percent slopes (MkD) is mostly along Palo Duro and Tierra Blanca Creeks, but a few narrow areas are around playas. This soil occurs mainly with Potter and Mobeetie soils. It is moderately extensive. Areas range from 15 to about 500 acres in size.

Included with this soil in mapping were Potter soils on small knolls. Also included were small areas in which the material underlying the surface layer has a reddish color.

The surface layer of this Mansker soil generally ranges from 6 to 8 inches in thickness. Caliche pebbles are common on the surface. Underlying the surface layer is material that contains slightly more clay than that of the soil described as typical of the series.

This soil is not suited to cultivation, because it is subject to water erosion and soil blowing. It supports a good stand of mid and short grasses, but gullying is likely in overgrazed areas. (Capability unit VIe–1, dryland; Hardland Slopes range site)

Mansker-Potter complex, 2 to 8 percent slopes (MpD) occurs in the Canadian breaks in small areas of range. The landscape consists of a series of sloping, smooth hills and ridges separated by foot slopes and shallow vales. On the crests of the hills and ridges are the very shallow and gravelly Potter soils. The moderately deep and loamy Mansker soils lie on the lower slopes. An average area is about 70 percent Mansker clay loam and 30 percent Potter gravelly loam. Typically, these soils are surrounded by large areas of Quay clay loam, which is on lower lying, less sloping ridges and divides. Other areas of these soils occur along streams.

Included in mapping were small areas of Vernon gravelly clay loam and Quay clay loam.

The Mansker soils are somewhat finer textured and slightly redder than the soils described as typical of the series. The Potter soils are similar to the soil described for the Potter series, but the surface layer contains pebbles of caliche.

On both the Mansker and Potter soils are stands of short grasses and traces of mid grasses, but the stands are dense on the Mansker soils and are sparse on the Potter. Heavily grazed areas, especially where slopes are steep, are susceptible to water erosion and gullying. (Capability unit VIe–1, dryland; Mansker soil is in Hardland Slopes range site; Potter soil is in Very Shallow range site)

Mobeetie Series

The Mobeetie series consists of deep, brown to reddish-brown, calcareous fine sandy loams. These soils are along Tierra Blanca Creek and below the escarpment in the Canadian breaks. Slopes range from 3 to 8 percent. In most places these soils developed in limy sandy loam deposits that weathered from materials of the High Plains, but a small area near Glenrio formed in wind-blown material that was derived from Triassic or Permian red beds.

The surface layer is generally brown or grayish-brown, friable, granular fine sandy loam that contains moderate amounts of free lime. It ranges from 6 to 12 inches in thickness.

The subsoil is a fine sandy loam about 10 inches thick. It is granular, friable, and contains many worm casts. Also in this layer are many veins and threads of lime and generally a few scattered lime pebbles. The layer is easily penetrated by roots.

The substratum begins at a depth of 20 to 30 inches (fig. 4). It consists of friable, light-brown, limy loam or fine sandy loam that has weathered little and is dry during most of the year. Roots deeply penetrate the substratum when it is moist. A few worm casts are generally present in the upper part.

Water readily enters the Mobeetie soils and easily moves through the surface layer and subsoil. Roots also readily penetrate these soils. But a large part of the rainfall is lost in runoff, and most of the time these soils are dry below a depth of 3 feet.

These soils make up some of the best rangeland in the county, and most areas are range. Under good management, these soils support dense stands consisting of blue grama, some sideoats grama, and scattered yucca. A few patches are in grain sorghum. Overgrazed or cultivated areas are susceptible to soil blowing and water erosion.

Mobeetie fine sandy loam, 3 to 5 percent slopes (MrC) is mostly on foot slopes below areas of Potter soils and Rough broken land. A few undulating to hummocky areas are in the Canadian breaks. A typical area is ½ to 1 mile long and 400 to 1,000 feet wide. It follows the contour of the stream or escarpment that it adjoins. The areas range from 15 to about 500 acres in size.

Included with this soil in mapping were small areas of Mansker clay loam, Bippus clay loam, and Quay fine sandy loam. In a few areas, the surface layer is reddish brown.

The surface layer of Mobeetie fine sandy loam, 3 to 5 percent slopes, is 8 to 12 inches thick. It is generally brown, but it ranges from brown to grayish brown or dark brown. Areas with the darker colored surface layer are generally on the lower slopes. In most places the subsoil is generally fine sandy loam, but it ranges to loam.

All of this soil is range, which supports moderately high yields of forage. The range is some of the best in the county. Although this soil can be cultivated, careful management is needed to control soil blowing and water erosion. In dryfarmed fields grain and forage sorghums are well suited. (Capability unit IVe–5, dryland, and IVe–2, irrigated; Mixed Land Slopes range site)

Mobeetie fine sandy loam, 5 to 8 percent slopes (MrD) is on side slopes along the drainageways in the High Plains and on foot slopes below escarpments in the Canadian breaks. This soil is near Potter soils, Rough broken land, and Mansker clay loam, 3 to 5 percent slopes. The areas range from 15 to 150 acres in size.

***Figure 4.*—Profile of a Mobeetie soil. Caliche pebbles in a horizontal line about 22 inches below the surface are at the top of the substratum. Other caliche pebbles are scattered throughout the profile.**

Included with this soil in mapping were small areas of Mansker clay loam and of Potter soils.

The surface layer of this soil ranges from 6 to 12 inches in thickness and is generally grayish brown, brown, or dark brown. On the lower slopes the surface layer is thicker and darker colored than it is on the upper slopes.

This soil produces moderately high yields of forage, mainly of sideoats grama and blue grama. Because this soil is susceptible to soil blowing and water erosion, a good cover of grass should be maintained. (Capability unit VIe–2, dryland; Mixed Land Slopes range site)

Montoya Series

The Montoya series consists of reddish-brown, deep, clayey soils that occupy flats or slight depressions in the Canadian breaks (fig. 5). These areas are locally called Galleta flats.

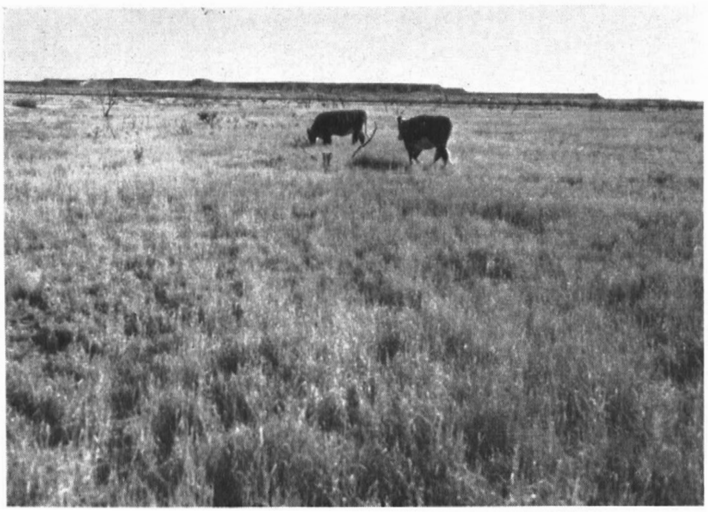

Figure 5.—**The soil is Montoya clay. Clay Flats range site in the northwestern part of the county has vegetation consisting of galleta and some areas of blue grama.**

The surface layer extends to a depth of about 9 inches and consists of reddish-brown, calcareous clay. It is very hard and, when dry, has large shrinkage cracks and breaks into medium to coarse blocks. When it is wet, this layer is sticky and gummy. Most of the plant roots are concentrated in its uppermost 6 inches.

Underlying the surface layer is about 15 inches of clay that has about the same color as the surface layer. Shrinkage cracks extend down into this material when it is dry, but water moves very slowly through the layer. The structure is coarse blocky. Roots generally follow the surfaces of blocks, but a few penetrate their interiors. The substratum consists of red-bed clays that are slightly weathered and contain considerable lime.

Montoya soils are droughty. Internal drainage is very slow and runoff is slow. The penetration of these dense, clayey soils by roots is difficult. All of the acreage of Montoya soils is rangeland. These soils are not suitable for cultivation.

Montoya clay (Mt) occupies nearly level flats, alluvial fans, and depressions in the Canadian breaks. The areas range from about 20 acres to more than 1,500 acres in size. These soils are adjoined mainly by the gently sloping Quay and Mansker soils.

Included with this soil in mapping were small areas of Quay clay loam.

Montoya clay is droughty and has low natural fertility. It takes in water very slowly, and its surface crusts readily.

This soil is well suited as rangeland, and all of it is range. It has a dense cover of galleta and lesser amounts of blue grama. The forage produced is not very palatable, and there are only moderate quantities of it. Areas of this soil should be crossed carefully in vehicles because there are random slump pits or holes that have vertical walls and are 1 to 3 feet deep. (Capability unit IVs-1, dryland; Clay Flats range site)

Olton Series

In the Olton series are deep, dark-brown, loamy soils that are slowly permeable. These soils occur on the High Plains, mostly in the southern and western parts of the county.

The surface layer is dark-brown, noncalcareous clay loam that ranges from 6 to 12 inches in thickness (fig. 6). It has fine subangular blocky structure. Under proper management this layer has a good tilth, but hoofpans or plowpans tend to form in the lower part if this soil is grazed or worked when too wet.

The subsoil is brown to reddish-brown clay loam about 36 inches thick. The upper subsoil is neutral, is moderately slowly permeable, and contains slightly more clay than the surface layer. When the soil dries, this layer breaks to slightly rounded blocks that have shiny surfaces. Roots can penetrate most of the subsoil, but not the interior of some of the denser blocks. The tightest part of the subsoil is between depths of 7 and 20 inches.

Figure 6.—**Profile of Olton clay loam that shows its thick solum and the underlying caliche.**

The lower subsoil begins at a depth of about 20 inches. It contains threads, veins, and a few nodules of free lime. It is slightly less clayey than the upper subsoil and is more friable and somewhat more permeable. Fine roots are common, even in the lower part of the subsoil.

The substratum is pink to white soft caliche 1 to 3 feet thick. Depth to this caliche ranges from 30 to 60 inches but averages about 40 inches. Under the caliche is reddish-brown to reddish-yellow, limy clay loam material.

Because Olton soils have moderately high natural fertility, moderate to high water-holding capacity, and good structure, they make up some of the best cropland in the county. These soils are dryfarmed, irrigated, and used as range.

Olton clay loam, 0 to 1 percent slopes (OcA) occurs on the High Plains, mainly surrounded by large areas of the Pullman soils. This soil adjoins the Zita soils in a few areas. Areas of this soil range from 50 to 400 acres in size.

Included with this soil in mapping were patches of Zita clay loam 5 to 15 acres in size.

The surface layer of this Olton soil is about 10 inches thick. The subsoil is blocky clay loam. Depth to free lime ranges from 18 to 25 inches, but depth to caliche is generally about 60 inches.

Most areas of this soil are cropland; the rest is range. This soil is easy to work, but plowpans form easily in the surface layer if it is plowed when too moist. Grain sorghum, wheat, vegetables, and sugarbeets are well suited. The native grasses are blue grama and buffalograss. (Capability unit IIIce-2, dryland, and I-1, irrigated; Deep Hardland range site)

Olton clay loam, 1 to 3 percent slopes (OcB) occupies areas adjoining draws and playas of the High Plains. The areas range from 20 to about 500 acres in size. This soil occurs mainly with the Pullman and Zita soils.

Included with this soil in mapping were spots and patches of Zita clay loam and of Ulysses clay loam.

The surface layer ranges from 6 to 8 inches in thickness. Depth to caliche is between 30 and 40 inches. The finest textured, tightest part of the subsoil is at a depth of about 15 inches.

This soil is slightly susceptible to soil blowing and water erosion. Water runs off the surface at a moderate rate. In a few places where water concentrates, rills and shallow gullies have formed. Plowpans form readily in the surface layer if the soil is cultivated when too wet.

Most of this soil is dryfarmed. Wheat and grain sorghum are the main dryland crops. In a few irrigated areas, wheat, cotton, sorghums, and grasses are grown. (Capability unit IIIe-2, dryland, and IIe-2, irrigated; Deep Hardland range site)

Potter Series

The Potter series consists of grayish-brown to light brownish-gray, gravelly soils that are very shallow over caliche (fig. 7). These soils occur on side slopes of streams and in sloping to steep areas that border escarpments.

The surface layer is limy, brownish, gravelly loam in which caliche pebbles and fragments make up 25 percent of the volume. It is generally about 9 inches thick but ranges from 4 to 10 inches in thickness.

Figure 7.—**Profile of a Potter soil.**

The substratum directly underlies the surface layer and consists of weakly cemented, pink to white caliche. The uppermost 1 to 2 feet of the substratum is hard when dry, but it can generally be dug through with a hand shovel. It consists of pebbles and fragments cemented together with softer caliche. The lower part consists mostly of soft masses of caliche that contain a few hard fragments. This layer grades to limy, light-brown to yellowish-red loam and clay loam.

The Potter soils are droughty and low in natural fertility. Runoff is moderate to rapid. Water is readily taken into the surface layer, but it moves slowly in the substratum. Permeability is moderate in part of the substratum, but it is slow in the cemented layers.

Potter soils are used only as range. They support a sparse stand of grasses. In some areas the underlying caliche is quarried and used locally as base material for roadbeds.

Potter soils (Pe) occupy the sloping to steep upper parts of slopes along Tierra Blanca and Palo Duro Creeks. They are also along the escarpments in the northwestern part of the county. Along the creeks, these soils are in bands that range from 200 to 500 feet in width and from a few hundred feet to a mile or more in length. Along the escarpment, spots and patches of these soils are intermingled with Rough broken land.

Included in mapping were small areas of Mansker clay loam, Mobeetie fine sandy loam, and a few spots and patches of nearly barren caliche.

Potter soils have a profile similar to the one described for the series.

On these soils the cover is of sparse native grasses, mainly sideoats grama, hairy grama, and three-awn. Overgrazed areas are susceptible to soil blowing. Because runoff is moderate to rapid, water erosion is likely. (Capability unit VIIs-1, dryland; Very shallow range site)

Pullman Series

The Pullman series consists of loamy, deep, nearly level to gently sloping soils that have a dark grayish-brown surface layer and a compact, clayey subsoil. These soils are on the smooth High Plains in broad areas of the tableland that stretches across the county. Pullman soils cover about 60 percent of the county and are the most important soils for farming. These soils are irrigated, dryfarmed, and used as range.

The dark grayish-brown surface layer is noncalcareous clay loam about 6 inches thick. It has weak granular structure and generally good tilth. It is easily worked throughout a wide range of moisture content, but it tends to crust after hard rains. The crusted surface is susceptible to soil blowing if it is bare. The surface layer is naturally fertile.

The subsoil extends to an average depth of about 50 inches. The upper part is about 18 inches thick and consists of noncalcareous, compact, dark-brown clay that breaks into medium-sized blocks. The blocks have shiny, smooth surfaces, are solid and dense, and have very few visible pores or root channels. Roots are common in this layer; they generally follow the surfaces of the blocks, though a few work their way into the interior (fig. 8). This layer cracks when it dries and swells when it is wet. The lower part of the subsoil is a reddish-brown clay loam or light clay that breaks into subangular blocks. It contains less clay than the upper part and is slightly more permeable. Roots are common, but their number decreases rapidly with depth. Below a depth of about 30 inches, the subsoil probably is an old buried soil that developed in parent material different than that of the upper subsoil.

The substratum is pink to pinkish-white, soft caliche earths. This layer is at an average depth of about 50 inches and is generally about 2 feet thick. Old rodent nests filled with light-brown, calcareous, loamy material are common in this layer. These nests are oval and range from about 4 to 18 inches in diameter. Underlying the caliche layer is light-brown to reddish-brown limy clay loam. A profile of Pullman clay loam is shown in figure 8, bottom.

The Pullman soils are slowly permeable. They crack when dry. When they are wetted, the water first moves into the subsoil at a moderate rate. Then the soil swells and tends to seal, and water moves very slowly downward.

Almost all of the acreage of the Pullman soils is moderately well suited to irrigation, mainly because slopes are smooth and nearly level. But these soils have a dense subsoil, and it is difficult to wet them to the bottom of their root zone. They are somewhat droughty, but in wet

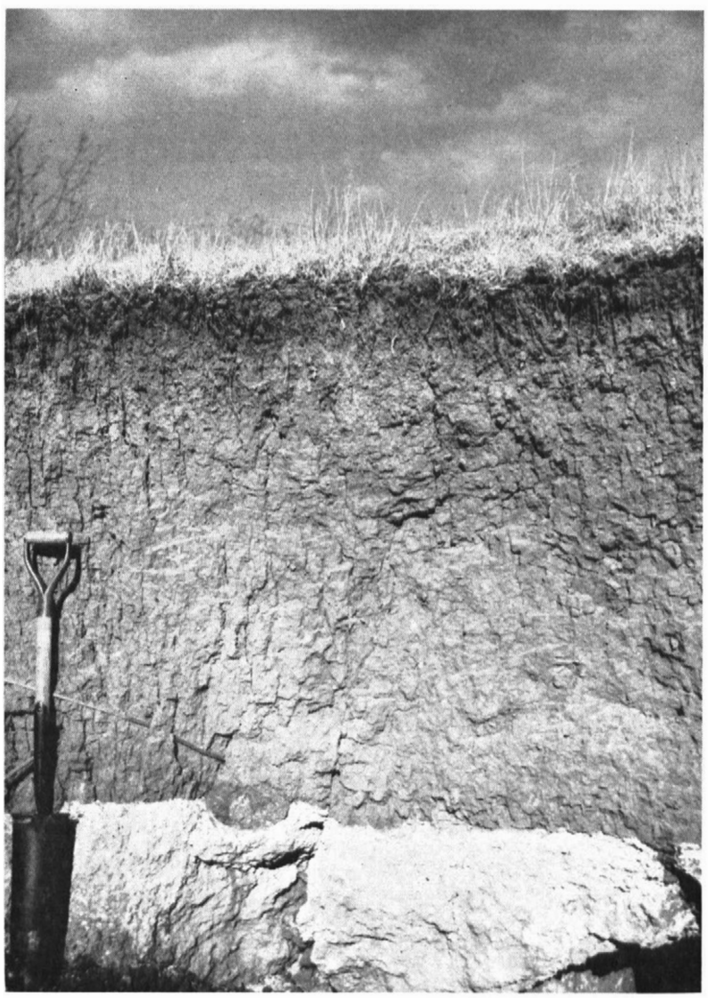

Figure 8.—Top, **Pullman clay loam has a subsoil of blocky structure.** ***Bottom,*** **Profile of Pullman clay loam: Dark surface layer about 6 inches thick; upper subsoil of slowly permeable clay extending to about the top of the shovel; slowly permeable clay loam, probably a horizon of a buried soil, extending to the white caliche; old rodent nest (krotovina) at the top of the caliche.**

years are well suited to dryfarmed wheat and grain sorghum. Wind erosion can be controlled by leaving moderate amounts of crop residue on the surface. One of the main problems is keeping the subsoil open so that the growth of roots and the movement of air and water are good.

Wheat and grain sorghum are the main irrigated and dryfarmed crops, but vegetables, alfalfa, cotton, and silage are grown on significant acreages. Short grasses grow on native range.

Pullman clay loam, 0 to 1 percent slopes (PmA) occupies about 55 percent of the county. Most of the soil is in one broad, continuous, nearly level area that extends across the High Plains part of the county. A few much smaller areas adjoin the Church and Randall soils of the playa depressions and the Olton, Ulysses, and Mansker soils on the nearly level uplands.

Included in mapping were small areas of Olton clay loam, of Ulysses clay loam, and of Randall clay in round or oval depressions. The Olton and Randall soils do not greatly influence use and management, but the Ulysses soil is somewhat more susceptible to soil blowing than this Pullman clay loam.

The surface layer of this Pullman soil is generally about 6 inches thick, but it ranges from 4 to 7 inches in thickness. It is dark grayish brown in the slightly depressional areas. Depth to free lime is about 24 inches, and depth to the caliche averages about 50 inches.

Because runoff is slow, damage by water erosion is little or none in most places. In most areas farmed in the 1930's, however, wind probably blew away from 1 to 3 inches of the surface soil.

This is the most extensive cultivated soil in the county. On it is grown a large part of the irrigated grain sorghum, wheat, and vegetables in the county, as well as most of the dryfarmed wheat and grain sorghum. Several thousand acres are rangeland. The main problem of management is keeping the tight, fine-textured subsoil loose enough for water to enter and roots to grow. (Capability unit IIIce–1, dryland, and IIs–1, irrigated; Deep Hardland range site)

Pullman clay loam, 1 to 3 percent slopes (PmB) is a gently sloping soil that borders draws and playa depressions on the High Plains. It is moderately extensive. This soil typically adjoins Pullman clay loam, 0 to 1 percent slopes, which is higher in the landscape. It also adjoins Mansker clay loam, 3 to 5 percent slopes, on the lower slopes.

Included with this soil in mapping were small areas of Ulysses clay loam and Olton clay loam. Also included were a few eroded, slightly rilled spots of Pullman clay loam that have only 2 to 4 inches of surface soil remaining.

The surface layer is about 4 to 6 inches thick and is thinnest where some of it has been washed away. Depth to free lime is about 18 inches, and depth to caliche averages about 36 inches. The subsoil is a little redder and is slightly more permeable than that of Pullman clay loam, 0 to 1 percent slopes.

This soil is used mostly for dryfarming and range, but a few areas are irrigated. The main concern in dryland management is holding water on the surface long enough for it to soak into the tight subsoil. Also troublesome is susceptibility to sheet and rill erosion, especially at the lower ends of long slopes. (Capability unit IIIe–1, dryland, and IIIe–1, irrigated; Deep Hardland range site)

Pullman clay loam, 1 to 3 percent slopes, eroded (PmB2) is in small areas that average about 30 acres in size. It occurs on slopes to playas and draws. The total acreage is inextensive.

Included with this soil in mapping were a few spots of eroded Ulysses clay loam and a few areas less than 5 acres in size of noneroded Pullman clay loam.

Numerous rills and shallow gullies 6 to 18 inches deep have been gouged in this soil by erosion. These are crossable with ordinary farm equipment. Between the rills and gullies, about 2 to 4 inches of the original surface layer remains. In most places the plow layer contains more clay than that of noneroded Pullman clay loam because clods from the clayey subsoil have been mixed into this layer by plowing and chiseling.

Because the amount of clay is increased in the surface layer, it is likely to crust, and it bakes more easily. There is more runoff and the soil is more droughty, since water enters the surface at a slower rate. This soil is less granular, less fertile, and more difficult to work because a large part of the organic matter has been washed away with the surface layer.

Most of the acreage is dryfarmed, but if cultivation is continuous, good management of crop residues and water control measures are needed. (Capability unit IVe–3, dryland, and IIIe-2, irrigated; Deep Hardland range site)

Pullman-Ulysses complex, 0 to 1 percent slopes (PuA) occupies nearly level areas on the High Plains. Large areas of Pullman soils are interspersed with somewhat smaller areas of Ulysses and Olton soils.

This complex, on the average, is made up of about 40 percent Pullman clay loam, 30 percent Ulysses clay loam, and 30 percent Olton clay loam. In places the percentages of these soils may vary as much as 15 percent.

Included with these soils in mapping were small spots of Mansker clay loam and of Randall clay in playas.

The surface appearance of Pullman and Olton soils differs somewhat from that of the spots and patches of Ulysses soil. Depth to caliche in the Pullman and Olton soils averages about 35 inches, which is somewhat less than that described as typical of soils in these two series. The Ulysses clay loam has a profile similar to the one described as typical of the Ulysses series.

A large part of this complex is rangeland. The rest is used for dryfarmed and irrigated crops. The Pullman and Ulysses soils require about the same management, but more intensive management is required on the Olton soil. Because the soil patterns in this complex differ, an investigation at the site is needed before an irrigation system is designed. (Capability unit IIIce–4, dryland, and IIs-2, irrigated; Deep Hardland range site)

Pullman-Ulysses complex, 1 to 3 percent slopes (PuB) occupies gently sloping areas around playa basins and along draws and creeks of the High Plains. Included in mapping were small spots of Mansker loam.

About 60 percent of this complex is Pullman clay loam; 20 percent, Ulysses clay loam; and 20 percent, Olton clay loam. Areas of these soils typically are about 50 acres in size and are elongated. They follow the contour of the drainageways or the outer rims of the playa basins. Pullman clay loam is on the higher parts of the areas; Olton clay loam is in intermediate positions; and Ulysses clay loam is in the lower parts. In some places the Ulysses soil occurs in spots and patches throughout the complex. Depth to caliche in the Pullman and Olton soils is generally between 30 and 35 inches, somewhat less than is typical for the Pullman and Olton series.

The soils in this complex are mostly rangeland, but some areas are irrigated and dryfarmed. Similar management is required on the Pullman and Olton soils for controlling soil blowing and water erosion, but more intensive management is required on the Ulysses soils for controlling soil blowing. In designing irrigation systems, separate consideration of each area is needed because the soil patterns and the rates of water intake vary. (Capability unit IIIe-7, dryland, and IIIe-5, irrigated; Deep Hardland range site)

Quay Series

The Quay series consists of reddish-brown, loamy soils that are calcareous. These soils are on rolling uplands, mainly in the northwestern part of the county. They developed in outwash that was derived from red beds.

The surface layer is friable clay loam or fine sandy loam, generally about 9 inches thick. When this soil is dry, it breaks into very fine, soft granules and fine subangular blocks that are easy to crush between the fingers. A few lime pebbles are in the layer, and roots are abundant. Pores and root channels are common.

The upper part of the subsoil is about 14 inches thick and consists of light reddish-brown clay loam. It extends to an average depth of 23 inches. Structure is about the same as that of the surface layer. Common in this layer, and increasing in number with depth, are worm casts, lime nodules, and whitish veins and threads of lime.

The substratum consists of light reddish-brown, porous, limy clay loam that contains few to many lime pebbles. Roots are common in the upper part but decrease rapidly with increasing depth. A few roots penetrate below a depth of 30 inches because this part of the substratum is dry most of the time.

Quay soils have moderate permeability and absorb water readily. Natural fertility is moderately high in the surface layer but is low in the subsoil. Because the surface layer is limy, these soils blow easily if cultivated.

All of the acreage of Quay soils is range. The vegetation consists of short grasses, such as blue grama and buffalograss, and of lesser amounts of sideoats grama and other mid grasses.

Quay clay loam, 0 to 1 percent slopes (QcA) occurs on nearly level flats, mainly in the northwestern part of the county. The areas typically lie between Montoya clay on the concave flats and Quay clay loam, 1 to 3 percent slopes, on higher slopes. The average area is about 200 acres in size.

Included with this soil in mapping were small areas of Montoya clay and Quay clay loam.

The surface layer of this soil is about 10 inches thick. In some places it is noncalcareous in the upper few inches. The subsoil is a limy clay loam that breaks into slightly rounded medium blocks and some intermixed granules. This layer contains slightly more clay than the surface layer of Quay clay loam, 1 to 3 percent slopes. In some places this soil has a clay substratum.

This soil is suited to wheat and grain sorghum. It has fair natural fertility and it takes in water readily. Because the surface layer is limy, soil blowing is likely. (Capability unit IIIce-3, dryland; Deep Hardland range site)

Quay clay loam, 1 to 3 percent slopes (QcB) is on smooth ridges and divides, mainly in the northwestern part of the county. Areas of this soil average about 250 acres in size. This soil is adjoined by Mansker-Potter complex, 2 to 8 percent slopes, on moderately sloping knolls and ridges. Other adjacent soils are Montoya clay and Quay clay loam, 0 to 1 percent slopes.

Included with this soil in mapping were small areas of Mansker, Potter, and Montoya soils.

All of this Quay soil is range. Soil blowing is the main hazard in cultivated fields because the limy surface blows easily. Grain sorghum and wheat are well suited, though expected yields are somewhat below the average for the county. (Capability unit IIIe-3, dryland; Deep Hardland range site)

Quay clay loam, 3 to 5 percent slopes (QcC) is mainly in the northwestern part of the county. It is in the area between the gently rolling plains and the rolling to steep hills near the escarpment. A few areas are on slopes of drainageways. The areas average about 125 acres in size. Adjoining soils are Quay clay loam, 1 to 3 percent slopes; Montoya clay; and Vernon-Quay complex.

Included with this soil in mapping were small areas of Mobeetie fine sandy loam, 3 to 5 percent slopes, and of Vernon gravelly clay loam.

The surface layer of this soil ranges from 6 to 9 inches in thickness. The subsoil is very friable, is light reddish brown, and contains many worm casts. It is slightly more limy than the subsoil of Quay clay loam, 1 to 3 percent slopes.

All of this soil is range. If it were cultivated, it would be susceptible to severe water erosion, but grain sorghum probably could be grown in rows closely spaced. (Capability unit IVe-2, dryland; Deep Hardland range site)

Quay fine sandy loam, 1 to 5 percent slopes (QfC) is on broad, moderately sloping ridges in the Canadian breaks near Glenrio. Its areas average about 200 acres in size. They are between lower lying areas of Quay clay loam, Montoya clay, and Zita clay loam and higher lying areas of Mobeetie fine sandy loam.

Included with this soil in mapping were small areas of Mansker clay loam and of Quay clay loam.

This Quay fine sandy loam has a slightly less clayey, more granular subsoil than the soil described for the series. The subsoil ranges from clay loam to loam. A calcareous fine sandy loam substratum is common below a depth of 2 feet.

Natural fertility is moderately low. Because the water from rain is taken in moderately easily, there is little runoff. If this soil is overgrazed, or if the surface layer is disturbed, soil blowing is likely. This soil is well suited to grain and forage sorghums.

All of this soil is range, for which it is well suited. It supports a dense stand consisting of blue grama, sideoats grama, and scattered yucca. Grain and forage sorghums can be grown in cultivated areas. (Capability unit IVe–5, dryland; Sandy Loam range site)

Randall Series

The Randall series consists of poorly drained, gray to dark-gray, clayey soils. These soils are on the bottoms of playas, or the enclosed depressions in the High Plains. Because the playas catch most of the runoff from the nearly level tableland, Randall soils are under water for a few weeks to several months each year.

The surface layer, generally about 10 inches thick, is gray clay that is sticky and gummy when wet and extremely hard when dry. It has weak, coarse, blocky structure that breaks into fine blocky structure. This layer cracks extensively when it is dry.

Gray clay, in a layer that ranges from 15 to 50 inches in thickness, underlies the surface layer. Large cracks extend into this clay when it is dry, but the cracks seal when the clay is wet. This layer has weak, coarse, angular blocky structure; the blocks are slick and shiny. Lime is dispersed throughout the layer, and in the lower part, soft masses and concretions are common.

In most places the substratum is clay that ranges from light gray to dark grayish brown. In a few areas the lower part of the substratum is yellowish-red clay loam.

Randall soils absorb water very slowly, especially after the initial wetting when the material swells, runs together, and seals. Because the movement of water downward almost stops after sealing, the water impounded in the playas is removed almost entirely through evaporation. Dry Randall soils are subject to soil blowing because they are powdery and generally lack vegetative cover. These soils are hard to work and manage because of their poor drainage and high content of clay, but they contain a good supply of plant nutrients.

These soils are mainly used for grazing. Where runoff is controlled, a few small playas are cultivated. The native vegetation consists mainly of sedges, smartweed, blueweed, ragweed, and other water-loving plants. Buffalograss and western wheatgrass grow in a few of the drier playas.

Randall clay (Ra) is in areas that are scattered throughout the High Plains part of the county. The areas typically are round or oval and about 125 acres in size, but they range from a few acres to more than 500 acres. The larger areas of this soil occupy the poorly drained, central part of the playa. Surrounding these areas are the Church, Olton, and Ulysses soils on moderately well drained benches. On the main level of the High Plains are areas only 1 to 5 acres in size. These are surrounded by Pullman, Olton, or Ulysses soils.

Included with this soil in mapping were narrow, sloping areas of Church clay between the playa benches and the playa bottoms. Also included, on the bottom of Garcia Lake, is a clay soil that resembles Randall clay but is dark brown instead of gray.

Because it is hard to work and frequently flooded, Randall clay is used almost entirely for grazing. A few of the better drained areas are cultivated. Soil blowing is a severe hazard where the soils are dry and bare. (Capability unit VIw–1, dryland; not assigned to a range site)

Rough Broken Land

Rough broken land (Ro) consists of very steep upper slopes, moderately steep to steep foot slopes, and nearly vertical walls and bluffs. It occurs mainly on the jagged rim and the somewhat rugged escarpment between the tableland stretching across the High Plains and the lower Canadian breaks (fig. 9). A few areas are along Tierra Blanca Creek. Typical areas are of jagged, irregular shape. They are generally between ½ and 2 miles long and range from 400 to about 800 feet in width. The total acreage in this county is small. The higher parts of this land are about 200 to 500 feet above the lower parts.

Included throughout areas mapped as Rough broken land are spots and patches of Mobeetie and Potter soils. Also included are a few areas of Vernon gravelly clay loam and of Quay clay loam.

All of this land is range that has low carrying capacity for grazing animals. The cover of grasses is sparse and consists mostly of little bluestem, sideoats grama, blue grama, black grama, sand dropseed, and three-awn. Catclaw, yucca, and juniper are common woody plants. This land has little value for farming or ranching, but the material from the caliche is used locally for building roads. (Capability unit VIIs–2, dryland; Rough Breaks range site)

Springer Series

The Springer series consists of gently sloping, reddish-brown fine sandy loams that occur in a few scattered areas in the Canadian breaks. These soils developed in eolian deposits of sandy loam that were derived from the Triassic red beds.

The surface layer is about 10 inches thick and consists of reddish-brown, friable, neutral fine sandy loam.

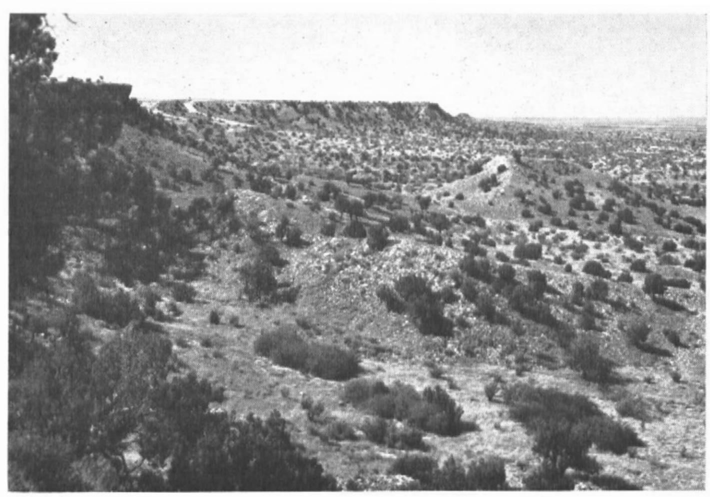

***Figure 9.*—Typical areas of Rough broken land along the escarpment. Nearly level High Plains are in the background; Canadian breaks are in the foreground. Mobeetie soils are on the foot slopes, and Vernon and Quay soils are on the rolling landscape in the foreground.**

The subsoil extends to an average depth of about 30 inches. It, like the surface layer, consists of a reddish-brown, friable fine sandy loam, but a fine sandy loam that contains slightly more clay. The subsoil has weak, coarse, subangular blocky structure. It is neutral and has moderately rapid permeability.

The substratum is a loam or fine sandy loam that contains films and veins of calcium carbonate. Depth to limy material ranges from 25 to 50 inches.

These soils take in water readily. Moisture and roots easily penetrate the subsoil. Natural fertility is fair to moderate.

All of the acreage of these soils is range that supports mid and tall grasses.

Springer fine sandy loam, 1 to 3 percent slopes (SfB) occupies gently sloping to undulating areas in the Canadian breaks. The areas range from 30 to about 150 acres in size and have a small total acreage. The adjoining soils are Mobeetie fine sandy loam, generally in higher, somewhat hummocky areas, and Quay and Montoya soils, in low areas consisting of smooth flats and valley fills.

Included in mapping were small areas of Quay fine sandy loam and Mobeetie fine sandy loam.

All of this soil is range consisting of mid and tall grasses. Unless grazing is managed in a way that maintains good cover of these grasses, soil blowing is likely. If this soil is cultivated, a good cover of crop residue should be kept on the surface at all times. (Capability unit IIIe-5, dryland; Sandy Loam range site)

Spur Series

The Spur series consists of loamy, dark-colored soils. These soils are in alluvium on flood plains along the main creeks on the High Plains and along some of the main waterways in the Canadian breaks.

The surface layer is very dark grayish-brown, calcareous clay loam about 18 inches thick. It has subangular blocky structure. This layer is naturally fertile, friable, and mellow.

The subsoil is dark grayish-brown clay loam that is friable and has subangular blocky and granular structure. Worm casts are common. This layer generally contains a few white threads and veins of lime.

The substratum is calcareous clay loam. It ranges from clay loam to loam and generally contains veins and threads of lime and scattered caliche pebbles.

Spur soils are among the most productive soils in the county, but most areas are so small and irregular in shape that cultivation is not practical.

Spur and Bippus soils (Sp) consist of soils on bottom lands that occur along Tierra Blanca Creek, Palo Duro Creek, and some of the main waterways in the Canadian breaks. Most areas are seldom flooded.

The landscape is a smooth flood plain that ranges from 200 feet to about ½ mile in width and that has been cut by an entrenched stream. The stream is 10 to 20 feet wide and 5 to 15 feet deep. It carries most of the runoff except that from heavy rains. The channel of this stream is tortuous and generally has cut the bottom land into such small areas that cultivation is impractical.

The Spur soils are dark-colored, calcareous clay loams that generally occur along the main stream channel. They occupy slightly lower areas than the Bippus soils. The Bippus soils are dark-colored, noncalcareous clay loams on the outer edges of the flood plain. They are adjacent to Mansker soils on the adjoining side slopes.

Except for a few small spots, all of the acreage of Spur and Bippus soils is range. Areas are generally so small that cultivation is not feasible. These soils produce large amounts of forage. They are well suited to switchgrass, indiangrass, western wheatgrass, and other tall grasses. In most places, however, the grasses are mostly blue grama and sideoats grama because grazing has been heavy. In a few slightly saline areas accumulations of salt caused the range to deteriorate to pure stands of alkali sacaton. (Capability unit Vw-1, dryland; Loamy Bottom Land range site)

Ulysses Series

The Ulysses series consists of moderately deep, brownish, loamy soils that are calcareous and have a substratum of pinkish-white caliche. These soils are nearly level to gently sloping. In this county they are in scattered areas throughout the High Plains and are moderately extensive.

The surface layer is a calcareous, dark-brown clay loam that is generally about 12 inches thick but that ranges from 7 to 14 inches in thickness. This layer is friable, granular, and easy to till.

The subsoil is a limy, brown, friable clay loam about 10 inches thick. It has medium and coarse, blocky structure. The blocks are somewhat rounded and are intermixed with granules or worm casts. A few lime pebbles or concretions occur in places.

The substratum begins at an average depth of 22 inches. The upper part consists of light-brown material mixed with pinkish-white caliche. By volume, this caliche makes up 5 to 10 percent of the upper part of the substratum. The lower part begins at a depth of about 45 inches and consists of limy, reddish clay loam material that typically contains about half as much lime as the upper part of the substratum.

Ulysses soils are well drained. Water soaks into the surface readily and moves easily through the subsoil. Roots grow without resistance. Capacity to hold water and plant nutrients is moderate. Because of the lime, however, phosphorus and other elements are released slowly for plant use. The lime also causes chlorosis, especially in grain sorghum. If the surface is left unprotected, these soils are likely to blow during windy periods.

Ulysses clay loam, 0 to 1 percent slopes (UsA) occurs on the nearly level High Plains and is surrounded by large areas of the Pullman soils. In a few areas this soil is intermingled with the Olton and Zita soils. A typical area of this soil is irregularly shaped and about 90 acres in size, but areas range from 5 to approximately 1,500 acres. Slopes are generally about 0.5 percent, but they range from 0 to 1 percent.

Included with most areas in mapping were spots and patches of Mansker, Zita, and Pullman soils.

The surface layer of this soil is brown, grayish brown, or dark grayish brown. Wind probably has removed from 1 to 2 inches of the surface soil. Depth to the zone of lime accumulation ranges from 20 to 30 inches.

This soil is friable, granular, and easy to work. It has moderate fertility and is moderately well suited to cultivation, but it blows readily where the surface is not protected.

About half of this soil is cultivated, and the rest is range. Several thousand acres are irrigated. Well-suited crops are sorghums and wheat. Cotton and alfalfa are well suited to irrigated areas. (Capability unit IIIce-3, dryland, and IIe-3, irrigated; Deep Hardland range site)

Ulysses clay loam, 1 to 3 percent slopes (UsB) occurs around playa basins and along draws and creeks of the High Plains. A few areas are on low rises or ridges adjoining Pullman clay loam. Slopes are mostly convex and single.

Included with this soil in mapping were small spots of Mansker soils. Also included were a few small, severely eroded areas 3 to 5 acres in size. These eroded areas have had most of the surface layer removed and are marked in places by many rills and shallow gullies.

The surface layer of this Ulysses soil is 8 to 10 inches thick, or slightly thinner than that described for the Ulysses series. Also, the lime accumulation in this soil is less distinct.

This soil is friable, mellow, and easy to till. It has moderate natural fertility but is moderately susceptible to soil blowing. Runoff gouges rills and shallow gullies where crop residue is not left on the surface and runoff is not controlled.

Most of this soil is range, but some is dryfarmed, and a small acreage is irrigated. Wheat and sorghums are well-suited crops. Alfalfa is particularly well suited to irrigated areas. (Capability unit IIIe-3, dryland, and IIIe-4, irrigated; Deep Hardland range site)

Vernon Series

The Vernon series consists of gravelly clay loams that are reddish brown and very shallow over shaly clay. These soils are on sloping to steep hills and ridges in the Canadian breaks.

The surface layer is reddish-brown gravelly clay loams about 6 inches thick. About 20 percent of its volume is angular pebbles of hard, white caliche. This layer holds only small amounts of water.

The substratum directly underlies the surface layer and consists of reddish clay shale that has thin platy structure. Roots commonly grow in the upper 3 to 4 inches of this layer, but a few penetrate below a depth of 15 inches.

All of the acreage of Vernon soils is range. The stands of native grasses are sparse, for these soils have rapid runoff, have low water-holding capacity, and are droughty.

Vernon-Quay complex (Vx) occupies rolling to steep red-bed hills and ridges in the Canadian breaks. This complex is inextensive. It consists of Vernon gravelly clay loam and Quay clay loam. Vernon gravelly clay loam, which is very shallow, occupies the crests of the hills and ridges. Quay clay loam is on the lower foot slopes and in the shallow draws or vales lying between the hills. About 60 percent of this complex is Vernon gravelly clay loam, and 25 percent is Quay clay loam. The rest consists of small areas of Potter, Spur, and Bippus soils. The Vernon clay loam is similar to the soil described as typical of the Vernon series, and the Quay clay loam is similar to the soil described as typical of the Quay series.

Included with these soils in mapping were small areas of Potter soils, nearly barren exposures of shaly red beds, and some gullied areas.

All of the acreage of this complex is range. The soils are shallow, susceptible to erosion, and not suited to cultivation. Because stands of native grasses are sparse on the Vernon soils, they are eroded readily by water if the stands are overgrazed. Quay soils support dense cover consisting of short grasses and some mid grasses. (Capability unit VIIs-1, dryland; Vernon gravelly clay loam is in Shallow Redland range site; Quay clay loam is in Deep Hardland range site)

Zita Series

In the Zita series are deep, brown, moderately sandy soils. These soils are in scattered areas throughout the county.

The surface layer is a neutral clay loam about 9 inches thick. It has fine subangular blocky and granular structure. Natural fertility is high because the short grasses contributed large amounts of decayed roots and leaves. Channels and pores left by decayed roots are common. This layer is easily tilled throughout a wide range of moisture content. Plowpans tend to form in the lower part if the layer is tilled when it is wet.

The subsoil is about 20 inches thick. The upper part is a neutral, dark-brown clay loam. It has coarse prismatic structure that breaks to medium subangular blocky and granular. Worm casts are common. The lower subsoil is a brown clay loam that is slightly less clayey than the upper subsoil and is more friable and granular. It generally has a few masses of soft lime and contains many threads or veins of lime.

The substratum is a layer of pink to white, soft caliche that ranges from 1 to 3 feet in thickness. It is underlain by reddish-brown, light-brown, or yellowish-red limy material.

Zita soils are moderately permeable and have good water-holding capacity because their subsoil consists of porous clay loam. These soils absorb water readily. Plant roots develop without resistance. Soil blowing can be controlled by leaving moderate amounts of residue on the surface.

Zita soils are among the best cultivated soils in the county. They are used for dryfarming, for irrigated farming, and as range. Wheat and grain sorghum are the main crops.

Zita clay loam, 0 to 1 percent slopes (ZcA) is in areas scattered throughout the county. The areas average about 100 acres in size, but total acreage in the county is small. This soil generally occurs within larger areas of Olton or of Pullman soils on the High Plains and next to Quay soils in the Canadian breaks. The areas of this soil are mostly in the western part of the county.

Included with this soil in mapping were mainly areas of Olton clay loam that generally range from 5 to 15 acres in size. Also included were some small spots and patches of Ulysses clay loam and of Mansker clay loam.

This Zita soil makes up some of the better cropland in the county. It is naturally fertile. Because it can take in water at a moderate rate, it is not so droughty as the associated Olton and Pullman soils. It is, however, moderately susceptible to soil blowing. Also, plowpans are likely to form if it is cultivated when too wet.

This soil is used for dryfarming, irrigated farming, and range. Special treatment is needed on the small included areas of Ulysses and Mansker soils because they are more susceptible to soil blowing than is this Zita soil. (Capability unit IIIce-2, dryland, and I-2, irrigated; Deep Hardland range site)

Zita clay loam, 1 to 3 percent slopes (ZcB) occurs mainly in the western part of the county. Most of the nearly level areas are on low rises above the adjoining level Pullman and Olton soils, but the gently sloping areas are around playas and along draws. The areas range from 20 to 150 acres in size.

Included with this soil in mapping were areas of Olton clay loam and Ulysses clay loam.

Soil blowing is a moderate hazard on this soil. Also, water erosion is a hazard unless runoff is controlled. Plowpans or compacted layers form when the soil is cultivated when it is moist. If properly managed, this is one of the best soils in the county for dryfarming. Because the texture and structure of the subsoil are favorable, air and water move easily through the soil. Also, plant roots develop without resistance.

This soil is mostly range; a few areas are dryfarmed. All crops commonly grown in the county, particularly grain sorghum and wheat, are well suited. (Capability unit IIIe-2, dryland, and IIe-1, irrigated; Deep Hardland range site)

Use and Management of Soils

The soils of Deaf Smith County are used partly as range and for dryfarmed and irrigated crops. This section explains how the soils may be managed for these main purposes and for windbreaks and wildlife habitat. A table gives predicted yields of the principal dryfarmed and irrigated crops. Also explained is how the soils can be used for building highways, farm ponds, and other engineering structures.

In discussing the use of the soils as cropland, rangeland, and wildlife habitat, the procedure is to describe groups of soils that have similar uses and that require similar management, and then to suggest management suitable for the group. The soils in each group are listed in the "Guide to Mapping Units" at the back of this survey.

Dryfarmed and Irrigated Crops

This subsection describes general practices for managing dryfarmed and irrigated soils, explains the grouping of soils according to their capability, and discusses the management of dryfarmed and of irrigated groups of soils. Also, a table lists, for cultivated soils, predicted yields of the principal irrigated and dryfarmed crops grown in the county.

General practices of dryfarming [3]

Management is needed on the soils of Deaf Smith County mainly to control soil blowing and to control water erosion and conserve moisture. The chief factor affecting management is the climate and its variable but generally low rainfall, severe droughts, occasional intense rains, high winds, and severe hailstorms.

Control of soil blowing.—In Deaf Smith County, the use of soils as cropland is hazardous unless practices that control soil blowing are followed. Soil blowing, particularly in bare areas, is most likely on the Ulysses, Drake, Mobeetie, and similar soils that have a high content of lime and a fine sandy loam surface layer.

The soils of the county can be protected against soil blowing by leaving a protective cover of crop residue on them during the critical dry, windy seasons of fall, winter, and spring. After these seasons have passed, the crop residues are plowed into the soil.

Stubble mulching is another way to manage the residues for protection against soil blowing. By this method, a protective cover of residues from a crop is left on the soil surface until the next crop is planted, and planting is in the stubble. After planting, all tillage and harvesting are performed by implements that leave most of the crop residues on the surface and anchored in the soil (fig. 10).

Mulching, or applying organic waste, is also effective in controlling soil blowing. By this method, some kind of organic material is placed on the soil to protect it. Cotton burs and the trash from cotton gins are widely used. Applications of at least 3 tons per acre effectively control soil blowing on most soils in the county.

If there is not enough crop residue on the soil for effective control, an emergency method that gives temporary protection is roughening the surface of the soil and making it cloddy. Durable clods form readily on the Pullman, Olton, and Zita soils, but less readily on the Ulysses and Mansker.

If tillage is excessive, is continual without the use of crop residues, or is performed when the soil is too wet, soil particles are broken down into finer particles or single grains that are highly susceptible to blowing. If these finer particles are silt and clay, they tend to run together and fill the natural pores and channels through which

Figure 10.—**Sweep used for stubble-mulch tillage to control soil blowing and water erosion by increasing the rate of water intake. This practice is used extensively on both dryfarmed and irrigated soils. The soil is Pullman clay loam, 0 to 1 percent slopes.**

[3] By JACK DOUGLAS, agronomist, Soil Conservation Service.

water and air move. Also, improper tillage impairs tilth and causes hard crusts to form on the surface and plowpans to form beneath the surface. The Olton and Zita soils are particularly susceptible to the formation of plowpans.

Conservation of moisture and control of water erosion.—Practices commonly used in this county for conserving moisture and controlling water erosion are (1) stubble mulching; (2) terracing and contour farming; (3) grassing of waterways; and (4) use of a suitable cropping system.

Stubble mulching is effective in controlling soil blowing and in controlling water erosion and conserving moisture as well. It can be used on all soils in the county. If this practice is used, the residues form a mulch that helps to conserve moisture by reducing evaporation, by holding snow until it melts so that more moisture enters the soil, and by increasing the rate of water intake. Stubble mulching also breaks the impact of falling raindrops.

On nearly level slopes, terracing and contour farming are used mainly for conserving moisture. These practices are used on the stronger slopes mainly for controlling erosion but also for conserving moisture. Contour farming is used to control erosion in many areas of the Pullman, Olton, Zita, and other nearly level soils that have not been terraced.

Grassed waterways help to control erosion by carrying runoff water at a safe, nonerosive rate. This is water that has collected in natural drainageways, field terraces, and diversion terraces. Grassed waterways are most effective where they are stabilized by grass or other plant cover and are protected from grazing and fire. The time needed for a good cover to establish itself is generally several years and depends on the moisture content of the soil. Somewhat more time is needed on the droughty Pullman soils than is needed on the less permeable Olton and Zita soils.

A flexible cropping system is needed on the soils of Deaf Smith County used for dryfarmed crops. Wheat and sorghums are the major dryfarmed crops because the supply of moisture in the soils is low and the growing season is relatively short. The cropping system varies widely. Farmers often use a system that provides a fallow period after harvest of a crop so that moisture is stored in the subsoil for use by the next crop. Fallowing is most effective on Pullman clay loam and other droughty soils in the county. Suitable cropping systems that provide fallow are (1) continuous wheat with occasional fallow; (2) wheat-grain sorghum with occasional fallow; or (3) wheat-fallow-wheat.

Wheat is the major crop in most dryland cropping systems. Straw, stubble, and other residues are needed on the soil surface until planting time. If the soils are wet to a depth of about 2 feet or more, the residues can be mixed into the soil before planting. Then the crop planted can use the moisture in the soil and grow fast enough to protect it. If there is no stored moisture, it is essential to plant wheat in the residues. The residues will protect the soil if the wheat crop fails.

Less intensive cropping systems are needed on the Mansker, Mobeetie, Ulysses, and other of the shallow to moderately deep, sloping, limy soils. Continuous small grain or close-drilled feed crops grown on the contour are suitable, but the residues from these crops should be used as a stubble mulch.

Capability groups of soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they are used for the ordinary field crops or sown pastures, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have their own special requirements for production. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible major reclamation.

In the capability system, all soils are grouped at three levels, the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groupings, are designated by Roman numerals I through VIII. These numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

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

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

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

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

Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

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

Class VII. Soils that have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production without major reclamation and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. No class VIII soils were mapped in Deaf Smith County.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, is used in those areas where climate is the chief limitation to the production of common cultivated crops.

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

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Deaf Smith County are described and suggestions for the use and management of the soils are given. All the soils in the county have been placed in dryland capability units, but only those soils suited to irrigation have been placed in irrigated capability units.

Management of dryland capability units

In the following pages, the dryland capability units are described, and suggestions for use and management are given. The soils in each capability unit can be determined by referring to the "Guide to Mapping Units" at the back of this soil survey. Also, the capability unit assigned to any soil is listed at the end of the description of that soil in the section "Descriptions of the Soils."

CAPABILITY UNIT IIIce-1 (DRYLAND)

Pullman clay loam, 0 to 1 percent slopes, is the only soil in this capability unit. It is a deep, well-drained, nearly level soil that has a slowly permeable, clayey subsoil. This soil occupies the main part of the nearly level, smooth High Plains, and it makes up a large part of the dry cropland in the county.

This soil contains moderately large amounts of plant nutrients and organic matter. Tilth is generally good, and the surface layer absorbs water moderately well when it is in good condition. After hard, beating rains, however, crusting is likely, especially if the surface is not protected by crop residues. Surface crusting is more severe in areas where tillage has mixed part of the clayey subsoil into the surface layer. The tight subsoil takes in water slowly and hinders the penetration of plant roots. Most plant roots grow along the surfaces of the soil aggregates.

This soil is ideally suited to farming on a large scale. Well-suited crops are wheat, grain sorghum, and forage sorghum.

The main concerns in managing this soil are improving the tilth of the surface layer, conserving moisture, and controlling soil blowing. The hazard of soil blowing, however, and of water erosion, is only slight. Sorghums and wheat both produce a large amount of crop residues. Terraces and contour farming are needed on long slopes so as to control water erosion and to increase the amount of water that soaks into the soil.

CAPABILITY UNIT IIIce-2 (DRYLAND)

In this unit are deep, nearly level soils that have a brown to dark grayish-brown clay loam surface layer and a clay loam subsoil that is moderate to moderately slow in permeability. The subsoil is underlain by pinkish-white to white caliche at a depth of 25 to 60 inches. In this county these soils occur throughout the High Plains and have a large total acreage.

The soils in this unit are moderately high in natural fertility. Water soaks into the surface and moves readily into the subsoil, where a moderately large amount is stored for use by plants.

These soils are among the most productive in the county for dryfarming. They are well suited to wheat, grain sorghum, and forage sorghum.

The main purposes in managing these soils are controlling erosion, maintaining good tilth, and conserving moisture. A good way to control soil blowing is to seed sorghum, wheat, and other crops that produce large amounts of residue and to leave most of the residues on the surface.

CAPABILITY UNIT IIIce-3 (DRYLAND)

This unit consists of moderately deep, nearly level, calcareous soils. These soils have a loamy surface layer and a moderately permeable subsoil.

The soils in this unit have moderate capacity for holding available water and plant nutrients. Water soaks into and through the soils at a moderate rate. Because a large part of the subsoil consists of worm casts, it is granular, is friable, and permits good development of plant roots. Tillage is easy throughout a wide range of moisture content. In areas in native grass the surface layer contains a moderate amount of organic matter, but much organic matter has been lost in cultivated areas. These soils blow easily if the surface is bare because the lime tends to disperse the soil aggregates or clods into fine, crumbly or powdery granules.

Wheat, grain sorghum, and forage sorghum are well-suited crops. During dry periods, the grain sorghum is affected by chlorosis because of the high content of lime.

The main concerns of management are controlling soil blowing and conserving moisture. Soil blowing can be controlled by leaving most of the crop residues on the surface and by the use of implements of the sweep or chisel type. Crop residues on the surface help to keep the soil open and to increase the water intake. Terraces may be needed on long slopes. Tillage should be such that the more limy subsoil is not brought to the surface.

CAPABILITY UNIT IIIce-4 (DRYLAND)

Only Pullman-Ulysses complex, 0 to 1 percent slopes, is in this capability unit. The complex is one of intermingled soils that are deep and moderately deep over soft caliche. These soils are nearly level, are well drained, and have a slowly to moderately permeable subsoil.

The soils in this unit contain moderately large amounts of plant nutrients and organic matter. Tilth is generally good. The surface layer absorbs water moderately well when the soils are in good condition, but crusting is likely after hard, beating rains. Crusting is especially noticeable on the Pullman soil where the surface is not protected by crop residues. Also, the tight subsoil of the Pullman soil hinders penetration of plant roots and water. On the Ulysses soil, the calcareous surface layer tends to accelerate wind erosion.

The soils in this unit are well suited to farming on a large scale. The most common crops are wheat, grain sorghum, and forage sorghum.

The main objectives in managing the soils in this capability unit are maintaining the tilth, conserving moisture, and controlling soil blowing. Sorghums and wheat both produce a large amount of crop residues. Terraces and contour farming are needed on long slopes so as to control water erosion and to increase the amount of water that soaks into the soil.

CAPABILITY UNIT IIIe-1 (DRYLAND)

Only Pullman clay loam, 1 to 3 percent slopes, is in this capability unit. It is a deep, gently sloping soil that has a brown to dark-brown, loamy surface layer and a compact, slowly permeable, clayey subsoil. Pink to white caliche is at a depth of about 40 inches. This soil is on gentle slopes around playas and along draws on the High Plains.

The surface layer of this soil generally has good tilth. It crusts easily, however, where plowing is deep and large amounts of the clayey subsoil are mixed into it. Crusting increases runoff and probably increases the hazard of soil blowing.

Wheat, grain sorghum, and forage sorghum are well-suited crops.

The main concerns in managing this soil are controlling water erosion and soil blowing and conserving moisture. Terracing and contour tillage help control water erosion and, by slowing runoff, allow more rainfall to soak into the soil. By leaving most of the crop residues on the surface, soil blowing is controlled, loss of water through evaporation is lessened, and sealing after rains is prevented. Another practice that helps control soil blowing is the use of chisels or sweeps to roughen the surface and keep it cloddy.

CAPABILITY UNIT IIIe-2 (DRYLAND)

In this unit are deep, gently sloping soils that have a loamy surface layer and moderate to moderately slow permeability in the subsoil. These soils have a brown to dark grayish-brown surface layer and a clay loam subsoil. The Olton and Zita soils in this unit are underlain by pink to white caliche at a depth of 25 to 60 inches, but the Bippus soils have a pale-brown, limy substratum.

The soils in this unit have good tilth and moderate to high fertility. Well-suited crops are dryfarmed wheat, grain sorghum, and forage sorghum.

The main concerns of management are conserving moisture and controlling soil blowing and water erosion. Soil blowing can be controlled by leaving most of the crop residues on the surface. Terracing and contouring are needed because they help to control water erosion and to slow down runoff so that more rainfall soaks into the soil. In most places some kind of an outlet is needed for terrace systems. In some areas the outlets empty onto adjoining rangeland. In other areas waterways are needed for draining the terraces.

CAPABILITY UNIT IIIe-3 (DRYLAND)

This unit consists of gently sloping, calcareous soils that have a granular clay loam subsoil. These soils are moderately extensive in this county, and they occur on the High Plains and in the Canadian breaks.

The soils in this unit take water at a moderate rate. They are mellow and easy to till. Natural fertility, though low in some eroded cultivated areas, is adequate for dryfarming. Because of the content of lime, soil aggregates in the surface layer break down easily if the layer is disturbed. These soils are susceptible to water erosion, especially where the surface is bare.

Well-suited crops are wheat, grain sorghum, and forage sorghum. The grain sorghum is commonly affected by chlorosis during dry periods.

Management is needed that controls soil blowing and water erosion and conserves moisture. Soil blowing can be controlled by using implements of the sweep or chisel type and by leaving most of the crop residues on the surface. Crop residues are also needed to lessen loss of soil moisture through evaporation. Terraces and contour farming help to control runoff and water erosion.

CAPABILITY UNIT IIIe-5 (DRYLAND)

Only Springer fine sandy loam, 1 to 3 percent slopes, is in this unit. This deep, gently sloping soil is inextensive in this county. It is in the Canadian breaks. The surface layer is grayish-brown, neutral, granular sandy loam. The subsoil is friable fine sandy loam that is moderately rapid in permeability. At a depth of 30 inches, this soil is generally calcareous and moderately alkaline.

This soil absorbs water readily. If formation of a plowpan is prevented, runoff is slight. This soil has fair natural fertility, but it tends to blow under cultivation and to lose organic matter and plant nutrients.

All of the acreage is range, but grain sorghum and forage sorghum are suited. The main purpose of management is controlling soil blowing. Practices are needed that leave as much of the crop residues on the surface as is possible. Enough of the stalks should be covered to anchor them.

CAPABILITY UNIT IIIe-7 (DRYLAND)

Only Pullman-Ulysses complex, 1 to 3 percent slopes, is in this capability unit. The complex is one of intermingled soils that are deep and moderately deep over caliche. These soils are gently sloping, are well drained, and have a slowly to moderately permeable subsoil.

The soils in this unit contain moderately large amounts of plant nutrients and organic matter. Tilth is generally good. The surface layer absorbs water moderately well when the soils are in good condition, but crusting is likely after hard, beating rains. Crusting is especially noticeable on the Pullman soil where the surface is not protected by crop residues. Also, the Pullman soil has a tight subsoil that restricts movement of water and roots. The Ulysses soil is most susceptible to soil blowing because of the lime in the surface layer.

These soils are suited to wheat, grain sorghum, and forage sorghum. The main hazards are moderate susceptibility to both soil blowing and water erosion.

The main objectives in managing this capability unit are maintaining the tilth of the surface layer, conserving moisture, and controlling soil erosion. Sorghums and wheat both produce large amounts of crop residues. Terraces, contour farming, and surface litter are needed to control water erosion and soil blowing and to increase the amount of water that soaks into the soil.

CAPABILITY UNIT IVe–2 (DRYLAND)

In this unit are moderately sloping, calcareous soils that have a loamy surface layer. These soils are shallow over soft or gravelly caliche. They are moderately extensive in this county. They occur in the Canadian breaks and on the slopes of Tierra Blanca and Palo Duro Creeks.

The soils in this unit are mellow and easy to work. The surface layer is moderate in natural fertility, but the subsoil is somewhat low in content of organic matter and plant nutrients. Water is taken into these soils readily, and it soaks through the subsoil at a moderate rate.

Well-suited crops are grain sorghum, wheat, and forage sorghum.

One of the main hazards in cultivating these soils is water erosion. Also, soil blowing is likely where the surface is bare, for the lime in the surface layer causes the soil aggregates to break down into powdery granules. Terraces and contour farming are necessary to prevent sheet erosion and gully erosion and to help conserve moisture. Tillage should be done in a manner that leaves most of the stalks and straw on the surface throughout the year. Also, it is advisable not to till these soils in a way that brings parts of the more limy subsoil to the surface.

CAPABILITY UNIT IVe–3 (DRYLAND)

Pullman clay loam, 1 or 3 percent slopes, eroded, is the only soil in this capability unit. It is a deep, gently sloping, loamy soil that is eroded and has a slowly permeable subsoil. This soil is around playas and along draws in small areas of the High Plains.

Rills and shallow gullies are numerous; in this eroded soil an average of only 2 to 4 inches of the original surface layer remains. In most places clods from the clayey subsoil have been mixed into the plow layer, and it contains more clay than the plow layer of uneroded Pullman soils. Consequently, the plow layer crusts readily and runoff increases. Fertility has been lessened by an average loss of 2 to 3 inches of the surface layer.

This soil is used mostly for dryfarming and range, but a few areas are irrigated. The main crops are grain sorghums and wheat.

Preventing further erosion and increasing the fertility of the surface layer are the main purposes of management. Field terraces, diversion terraces, and contour farming are needed to control runoff. In some places grassed waterways are needed as outlets for terraces. Soil blowing can be controlled by leaving most of the crop residues, stalks and straw, on the soil surface. Crop residues are especially needed in winter when the surface is bare.

CAPABILITY UNIT IVe–5 (DRYLAND)

This unit consists of deep, calcareous, loamy soils that have moderately rapid permeability in the subsoil. These soils are on side slopes of draws and on foot slopes below escarpments. Their profile is fine sandy loam throughout.

The surface layer takes in water readily, but these soils normally are dry below about 30 inches because water is lost as runoff.

The soils of this unit are better suited as rangeland than as cropland, but grain sorghum or forage sorghum can be grown.

The main concerns of management are controlling runoff and soil blowing. Terraces and contour farming are needed for control of water erosion. Susceptibility to soil blowing is increased by the lime in the surface layer. Crop residues should be covered with just enough soil to anchor them. During the fallow period, especially in winter and spring when soil blowing is most likely, crop residues should be left on the surface.

CAPABILITY UNIT IVe–9 (DRYLAND)

In this unit are calcareous, loamy soils that are underlain by caliche. These soils have a limy surface layer underlain by a granular, friable layer. The Mansker soils in this unit are shallow over soft or gravelly, whitish caliche. The Lea soils are moderately deep over indurated caliche. These nearly level to gently sloping soils are on the High Plains. They range from patches a few acres in size to as much as about 100 acres.

The soils in this unit are easy to work. Their natural fertility is adequate for dryfarming. Water soaks readily into the surface, and it moves easily through the subsoil.

Grain sorghum, wheat, and forage sorghum are suitable crops.

Management is needed to control erosion. Most of the crop residues should be left on the surface throughout the year. Water erosion can be controlled by terraces and contour farming. It is advisable to till in such a way that little or none of the limy subsoil is mixed into the surface layer.

CAPABILITY UNIT IVes–1 (DRYLAND)

Church clay is the only soil in this unit. This soil is deep, limy, and very slowly permeable. In this county it is moderately extensive and occurs on the High Plains on level, smooth benches surrounding the larger playas.

The soil in this unit is moderately high in natural fertility, and it has high capacity for storing plant nutrients. It also holds a large amount of water, but this moisture is released slowly to plants because the content of clay is high. Soil blowing is likely if a good vegetative cover is not kept on the surface. Following hard rains, when the surface crusts, this soil is especially susceptible to blowing.

Grain sorghums and wheat are well suited.

Management is needed mainly for controlling soil blowing and conserving moisture. Most of the crop residues should remain on the surface, especially during winter and spring when soil blowing is critical.

CAPABILITY UNIT IVs–1 (DRYLAND)

Only Montoya clay is in this unit. This reddish-brown, nearly level soil is deep, but it has a very slowly permeable subsoil. It occupies nearly level flats or slight depressions in the Canadian breaks. These areas are locally called Galleta flats because they have a dense cover of galleta.

This soil is low in natural fertility. Surface runoff is slow, and internal drainage is very slow. This soil is droughty, and it cracks when it is dry. It swells and tends to seal when it is wet. Large amounts of water in the profile are stored in this deep soil, but in summer the water from showers is stored mainly in the upper few inches and is lost through evaporation.

All of the acreage of this soil is range. The main concerns of management are conserving moisture and controlling soil blowing.

CAPABILITY UNIT Vw-1 (DRYLAND)

Only the mapping unit Spur and Bippus soils is in this capability unit. These soils occur along Tierra Blanca and Palo Duro Creeks and are occasionally flooded. They are on smooth, level bottom lands, which are cut by an intermittent, ditchlike channel that carries most of the streamflow. The soils are deep clay loams to fine sandy loams.

These soils receive extra runoff that helps them to support heavier stands of grasses than soils of similar texture on uplands. Erosion is none to slight, but the entrenched stream channel may cut further into the bottom land.

The main practice needed on these soils is managing the grazing so that good stands of grasses are maintained. The better grasses are western wheatgrass, switchgrass, and sideoats grama.

CAPABILITY UNIT Vw-2 (DRYLAND)

Lincoln soils, the only soils in this capability unit, are on bottom lands of the Canadian breaks and are flooded from time to time. These soils are deep. They consist of the sediments deposited by the floods in stratified layers of coarse sand, fine sand, and loamy sand. In this county the total acreage of these soils is small.

All of the acreage of these soils is range. The present vegetation is sand dropseed, blue grama, and sagebrush.

Soil blowing is the main concern of management, for the overgrazed areas blow easily. Switchgrass, indiangrass, sand bluestem, and other tall grasses can grow on these soils if management is good.

CAPABILITY UNIT VIe-1 (DRYLAND)

This unit consists of calcareous, loamy, sloping soils that have a moderately permeable subsoil. These soils are moderately deep and have a limy surface layer and a granular, friable subsoil. They are mostly on slopes around playas and along streams of the High Plains, but some areas are along streams and draws in the Canadian breaks.

Because erosion is a hazard, the soils in this unit are not suitable for cultivation. All of the acreage is native range on which the cover is mainly blue grama, some sideoats grama, and in most areas, scattered yucca.

CAPABILITY UNIT VIe-2 (DRYLAND)

Mobeetie fine sandy loam, 5 to 8 percent slopes, is the only soil in this capability unit. This soil is moderately extensive in the county and occurs on side slopes of draws and on foot slopes below escarpments. It is calcareous and has a subsoil of sandy loam that is moderately rapid in permeability.

Water is taken readily into the surface layer, and it moves easily through the subsoil. A good cover of grass prevents damage by runoff, but this soil washes and blows easily if grazing is excessive.

This soil is not suitable for cultivation, because of the severe hazard of soil blowing and water erosion. All of this soil is range that provides some of the best grazing in the county. The native vegetation consists of blue grama, sideoats grama, and scattered yucca.

CAPABILITY UNIT VIe-3 (DRYLAND)

This unit consists of moderately deep, sloping soils that have a high content of lime. These soils occur on the eastern sides of playas of the High Plains. They have a granular, moderately permeable subsoil. The water from rain soaks into the surface readily and moves through the surface layer and subsoil at a moderate rate.

Soil blowing is the main hazard. Soil particles in the surface layer are fluffy or floury because of the high content of lime. When the surface layer is bare, a slight breeze picks up these particles and carries them away. Water erosion is also a hazard in areas that lack a cover of plants.

These soils are suitable only for range. Grazing should be controlled so that sideoats grama and blue grama provide a good cover.

CAPABILITY UNIT VIw-1 (DRYLAND)

Randall clay is the only soil in this unit. It is a poorly drained soil at the bottom of the playas, where it formed from clayey sediments washed from the High Plains. It is subject to flooding for a few weeks to several months each year. Because the content of clay is high, this soil shrinks and cracks when it is dry and seals when it is wet. When the cracks are closed the movement of water through the soil nearly ceases.

In winter the larger playas provide food, protection, and water for large numbers of ducks. In wet seasons some of the playas provide dense forage for livestock. The native vegetation mainly consists of smartweeds, sedges, blueweeds, and ragweeds. Western wheatgrass and buffalograss grow in some of the drier playas.

Only a small acreage of this soil is cultivated. A few of the smallest areas, 2 to 5 acres in size, are farmed with the adjacent areas of Pullman or Ulysses soils. The main concern in managing this soil is soil blowing. Soil blowing generally follows the drowning of the vegetation and the drying of the lake. Then the surface of this soil is bare.

CAPABILITY UNIT VIIs-1 (DRYLAND)

This unit consists of strongly calcareous, gently sloping to steep soils. These soils are very shallow over soft caliche, indurated caliche, or clayey shale. They are in gently sloping to moderately sloping areas of the High Plains, in sloping to steep areas along draws and escarpments, or on ridges and steep hills of the High Plains and the Canadian breaks.

The soils in this unit have a surface layer 4 to 12 inches thick that overlies unweathered cemented caliche, indurated caliche, or shaly red beds.

These soils have very low natural fertility and waterholding capacity. Most of the rainfall is lost as runoff because slopes are generally strong or steep and the soils are very shallow to cemented caliche.

These soils are mostly range, but they provide only a little forage. Mid and short grasses are sparse. Controlled grazing is essential for improving the stands and controlling water erosion.

CAPABILITY UNIT VIIs-2 (DRYLAND)

Only Rough broken land is in this unit. It is strongly calcareous and occurs in sloping to very steep, rough, broken areas. This land is suitable only for limited grazing and for wildlife. The vegetation is generally sparse in most places, but on the lower slopes, a few small pockets of the deeper soil material support fair stands of grasses. A few good patches of grass grow on the very steep slopes where grazing is difficult. Nearly all the kinds of grasses in Deaf Smith County grow on this land. Little bluestem, sand bluestem, and sideoats grama are common north-facing slopes. On the drier southern slopes, the grasses are mainly hairy grama, black grama, blue grama, and three-awn.

This land is the main habitat for the mule deer in Deaf Smith County.

Managing irrigated soils

Managing irrigated soils began in Deaf Smith County after the first irrigation wells were drilled during the early part of the 1940's. The number of wells increased slowly until the first part of the 1950's. Then a severe drought emphasized the need for supplemental irrigation, and the number of irrigation wells increased rapidly. An estimated 2,500 to 3,000 wells in the county currently are furnishing water to about 280,000 irrigated acres (fig. 11).

The wells are 200 to 400 feet deep, and in most of them water is pumped from the sand and gravel at the base of the Ogallala formation. The rate of pumping ranges from about 400 to 900 gallons per minute and averages about 700 gallons. This water, except for some of it in the deepest wells, is of high quality. From a few of the deepest wells, water is pumped from below the Ogallala formation and contains harmful salts.

Most of the irrigated soils are clay loams or loams of the Pullman, Olton, and Ulysses series. The infiltration rate for these soils ranges from about 0.1 to 1 inch per hour. The infiltration rate, or the rate water enters the

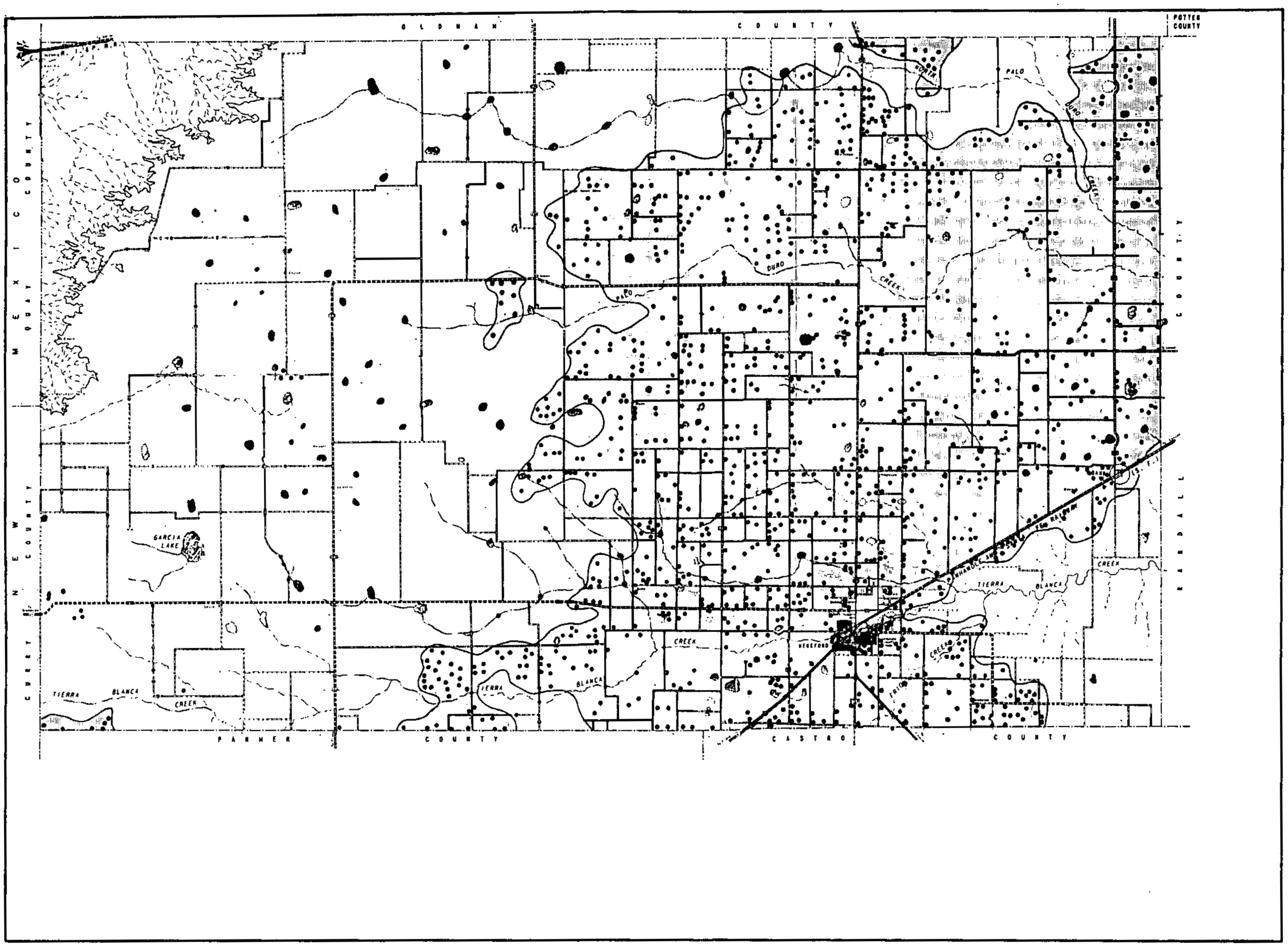

Figure 11.—**In Deaf Smith County, practically all of the irrigation wells are in the eastern half.**

soils, generally determines the lengths of irrigation runs that the farmers use. The nearly level, smooth soils that dominate on the High Plains are well suited to graded-furrow irrigation, which is the method most commonly used. Most areas require only a little land leveling or smoothing before they are irrigated. Water is pumped from the irrigation wells into open ditches or underground pipelines. These ditches or pipelines convey the water to the high end of the fields, where it is turned into the furrows. Some of the more sloping areas are leveled and irrigated by the graded-border and graded-furrow methods.

Wheat and grain sorghum are the principal irrigated crops in Deaf Smith County, but there are smaller acreages of forage sorghum, silage, alfalfa, soybeans, vegetables, and sugarbeets. Because a new sugar refinery was recently constructed at Hereford, the acreage in sugarbeets is increasing.

The main practices needed on soils used for irrigation are (1) suitable cropping systems, (2) good management of crop residues, (3) adequate fertilization, (4) proper management of water, and (5) measures for controlling soil blowing and water erosion.

Essentially the same cropping systems as those used for dryland can be used under irrigation. On irrigated soils, however, a better soil-improving and fertility program is needed because the crops generally grown are high yielding and quickly deplete the soil of plant nutrients. Also, the additional water enables the farmer to grow a larger number of crops. More residues can be produced, and more crops can be grown for cover and green manure.

Better use can be made of the crop residues, such as wheat and sorghum stubble, if plenty of moisture is available. The most practical way to improve and to maintain fertility and productivity is to return large amounts of fertilized crop residues to the soils. Nitrogen fertilizer is applied on crop residues to help decompose them. This prevents a nitrogen shortage in the following crop.

Under irrigation, crop residues—stalks and straw—are left on the surface for the purpose of protecting it. Following harvest, the residues are usually gone over with a shredder and tandem disc. This chops up the residues and tucks, or anchors them, into the soil to prevent them from blowing and washing away and at the same time leaves a protective cover on the surface. This cover is maintained until the seedbed is prepared for preirrigation and planting.

Fertilizer is added to nearly all of the irrigated crops in Deaf Smith County. The amount added is based on previous cropping history, soil tests, results of research, and the farmer's production goal. Technicians of the Soil Conservation Service or Agricultural Extension Service will assist farmers in planning fertilization programs. Generally soils under irrigation are low in nitrogen and phosphorus but are high in potash.

Water must be applied to the soils in such a way that prevents waste of the water and loss of soil through erosion. Also, it must be applied in amounts determined by the needs of the crops grown. Deep-rooted crops, such as wheat, permit greater applications of water at less frequent intervals than vegetables. Pullman clay loam and other deep soils require heavier applications of irrigation water than the Mansker and other shallow soils.

For control of soil blowing and water erosion about the same kind of practices are needed on irrigated soils as are needed on dryfarmed soils.

The acreage in irrigated pasture has been increasing in recent years. The pasture is of two kinds. On one kind the grasses are indiangrass, switchgrass, sand bluestem, and other tall native grasses. The other kind consists of irrigated domestic (tame) grasses, such as Midland bermudagrass. If these kinds of pasture are to produce the maximum forage, a good program of maintaining fertility, managing water, and regulating grazing must be followed.

In 1962 about 12,000 acres of vegetables and sugarbeets were grown in Deaf Smith County. Most of this acreage was on Pullman clay loam, Ulysses clay loam, and Olton clay loam.

In Deaf Smith County, the main vegetable crops and their average acreage in recent years are approximately (1) potatoes, 4,000 acres; (2) onions, 2,500 acres; (3) lettuce, 2,500 acres; (4) carrots, 2,000 acres; and (5) cabbage, 200 acres. Sugarbeets are grown on about 1,200 acres, and there are smaller acreages of spinach, tomatoes, beans, pumpkins, watermelons, and peppers. Vegetables are farmed mostly within a 20-mile radius of Hereford.

The yields of sugarbeets and vegetables depend mainly on (1) the amounts and frequency of irrigation; (2) the kind and amount of fertilizer used; (3) the practices used for control of insects and diseases; (4) the time of planting; and (5) the prevailing climate from the time of planting through harvesting.

Average acre yield on Pullman clay loam and Olton clay loam under good management are—

Potatoes (100 lb. sacks)	190
Lettuce (cartons)	550
Onions (50 lb. sacks)	500
Carrots (tons)	10
Sugarbeets (tons)	20

Yields are slightly less on the Ulysses soils.

Heavy applications of fertilizers, mainly nitrogen and phosphorus, are used on all vegetables. A crop of potatoes is commonly followed with wheat or another small grain. The small grain generally grows well, apparently because of the unused fertilizer that remains from the heavy applications. A small grain also provides good winter cover. Where a vegetable is not followed in fall by a small grain, the tops of the vegetable plants are generally left on the surface to lessen soil blowing. This practice and emergency tillage usually are enough to prevent soil blowing.

Management of irrigated capability units

In the following pages the irrigated capability units are described and management of these units is suggested. Only those soils suitable for irrigation have been placed in irrigated capability units. The soils in each unit can be found by referring to the "Guide to Mapping Units" at the back of this soil survey.

CAPABILITY UNIT I-1 (IRRIGATED)

Olton clay loam, 0 to 1 percent slopes, is the only soil in this capability unit. This nearly level soil is deep, well drained, and nearly level. It has a clay loam surface layer and moderately slow permeability in the subsoil. In this county most areas of this soil are on the High Plains, but some areas are on playa benches.

This soil is moderately high in natural fertility. Its surface layer generally has good tilth, is mellow, and easy to work, but it is slightly susceptible to soil blowing. Where the surface is bare, the surface layer is likely to crust after hard, beating rains. The clay loam subsoil is moderately tight and permits only slow movement of water and air, but the roots of plants penetrate readily and absorb plant nutrients and water.

All kinds of irrigated crops commonly grown in the county are suited to this soil. Among these suitable crops are wheat, cotton, grain and forage sorghums, vegetables, perennial grasses, and alfalfa.

To keep the surface layer mellow and easy to work, most of the stalks, straw, and other crop residues should be left on the surface. This prevents the surface from sealing and allows it to take in water faster. The residues also help to control soil blowing during dry, windy periods. If commercial nitrogen is applied on the dead litter, its decay is hastened, and the nutrients in the litter become more quickly available to plants. Alfalfa, switchgrass, indiangrass, and other grasses or legumes should be included with sorghum or wheat in the cropping system so as to maintain soil tilth and fertility.

CAPABILITY UNIT I–2 (IRRIGATED)

Zita clay loam, 0 to 1 percent slopes, is the only soil in this capability unit. This deep, nearly level soil has a moderately permeable subsoil. It occurs in inextensive areas on the High Plains in the western part of the county. Some areas are near the Pullman and Olton soils.

This soil is moderately high in plant nutrients and water-holding capacity. Natural fertility is moderate in the surface layer and subsoil. The surface layer is easy to work and takes in water readily. The subsoil has structure favorable for the growth of plants and is easily penetrated by roots. If this soil is cultivated when it is too wet, plowpans tend to form in the lower part of the surface layer. Susceptibility to soil blowing is slight to moderate.

This soil is one of the most productive soils in the county. Well-suited crops are wheat and grain sorghums. Vegetables and cotton are grown in a few areas.

To control soil blowing, it is necessary to leave stalks and straws on the surface most of the time. Commercial fertilizer should be added to growing crops, as needed. Applying nitrogen to the crop residues hastens their decay. The nitrogen also helps to improve tilth and to raise the level of plant nutrients. A soil-improving crop, such as alfalfa or perennial grasses, is needed in the cropping system to keep the soil open and to maintain fertility.

CAPABILITY UNIT IIe–1 (IRRIGATED)

This unit consists of deep, gently sloping soils that have a clay loam surface layer and a moderately permeable subsoil. In this county these soils are along draws and around playas of the High Plains.

These soils have moderately high natural fertility and water-holding capacity. The surface layer is moderately easy to till, and it absorbs water readily. The subsoil has a moderate supply of plant nutrients. It is thick enough and has structure favorable for the growth of roots. The hazard of soil blowing is slight to moderate. Plowpans tend to form in the lower part of the surface layer if these soils are worked when wet. These soils are suited to wheat, grain sorghum, forage sorghum, vegetables, and perennial grasses. Cotton and forage sorghum are grown on a few acres.

For control of soil blowing and surface crusting, stalks and straws should be left on the surface most of the time. The residues on the surface also help to control wind erosion and to prevent surface crusting. Some farmers add nitrogen to the residues to hasten their decay and improve tilth.

CAPABILITY UNIT IIe–2 (IRRIGATED)

Olton clay loam, 1 to 3 percent slopes, is the only soil in this unit. This deep, nearly level soil has moderately slow permeability in the subsoil. It is on slopes around playas and along draws of the High Plains.

The soil in this unit is moderately high in organic-matter content and plant nutrients. The surface layer is mellow and easy to work when it is in good tilth, but plowpans tend to form in the lower part if this soil is worked when too wet. The clay loam subsoil is moderately tight, but most of it can be penetrated by roots. Water and air move slowly through the subsoil. The hazard of soil blowing is slight to moderate.

Well-suited crops are wheat, grain and forage sorghums, vegetables, sugarbeets, perennial grasses, and alfalfa. Small acreages of cotton and silage are grown.

For the purpose of keeping the surface layer mellow and easy to work, most of the stalks, straw, and other litter should be left on the surface. These residues protect this soil against erosion and keep the surface layer from sealing after heavy rains. By adding nitrogen to the crop residues, decay is hastened and the nutrients in the residues are sooner available to crops.

CAPABILITY UNIT IIe–3 (IRRIGATED)

Ulysses clay loam, 0 to 1 percent slopes, is the only soil in this capability unit. It is a deep, nearly level, calcareous soil that has a moderately permeable subsoil. This soil is on the High Plains, where it occurs with the Pullman and Olton soils.

This soil takes in water readily and permits it to move easily through the subsoil. Roots thoroughly permeate the soil mass. The surface layer contains a moderate supply of plant nutrients, but the subsoil is somewhat low in fertility. The underlying caliche supplies roots with only a small amount of plant nutrients and water. Because the surface layer has a high content of lime, it becomes powdery when tilled and blows easily. At times sorghums are affected by chlorosis, or yellowing of the leaves. Chlorosis is especially noticeable during dry periods. Wheat, grain sorghum, and alfalfa are well suited, and a small acreage is in vegetables and cotton.

On this soil good management is needed for maintaining or improving fertility, controlling erosion, and using irrigation water effectively. Organic matter can be maintained at a high level in the surface layer by growing grain sorghum, small grains, and other crops that produce large amounts of stalks or straw. These residues are left on the surface, and commercial fertilizer is added so as to speed the decaying processes. Organic matter is also maintained by using perennial grasses or legumes in the cropping system with wheat or grain sorghum. Alfalfa is especially well suited. The main grasses suited are bermudagrass, switchgrass, and indiangrass. They improve the soil and can be used for hay and grazing.

CAPABILITY UNIT IIs-1 (IRRIGATED)

Pullman clay loam, 0 to 1 percent slopes, is the only soil in this capability unit. It is a deep, nearly level soil that has a loamy surface layer and a slowly permeable, clayey subsoil. It lies on the nearly level, smooth High Plains and makes up most of the irrigated cropland in the county.

This soil is moderately high in natural fertility. Its surface layer generally has good tilth and absorbs water readily when in good condition. After hard, beating rains, however, crusting is likely, especially where the surface is bare. Surface crusting is most severe where large amounts of the clayey subsoil have been mixed into the surface layer by plowing. The surface layer is moderately easy to work, but working the tight, clayey subsoil is difficult. It is extremely hard when dry and sticky when wet, and water moves through it very slowly.

This soil produces most of the irrigated wheat, grain sorghum, and forage sorghum in the county and a large part of the potatoes, onions, carrots, lettuce, and sugarbeets. Also grown are smaller acreages of cotton, alfalfa, perennial grasses, and silage.

The main concerns in managing this soil are maintaining or improving fertility and tilth, controlling erosion, and making the best use of irrigation water. Tilth is improved where stalks and straw from the wheat or sorghums are left on the surface. The residues on the surface also prevent wind erosion and make the surface layer easier to work. If fertilizer is applied, the plant nutrients in the residues are used sooner by the crops.

Where vegetables are grown, most of the tops and other residues should be left on the surface during winter so as to control wind erosion. Some growers include winter wheat in the crop rotation with vegetables and in this way use the wheat both as a cover crop and cash crop.

CAPABILITY UNIT IIs-2 (IRRIGATED)

Only Pullman-Ulysses complex, 0 to 1 percent slopes, is in this capability unit. This is a complex of intermingled soils that are deep and moderately deep over soft caliche. These soils are nearly level, are well drained, and have a slowly to moderately permeable subsoil.

The soils in this unit contain moderately large amounts of plant nutrients and organic matter. Tilth is generally good. The surface layer absorbs water moderately well when in good condition, but crusting is likely after hard, beating rains. Crusting is especially noticeable on the Pullman soil where the surface is not protected by crop residues. Crusting is most severe where large amounts of the clayey subsoil have been mixed into the surface layer by plowing. The surface layer is moderately easy to work, but working the clayey subsoil is difficult. The limy surface layer of the Ulysses soil tends to blow and erode. Chlorosis, or yellowing of leaves, is common on grain sorghum grown on the Ulysses soil.

These soils are well suited to wheat, grain sorghum, and forage sorghum, which are grown extensively. They are also suited to potatoes, onions, carrots, lettuce, and sugarbeets, but these crops are less extensively grown.

The main concerns in managing these soils are maintaining or improving fertility and tilth, controlling soil erosion, and making the best use of irrigation water. Tilth is improved where stalks and straw are left on the surface. These residues also prevent soil blowing and make the surface layer easier to work. Fertilizer applied to the plant residues hastens their decay so that the nutrients can be used sooner by the crops.

Where vegetables are grown, most of the tops and other residues should be left on the surface during winter so as to control soil blowing.

CAPABILITY UNIT IIIe-1 (IRRIGATED)

Pullman clay loam, 1 to 3 percent slopes, is the only soil in this unit. This is a deep, gently sloping soil that has a slowly permeable, clayey subsoil. This soil occurs on the High Plains around playas and on side slopes of draws.

This soil is moderately high in organic matter and plant nutrients. Tilth is generally good in the surface layer. After hard rains, however, crusting is likely where the surface is bare, runoff increases, and the soil blows more readily. This soil is slightly susceptible to soil blowing and is moderately susceptible to water erosion. The surface layer is easy to work, but the subsoil is tight and clayey and permits only slow movement of air and water. Roots generally follow the cracks between the dense blocks or cubes in the subsoil.

Well-suited crops are wheat, grain sorghum, forage sorghum, and vegetables. Cotton and alfalfa are grown in small acreages.

For large amounts of residues, wheat, sorghums, and similar crops should be grown. Leaving crop residues on the surface is a good way to increase the water intake and control soil blowing.

CAPABILITY UNIT IIIe-2 (IRRIGATED)

Pullman clay loam, 1 to 3 percent slopes, eroded, is the only soil in this unit. It is a deep, slowly permeable, eroded soil that occurs around playas on the High Plains. Rills and shallow gullies are numerous, and between 50 and 75 percent of the surface layer has been removed by sheet erosion. The surface layer is more clayey and less fertile than originally because clayey clods from the subsoil have been mixed into it by plowing. Runoff is apt to increase because the surface tends to crust and bake.

By keeping this soil in legumes or perennial grasses, fertility is built up and tilth is improved. Also, soil blowing is controlled. If crops are grown, they should be ones that produce a large amount of stalks and straw, such as sorghums or wheat. Adding commercial fertilizer to residues left on the surface hastens their decay and greatly increases soil fertility.

CAPABILITY UNIT IIIe-4 (IRRIGATED)

Ulysses clay loam, 1 to 3 percent slopes, is the only soil in this capability unit. This deep, gently sloping soil is calcareous. It is moderately deep over soft caliche. The subsoil is clay loam and is moderately permeable. This soil occurs with the Olton and Pullman soils.

Well-suited crops are grain sorghum, wheat, forage sorghum, and alfalfa.

The surface layer contains moderate amounts of organic matter and nutrients, but the subsoil is somewhat low in natural fertility. Water soaks into the surface readily, and it moves easily through the subsoil. This soil is susceptible to soil blowing because the lime in the surface layer makes it powdery and loose, especially where tillage is excessive. Also, the lime causes chlorosis, or yellowing of leaves, in sorghums, especially if the plants need water.

Fertility can be maintained if large amounts of organic residues are kept on the surface. This treatment also helps in controlling soil blowing. Adding nitrogen to these residues speeds their decay and releases nutrients for the next crop.

If perennial grasses, legumes, or other soil-improving crops are grown part of the time in the cropping system, they help build up tilth and fertility. Alfalfa, a lime-tolerant plant, grows especially well.

CAPABILITY UNIT IIIe-5 (IRRIGATED)

Only Pullman-Ulysses complex, 1 to 3 percent slopes, is in this capability unit. This is a complex of intermingled soils that are deep to moderately deep over soft caliche. These soils are gently sloping, are well drained, and have a slowly to moderately permeable subsoil.

The soils in this unit contain moderately large amounts of organic matter and plant nutrients. Tilth is generally good. The surface layer absorbs water moderately well when in good condition. It is moderately easy to work, but the limy surface of the Ulysses soil tends to blow and erode. Chlorosis, or yellowing of the leaves, is common on grain sorghum grown on the Ulysses soil. Surface crusting is common on the Pullman soil.

These soils are suited to wheat, grain sorghum, and forage sorghum, which are grown extensively. Potatoes, onions, carrots, lettuce, and sugarbeets are less extensively grown.

The main concerns in managing these soils are maintaining or improving fertility and tilth, controlling soil erosion, and making the best use of irrigation water. Tilth is improved where stalks and straw are left on the surface. The residues on the surface also prevent soil blowing and make the surface layer easier to work. The plant nutrients in the residues are used sooner by the crops if fertilizer is applied.

CAPABILITY UNIT IIIe-10 (IRRIGATED)

In this unit are calcareous clay loams that are shallow over soft or gravelly caliche and are nearly level to gently sloping. In this county these soils occur on the High Plains.

Legumes and perennial grasses are well-suited crops, but cotton, wheat, forage sorghum, and grain sorghum are also grown.

These soils generally have fair amounts of organic matter in their surface layers but low amounts in their subsoil. Moisture-holding capacity is low because these soils are shallow over caliche. Plants take in only small amounts of water and plant nutrients from the limy substratum. Soil blowing is likely if the surface is left bare. Susceptibility to water erosion is slight.

The main concerns of management are controlling erosion and using fertilizer effectively. Erosion can be controlled and these soils improved by growing perennial grasses or legumes. Alfalfa is especially well suited to these soils. Sorghums, wheat, or other crops that produce large amounts of stalks or straw also can be grown. Crop residues should be left on the surface to control soil blowing. The hazard of soil blowing is increased if plowing is deep enough to mix part of the limy subsoil with the surface layer.

CAPABILITY UNIT IIIes-1 (IRRIGATED)

Only Church clay is in this capability unit. It is a deep, limy, very slowly permeable, clayey soil. This moderately extensive soil occurs on the High Plains on the nearly level, smooth benches that surround the larger playas.

This soil is moderately high in natural fertility and produces about average yields of irrigated crops. Capacity for holding water and plant nutrients is high. The surface layer is moderately easy to work when it is moist. It is extremely hard when it is dry, and it tends to clod if tilled. The clayey subsoil is compact and hard to plow. It is extremely hard when dry and sticky when wet. Water and air move very slowly through it.

Well-suited crops are grain sorghum, forage sorghum, and wheat. Management is needed mainly to maintain and improve fertility and tilth, to control erosion, and to save irrigation water. Leaving a large part of the stalks, straw, and other residues on the surface helps in maintaining tilth and fertility. Adding commercial fertilizer causes much faster decay of the residues.

CAPABILITY UNIT IVe-2 (IRRIGATED)

Mobeetie fine sandy loam, 3 to 5 percent slopes, is the only soil in this capability unit. It is a moderately sloping, calcareous soil. The subsoil has moderately rapid permeability. In this county this soil is on side slopes of draws on the High Plains.

The soil in this unit is easy to work. The surface layer absorbs water readily. The subsoil is friable and open, and it permits water and roots to move through it freely. This soil has a fair supply of organic matter and plant nutrients, but it blows easily because the surface layer is calcareous and contains much sand. Since slopes are moderate, water erosion and gullying are likely.

Well-suited crops are perennial grasses, legumes, grain sorghum, and forage sorghum.

Soil blowing is lessened by growing sorghums and other crops that produce large amounts of stalks in the cropping system. Most of the litter should be left on the surface. Alfalfa, perennial grasses, and other soil-improving crops are also necessary to maintain tilth and to sustain fertility.

CAPABILITY UNIT IVe-4 (IRRIGATED)

Drake soils, 3 to 5 percent slopes, are the only soils in this capability unit. These soils are lime enriched and are moderately sloping.

Natural fertility is somewhat low. In cultivated fields the lime in the surface layer makes it powdery, loose, and highly susceptible to soil blowing. The lime also ties up some nutrients, mainly phosphorus and iron, so that they are not available to plants. This deficiency is indicated by the yellowing of leaves, especially if plants need water.

The chief concerns of management are controlling soil blowing and using irrigation water effectively. Needed in the cropping system are crops that produce large amounts of litter. Most of the litter should be left on the surface to control soil blowing. Alfalfa, perennial grasses, or other crops that improve the soil should be grown at least half the time to sustain tilth or improve fertility.

CAPABILITY UNIT IVe-6 (IRRIGATED)

Mansker clay loam, 3 to 5 percent slopes, the only soil in this unit, is calcareous and moderately sloping. The subsoil has moderate permeability. In this county this soil lies along draws and around playas.

The surface layer contains a fair amount of organic matter and nutrients, but the subsoil is low in fertility. Because this soil is somewhat shallow over soft or gravelly caliche, its moisture-holding capacity is low. The hazard of erosion is moderate.

Well-suited crops are alfalfa, perennial grasses, and grain sorghum.

In the cropping system grain sorghum produces more residues if grown in rows that are closely spaced, or 20 inches or less apart. Crop residues left on the surface help to control blowing. If perennial grasses or legumes are alternated with row crops, they greatly improve tilth and fertility.

Predicted Yields

Predicted average yields per acre of principal crops grown on soils of Deaf Smith County are shown in table 2. The predicted yields of wheat, grain sorghum, cotton, and alfalfa are given for both dryfarmed and irrigated soils under two levels of management. These are average yields to be expected over a period of years. Although small acreages of crops other than those listed are grown in Deaf Smith County, the yields for these crops are not listed because reliable data on yields are not available.

The average level of management is one in which the majority of the farmers use most but not all of the better practices for managing soils, plants, and water. The high level of management is one in which farmers use all of the better practices for managing soils, plants, and water. Only a few farmers use this level of management.

The figures in columns A are predicted yields to be expected under an average kind of management; those in columns B are predicted yields to be expected under a high level of management. For soils that are both dryfarmed and irrigated, yields are given for both methods of farming. If only one method is practical, yields are given for only one method. Not included in table 2 are soils that are used mostly as range.

The figures given in the table are based on information obtained from research; on interviews with farmers; and on observations of others who know the soils and crops of the county.

Use of Soils as Range [4]

The raising of livestock is one of the largest enterprises in Deaf Smith County. Most ranchers have a cow-calf type of operation, consisting mainly of raising calves that are marketed at weaning time. Some ranchers buy

[4] This subsection by DOUGLAS E. CUNNINGHAM, range conservationist, Soil Conservation Service.

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

[Yields in columns A are those obtained under average management; those in columns B are yields to be expected under a high level of management. Absence of figure indicates that crop is not suited or that it is grown only in small amounts. No predictions are given for soils in the Canadian breaks, because no data are available, and these soils probably will not be cropped in the foreseeable future]

Soil	Wheat				Grain sorghum				Cotton		Alfalfa	
	Dryland		Irrigated		Dryland		Irrigated		Irrigated		Irrigated	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lbs.*	*Lbs.*	*Tons*	*Tons*
Bippus clay loam	10. 5	14. 5	40	55	13	15	70	120	550	850	4. 0	6. 0
Church clay	7. 5	9. 0	30	45	8	10	50	70	500	800	3. 0	5. 0
Drake soils, 3 to 5 percent slopes	—	—	—	—	—	—	45	65	500	800	3. 0	4. 0
Mansker clay loam, 0 to 1 percent slopes	7. 0	10. 0	28	37	10	12	50	70	475	725	2. 0	4. 0
Mansker clay loam, 1 to 3 percent slopes	6. 0	9. 0	28	37	9	12	50	70	475	725	2. 0	4. 0
Mansker clay loam, 3 to 5 percent slopes	5. 0	8. 0	—	—	7	11	45	65	—	—	2. 5	3. 0
Mobeetie fine sandy loam, 3 to 5 percent slopes	—	—	—	—	9	11	45	60	—	—	—	—
Olton clay loam, 0 to 1 percent slopes	11. 0	14. 0	35	50	13	17	70	120	550	850	4. 0	5. 5
Olton clay loam, 1 to 3 percent slopes	9. 0	12. 0	35	50	13	16	65	100	500	800	3. 2	5. 0
Pullman clay loam, 0 to 1 percent slopes	9. 0	13. 0	35	55	12	14	70	115	550	825	3. 5	5. 5
Pullman clay loam, 1 to 3 percent slopes	8. 0	13. 0	30	45	10	12	65	100	500	800	3. 2	5. 0
Pullman clay loam, 1 to 3 percent slopes, eroded	7. 0	10. 0	27	35	9	11	50	70	280	350	2. 0	3. 0
Pullman-Ulysses complex, 0 to 1 percent slopes	8. 0	12. 0	35	55	11	13	70	110	550	850	3. 5	5. 5
Pullman-Ulysses complex, 1 to 3 percent slopes	8. 0	11. 0	30	45	10	12	60	100	500	800	3. 2	5. 0
Ulysses clay loam, 0 to 1 percent slopes	7. 0	11. 0	40	55	12	14	60	100	550	850	3. 5	5. 0
Ulysses clay loam, 1 to 3 percent slopes	7. 0	10. 0	32	45	11	13	50	85	500	800	3. 0	4. 5
Zita clay loam, 0 to 1 percent slopes	11. 0	14. 0	40	55	14	18	70	120	550	850	4. 0	6. 0
Zita clay loam, 1 to 3 percent slopes	9. 0	12. 0	35	50	14	16	65	100	500	800	3. 2	5. 0

262-475—68——3

steers at weaning time, graze them for a year, and then sell them to local feeders.

In Deaf Smith County, rangeland accounts for 396,365 acres, or approximately 40 percent of the total land area. Most of the acreage occurs along Tierra Blanca Creek and Palo Duro Creeky and in the Canadian breaks, but small areas are scattered throughout the rest of the county. There are about 90 ranches that range from a few hundred acres to about 25,000 acres in size.

Most of the rangeland is on a rolling landscape, and a small part is hilly, broken, or stony land. Some scattered areas are on the nearly level High Plains.

The native vegetation is mainly short grasses, mostly blue grama and buffalograss. These short grasses are dominant on the Pullman, Olton, and Zita soils of the High Plains and on the Quay soils of the Canadian breaks. On the limy, shallow soils, such as the Mansker, and the moderately sandy soils, such as the Mobeetie, the native vegetation is mid and tall grasses, mainly sideoats grama, switchgrass, and sand bluestem.

In general, most of the rangeland is in fair to good condition. But in places, there has been so much overgrazing that most of the better grasses are gone and the range is in a poor condition. Buffalograss has thickened on most ranges and has taken over some areas originally in native blue grama. Likewise, blue grama has taken over much of the range that was originally bluestem, sideoats grama, and mid and tall grasses. In both places, forage production has decreased. In a few areas, woody plants have invaded, particularly in the Canadian breaks where mesquite is encroaching. Cholla cactus and pricklypear are increasing considerably. On the sandier sites, yucca and sagebrush are increasing and are taking over the area once covered by native grasses.

Range sites and condition classes

A range site consists of soils that support similar kinds and amounts of the original, or climax, vegetation. In a given climate, range sites differ only in the kinds and amounts of natural vegetation they can support. Determining the kinds and amounts of plants that can be grown on a range site is necessary in planning management. The kinds of grasses a soil will grow are mainly determined by soil depth, structure, texture, lime content, and to a lesser extent, its location in the landscape.

Each range site becomes the basis for rangeland treatment because it indicates the kinds and amounts of vegetation that will grow on the site. Each site responds in its own way to grazing use, or to the selective grazing habits of livestock, the numbers of livestock on the site, and the time of year the site is grazed.

On most ranches, a grazing unit, or pasture, generally includes more than one range site. Because livestock are selective and graze one kind of vegetation in preference to others, one of the sites in a grazing unit is likely to be overgrazed first. This part, called the key site, should be used as a basis for managing the grazing of the entire pasture. If the key site is managed correctly, the rest of the pasture will improve.

Livestock are selective in grazing; they seek the most palatable and nutritious plants. Such plants decrease under grazing and are called *decreasers*. As decreasers are grazed out or eliminated, the stands thin out and other plants that were standing by move in. These plants that increase under grazing are called *increasers*.

If overgrazing continues, the successively less desirable plants, called *invaders*, encroach on the site, and the increasers and decreasers are gradually eliminated.

By this process, there are changes in composition of the vegetation on a site. Range condition classes are stages in the downward trend in range vegetation under heavy grazing. Four classes of range condition are recognized, *excellent*, *good*, *fair*, and *poor*. On range in excellent condition, 76 to 100 percent of the plant cover consists of the original vegetation. Range in good condition has a plant cover in which 51 to 75 percent of the vegetation is that originally on the site. On range in fair condition, 26 to 50 percent of the vegetation represents that originally on the site; and on range in poor condition, not more than 25 percent of the original, or climax, vegetation remains.

Descriptions of the range sites

The soils of Deaf Smith County have been grouped into range sites according to the kinds and amounts of climax vegetation produced. The soils that make up each site can be determined by referring to the "Guide to Mapping Units" at the back of this soil survey. Each range site is briefly discussed in this subsection. For each site, the soils are described and the potential vegetation of the site is given.

CLAY FLATS RANGE SITE

Montoya clay is the only soil in this range site, which occupies nearly level to flat areas in the Canadian breaks. Most areas are slightly concave or dish shaped, but some are flat and plainlike. In most places this site receives some runoff from adjoining slopes, but not enough to cause ponding or poor drainage.

The soil in this site is reddish brown, deep, limy, and clayey. When it is dry, many cracks form in the upper 2 to 3 feet. Slump pits or holes 1 to 3 feet deep are common.

The main decreasers on this site are blue grama, sideoats grama, and western wheatgrass. Where moisture is favorable, small amounts of white tridens grow. The main increasers are galleta and buffalograss. Under heavy grazing, galleta increases and the other species decrease. Grazing needs to be regulated so that the site is grazed most heavily during April, May, and June when the galleta is most palatable. Galleta grows in most areas and is likely to remain dominant if present management continues. Small amounts of scrubby mesquite are common in some areas, and cholla cactus is scattered throughout the site.

The estimated potential yield of air-dry herbage ranges from about 2,000 pounds per acre when moisture is favorable to about 800 pounds in dry years.

DEEP HARDLAND RANGE SITE

This range site is on the nearly level to gently sloping, smooth tableland of the High Plains and the level to gently sloping areas of the Canadian breaks. It is the most extensive range site in the county. Most of it is in moderately large ranches in the western half of the county, but smaller tracts are scattered throughout the dry and irrigated cropland of the eastern part. This site is locally called shortgrass country.

The soils in this range site have a clay loam surface layer and a clay to clay loam subsoil. They are deep and have moderate to moderately high natural fertility. Permeability of the subsoil ranges from moderate to very slow. These soils are able to store a large amount of water for plant use, but they are droughty because much of the moisture evaporates from the surface layer. These soils are susceptible to slight wind and water erosion unless they are protected by a plant cover.

The dominant climax grass is blue grama, but traces of sideoats grama grow in a few areas of the Ulysses, Quay, and other calcareous soils in this range site. Buffalograss, the dominant increaser, thickens when the site is overgrazed. The main invaders are three-awn, broom snakeweed, and mesquite, but these plants invade slowly and are a problem only when overuse is extreme. Carrying capacity is reduced by overgrazing because blue grama decreases and buffalograss increases. Grazing should be regulated so that a high percentage of blue grama is maintained. Most areas of this site are kept in good condition, but a few areas are so overgrazed that broom snakeweed and three-awn are dominant.

This site includes some of the better rangeland of the county. The estimated potential yield of herbage ranges from approximately 2,100 pounds per acre in favorable years to 1,300 pounds in unfavorable years.

The more permeable Ulysses, Quay, and Zita soils generally respond more quickly to range seeding than the more clayey Pullman and Olton soils. On all the soils, however, good stands can be obtained if suitable grasses are seeded and the seedlings are protected until well established.

HARDLAND SLOPES RANGE SITE

Most of this site is on slopes along the Palo Duro and Tierra Blanca Creeks. The rest is in small, sloping areas around playa basins and in sloping areas in the Canadian breaks.

The soils in this site are limy clay loams that have a moderately permeable subsoil. These soils are shallow to soft or gravelly caliche. Slopes are mainly between 3 and 8 percent, but a few areas are nearly level to gently sloping.

This site is moderately susceptible to washing and blowing where it is not protected by vegetation. In most areas, especially on the stronger slopes, much of the rainfall is lost in runoff.

On this site important decreasers are sideoats grama and blue grama. If grazing is heavy, the blue grama, buffalograss, and other increasers replace the sideoats grama. Under moderately heavy grazing, this site maintains a good cover. Response to management is good. Maximum yields are obtained when the site is managed in such a way that sideoats grama is maintained. A thinning of sideoats grama is a good indication that the site is overgrazed. Western ragweed, pricklypear, small soapweed, and broom snakeweed are the invaders. In most areas blue grama and moderate amounts of sideoats grama are dominant. Most areas of this range site are kept in good condition.

The estimated potential yield of air-dry herbage ranges from approximately 2,100 pounds per acre in favorable years to 1,200 pounds in unfavorable years.

HIGH LIME RANGE SITE

This range site occurs on the level benches that encircle the playa basins on the High Plains. It is also on the eastern slopes of the basins. Church clay is on the playa benches, and Drake soils are on the slopes. This site is in small, scattered areas, mostly in the western part of the county.

The soils in this range site have a surface layer of limy gray clay, grayish-brown clay loam, or loam. They are moderate to very slow in permeability and are somewhat low in natural fertility. Because of the high content of lime, soil blowing is likely if the surface is not protected by a good cover. The Drake soils are susceptible to water erosion.

The decreasers on this site are sideoats grama, blue grama, and vine-mesquite. Some areas in the playa basins have spots and patches of western wheatgrass. Overgrazed areas have a thin cover in which sand dropseed and buffalograss are dominant, and the invaders include inland saltgrass, sand muhly, and yucca. The overgrazed areas of Church clay in the playa basins generally respond more quickly to deferred grazing than areas of Drake soils on the slopes of basins. The present cover on this moderately productive site consists mainly of blue grama and traces of sideoats grama.

The estimated potential yield of air-dry herbage ranges from approximately 2,000 pounds per acre in favorable years to 1,300 pounds in unfavorable years.

LOAMY BOTTOM LAND RANGE SITE

This site consists of only the mapping unit Spur and Bippus soils. These soils are on bottom lands along streams and valleys (fig. 12) in both the High Plains and the Canadian breaks.

The soils in this site formed in alluvium. They have a clay loam, loam, or fine sandy loam surface layer and a clay loam to loam subsoil that is moderately permeable. Partly because these soils receive some runoff from adjacent slopes, the plant cover is excellent in most places. Areas not protected by plant cover, however, are subject to scouring, gullying, and soil blowing. In some areas

Figure 12.—**Loamy Bottom Land range site along Tierra Blanca Creek. Vegetation is mainly western wheatgrass and blue grama. This is the most productive site in the county.**

these soils are slightly saline. A few areas have a high water table.

The main decreasers are indiangrass, switchgrass, bluestem, and other tall grasses. The main increasers are western wheatgrass, vine-mesquite, alkali sacaton, and blue grama. The principal invaders are buffalograss, inland saltgrass, and western ragweed.

Most areas of this range site are now somewhat overgrazed. Unless areas are fenced, cattle tend to overgraze the bottom lands and undergraze the adjoining slopes. In the somewhat overgrazed areas, the present vegetation consists of blue grama, western wheatgrass, and other increasers. This site includes a few slightly saline and wet areas that are dominantly in alkali sacaton.

This is the most productive range site in Deaf Smith County. The estimated potential yield of air-dry herbage ranges from approximately 3,100 pounds per acre in favorable years to 1,900 pounds in unfavorable years.

MIXED LAND SLOPES RANGE SITE

This range site is on slopes along Tierra Blanca Creek and below the escarpment in the Canadian breaks. It is moderately extensive.

The soils in this site are limy and have a fine sandy loam surface layer. The subsoil is moderately rapid in permeability. Rainfall enters the surface easily and moves readily through the subsoil, but some of the rainfall is lost in runoff from the long slopes. Soil washing and blowing are likely in overgrazed areas where the cover is thin. In most places, however, erosion is none to slight, except for a few gullies that have been cut in old cattle trails and roads.

The decreasers are mostly mid grasses, but there are traces of sideoats grama, little bluestem, sand bluestem, and other tall grasses in most areas. Among the increasers are blue grama, buffalograss, three-awn, and hairy grama. Invaders are mainly western ragweed, yucca, and annual weeds and grasses. Most areas have mixtures of sideoats grama and blue grama and a scattering of yucca. In a few areas sagebrush grows and is becoming thicker.

This site includes some of the better rangeland of the county. The estimated potential yield of air-dry herbage ranges from approximately 2,500 pounds per acre in favorable years to 1,200 pounds in unfavorable years.

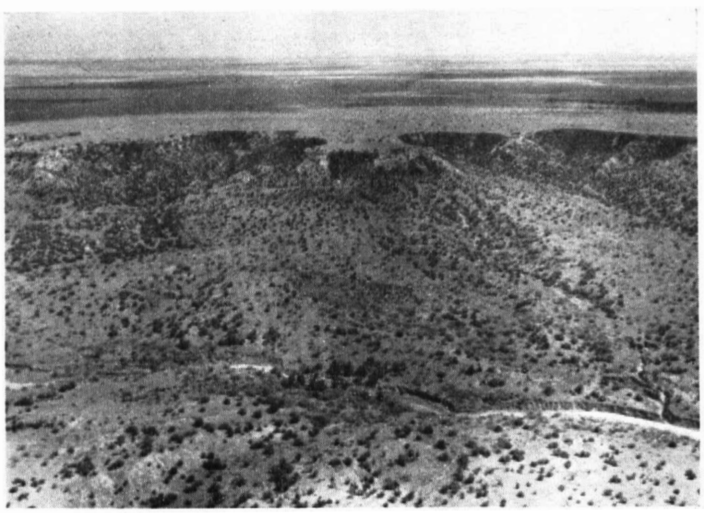

Figure 13.—**Escarpment in northwestern part of Deaf Smith County, showing typical areas of Rough Breaks range site (Rough broken land). Mixed Land Slopes range site (Mobeetie soils) is on foot slopes. Very Shallow range site (Potter soils) and Shallow Redland range site (Vernon soils) are on ridges and knolls.**

ROUGH BREAKS RANGE SITE

Only Rough broken land is in this range site. The site covers the escarpment between the tableland of the High Plains and the lower lying Canadian breaks (fig. 13). A few small areas are along Palo Duro and Tierra Blanca Creeks. The total acreage is small. This site is a landscape consisting of very steep slopes, nearly vertical escarpment walls, and lower lying, steep, gravelly foot slopes. Some barren cliffs, a few severely gullied areas, and a few spots of Potter and Mobeetie soils also occur.

This site is susceptible to very severe water erosion. The soil material is droughty and very low in fertility. Water seldom soaks below the upper few inches. Most areas are so steep that it is difficult for cattle to graze. A few areas are inaccessible.

The decreasers are mid grasses and, in lesser amounts, tall grasses. Among these grasses are sideoats grama, blue grama, black grama, and little bluestem. The main increasers are hairy grama, three-awn, sand dropseed, and rough tridens. Woody plants, such as yucca, catclaw, and redberry juniper, are scattered over the area. On south-facing slopes, mid and short grasses are dominant. Taller grasses grow on the north-facing slopes.

Plant cover is sparse on this site. If grazing is excessive, the slopes become nearly barren, and less desirable plants, such as three-awn, dropseed, and yucca, take over the site. Because most livestock prefer to graze the less sloping areas, the best use of the adjacent, smoother range sites insures proper use of this site.

Most areas of this site are kept in good condition. The estimated potential yield of herbage varies considerably because soil depth, slope gradients, and exposures are variable. The total annual yield of air-dry herbage seldom exceeds 1,400 pounds of material per acre.

SANDY BOTTOM LAND RANGE SITE

This range site consists of only the mapping unit Lincoln soils. It is inextensive and occurs on some of the bottom land along streams in the Canadian breaks.

The soils in this range site consist of stratified layers of coarse sand, fine sand, and loamy sand. They are somewhat low in fertility, but they receive enough moisture as overflow and in runoff from the adjoining slopes to support an excellent plant cover. Areas not protected by a plant cover, however, are susceptible to scouring and gullying, and especially to severe soil blowing.

The climax vegetation consists of tall and mid grasses, such as switchgrass, indiangrass, sand bluestem, and sideoats grama. If the site is overgrazed, the dropseeds, shorter gramas, and other increasers take over. If overgrazing is continuous, sand sagebrush, yucca, weeds, and other invaders eventually take over. Most areas are overgrazed; yucca and sand dropseed are taking over the plant community.

Potentially, this site can produce high yields. Careful management is needed because the plant cover deteriorates rapidly if overused. The estimated potential yield of air-dry herbage ranges from about 3,500 pounds per acre in favorable years to 2,000 pounds in unfavorable years.

SANDY LOAM RANGE SITE

This range site is in undulating and gently rolling areas of the Canadian breaks. The soils have a fine sandy loam surface layer and a subsoil that has moderately rapid permeability. Rainfall is used efficiently, and there is little runoff, because water enters the surface easily and soaks readily into the subsoil.

These soils blow readily where the plant cover has been thinned through overgrazing. Also, hoofpans form easily in the surface layer if the site is heavily trampled during rainy periods.

The decreasers are mainly sideoats grama, but there are traces of little bluestem. Yucca and a few plants of sand sagebrush are scattered in most areas. In the overgrazed areas, blue grama and buffalograss thicken and are dominant. If abuse of the range is continued, broom snakeweed, western ragweed, mesquite, cactus, and other invaders take over. In most areas blue grama is dominant, and yucca is thickening.

The estimated potential yield of air-dry herbage ranges from approximately 2,500 pounds per acre in favorable years to 1,600 pounds in unfavorable years.

SHALLOW REDLAND SITE

Vernon gravelly clay loam, in the Vernon-Quay complex, is the only soil in this range site. This site occupies the rolling hills just below the escarpment. All of the acreage is in the Canadian breaks.

The soil in this site consists of very shallow gravelly clay loam that formed in red-bed material. Because slopes are strongly sloping, most of the rainfall is lost in runoff. Water-holding capacity and natural fertility are low.

The vegetative cover is sparse. The main decreasers are blue grama, sideoats grama, and little bluestem. The increasers are mainly galleta, black grama, hairy grama, and three-awn. Redberry juniper, catclaw, hairy grama, and hairy tridens are the main invaders. Most areas are kept in good condition.

Careful management is needed to prevent overgrazing because the grass cover thins rapidly. Recovery is slow even under good management. Because grazing is excessive, the climax plants are decreasing and hairy grama, three-awn, and the woody plants are increasing.

The estimated potential yield of air-dry herbage ranges from approximately 800 pounds per acre in favorable years to 400 pounds in unfavorable years.

VERY SHALLOW RANGE SITE

This range site is in gently rolling to steep areas. The largest areas are along the escarpment of the Canadian breaks. Other areas are along Tierra Blanca Creek and in gently rolling areas south of Dawn.

The soils in this range site are limy, very shallow loams and gravelly loams (fig. 14). Depth to caliche is generally less than 12 inches. These soils are naturally low in fertility and have low water-holding capacity. In most areas much of the rainfall is lost in runoff.

On this site, the cover of grasses is thin. The kinds of grasses that grow depend on slope, exposure, and the hardness of the caliche substratum. Sideoats grama,

Figure 14.—**Very Shallow range site along Tierra Blanca Creek, showing thin stands of grasses on Potter soils. The grasses are mainly sideoats grama and three-awn.**

hairy grama, and little bluestem grow on the soils underlain by a soft caliche substratum. Blue grama and buffalograss grow mainly on the soils underlain by indurated caliche. In most places small amounts of catclaw, acacia, yucca, and other woody plants are generally present.

In most areas, the present cover consists mainly of blue grama and buffalograss and there are only traces of sideoats grama.

This site produces only small amounts of forage. Careful management is needed to maintain a cover that is thick enough for controlling erosion. The estimated potential yield of air-dry herbage ranges from approximately 1,600 pounds in favorable years to 800 pounds in unfavorable years.

Use of Soils for Wildlife

A large part of Deaf Smith County is a nearly level, treeless prairie that is dissected by a few intermittent streams. The rest of the county is a rolling landscape interspersed with broken areas. About two-thirds of the county remains in native grass; the rest is cultivated.

Most of the once abundant wildlife in Deaf Smith County was killed off after livestock were brought in, and the area was overgrazed, fenced, or cultivated. Although deer were once plentiful and made their habitat along rough, broken areas, only limited numbers now remain. Prairie dogs were once plentiful but are now almost extinct. Antelope, prairie chicken, and quail originally were abundant. Large numbers of quail, dove, various songbirds, small animals, and predators still inhabit the county. Grainfields attract many ducks and geese during their flights, and many of them alight on playa lakes, streams, and impoundments. In this county production of fish is limited to farm and ranch ponds and similar artificial impoundments.

Described in this subsection are the three wildlife sites in Deaf Smith County and the food and cover required by the main kinds of wildlife inhabiting the area.

262-475—68——4

Wildlife sites

Each of the three wildlife sites in this county is a distinct physiographic area. These areas are the High Plains, the Canadian breaks, and the playa lakes. Each site has different topography, productivity, kinds and amounts of plants, and principal species of wildlife. Also different for each site is the management needed for wildlife.

HIGH PLAINS HARDLANDS WILDLIFE SITE

This wildlife site covers the High Plains and takes in most of the county. It consists of a nearly level plain in which intermittent lakes are scattered. The major soils on this wildlife site are the Pullman, Olton, Ulysses, and Zita. Short grasses are dominant in the native vegetation and include buffalograss, blue grama, and western wheatgrass. Associated legumes and forbs are also present. A few trees, such as Chinese elm and redberry juniper, have been planted around farmsteads. The principal animals on this wildlife site are badger, coyote, rabbit, and fox. Dove, quail, pheasant, and songbirds are the principal birds.

CANADIAN BREAKS WILDLIFE SITE

This wildlife site covers the Canadian breaks, a gently rolling to steep landscape that is cut by intermittent streams. The major soils of this site are the Quay, Mansker, Mobeetie, and Potter. The Spur, Lincoln, and Bippus soils occur on the narrow bottom lands. All of the soils in this wildlife site are in range. Among the short and tall grasses on the site are buffalograss, blue grama, sideoats grama, little bluestem, sand bluestem, switchgrass, and indiangrass. Also present are associated legumes and forbs. The principal animals are deer, antelope, rabbit, badger, and coyote. The principal birds are eagle, hawk, borrowing owl, dove, quail, and various songbirds.

PLAYA LAKE WILDLIFE SITE

This wildlife site consists of intermittent lakes that are flooded from time to time. The lakes are mainly in areas of Randall clay. Their constantly changing water level helps in the production of barnyard grasses, smartweed, and other plants that provide excellent food for dove, quail, and waterfowl. Nesting places for pheasants are also excellent. The principal wildlife on the Playa Lake wildlife site are ducks and pheasants.

Food and cover for wildlife

Each species of wildlife in the county requires definite kinds of food, cover, and water supply. If any of these elements are lacking in an area, the number of wildlife diminishes or the species disappears. The soils in each wildlife site in the county are capable of producing certain plants for food and cover that meet the needs of wildlife. Farmers and ranchers can obtain assistance in developing wildlife habitat from wildlife specialists of the Soil Conservation Service, the Texas Agricultural Extension Service, and the Texas Parks and Wildlife Department.

Ducks and Geese.—In this county water areas are heavily used by wild ducks and geese for feeding and roosting. Both ducks and geese range for food to surrounding cultivated fields, where they feed on waste grain. Geese feed heavily on winter weeds and young wheat in the fields. Ducks eat seed from barnyard grass, smartweed, and other plants that grow at the rims of ponds, on streambanks, and in playas. If grazing is not excessive, the growth of these plants is good on Randall clay in the intermittent playa lakes. Playa lakes provide excellent feeding areas for ducks in the fall if the playas are flooded by rainwater or the water from irrigation wells.

Deer.—Deer roam the escarpment of the Canadian breaks in the northwestern part of Deaf Smith County. They forage on native legumes, weeds, vines, some grasses and leaves, twigs, buds, and the fruit of various shrubs. They also feed heavily on winter grain. The best places in the county for developing as deer habitat are areas of Mansker, Ulysses, Olton, and Mobeetie soils above and below the breaks. These areas can be planted to crops that provide food for deer.

Quail and Pheasant.—These gamebirds require a year-round supply of food, such as seed from weeds, grasses, legumes, small grains, and sorghums. Large numbers of insects are eaten during spring and summer. Low-growing shrubs provide shade, some food, and cover that permits escape cover from predators. Overgrown fence rows and field borders provide cover and food, as well as a protected strip that enables the birds to move from place to place. Several species of shrubs are suited to each soil in Deaf Smith County. Shrubs can be planted in areas where there is a shortage. Some native shrubs furnish no cover because of livestock grazing or trampling. Fencing prevents damage from livestock. Cultivating the soil stimulates the growth of annual weeds and grasses which produce high-quality food. On the Pullman, Olton, Ulysses, and other soils suitable for cultivation, millet, sorghum almum, or rye are good for food plantings. For best results, food plants are grown near good cover.

Antelope.—In Deaf Smith County small numbers of antelope frequent the Canadian breaks. These animals prefer open grassland plants. The major food plants are native grasses and weeds, cactus, and sand sagebrush. Planting winter small grain on the Spur, Bippus, and similar soils and eradicating invading brush are effective ways to improve habitat for antelope. For best results, the plantings should be near watering facilities.

Farmstead and Feedlot Windbreaks

Trees and shrubs are used to form windbreaks around farmsteads or feedlots and for esthetic purposes. They beautify the farmstead, protect it from blowing soil and snow, and reduce the velocity of wind around the farmstead or feedlot. Windbreaks are needed around feedlots to protect livestock from blowing snow and to make them more comfortable. Trees planted near farmsteads provide nesting and roosting places for many songbirds.

In Deaf Smith County the best trees for windbreaks are introduced species that are planted as seedlings. Only a few trees are native, and these grow mostly on bottom lands on Spur and Bippus soils.

The soils of Deaf Smith County will support trees if they are watered from time to time. Chinese elm and eastern redcedar are suited to moderately fine textured soils, such as Pullman clay loam and Olton clay loam. On these soils they are used mostly for windbreaks around farmsteads and feedlots. On the sandier soils, such as Mobeetie fine sandy loam and Springer fine sandy loam, Chinese elm, eastern redcedar, and ponderosa pine are suitable. Russian-olive, wild plum, desert willow, and similar shrubs are used in windbreaks and for food and cover in wildlife sanctuaries.

Information on planning windbreaks, proper spacing, and selection of trees and shrubs can be obtained from technicians assisting the Soil Conservation District or from other qualified specialists.

Engineering Uses of Soils [5]

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

The information in this report can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that will help in the planning of agricultural drainage systems, farm ponds, irrigation systems, and other field and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, pipelines, airports, and cables, and in planning detailed investigations at the selected locations.
4. Locate probable sources of sand, gravel, and other material for use in construction.
5. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
6. Correlate the performance of engineering structures with soil mapping units, and thus develop information for planning that will be useful in designing and maintaining the structures.
7. Supplement the information obtained from other published maps and reports and from aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for areas or sites that may require special construction methods or special design to insure a satisfactory structure.

With the use of the soil map for identification, the engineers interpretations in this subsection can be useful for many purposes. It should be emphasized that they may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the 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 the soil scientists may not be familiar to the engineer, and some terms may have a special meaning in soil science. Several of these terms are defined in the Glossary at the back of this survey.

Most of the information in this subsection is in tables 3, 4, and 5, but additional information useful to engineers can be found in other sections of this soil survey, particularly "Descriptions of the Soils" and "Genesis, Classification, and Morphology of Soils."

Engineering classification systems

Two systems of classifying soils are in general use by engineers. Both of these systems are used in this survey.

Many engineers use the system of soil classification developed by the American Association of State Highway Officials (AASHO) (*1*). In this system, soils are placed in seven main groups on the basis of field performance. The groups range from A–1 (gravelly soils having high bearing capacity) to A–7 (clayey soils having low strength when wet). Of these groups, only A–2, A–4, A–6, and A–7, occur in Deaf Smith County. Within each group the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest. They are shown in table 4, in parentheses after the AASHO classification symbols.

The Unified system of soil classification was established by the Corps of Engineers, U.S. Army (*9*). This system is based on texture and plasticity of soils and the performance of the soils as material for engineering works. Of the 15 classes in this system, eight are for coarse-grained material, six for fine-grained material, and one for highly organic material. Each class is identified by a letter symbol. The only classes represented in Deaf Smith County are CL, CH, ML, SC, SM, and SP. Soils in class CL are silts and clays that have a low liquid limit. CH identifies inorganic clays that are highly plastic. ML identifies inorganic silts and very fine sands, rock flour, silty or clayey fine sands, and clayey silts of slight plasticity. Soils in SC are sands mixed with an appreciable amount of fines, mostly silt. Soils in class SP consist of poorly graded sands and gravelly sands and little or no fines.

Engineering test data

Under a cooperative agreement with the Bureau of Public Roads, the Texas State Highway Department furnished test data on soils in the Mansker, Pullman, Randall, and Ulysses series. These data are shown in table 3. Each soil listed in the table was sampled at three locations. The profile at the first location listed for each soil is modal, or a profile typical of that soil as it occurs in Deaf Smith County. The second and third are nonmodal, or profiles that vary from the modal but are in the range allowed for that series.

[5] By DAN C. HUCKABEE, area engineer, Soil Conservation Service.

TABLE 3.—*Engineering*

[Tests performed by the Texas Highway Department in accordance with standard procedures of the American Association of U.S. Department of Commerce,

Soil name and location	Parent material	Texas report No.	Depth	Horizon
Mansker clay loam:			*Inches*	
3,500 feet south and 3,560 feet west of northeast corner of section 66, Block K–7. (Modal profile).	Moderately fine textured, calcareous sediments of the High Plains.	61–387–R 61–388–R	8–25 25–60	AC C
590 feet north and 275 feet east of southwest corner of section 24, Block K–5. (Clayey A and AC horizons).	Moderately fine textured, calcareous sediments of the High Plains.	61–404–R 61–405–R	10–20 20–60	AC C
1,950 feet west and 500 feet north of southeast corner of section 30, Block 8. (Less clayey modal profile).	Moderately fine textured, calcareous sediments of the High Plains.	61–406–R 61–407–R	9–24 24–50	AC C
Pullman clay loam:				
475 feet north and 30 feet west of southeast corner of section 76, Block K–4. (Modal profile).	Fine-textured, calcareous sediments of the High Plains.	61–389–R 61–390–R 61–391–R	12–26 40–55 55–90	B22 Bb2 Cab1
1,630 feet south and 70 feet west of northeast corner of section 9, Block K–3. (Shallower than modal profile).	Fine-textured, calcareous sediments of the High Plains.	61–408–R 61–409–R 61–410–R	13–20 20–30 38–75	B22 Bb Ccab2
5 miles north of Dawn. (Clayey B22 horizon)	Fine-textured, calcareous sediments of the High Plains.	61–411–R 61–412–R 61–413–R	12–20 48–60 60–90	B22 Bb2 Ccab
Randall clay:				
100 feet south and 650 feet east of windmill, section 5, T. 3 N., R. 4 E. (Modal profile).	Sediments of the lake (playa) bottoms.	61–384–R 61–385–R 61–386–R	0–18 18–48 48–90	A AC C
205 feet north and 200 feet west of southeast corner, section 40, Block 7. (Strongly calcareous phase).	Sediments of the lake (playa) bottoms.	61–398–R 61–399–R 61–400–R	0–12 12–45 45–70	A AC C
560 feet north and 360 feet west of southeast corner of section 14, Block 3. (More sandy than in modal profile).	Sediments of the lake (playa) bottoms.	61–401–R 61–402–R 61–403–R	0–12 12–40 40–60	A AC C
Ulysses clay loam:				
300 feet east and 50 feet south of northwest corner of section 97, Block K–8. (Modal profile).	Moderately fine textured, calcareous sediments of the High Plains.	61–381–R 61–382–R 61–383–R	0–12 12–22 22–45	A AC Cca
210 feet east and 110 feet north of southwest corner of section 320, Block M–6. (Less clayey than modal profile).	Moderately fine textured, calcareous sediments of the High Plains.	61–392–R 61–393–R 61–394–R	0–7 7–22 22–65	A AC Cca
300 feet east and 360 feet north of southwest corner of section 30, Block K–7. (More clayey than modal profile).	Moderately fine textured, calcareous sediments of the High Plains.	61–395–R 61–396–R 61–397–R	6–14 14–20 20–45	A1 AC Cca

[1] Mechanical analyses according to the AASHO Designation T 88–57 (*1*). Results obtained by this procedure may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by

test data

State Highway Officials (AASHO)(*1*). The work by the Highway Department was performed under a cooperative agreement with the Bureau of Public Roads]

Shrinkage			Mechanical analysis [1]								Liquid limit	Plasticity index	Classification	
			Percentage passing sieve—					Percentage smaller than—						
Limit	Lineal	Ratio	3/4-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.			AASHO [2]	Unified [3]
	Percent													
13	12.2	1.89	100	99	97	91	74	65	35	28	38	22	A-6(13)	CL.
13	8.2	1.91		100	99	97	74	61	27	23	29	14	A-6(9)	CL.
15	10.7	1.84	100	98	93	86	77	66	40	30	37	19	A-6(12)	CL.
13	11.2	1.95	100	99	96	90	82	73	44	33	35	20	A-6(12)	CL.
15	8.1	1.82	100	99	97	93	66	55	25	19	31	13	A-6(7)	CL.
14	10.2	1.89	100	99	97	94	73	63	30	26	34	19	A-6(11)	CL.
12	17.4	1.96			100	97	92	89	53	45	51	31	A-7-6(18)	CH.
13	14.5	1.91		100	99	98	90	79	40	34	44	27	A-7-6(16)	CL.
15	9.5	1.88		100	99	99	92	85	62	46	34	18	A-6(11)	CL.
13	14.2	1.89			100	98	87	77	40	34	44	26	A-7-6(15)	CL.
13	14.5	1.91			100	97	85	73	43	39	44	24	A-7-6(14)	CL.
18	6.2	1.75	100	96	92	84	75	70	48	37	31	11	A-6(8)	CL.
11	16.7	2.00			100	99	82	75	47	41	48	30	A-7-6(18)	CL.
13	15.0	1.94			100	99	89	80	44	38	45	27	A-7-6(16)	CL.
16	9.5	1.83		100	99	98	90	83	58	47	35	18	A-6(11)	CL.
11	20.0	1.96			100	99	97	92	73	57	60	37	A-7-6(20	CH.
12	20.2	1.94			100	98	96	93	69	60	62	39	A-7-6(20)	CH.
11	21.0	1.97			100	98	95	93	65	52	63	38	A-7-6(20)	CH.
12	20.5	2.01			100	98	94	92	63	54	61	38	A-7-6(20)	CH.
11	21.1	1.99			100	98	95	93	66	58	64	41	A-7-6(20)	CH.
11	22.0	1.97			100	96	95	92	63	57	67	45	A-7-6(20)	CH.
11	17.5	1.97			100	98	85	78	54	47	51	31	A-7-6(18)	CH.
12	17.5	1.97			100	99	85	75	34	47	52	33	A-7-6(18)	CH.
11	16.7	1.96				100	83	74	46	41	49	32	A-7-6(18)	CL.
17	9.5	1.76	100	99	96	89	76	62	33	24	37	18	A-6(11)	CL.
15	9.2	1.85		100	98	93	79	70	41	31	33	17	A-6(11)	CL.
12	11.2	1.96		100	99	96	82	72	48	36	33	18	A-6(11)	CL.
17	7.6	1.74		100	95	86	59	50	18	13	32	11	A-6(5)	CL.
17	8.5	1.75	100	98	93	86	62	54	26	20	35	16	A-6(8)	CL.
12	11.3	1.95	100	99	98	93	75	68	45	34	34	21	A-6(12)	CL.
15	11.5	1.80			100	99	94	83	33	24	40	20	A-6-(12)	CL.
14	14.4	1.87			100	95	93	88	53	41	46	26	A-7-6(16)	CL.
30	13.4	1.80			100	96	95	94	71	53	47	25	A-7-6(15)	CL.

the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes of soils.

[2] Based on AASHO Designation M 145-49 (*1*).

[3] Based on the Unified Soil Classification System (*9*) Tech. Memo. No. 3-357, 2 v., Waterways Experiment Station, Corps of Engineers.

TABLE 4.—*Estimated engineering*

Soils and map symbols	Depth from surface	Classification		
		USDA texture	Unified	AASHO
	Inches			
Bippus (Br)	0–60	Clay loam	CL	A–6
Church (Ch)	0–15	Clay	CH or CL	A–7
	15–60	Clay	CH	A–7
Drake (DrC, DrD)	0–15	Clay loam	CL	A–6
	15–60	Silty clay loam	CL	A–6
Kimbrough (Kl) (For properties of the Lea soil in this mapping unit, refer to the Lea soil series.)	[1] 0–7	Loam	SM or SC	A–4
Lea (Kl)	0–7	Loam	CL	A–6
	[2] 7–18	Clay loam	CL or CH	A–7
Lincoln (Ln)	0–70	Loamy sand	SP or SM	A–2
Mansker (MkA, MkB, MkC, MkD, MpD) (For properties of the Potter soil in mapping unit MpD, refer to the Potter soil series.)	0–10	Clay loam	CL or SC, ML	A–4 or A–6
	10–45	Clay loam	CL or SC	A–6
Mobeetie (MrC, MrD)	0–20	Fine sandy loam	SM or SC	A–4 or A–2
	20–60	Loam	CL	A–6
Montoya (Mt)	0–9	Clay	CH	A–7
	9–60	Clay	CH	A–7
Olton (OcA, OcB)	0–14	Clay loam	CL	A–6
	14–41	Heavy clay loam	CL	A–6
	41–60	Silty clay loam	CL	A–6
Potter (Pe)	[3] 0–9	Gravelly loam	ML or CL	A–4
Pullman (PmA, PmB, PmB2, PuA, PuB) (For properties of the Ulysses soil in mapping units PuA and PuB, refer to the Ulysses soil series.)	0–7	Clay loam	CL	A–7
	7–24	Clay	CL or CH	A–7
	24–52	Heavy clay loam	CL or CH	A–7
	52–74	Silty clay loam	CL	A–7
Quay:				
Clay loam (QcA, QcB, QcC, Vx)	0–9	Clay loam	CL	A–4
	9–60	Clay loam	CL	A–6
Fine sandy loam (QfC)	0–10	Fine sandy loam	SM, SC, or CL	A–4 or A–6
	10–60	Clay loam	CL	A–6
Randall (Ra)	0–70	Clay	CH	A–7
Rough broken land (Ro)	0–60	Loam to clay loam; large caliche ledges, sandstone outcrops, and sandstone conglomerates, mixed with some sandy loam.		
Springer (SfB)	0–60	Fine sandy loam	SM	A–2, A–4
Spur (Sp) (For properties of the Bippus soil in this mapping unit, refer to the Bippus series.)	0–60	Clay loam	CL	A–6
Ulysses (UsA, UsB, PuA, PuB)	0–10	Clay loam	CL	A–4
	10–70	Clay loam	CL	A–6
Vernon (Vx) (For properties of the Quay soil in this mapping unit, refer to the Quay series.)	[4] 0–6	Gravelly clay loam	CL	A–6
Zita (ZcA, ZcB)	0–9	Clay loam	CL	A–4 or A–6
	9–35	Clay loam	CL	A–6
	35–60	Clay loam	CL	A–6

[1] Hard, platy caliche at a depth of 7 inches.

[2] Hard, platy caliche at a depth of 18 inches.

properties of the soils

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH*	
100	95–100	50–75	0. 5–1. 0	0. 16	7. 5–8. 0	Moderate.
100	100	70–90	0. 02–0. 5	. 18	7. 0–8. 0	High.
100	100	75–95	0. 02–0. 5	. 18	7. 5–8. 0	High.
100	100	50–60	1. 0–2. 0	. 15	8. 0–8. 5	Low.
100	100	55–65	1. 0–2. 0	. 14	8. 0–8. 5	Low.
100	95–100	40–50	0. 5–1. 5	. 10	7. 5–8. 2	Low.
100	100	55–65	0. 5–1. 0	. 17	7. 5–8. 0	Moderate.
100	100	60–70	0. 5–1. 0	. 18	7. 5–8. 2	Moderate.
100	95–100	20–25	3. 0–5. 0	. 05	7. 5–8. 2	Low.
95–100	95–100	40–80	1. 0–1. 5	. 16	8. 0–8. 3	Low to moderate.
100	95–100	45–90	0. 2–0. 8	. 16	8. 0–8. 3	Moderate.
95–100	90–95	30–40	1. 5–2. 5	. 13	7. 8–8. 3	Low.
95–100	90–95	60–70	1. 0–1. 5	. 16	7. 8–8. 3	Low to moderate.
100	100	75–90	0. 1–0. 5	. 20	7. 5–8. 5	High.
100	100	75–90	0. 1–0. 5	. 20	7. 5–8. 5	High.
100	95–100	70–80	0. 2–0. 8	. 17	6. 8–7. 5	High.
100	95–100	70–80	0. 2–0. 8	. 17	7. 5–8. 3	High.
100	95–100	70–80	0. 2–0. 8	. 15	8. 0–8. 5	Moderate.
90–100	85–95	50–60	1. 0–2. 0	. 15	8. 0–8. 5	Low to moderate.
100	95–100	80–95	0. 2–0. 8	. 18	7. 0–7. 2	High.
100	95–100	80–95	0. 1–0. 5	. 18	7. 0–7. 2	High.
100	95–100	75–95	0. 1–0. 5	. 18	7. 5–8. 0	High.
100	95–100	75–95	0. 2–0. 8	. 18	8. 0–8. 5	Moderate.
100	95–100	80–90	0. 5–1. 0	. 15	7. 5–8. 0	Moderate.
100	100	75–80	0. 5–1. 0	. 15	7. 8–8. 2	Moderate.
100	100	45–65	1. 0–1. 5	. 13	7. 5–8. 2	Low to moderate.
100	100	70–80	0. 5–1. 0	. 14	7. 5–8. 2	Moderate.
100	100	80–98	0. 1–0. 2	. 18	7. 0–8. 0	High.
100	75–90	25–40	1. 0–2. 5	. 13	6. 0–7. 0	Low.
100	100	70–80	0. 2–0. 8	. 16	7. 5–8. 3	Moderate.
100	95–100	50–95	1. 0–2. 0	. 15	8. 0–8. 5	Moderate.
100	100	55–95	0. 2–0. 8	. 15	8. 0–8. 5	Moderate.
75–90	75–85	60–80	0. 2–0. 8	. 17	7. 8–8. 5	Moderate.
100	95–100	50–65	0. 5–1. 0	. 15	7. 0–7. 4	Low.
100	95–100	60–70	0. 5–1. 0	. 15	7. 4–8. 0	Moderate.
100	95–100	50–65	0. 5–1. 0	. 15	8. 8. 0–5	Moderate.

[3] Caliche at a depth of 9 inches.

[4] Clayey shale at a depth of 6 inches.

TABLE 5.—*Engineering*

Soils and map symbols	Suitability as a source of—		Soil features affecting—
	Topsoil	Road fill	Reservoir areas
Bippus (Br)	Good	Fair	Moderate seepage losses
Church (Ch)	Fair	Poor	Caliche substratum at a depth of 6 to 8 feet; can be sealed.
Drake (DrC, DrD)	Unsuitable	Fair	High seepage losses; moderately rapid permeability; highly calcareous subsoil.
Kimbrough (Kl) (For the Lea part of the mapping unit Kl, refer to the Lea series.)	Unsuitable	Poor; many large platy rocks.	Substratum is mostly large, platy caliche rocks; moderate seepage losses.
Lea (Kl)	Unsuitable	Poor; many large platy rocks.	Substratum is mostly large, platy caliche rocks; moderate seepage losses.
Lincoln (Ln)	Poor	Fair to good	High permeability; high seepage losses
Mansker (MkA, MkB, MkC, MkD, MpD) (For the Potter part of the mapping unit MpD, refer to the Potter series.)	Poor to fair	Fair	Moderately rapid permeability; excessive seepage.
Mobeetie (MrC, MrD)	Fair	Fair	Moderate seepage losses; can be sealed; siltation in some areas.
Montoya (Mt)	Unsuitable	Unsuitable	Practically impervious
Olton (OcA, OcB)	Good	Fair	Substratum has moderate seepage losses but can be sealed.
Potter (Pe)	Unsuitable	Good	Moderately rapid permeability; excessive seepage losses.
Pullman (PmA, PmB, PmB2, PuA, PuB) (For the Ulysses part of the mapping units PuA and PuB, refer to the Ulysses series.)	Fair	Poor	Caliche substratum at a depth of 6 to 8 feet; can be sealed.
Quay (QcA, QcB, QcC, QfC, Vx)	Fair	Fair	Moderate permeability; seepage losses; generally seals by siltation.

interpretations

Soil features affecting—Continued				
Embankments	Irrigation	Field and diversion terraces	Waterways	Highway location
Good to fair stability if soil is compacted.	Moderate to high water-holding capacity; moderate intake rate.	Hazard of soil blowing and water erosion; moderately permeable.	Hazard of water erosion; good fertility.	Good drainage; moderate shrink-swell potential; moderate cuts and fills necessary in places.
High shrink-swell potential; good core material.	Low intake rate; high water-holding capacity; easily eroded.	Susceptibility to cracking; graded terraces desirable; easily eroded.	Susceptibility to water erosion; supports good growth of grasses.	High shrink-swell potential; easily eroded; fair drainage on slopes.
Fair stability if soil is properly compacted.	Moderate intake rate; easily eroded; moderate water-holding capacity.	High susceptibility to soil blowing and water erosion; surface layer is unstable if used as fill material.	High susceptibility to soil blowing and water erosion; low fertility; vegetation difficult to establish.	Fair stability if soil is properly compacted, low shrink-swell potential; easily eroded.
Platy rocks in substratum up to 4 to 5 feet in diameter; poor stability.	Shallow over caliche; not suitable for irrigation.	Too shallow for construction of terraces.	Shallow over caliche; low fertility; susceptible to water erosion.	Good stability if soil is properly compacted; low shrink-swell potential.
Poor stability	Shallow over caliche; moderate intake rate; low to moderate water-holding capacity.	Shallow over caliche; moderate hazard of erosion.	Moderate hazard of erosion; shallow over caliche; cuts and fills limited.	Fair stability; rocks may be construction hazard; moderate shrink-swell potential.
Poor stability; soil may be used for embankment if erosion is properly controlled.	Low water-holding capacity; moderate to high permeability.	High susceptibility to erosion; complex slopes.	Susceptibility to soil blowing; undulating.	Poor stability; may be used for highways if soil is properly confined.
Fair stability if side slopes are not steep.	Moderate to high intake rates; low water-holding capacity	Shallow over caliche; hazard of erosion.	Erodible even on gentle slope; soil material difficult to stabilize.	Moderate shrink-swell potential; good internal drainage.
Fair to good stability if soil is compacted; sites may not be suitable for spillways.	Low to moderate water-holding capacity; high to moderate permeability; generally unsuitable for irrigation.	Slopes highly erodible; moderately rapid permeability.	High erodibility; low fertility; vegetation difficult to establish.	Slopes easily eroded; deep cuts and fills; calcareous; low shrink-swell potential.
Suitable for cores if soil is properly compacted; high shrink-swell potential.	Very slow intake rate; high water-holding capacity.	Nearly level, uniform slopes; slight hazard of soil blowing; no water erosion.	Waterways not needed	High shrink-swell potential; very little natural drainage.
Good to fair stability if soil is compacted; some cracking expected.	Moderate to high water-holding capacity; moderate intake rate.	Moderate permeability; subject to soil blowing and water erosion.	Good fertility; hazard of soil blowing and water erosion.	Good drainage; moderate shrink-swell potential; moderate cuts and fills needed in places.
Fair stability; low shrink-swell potential.	Very shallow over caliche; not suitable for irrigation.	Very shallow over caliche; construction difficult.	Very shallow soil over caliche; waterways not suited.	Fair stability; moderate shrink-swell potential; good internal drainage.
High shrink-swell potential; good core material.	Low intake rate; high water-holding capacity; easily eroded.	Subject to cracking; graded terraces needed; easily eroded.	Susceptibility to water erosion; supports vegetation.	High shrink-swell potential; easily eroded; fair drainage on slopes.
Low to moderate shrink-swell potential; fair stability; spillway sites generally poor.	Moderate water-holding capacity; moderate to high intake rate.	Severe hazard of soil blowing and water erosion; fair stability.	Vegetation difficult to establish; subject to soil blowing and water erosion.	Moderate shrink-swell potential; good internal drainage.

262-475—68——5

TABLE 5.—*Engineering*

Soils and map symbols	Suitability as a source of—		Soil features affecting—
	Topsoil	Road fill	Reservoir areas
Randall (Ra)	Unsuitable	Unsuitable	Practically impervious
Springer (SfB)	Fair	Fair	Moderately rapid permeability; high seepage losses.
Spur (Sp) (For the Bippus part of the mapping unit Sp, refer to the Bippus series.)	Good	Fair	Moderate permeability; some seepage loss; seals by siltation.
Ulysses (UsA, UsB, PuA, PuB)	Poor to fair	Fair	Moderate permeability throughout profile; seepage losses; generally seals by siltation.
Vernon (Vx) (For the Quay part of the mapping unit Vx, refer to the Quay series.)	Unsuitable	Unsuitable	Moderately rapid permeability; excessive seepage losses.
Zita (ZcA, ZcB)	Good	Fair	Moderate to excessive seepage

Some of the terms used in table 3 may require explanation. As moisture is removed from a soil, the volume of the soil decreases, in direct proportion to the loss of moisture, until a condition of equilibrium, called the *shrinkage limit*, is reached. Beyond the shrinkage limit, more moisture may be removed, but the volume of soil does not change. In general the lower the shrinkage limit, the higher the content of clay.

Lineal shrinkage is the decrease in one dimension of the soil mass that occurs when the moisture content is reduced from a stipulated percentage to the content at shrinkage limit. Lineal shrinkage is expressed as a percentage of the original dimension.

The *shrinkage ratio* is the volume change resulting from the drying of soil material, divided by the loss of moisture caused by drying. The ratio is expressed numerically.

The engineering soil classifications in table 3 are based on data obtained by mechanical analyses and by tests to determine the liquid limit and the plastic limit. The *plastic limit*, not shown in table 4, is the moisture content at which the soil material passes from a semisolid to a plastic state. The *liquid limit* is the moisture content at which the material passes to a liquid state. The *plasticity index* is the numerical difference between the plastic limit and the liquid limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Engineering properties of soils

Listed in table 4 are estimated engineering properties for the soils of each series in Deaf Smith County. The estimates are for a profile typical of the series.

Unified and AASHO classifications in table 4 for the Mansker, Pullman, Randall, and Ulysses soils were based on the test data given in table 3. For the other soils, classification was based on data from field tests and on experience and knowledge of the soils in the area. Also used as a basis for classification were the data in soil surveys of counties having some of the same soils as this county.

Permeability, given in table 4 in inches per hour, was estimated for each soil as it occurs in place. The estimates were based on soil structure and porosity and were compared with the results of permeability tests on undisturbed samples of similar soil material.

In the column headed "Reaction," the degree of acidity or alkalinity is expressed in pH values. The pH of a neutral soil is 7.0, of an acid soil is less than 7.0, and of an alkaline soil is more than 7.0. Most of the soils in this county are alkaline.

The shrink-swell potential indicates the change in volume that occurs in a soil when the moisture content changes. The estimates are based on volume change tests or on other physical characteristics of the soil. Randall clay, for example, is very sticky when wet and develops large shrinkage cracks when it dries. It has a high shrink-swell potential. Lincoln loamy sand is almost *interpretations*—Continued

Soil features affecting—Continued				
Embankments	Irrigation	Field and diversion terraces	Waterways	Highway location
High shrink-swell potential; suitable for cores if soil is properly compacted.	High water-holding capacity; very slow intake rate.	Nearly level, uniform slopes; no water erosion; slight hazard of soil blowing.	Waterways not needed.	High shrink-swell potential; very little natural drainage.
Fair stability; may be used for embankment if soil is properly compacted.	Moderate to low water-holding capacity; moderate to high intake rate.	Moderate hazard of soil blowing.	Severe hazard of water erosion; moderate hazard of soil blowing.	Susceptibility to erosion if soil is not properly protected.
Poor foundation material; fair stability in embankments.	High water-holding capacity; low to moderate intake rate.	Occasional flooding; hazard of water erosion; subject to outside runoff.	Occasional flooding; hazard of water erosion.	Occasional flooding; high water table probable in some places during wet season.
Low to moderate shrink-swell potential; fair stability; spillway sites generally poor.	Moderate water-holding capacity; moderate to high intake rate.	High hazard of soil blowing and water erosion; fair stability.	Vegetation difficult to establish; subject to soil blowing and water erosion.	Moderate shrink-swell potential; good internal drainage.
Fair stability; low shrink-swell potential.	Very shallow over shaly clay; not suitable for irrigation.	Very shallow over shaly clay; construction difficult.	Shallow over shaly clay; waterways not suited.	Fair stability; moderate shrink-swell potential; good internal drainage.
Fair to good stability if soil is compacted; hazard of erosion at spillways.	High intake rate; low water-holding capacity.	Susceptibility to gully erosion and sheet erosion; maintenance problem.	High erodibility; vegetation difficult to establish.	Fair stability if soil is compacted; low to moderate shrink-swell potential; easily eroded.

structureless and is nonplastic, and it has a low shrink-swell potential.

Engineering interpretations

In table 5 the soils are evaluated for engineering uses. Specific features of the soil profile that may affect engineering work are pointed out. These features were estimated on the basis of test data in table 3, the engineering properties listed in table 4, and observations of field performance.

Topsoil is fertile soil material, ordinarily rich in organic matter, used to topdress roadbanks, gardens, and lawns. Olton, Bippus, Spur, and Zita soils are good sources of topsoil, but the Drake, Montoya, Potter, and Lea soils have a high content of lime and are rated unsuitable. Randall soils are too clayey, and Kimbrough soils contain too many large platy rocks.

The suitability of a soil for road fill depends largely on texture and content of hydroscopic water. Plastic soils with a high percentage of this water, such as Church clay, Randall clay, and Pullman clay loam, are difficult to compact and to dry to a desired moisture content. These soils are poor as a source of road-fill material. Springer fine sandy loam is rated fair because this soil is difficult to place. It contains a large amount of sand but not enough binding material.

Sand and gravel have not been located in Deaf Smith County in significant amounts, but the substratum of the Kimbrough and Lea soils is a good source of hard caliche. This hard caliche is generally in layers 2 to 4 feet thick. Soft caliche underlies the Potter soils and Rough broken land, and material similar to this soft caliche underlies many other soils of the High Plains. It is at a depth ranging from 2 to 8 feet and is 1 to 2 feet thick.

The red-bed material that outcrops in the Canadian breaks is a good source of fines, for the fines can be mixed with sands to make a good material for road fill.

Embankments for impounding water can be constructed safely on most soils of the county if suitable material is carefully placed and the soil is compacted. On some soils the reservoir area for farm ponds needs special treatment for reducing excessive seepage losses.

Under the heading "Irrigation," ratings of water-holding capacity, intake rate, and other features that affect irrigation are given. Turn to the subsection "Managing Irrigated Soils" for additional information.

Field terraces and diversion terraces that are constructed on the coarser textured soils are difficult to maintain. The ridges and channels of these terraces are likely to be damaged through both soil blowing and water erosion.

Soil blowing makes waterways difficult to manage in some areas. On highly erodible soils windblown material may cover the permanent vegetation and reduce the capacity of the waterway to carry water.

Soil features affecting highway locations or road subgrades are based on the estimated classification of the soil material. In flat terrain the features apply to materials in the A and B horizons. Where the slopes are 5 percent or steeper, the features listed mainly apply to soil materials in the C horizon. Randall clay, Church clay, Pullman clay loam, and similar soils provide poor locations for highways because they have a plastic clay layer that impedes internal drainage and because soil stability is low when these soils are wet. Loamy fine sands provide fair to good locations for highways. They are very susceptible to erosion, have a low percentage of material passing the No. 200 sieve, are poorly graded, and generally lack stability unless they are confined. Soils coarser textured than loamy fine sands are generally better graded and provide good sites for the location of highways.

Winter grading and frost action are not considered serious problems, because subfreezing temperatures are of relatively short duration and the soils generally have a low content of moisture in winter. Soil salinity in Deaf Smith County is no problem, since no naturally saline soils occur.

In rural areas and in small communities beyond the existing sewage lines, it is necessary to install private sewage disposal systems. The sandy, moderately sandy, and calcareous soils that have moderate to rapid permeability are well suited for sewage filter fields. Filter fields in Pullman, Olton, and Church soils do not function properly, because the subsoil of these soils is slowly permeable or very slowly permeable. Wells or seepage pits, about 3 feet in diameter and 40 to 50 feet deep, are commonly used for sewage disposal. The effluent flows into the calcareous loamy substratum, which underlies most of the soils in Deaf Smith County.

Genesis, Classification, and Morphology of Soils

The purpose of this section is to present the outstanding morphologic characteristics of the soils of Deaf Smith County and to relate them to the factors of soil formation. Physical and chemical data are limited for these soils, and the discussion of soil genesis and morphology is correspondingly incomplete. The first part of the section deals with the environment of the soils; the second, with the classification of soils; and the third, with the morphology of the soils. Chemical and physical analyses of some of the soils can be found in the soil surveys of Hansford County, Tex., and Curry County, N. Mex.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are the active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme instances, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for the differentiation of horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil genesis are so closely interrelated in their effects on soils that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are unknown. The following paragraphs briefly describe the climate, plant and animal life, parent material, and relief of Deaf Smith County and tell how time has affected the formation of the soils.

Climate

Deaf Smith County has a semiarid, continental climate. The average amount of precipitation received annually is about 18 inches, but the amount fluctuates a great deal from year to year. As little as 8 inches and as much as 40 inches have been recorded. Thus, there are periods of extreme drought in some years. In other years more than enough rainfall is received for dryland crops. Most of the precipitation comes in summer, and much of it is in hard showers of short duration. The winter months are mostly dry and windy, with occasional snows. Temperatures throughout the year range from slightly above zero in winter to about 100° F. in summer. In summer temperatures generally reach the middle nineties during the day and are in the sixties during the night.

Climate has affected the soils in several ways. Not enough rainfall has been received, for example, to leach or wash the carbonates out of the soil profile. Thus, carbonates have accumulated in the lower part of the solum or below the solum at about the average depth to which rainfall has penetrated. As a result, most of the soils are underlain by a layer of caliche or lime.

In the Pullman, Olton, Zita, and similar soils, all of the free carbonates have been leached out of the upper part of the solum and into the layer of caliche. In the Mansker, Ulysses, and other soils that are forming in material high in content of lime, the process is still going on and some free lime remains in the upper foot or so of the soil profile.

In some soils—especially in the Pullman, Olton, and Zita—clay is moving from the surface layer into the subsoil. This is evidenced by the presence of clay films in the subsoil and by a more clayey texture in the subsoil than in the surface layer. The downward movement of clay is a process somewhat similar to the downward movement of carbonates by leaching, but it takes place at a much slower rate. Also, it apparently begins only after all the carbonates have been leached out.

Climate has affected the formation of some of the soils through the action of strong winds. The Drake soils, for example, have formed on the eastern slopes of playas in strongly calcareous windblown sediments. These sediments were blown from the playa basin by westerly winds.

Local differences in climate are apparent in the escarpment areas of the Canadian breaks. In those areas soils on the north-facing slopes are protected from the sun and warm south winds. They are cooler and more moist than those on the unprotected south-facing slopes. Therefore, the cover of grass is denser and taller on those slopes than on the south-facing slopes. Also, geologic erosion is less active than on the more sparsely vegetated south-facing slopes.

Plant and animal life

Plants, earthworms, micro-organisms, and other forms of life that live on and in the soil contribute to the development of the soil profile. The kinds of organisms are determined mainly by the climate and by the kind of parent material.

In Deaf Smith County, climate has limited the kind of vegetation mainly to grasses. The parent material determined whether the grasses would be tall, as on the sandy soils, or short, as on the finer textured, loamy soils. The tall grasses growing on sandy soils help to stabilize dunes and hummocks so that a soil profile can form. The short grasses growing throughout most of the county contribute a moderately large amount of organic matter to the soils. When their leaves and stems decay, they add organic matter to the surface soil. When the fine roots die and decompose, they help build up a supply of plant nutrients in the rest of the solum. As the roots decay, they provide food for bacteria, actinomycetes, and fungi. The network of pores and tubes left by decaying roots hastens the passage of air and water through the soils.

Earthworms are the most obvious form of animal life in most of the soils. The subsoil of the Ulysses, Mansker, and Mobeetie soils contains many worm nests. These soils also contain many worm casts, which are the round, granular excretions left by burrowing earthworms. In contrast, the subsoils of the Pullman soils contain few or no worm nests and worm casts, because these clayey soils are not a favorable burrowing place for earthworms. Worm casts add greatly to the fertility of soils and to the movement of air, water, and plant roots through the soil profile.

Because of the part they play in releasing plant nutrients from the parent material, micro-organisms are important in the formation of soils. They take nitrogen from the air and store it in the soil. Also, they are active in helping to decompose plant residue.

In some soils rodents that dwell in the soils have played a part in the development of a soil profile. By their burrowing, these animals mix the soil material, and this mixing tends to offset the effects of the leaching of carbonates and the downward movement of clay. Nests made by rodents are common in the Cca and C horizons of the Pullman (see fig. 8, p. 14), Olton, Zita, and Ulysses soils. The nests or krotovinas range from about 4 to 18 inches in diameter. They are filled with grayish-brown, silty material that has a high content of organic matter. No doubt bison, pronghorn, deer, rabbits, and other animals have also affected the formation of soils in various ways.

Parent material

Parent material has probably had more influence than any other factor on the kinds of soils (*3*, *4*) that have formed in this county. The soils have formed in material from two major geologic formations. These are High Plains deposits and red beds of Triassic age.

High Plains deposits overlie the red beds. They have two main parts. The lower part is the Ogallala formation, and the upper part is a mantle of loess. The Ogallala formation consists of very strongly calcareous outwash made up of sand, gravel, and caliche. It is exposed along the escarpment in the northwestern part of the county and along some of the creeks. The Potter soils have formed in exposed material from that formation. Severely eroded areas of this exposed formation are classified as the miscellaneous land type, Rough broken land.

The upper part of the High Plains deposits consists of a mantle of loess that blankets much of the part of the county occupied by the High Plains. It is the formation in which most of the soils of the county have formed. This mantle consists of alternating layers of clay loam, sandy clay loam, and loam, interbedded with layers of soft, pinkish-white caliche. The kind of soil that has formed at any given place on the High Plains appears to depend mainly on the kind of parent material at the surface at that particular place. The Pullman and Church soils, for example, have formed in material from the finer textured layers, which accounts for the clayey, dense subsoil of those soils. The Mansker and Ulysses soils are calcareous because they have formed in limy material from the layers of loamy caliche. The Olton and Zita soils have formed in the layers of clay or sandy clay loam.

Several soils have formed in reworked sediments from the mantle of loess. Among these are the Randall, Drake, Bippus, and Mobeetie. The Randall soil has formed in playa basins in beds of clay settlings. The Drake soils have formed in windblown sediments that have a high content of lime and that have blown out of the bottoms of playas during dry periods. (See fig. 3, p. 5.) The Bippus soil has formed in valley fill and in material deposited by streams. The Mobeetie soils have formed in calcareous colluvium that has settled on slopes along draws below escarpments. (See fig. 2, p. 4.)

Most of the soils of the Canadian breaks have formed in outwash derived mainly from red beds of Triassic age but containing some minor blendings of material from the High Plains deposits. The Vernon soils are exceptions. They have formed in place over clayey red beds. The Montoya soils have formed on nearly level flats and fans in outwash from clayey red beds. A more detailed discussion of the formations in the county is given in the subsection titled "Geology" near the back of this soil survey.

Relief

Relief influences the formation of soils, mostly through its effect on drainage and runoff. If other factors of soil formation are equal, the degree of profile development depends mainly on the average amount of moisture that enters and passes through the soil. Steep soils absorb less moisture than less sloping ones, and they are more susceptible to erosion. Therefore, they generally have a thinner, less well developed profile.

Some soils in the county, for example, the Pullman, Olton, and Zita, are nearly level or gently sloping. Most of the moisture from rainfall has penetrated those soils;

therefore, relief has not been a limiting factor in the development of a soil profile.

In contrast, the Potter soils have been strongly influenced by relief. Because those soils are moderately sloping to steep, runoff is rapid and geologic erosion is active. Rainfall penetrates to only a limited depth, and the vegetation is, therefore, sparse. As a result, the factors of vegetation, time, and climate can cause and sustain the formation of a soil that has only a shallow profile over the beds of caliche.

To a lesser extent than in the Potter soils, relief has affected the formation of a profile in the Mobeetie, Mansker, and Drake soils. In those soils runoff, as a result of relief, is constantly wearing away the upper part of the soil profile as fast as it is formed.

The Randall soils are also affected, to some extent, by relief. They are poorly drained and are covered by water for long periods. Consequently, some of the minerals in those soils, especially iron and manganese, have been changed, and the kinds and amounts of clay probably have been affected.

Time

Time is required for the formation of a mature soil. The amount of time required depends on the kind of parent material in which the soil has formed and on the environment, that is, on the climate, plant and animal life, and relief. A mature soil is considered to be stable within its environment. It changes little with the passage of time because the environmental factors have already exerted their influence on the parent material. A young soil, on the other hand, is one in which the climate, plant and animal life, and relief have only begun to alter the parent material. Those factors are making their impression on the soil profile, but more time is needed for a mature soil to form. Thus, the age of a soil is determined by the degree to which the parent material has been changed toward the full development of a soil profile that has its own unique set of characteristics.

Soils of the Pullman, Zita, and Olton series have been in place long enough to have developed a mature profile. They are deep and have pronounced horizon development. Free lime has been leached into the lower horizons, and much of the clay has moved out of the surface layer and into the subsoil. The A, B, and C horizons of these soils are distinct. The Mobeetie and Drake soils, on the other hand, are young and immature. They have been in place such a short time that horizons have barely begun to form. There has been a slight movement of lime into the subsoil, and the surface layer has been darkened somewhat by vegetation.

The Mansker, Ulysses, and Quay soils are also immature. Although considerable amounts of lime have moved out of their solum, these soils, as yet, do not show the full effects of their environment. The horizons in their profile are weakly expressed.

Because of the clayey texture of the Randall soils, time probably has had little influence on the development of a profile in those soils. The factors of parent material and relief have been dominant in the formation of the Randall soils. The profile of those soils will probably not change much in the future unless some change takes place in the environment.

Irrigation probably has some effects on the formation of soils through changes it brings about in the climatic factor. At present, though the supplies of plant nutrients and organic matter in the soils have been altered by irrigation, no horizon changes in the soil profiles, as a result of irrigation, can be seen.

The oldest soils in this county are the buried soils formed in the mantle of loess on the High Plains. The loess appears to have been deposited during different periods. After one deposition, soils formed at the surface for an extended period and were then covered when the next layer of loess was deposited. The most prominent one of the buried soils in this county is a brown to reddish-brown layer in the lower part of the Pullman profile.

Classification of Soils

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

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*8*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*5*, *7*). Therefore, readers interested in development of the system should search for the latest literature available.

Under the current system of classification, six categories are used. Beginning with the broadest and most inclusive, these are the order, the suborder, the great group, the subgroup, the family, and the series. Ten soil orders are recognized in the current system. In contrast, probably more than 8,000 soil series have been mapped in the United States alone. Table 6 gives the family, subgroup, and order for each series in the county under the current classification, as well as the great soil group of the 1938 classification system.

Only five of the orders—Entisols, Vertisols, Aridisols, Mollisols, and Alfisols—are represented in this county. These are briefly defined in the following paragraphs.

Entisols are young mineral soils that do not have genetic horizons or have only the beginning of such horizons.

Vertisols are soils in which natural churning or inversion of soil material takes place, mainly through the swelling and shrinking of clays.

Aridisols are primarily soils of dry places. They have a light-colored surface soil, and some have a clay-enriched

TABLE 6.—*Soil series classified according to current and old systems*

Series	Current classification			Great soil groups of the 1938 classification system
	Family	Subgroup	Order	
Bippus	Fine-loamy, mixed, thermic	Pachic Haplustolls	Mollisols	Chestnut soils.
Church	Fine, mixed, mesic	Aquic Calciorthids	Aridisols	Grumusols.
Drake [1]	Fine-carbonatic, thermic	Ustollic Camborthids	Aridisols	Regosols.
Kimbrough	Loamy, mixed, thermic, shallow	Petrocalcic Calciustolls	Mollisols	Lithosols.
Lea	Fine-loamy, mixed, thermic	Petrocalcic Paleustolls	Mollisols	Chestnut soils.
Lincoln	Sandy, mixed, thermic	Typic Ustifluvents	Entisols	Alluvial soils.
Mansker	Fine-carbonatic, thermic	Typic Calciustolls	Mollisols	Calcisols.
Mobeetie	Coarse-loamy, mixed, thermic	Ustollic Camborthids	Aridisols	Regosols.
Montoya [2]	Fine, mixed, mesic	Torrertic Camborthids	Aridisols	Grumusols.
Olton	Fine, mixed, thermic	Typic Argiustolls	Mollisols	Reddish Chestnut soils.
Potter	Fine-carbonatic, thermic, shallow	Typic Calciorthids	Aridisols	Lithosols.
Pullman [1]	Fine, mixed, thermic	Vertic Paleustolls	Mollisols	Chestnut.
Quay	Fine-silty, mixed, thermic	Ustollic Calciorthids	Aridisols	Regosols.
Randall	Fine, montmorillonitic, thermic	Udic Pellusterts	Vertisols	Grumusols.
Springer	Coarse-loamy, mixed, thermic	Typic Haplustalfs	Alfisols	Reddish Chestnut soils.
Spur	Fine-loamy, mixed, thermic	Fluventic Haplustolls	Mollisols	Alluvial soils.
Ulysses	Fine-silty, mixed, mesic	Typic Haplustolls	Mollisols	Calcisols.
Vernon [3]	Fine, mixed, thermic	Ustollic Camborthids	Aridisols	Lithosols.
Zita	Fine-loamy, mixed, thermic	Typic Haplustolls	Mollisols	Chestnut.

[1] Classification is tentative and is questionable.
[2] The concept and range of the Montoya series is in question and is under study. The classification given, however, is appropriate for the soils represented in this survey.
[3] The Vernon soils in this county are now considered too shallow for the Vernon series, though a new series has not been approved for this kind of soil.

B horizon high in base saturation. Others have free carbonates throughout their profile.

Mollisols are dark-colored soils that have a moderate to high content of organic matter and high base saturation. Some have a clay-enriched B horizon, and others have free carbonates throughout their profile.

Alfisols are soils containing a clay-enriched B horizon that has high base saturation.

Morphology of Soils

In this subsection the outstanding morphologic characteristics of each soil series in Deaf Smith County are given. Each series represented in the county is discussed, a soil profile typical of the series is described in detail, and the range of important characteristics is given. Rough broken land is not a member of a soil series; therefore, it is not discussed in this subsection.

Bippus Series

The Bippus series consists of loamy, dark-colored, deep, granular soils on old alluvial fans and in nearly level areas along the main drainageways of the High Plains. These soils are well drained. They have formed in sediments of calcareous clay loam washed from soils of the High Plains. The slopes range from 0 to 3 percent.

These soils have a thick, dark A horizon of clay loam and a moderately permeable subsoil, also of clay loam. Because they have formed under a dense cover of native grasses, they are moderately high in content of organic matter and are naturally fertile.

The Bippus soils occur with Mansker soils but have a darker, thicker A horizon than those soils. They are darker and less sandy than the Mobeetie soils, and they lack the distinct limy substratum that is characteristic of the Ulysses soils.

Typical profile 1,200 feet north and 1,300 feet east of SW. corner of sec. 6 of the Gregg County School land survey:

A1—0 to 18 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, coarse, prismatic and weak subangular blocky and granular structure; hard when dry, friable when moist, and slightly sticky when wet; common fine and medium pores and common worm casts; few fine concretions of calcium carbonate; calcareous and mildly alkaline; diffuse boundary.

B2—18 to 31 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic and weak subangular blocky and granular structure; very hard when dry, friable when moist, and slightly sticky when wet; few worm casts; common fine and a few medium concretions of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

Cca—31 to 51 inches +, light brownish-gray (10YR 6/2, moist) clay loam; hard when dry and friable when moist; few worm casts and fine roots; common medium concretions of calcium carbonate; calcareous and moderately alkaline.

In a few places, the A horizon ranges from loam to silty clay loam. When the soil is dry, the color of the A horizon is very dark grayish brown in places instead of grayish brown. This horizon ranges from 12 to 25 inches in thickness and is noncalcareous in a few places. In places the B2 horizon is a heavy clay loam and has moderate subangular blocky structure. When the soil is dry, the hue of the B2 horizon ranges to 7.5YR, has a value of 4 or 5, and has a chroma of 2 or 3. In places the Cca horizon is brown instead of light brownish gray. The Cca horizon is silty clay instead of clay loam in places.

In some soil profiles, it is stratified and contains thin layers of sand or gravel.

Church Series

The Church series consists of dark-gray, moderately well drained soils that are clayey and limy. These soils are on benches of most of the larger playas in Deaf Smith County. The material in which they formed consists of clayey, calcareous sediments from High Plains deposits. These soils swell extensively when wet and crack when dry. They generally occupy nearly level or slightly concave areas, but the slopes are as strong as 1 percent in a few areas between the playa benches and the bottoms of the playas.

The Church soils have a darker color, are less clayey, and are better drained than the Randall soils. They are grayer and have less distinct horizons than the Pullman soils. Also, their upper horizons are not leached of lime like those of the Pullman soils.

Typical profile 17 miles north of Hereford on the west side of U.S. Highway No. 385 (500 feet north and 150 feet west of the SE. corner of NE¼ sec. 72, block K–4):

A1—0 to 15 inches, dark-gray (10YR 4/1) light clay, very dark gray (10YR 3/1) when moist; moderate, fine and very fine, subangular blocky structure; firm when moist and sticky when wet; common worm casts; common very fine pores; abundant roots; calcareous and moderately alkaline; gradual boundary.

AC—15 to 35 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; weak, coarse, blocky structure; extremely hard when dry, very firm when moist, and sticky when wet; a few worm casts; a few medium pores; roots common; a few fine concretions of calcium carbonate the size of sand; calcareous and moderately alkaline; gradual boundary.

C1—35 to 55 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; weak blocky structure breaking to moderate, medium and coarse, subangular and irregular blocky structure; extremely hard when dry, very firm when moist, and sticky when wet; common shiny pressure faces; a few fine roots; contains a few concretions like those in the AC horizon; calcareous and moderately alkaline; gradual boundary.

C2—55 to 60 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; moderate, coarse and medium, blocky structure breaking to fine irregular blocky; extremely hard when dry, very firm when moist, and sticky when wet; slick pressure faces evident; common very fine pores; common threads of calcium carbonate on the surfaces of the peds.

The A horizon ranges from 10 to 20 inches in thickness. When the soil is dry, the A horizon is gray in some places instead of light gray. It generally has a value of 4 or 5 and chroma of 1 to 1.5, but the chroma ranges to 2 in a few areas. The A horizon is generally light clay, but it is heavy clay in places. The structure of the AC horizon ranges from moderate blocky in some profiles to weak blocky where the profile is more clayey. Depth to the C1 horizon ranges from 25 to 60 inches. In places the color of the C horizons is light gray instead of gray.

Drake Series

The Drake series consists of light-colored, loamy soils that contain lime. These soils have formed in windblown deposits that have settled on the eastern sides of playa depressions in the High Plains. The typical area consists of a low, smooth dune that partly encircles a playa. The slopes are convex and range from 3 to about 8 percent. These soils are not extensive and are mostly in the eastern half of the county. They are highly susceptible to wind erosion.

Drake soils are lighter colored and more limy than the Mansker and Ulysses soils, and they are less clayey than the Church. Unlike the Mobeetie soils, they have a limy B2 horizon. Their B2 horizon is less sandy than that of the Mobeetie soils.

Typical profile about 6½ miles north and a quarter of a mile east of Hereford (3,300 feet west and 1,500 feet south of the NE. corner of sec. 68):

A1—0 to 9 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic structure breaking to weak subangular blocky and granular structure; slightly hard when dry and friable when moist; many pores; worm casts common; calcareous and moderately alkaline; smooth, clear boundary.

B2—9 to 15 inches, light-gray (10YR 7/2) clay loam, brown (10YR 5/3) when moist; moderate, coarse, prismatic structure breaking to moderate, fine, subangular blocky and granular structure; slightly hard when dry and friable when moist; many pores; many worm casts; calcareous and moderately alkaline; clear boundary.

C—15 to 60 inches, light-gray (10YR 7/2) silty clay loam but light brownish gray (10YR 6/2) in lower part; light brownish gray (10YR 6/2) when moist; massive; slightly hard when dry and friable when moist; many pores; a few worm casts in upper part; calcareous and moderately alkaline.

The A horizon ranges from 7 to 10 inches in thickness. When the soil is dry, the color of the A horizon ranges from grayish brown to light brownish gray or light gray. In general, the texture of the A horizon is clay loam to loam, but it is fine sandy loam in a few places. The B2 horizon ranges from 6 to 12 inches in thickness. Its color ranges from light brownish gray to light gray in a 10YR hue. The B2 horizon typically contains slightly more clay than the A horizon, and its texture ranges from loam to silty clay loam. The color of the C horizon ranges from light brownish gray to white in hues of 10YR to 2.5Y. The texture of that horizon is clay loam instead of silty clay loam in some places. Where these soils occur with Pullman soils, they generally contain a layer of brown to dark-brown clay loam—the surface layer of a buried soil—below a depth of about 3 feet.

Kimbrough Series

Dark grayish-brown, loamy soils that are underlain by platy, indurated caliche are in the Kimbrough series. These soils are gently sloping and occupy low, convex ridges and knolls on the High Plains. They are mainly in the southeastern part of the county, but a few patches occur on the High Plains in other parts.

The Kimbrough soils are darker and less limy than Potter soils, and they are underlain by a substratum of harder caliche. They occur with Lea soils but have a thinner solum than those soils. In this county the Kimbrough soils are mapped only in a complex with the Lea soils.

Typical profile 1 mile west and 1¼ miles south of Dawn (900 feet south and 30 feet east of the NW. corner of sec. 27, block 3):

A1—0 to 9 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky and granular structure; slightly hard when dry, friable when moist, and sticky when wet; many roots; a few, medium and fine, rounded caliche pebbles and angular fragments of caliche; calcareous and moderately alkaline; clear, irregular boundary.

R&AC—9 to 18 inches, about 85 percent indurated, white caliche plates and fragments, mostly between 5 and 10 inches in diameter; the rest is grayish-brown (10YR 5/2, dry) loam that is calcareous and granular; roots common in the loam; abrupt, irregular boundary.

R—18 to 20 inches +, indurated, white caliche plates 1 to 3 feet in diameter and 3 to 8 inches thick; plates strongly cemented together with secondary calcium carbonate.

When the A horizon is dry, its color ranges from dark brown to grayish brown or dark grayish brown. The texture of the A horizon is light clay loam in some places. Pebbles and fragments of caliche are common throughout that horizon. Depth to the R&AC horizon ranges from 4 to about 12 inches. The content of indurated caliche stones and plates in that horizon ranges from about 75 to 95 percent. The interspaces between the stones and plates are filled with soil material similar to that in the A horizon. In some places the R&AC horizon is absent, but it is as thick as 20 inches or more in others. Where the R&AC horizon is absent, an abrupt boundary separates the A horizon from plates of caliche 3 to 4 feet in diameter. The R horizon consists of slabs or plates of indurated caliche cemented together with a softer calcium carbonate. The indurated caliche of the R horizon extends to a depth of 5 to about 15 feet, and there grades to soft caliche.

Lea Series

The Lea series consists of dark grayish-brown, loamy soils that are shallow to moderately deep over platy, indurated caliche. These soils are mainly in the southeastern part of the county near Dawn. A few areas, however, are scattered throughout the rest of the High Plains. The slopes range from 1 to 4 percent.

In this county the Lea soils are mapped only in a complex with the Kimbrough soils. They have a thicker solum than the Kimbrough soils, but the soils of both series are underlain by indurated caliche. The Lea soils are similar to the Mansker soils in depth, but they have a less limy solum and a substratum of indurated caliche.

Typical profile 1 mile west and 6 miles south of Dawn (1,150 feet south and 30 feet east of the NW. corner of sec. 23, block K–14):

A1—0 to 13 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, fine, subangular blocky and granular structure; hard when dry, friable when moist, and slightly sticky when wet; common worm casts; a few, medium, hard pebbles of caliche and common, very fine, hard concretions; calcareous and moderately alkaline; gradual boundary.

B2—13 to 20 inches, brown (7.5YR 5/3) clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, subangular blocky and granular structure; hard when dry, friable when moist, and slightly sticky when wet; common worm casts and pores; common very fine concretions of caliche; calcareous and moderately alkaline; clear, irregular boundary.

R&AC—20 to 28 inches, 75 to 90 percent, by volume, fractured, indurated caliche plates 6 to 12 inches in diameter; fissures and voids filled with light-brown, calcareous loam containing common roots and worm casts; abrupt, irregular boundary.

R—28 to 32 inches +, white, indurated caliche plates 1 to 3 feet in diameter and about 3 to 8 inches thick; plates strongly cemented with calcium carbonate.

The A horizon ranges from loam to light clay loam in texture and from 8 to 15 inches in thickness. When dry, it is grayish brown (10YR 5/2) in places. In most places the A horizon is calcareous, but the uppermost 3 to 4 inches is noncalcareous in a few places. The B2 horizon is grayish-brown to dark grayish-brown clay loam to loam, and it ranges from 6 to 12 inches in thickness. Depth to the R&AC horizon ranges from about 12 to 25 inches.

Lincoln Series

The Lincoln series consists of light-colored, sandy soils on bottoms along some of the larger creeks in the Canadian breaks. These soils have formed in calcareous loamy sands and sands. The material in which they formed was derived mainly from the Ogallala formation but partly from sands of the red beds of Triassic age.

The Lincoln soils are lighter colored, more sandy, and more permeable than the Spur soils. They occur with Springer and Mobeetie soils but are also somewhat more sandy and lighter colored than those soils.

Typical profile about 5½ miles south and 1½ miles east of Glenrio (0.6 mile south and 0.3 mile west of the NE. corner of sec. 20 and 500 feet south of a windmill):

A1—0 to 10 inches, brown (10YR 5/3) loamy fine sand, brown (10YR 4/3) when moist; weak granular structure; soft to loose when dry and very friable when moist; most roots are in this horizon; calcareous and moderately alkaline; gradual boundary.

C—10 to 60 inches, light-brown (7.5YR 6/3) loamy fine sand grading to fine sand below a depth of 30 inches; brown (7.5YR 5/3) when moist; dominantly single grain but has some weak granular structure; loose when dry; calcareous and moderately alkaline.

The A horizon ranges from 8 to 15 inches in thickness. In a few places, its texture is fine sandy loam instead of loamy fine sand. When dry, the A horizon ranges from brown to light brown or pale brown in color. In a few places, the C horizon is fine sand or medium sand instead of loamy fine sand. Pebbles of quartz and caliche are common throughout the profile in some places.

Mansker Series

Grayish-brown, loamy soils that contain a large amount of lime are in the Mansker series. These soils have formed in strongly calcareous, windblown material of the High Plains but are moderately shallow over a layer of soft or gravelly caliche. They occur throughout the county, except in the Canadian breaks. Mostly, they occupy sloping areas of the High Plains, around playas and along draws, but some smooth, nearly level patches are on tablelands. The slopes range from 0 to about 8 percent.

Mansker soils occur with Ulysses soils but are shallower over caliche and are more limy than those soils. They are less limy but are deeper and darker colored than the Potter soils.

Typical profile 15 miles north of Bootleg on the east side of the road (1,500 feet south and 30 feet east of the NW. corner of sec. 29, T. 5 N., R. 38):

A1—0 to 10 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak subangular blocky and granular structure; slightly hard when dry and friable when moist; many worm casts; common medium pores; a few threads and films and a few fine and medium, strongly cemented concretions of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

B2ca—10 to 18 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) when moist; weak subangular blocky and granular structure; slightly hard when dry, friable when moist, and sticky when wet; more than 50 percent, by volume, of horizon is worm casts; common medium and fine pores; calcareous and contains common fine concretions of caliche; moderately alkaline; clear boundary.

Cca—18 to 36 inches, pink (7.5YR 7/4) clay loam, light brown (7.5YR 6/4) when moist; weak subangular blocky structure; friable when moist and sticky when wet; a few roots and worm casts in upper part; 30 to 50 percent, by volume, calcium carbonate in soft, coarse masses; moderately alkaline; clear boundary.

C—36 to 45 inches +, reddish-yellow (5YR 6/5) clay loam, yellowish red (5YR 5/5) when moist; friable when moist and sticky when wet; approximately 10 to 15 percent, by volume, calcium carbonate in fine and very fine, soft masses, films, and coatings; moderately alkaline.

The color of the A horizon ranges from dark grayish brown to grayish brown or brown in 10YR and 7.5YR hues. The A horizon is generally no more than 10 inches thick, but it ranges from 4 to 12 inches in thickness. Because the B2ca horizon contains a large amount of worm casts, the structure of that horizon is mostly granular, although it is moderate subangular blocky in some areas. In general, depth to the Cca horizon ranges from 12 to 20 inches, but a few pebbles of caliche are on the surface in many places. The Cca horizon ranges from a few inches to 2 or 3 feet in thickness, and it generally is underlain by reddish-brown to yellowish-red material similar to that underlying the Pullman soils. This material probably is not genetically related to the material in the solum.

Mobeetie Series

The Mobeetie series consists of brown, loamy soils that are deep. Calcareous colluvium or local alluvium was the material in which these soils formed. This colluvium or alluvium was derived mainly from the more sandy High Plains deposits but, to a lesser extent, from deposits of windblown material from red beds of Triassic or Permian age. The B2 horizon is friable loam or fine sandy loam that has granular structure. In many places the substratum has a texture similar to that of the B2 horizon, but it is calcareous.

Profile development has been limited to a slight movement of lime from the surface soil downward into the B2 horizon. The Mobeetie soils are moderately sloping to sloping. They occur below the escarpments in the Canadian breaks and along main drainageways of the High Plains.

The Mobeetie soils occur with Quay soils. Their horizonation resembles that of the Quay soils, but they have less clay throughout their profile than do those soils. The Mobeetie soils are more sandy and are lighter colored than the Mansker soils. They are lighter colored, less limy, and more permeable than the Bippus soils on the adjoining lower slopes.

Typical profile 8 miles west and 4 miles south of Bootleg (1,800 feet west and 1,900 feet south of the NE. corner of sec. 23, T. 2 N., R. 1 E.):

A1—0 to 11 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; compound weak prismatic structure breaking to weak subangular blocky and granular structure; slightly hard when dry and very friable when moist; many pores; a few faint films of calcium carbonate on the surfaces of the peds; a few concretions of calcium carbonate 1 to 5 millimeters in diameter; calcareous and moderately alkaline; gradual smooth boundary.

B2—11 to 20 inches, light-brown (7.5YR 6/3) fine sandy loam, brown (7.5YR 5/3) when moist; weak subangular blocky and granular structure; slightly hard when dry and very friable when moist; many worm casts; many fine pores; contains common films and threads of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

Cca—20 to 60 inches +, light-brown (7.5YR 6/4) loam, brown (7.5YR 5/4) when moist; slightly hard when dry and friable when moist; common very fine pores and root channels; a few roots; common concretions of calcium carbonate 1 to 5 millimeters in diameter; calcareous and moderately alkaline.

The A horizon is generally about 10 inches thick but ranges from 6 to 12 inches in thickness. Its texture is loam or fine sandy loam. When the A horizon is dry, its color ranges from grayish brown to brown or dark brown in 10YR and 7.5YR hues. The B2 horizon is fine sandy loam or loam. In that horizon worm casts are common to many. In many places the B2 horizon contains a network of thin veins or threads of calcium carbonate. The Cca horizon consists of loam to fine sandy loam that is calcareous but slightly weathered. In some areas the profile contains thin layers of gravel at various depths. Where these soils occur below the escarpments in the Canadian breaks, the hues throughout the profile range to 5YR.

Montoya Series

Reddish-brown, calcareous, clayey soils are in the Montoya series. These soils have formed in clayey alluvium washed in from red beds of Triassic age. They are on flats in the Canadian breaks. The slopes range from 0 to about 1½ percent, and some are concave. Generally, runoff is moderately slow. In some places, however, it is moderate in areas where a weak drainage pattern has developed. The Montoya soils support a dense stand of galleta grass. All of the acreage is in range.

Montoya soils occur with Quay soils, but their profile is more clayey throughout than that of the Quay soils. They are more reddish and are better drained than the Randall soils.

Typical profile about 4½ miles east and 3 miles south of Glenrio (1½ miles west-southwest from the ranch headquarters in that vicinity, 150 feet south, and 550 feet east of the point where a fence that runs northwest-southeast intersects an east-west fence):

A1—0 to 9 inches, reddish-brown (5YR 5/3) light clay, reddish brown (5YR 4/3) when moist; weak, medium and coarse, blocky structure; extremely hard when dry, extremely firm when moist, and sticky when wet; common very fine pores; many roots; common shiny pressure faces; calcareous and moderately alkaline; clear boundary.

AC—9 to 24 inches, reddish-brown (5YR 5/3) clay, reddish brown (5YR 4/3) when moist; weak, medium and coarse, blocky structure; extremely hard when dry, extremely firm when moist, and sticky when wet; the peds have shiny surfaces; contains a few very fine concretions of calcium carbonate and a few fine quartzose pebbles; calcareous and moderately alkaline; gradual boundary.

C1—24 to 50 inches, reddish-brown (5YR 5/3) clay, reddish brown (5YR 4/3) when moist; weak blocky structure; extremely hard when dry, extremely firm when moist, and sticky when wet; peds have shiny surfaces; a few very fine roots and pores; a few fine concretions of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

C2—50 to 60 inches, reddish-brown (5YR 5/5) heavy clay loam; very hard when dry, firm when moist, and sticky when wet; a few films of calcium carbonate and common, noncalcareous, crystalline masses, apparently of calcium sulfate, in old root channels; common very fine concretions of calcium carbonate; calcareous and moderately alkaline.

The texture of the A horizon is typically light clay, but it ranges to heavy clay in places. In some areas a layer of reddish-brown clay loam about 1 to 3 inches thick has been deposited on the surface. The AC and C horizons are typically clay or heavy clay, and the structure in those horizons is weak to moderate blocky.

Olton Series

The Olton series consists of deep, dark-brown soils, mostly on low slopes of the High Plains in the southern and western parts of the county. These soils have a surface layer of clay loam. The upper part of their subsoil has subangular blocky structure, but the lower part has blocky structure and is slowly permeable. These soils are underlain by a layer of soft, pink to pinkish-white caliche. They have formed in thin layers of clay loam—part of the mantle of windblown material that blankets the High Plains. The slopes range from 0 to 3 percent.

Olton soils occur mainly with Pullman soils, generally in broad areas of the High Plains. They have a less clayey, more permeable subsoil than the Pullman soils but have similar horizonation. The Olton soils have a more clayey subsoil and a slightly thicker solum than the Zita soils.

Typical profile 11 miles west and 3½ miles south of Hereford (100 feet east and 1,100 feet north of the SW. corner of sec. 17):

A1—0 to 7 inches, dark-brown (7.5YR 4/2) light clay loam, dark brown (7.5YR 3/2) when moist; weak subangular blocky and granular structure; hard when dry and slightly sticky when wet; noncalcareous; neutral in reaction; gradual boundary.

B21t—7 to 14 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, fine and medium, subangular blocky structure; very hard when dry and sticky and plastic when wet; common worm casts and fine and medium pores; patchy clay films; neutral reaction; gradual boundary.

B22t—14 to 24 inches, brown (7.5YR 5/3) heavy clay loam, dark brown (7.5YR 4/3) when moist; moderate, fine and medium, blocky structure; very hard when dry, very firm when moist, and sticky when wet; a few fine pores and a few worm nests; thin, continuous clay films; roots generally follow the surfaces of the peds but are also common in ped interiors; about neutral in reaction; gradual boundary.

B3ca—24 to 41 inches, reddish-brown (5YR 5/4) heavy clay loam, reddish brown (5YR 4/4) when moist; weak blocky to moderate, fine, subangular blocky structure; very hard when dry and sticky when wet; common fine roots; patchy clay films; films and threads of calcium carbonate common throughout horizon; calcareous and moderately alkaline; clear boundary.

Cca—41 to 63 inches, pink (5YR 7/4) silty clay loam, light reddish brown (5YR 6/4) when moist; slightly hard when dry and slightly sticky when wet; approximately 20 to 30 percent, by volume, soft calcium carbonate occurring as soft, pink and white masses; porous; moderately alkaline; gradual boundary.

C—63 to 65 inches +, light reddish-brown (5YR 6/4) silty clay loam, reddish brown (5YR 5/4) when moist; hard when dry, friable when moist, and slightly sticky when wet; many very fine pores; common films of calcium carbonate; moderately alkaline.

The A horizon ranges from 6 to 12 inches in thickness and from dark brown (7.5YR 4/2 or 4/3) to brown (7.5YR 5/2) in color. In places the texture of that horizon is clay loam instead of light clay loam. The B21t horizon ranges from 6 to 10 inches in thickness and from clay loam to heavy clay loam in texture. When dry, it is brown to reddish brown. The B22t horizon has weak blocky to strong subangular blocky structure in profiles that are less clayey than the one described as typical, and it contains thin, patchy clay films and a few worm casts. Depth to the B3ca horizon ranges from 20 to 30 inches. The color of the B3ca horizon ranges from reddish brown to brown in 5YR and 7.5YR hues. Depth to the Cca horizon ranges from 30 to 60 inches. That horizon ranges from about 1 to 3 feet in thickness. It is calcareous, and its color ranges from light reddish brown to pink. Beneath the Cca horizon is reddish-brown or light reddish-brown to reddish-yellow soil material.

Potter Series

The Potter series consists of grayish-brown to light brownish-gray, gravelly soils that are sloping to steep and are well drained to somewhat excessively drained. These soils are underlain by caliche that is cemented to some extent, or by a mixture of caliche and soil material. They are on the side slopes of draws, or occupy sloping areas below the edge of the escarpment in the northwestern part of the county. Geologic erosion is active.

The Potter soils have more gravel and lime in their surface layer than the Kimbrough soils, and they are underlain by softer caliche. Their solum is more gravelly and more limy than that of the Mansker soils, and they are shallower over caliche.

Typical profile along a tributary in the watershed of Garcia Lake in the western part of the county (2,800 feet west and 1,200 feet south of the NE. corner of sec. 14, T. 3 N., R. 2 E.):

A1—0 to 9 inches, light brownish-gray (10YR 6/2) gravelly loam, dark grayish brown (10YR 4/2) when moist; 20 to 30 percent, by volume, fine to medium, hard, subangular pebbles of caliche, and a few, coarse, angular pebbles; weak granular structure; soft when dry and friable when moist; abundant roots; very calcareous and moderately alkaline; clear boundary.

C—9 to 20 inches +, pink (7.5YR 8/4), soft and weakly cemented caliche; 10 to 15 percent, by volume, material similar to that in A1 horizon; common roots in upper part of horizon and a few in lower part; moderately alkaline.

The A horizon ranges from 5 to 10 inches in thickness. When the A horizon is dry, its color ranges from dark grayish brown to light brownish gray or light brown in hues of 10YR to 7.5YR. The content of caliche pebbles and fragments of caliche in the A horizon ranges from 15 to about 60 percent, by volume. In the C horizon, the content of concretions of calcium carbonate ranges from 50 to 90 percent, by volume. The concretions are soft to strongly cemented, and their color ranges from pink to white. In some areas the upper part of the C horizon is weakly cemented.

Pullman Series

In the Pullman series are dark grayish-brown soils that have a firm, clayey, blocky subsoil. These soils have formed in the mantle of windblown material that blankets the High Plains. They are the most extensive soils in Deaf Smith County and occupy most of the nearly level to gently sloping parts of the tableland. The slopes range from 0 to 3 percent.

Pullman soils have a somewhat less clayey subsoil than the Church soils, and a more compact, less permeable subsoil than the Olton soils. They are deeper, have a better developed profile, and are more clayey than the Ulysses soils. Unlike the Ulysses soils, they are free of calcareous material throughout the profile.

Typical profile 10½ miles north of Hereford on U.S. Highway No. 385 (1,320 feet north and 200 feet east of the southwest corner of sec. 62, block K-4):

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak granular structure; hard when dry, friable when moist, and sticky when wet; neutral reaction; clear boundary.

B21t—6 to 13 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; moderate, medium, blocky structure; very firm when moist and sticky when wet; a few fine and medium pores and a few worm casts; continuous clay films; most roots on the surfaces of peds but a few in ped interiors; neutral reaction; gradual boundary.

B22t—13 to 24 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; moderate to strong, medium, blocky structure; extremely hard when dry, very firm when moist, and sticky when wet; thin, distinct, continuous clay films; a few very fine pores; roots on surfaces of peds; neutral reaction; clear boundary.

B23tca—24 to 30 inches, brown (7.5YR 5/3) light clay, dark brown (7.5YR 4/3) when moist; moderate, medium, blocky structure; very hard when dry, firm when moist, and sticky when wet; a few, soft, very fine masses of calcium carbonate; a few fine pores and roots; calcareous and mildly alkaline; gradual boundary.

B21tb—30 to 38 inches, reddish-brown (5YR 5/4) light clay, reddish brown (5YR 4/4) when moist; moderate, medium, blocky structure; very hard when dry, firm when moist, and sticky when wet; common root channels and a few fine roots; common, very fine, black coatings in interiors of peds; common thin veins of calcium carbonate; calcareous and mildly alkaline; gradual boundary.

B22tb—38 to 52 inches, yellowish-red (5YR 5/6) heavy clay loam, yellowish red (5YR 4/6) when moist; weak, medium, blocky structure; very hard when dry, firm when moist, and sticky when wet; common very fine pores; common to many old root channels; many films and threads and a few, fine, soft concretions of calcium carbonate; a few fine masses of white material that apparently is calcium sulfate; soil mass noncalcareous and mildly alkaline; abrupt boundary.

C1ca—52 to 74 inches, pink (5YR 7/3) silty clay loam, light reddish brown (5YR 6/3) when moist; approximately 60 to 80 percent, by volume, is soft calcium carbonate mixed with reddish-brown, calcareous clay loam; moderately alkaline; clear boundary.

C2ca—74 to 78 inches +, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) when moist; friable when moist and sticky when wet; approximately 30 to 50 percent is soft calcium carbonate mixed with reddish-brown, calcareous clay loam.

The A horizon ranges from 4 to 7 inches in thickness. When dry, it is dark brown to brown or dark grayish brown and has a value of 5 to 4 and a hue that is mostly 7.5YR but ranges to 10YR. In many places, 1 inch to 2 inches of silt loam has accumulated on rangeland.

The B21t horizon modally extends to a depth of about 13 inches below the surface, but the depth ranges from 10 to 15 inches. The B21t horizon has weak blocky to moderate, medium, blocky structure and has clay to light clay texture. The B22t horizon typically contains slightly more clay than the B21t horizon and has stronger structure. The structure of the B22t horizon modally is moderate, medium, blocky ranging to strong, medium, blocky. In some areas the structure of the lower part of the B22t horizon appears compressed and has stronger horizontal than vertical cleavages. The B21tb horizon generally contains slightly less clay than the overlying horizons and ranges from light clay to clay loam. The B22tb horizon is typically noncalcareous throughout, but there are generally a few films and thin veins of calcium carbonate on the ped surfaces. The B22tb horizon is calcareous in a few places. It is yellowish-red to reddish-brown light clay or heavy clay loam. In Pullman soils having a solum thinner than that described, the buried B22tb horizon is generally absent. The C1ca horizon begins at a depth ranging from 30 to 75 inches.

Quay Series

The Quay series consists of reddish-brown, calcareous, loamy soils that are nearly level to gently rolling. These soils are in the Canadian breaks. They formed in outwash of calcareous clay loam from red beds of Triassic age, intermixed with sediments from High Plains deposits. The surface layer of these soils is loam to fine sandy loam. Beneath the surface layer is moderately permeable clay loam.

The Quay soils occur with Montoya soils but are better drained and less clayey than those soils. Their profile is more reddish than that of the Mobeetie soils, and their B and C horizons are more clayey. Also, these soils formed mainly in outwash from red beds rather than in sediments from the High Plains.

Typical profile about 6 miles east and 2½ miles south of Glenrio on the Moser ranch; reached by following fenceline southeast 3,500 feet from ranch headquarters, thence due east 1,200 feet:

A1—0 to 9 inches, brown (7.5YR 5/3) clay loam, dark brown (5YR 4/3) when moist; weak subangular blocky and granular structure; friable when moist and slightly sticky when wet; many roots; a few, strongly cemented, fine concretions of calcium carbonate; calcareous and moderately alkaline; clear boundary.

B21ca—9 to 23 inches, light reddish-brown (5YR 6/4) clay loam, reddish brown (5YR 4/4) when moist; weak subangular blocky and granular structure; friable when moist and sticky when wet; common fine pores; common worm casts; common films and threads, and a few fine concretions of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

B22ca—23 to 32 inches, light reddish-brown (5YR 6/4) light clay loam, reddish brown (5YR 5/4) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, and slightly sticky when wet; roots common; many fine pores; common very fine and fine concretions and common veins and coatings of calcium carbonate; moderately alkaline; gradual boundary.

Cca—32 to 57 inches +, pink (5YR 7/4) clay loam, light reddish brown (5YR 6/4) when moist; friable when moist and sticky when wet; a few roots; many, very fine, continuous pores; common hard concretions; calcareous and moderately alkaline.

The A horizon ranges from 6 to 11 inches in thickness and from clay loam to fine sandy loam in texture. When the A horizon is dry, its color ranges from reddish brown (5YR 5/3 or 5/4) to brown (7.5YR 5/4). In the less sloping areas, the A horizon is noncalcareous to a depth of 3 or 4 inches. In some areas the B21ca horizon has moderate subangular blocky structure. The Cca horizon is typically clay loam containing 5 to 10 percent, by volume, calcium carbonate in fine, hard concretions and in films and coatings. In places below a depth of about 30 inches, these soils are underlain by reddish-brown or reddish-yellow clay or fine sandy loam.

Randall Series

The Randall series consists of poorly drained, gray, clayey soils that occupy the bottoms of playas on the High Plains. These soils have formed in calcareous clayey sediments. They are sticky when wet and become extremely hard when dry. When the soils are dry, deep cracks form. These soils are flooded for a few weeks to several months each year.

Randall soils occur mainly with Church and Pullman soils. They are less well drained and more clayey than the Church soils and have less distinct horizons. Also, they are on the bottoms of playas instead of on playa benches. The Randall soils are more clayey than the Pullman and have a lighter, more grayish color.

Typical profile about 10½ miles north and 5.2 miles east of Hereford (1,700 feet east and 800 feet north of the SW. corner of sec. 18, block K–4):

A1—0 to 10 inches, gray (2.5Y 5/1) clay, dark gray (2.5Y 4/1) when moist; weak, coarse, blocky structure breaking to fine irregular and subangular blocky structure; extremely hard when dry, extremely firm when moist, and sticky when wet; a few medium-sized root channels; contains a few, very fine, white spots and masses of calcium carbonate; calcareous; gradual boundary.

AC1—10 to 24 inches, gray (2.5Y 5/1) clay, dark gray (2.5Y 4/1) when moist; weak to moderate, coarse, blocky structure; extremely hard when dry, extremely firm when moist, and sticky when wet; common shiny pressure faces on the surfaces of the peds; a few roots and very fine pores; a few very fine concretions of calcium carbonate; calcareous; gradual boundary.

AC2—24 to 55 inches, gray (2.5Y 6/1) clay, gray (2.5Y 5/1) when moist; common, distinct, light-gray mottles; weak, coarse, blocky structure; extremely hard when dry, extremely firm when moist, and sticky when wet; patchy, shiny pressure faces; a few very fine roots; a few very fine concretions of calcium carbonate like those in the AC1 horizon; calcareous and moderately alkaline; diffuse boundary.

C—55 to 60 inches, light-gray (2.5Y 7/1) clay, light gray (2.5Y 6/1) when moist; a few, distinct, gray mottles; extremely hard when dry, very firm when moist, and sticky when wet; a few, very fine, light yellowish-brown flecks and coatings; contains common soft coatings and masses of calcium carbonate; calcareous and moderately alkaline.

The profile of this soil ranges from calcareous to noncalcareous. When the A horizon is dry, it is typically gray (10YR 5/1), but its color ranges to dark gray (10YR 4/1) and, in a few areas, to very dark gray (10YR 3/1). The A horizon ranges from 8 to 15 inches in thickness. The combined AC horizons range from 15 to 50 inches in thickness. Weak blocky structure and shiny pressure faces are characteristic of those horizons. The color of the AC horizons ranges to gray (10YR 5/1 or 6/1). In a few areas, the color in the AC1 horizon ranges to dark gray (10YR 4/1). In general, the color of the C horizon ranges from light gray to dark grayish brown. In a few places, however, these soils are underlain by reddish-brown, brown, or reddish-yellow, calcareous clay loam below a depth of about 30 inches.

Springer Series

The Springer series consists of reddish-brown, gently sloping fine sandy loams on uplands in the Canadian breaks. These soils have formed in reddish-brown, moderately sandy, calcareous, windblown sediments. Beneath the surface layer, the soil material is friable and has granular structure. Permeability is moderately rapid. These soils have a weakly developed B horizon, and horizonation within the solum is weakly expressed.

The Springer soils occur mainly with Mobeetie and Quay soils. Their texture is similar to that of the Mobeetie soils, but they are more limy than those soils and they show little or no development of a horizon of clay accumulation. The Springer soils have colors similar to those of the Quay soils, but they are more limy and clayey than the Quay soils.

Typical profile 1.3 miles east and 1.1 miles south of Glenrio, 3,800 feet south of a windmill:

A1—0 to 10 inches, reddish-brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) when moist; weak subangular blocky and granular structure; slightly hard when dry and friable when moist; noncalcareous; about neutral in reaction; gradual boundary.

B2t—10 to 28 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) when moist; moderate, coarse, prismatic structure breaking to weak subangular blocky and granular structure; slightly hard when dry and friable when moist; roots uniformly distributed throughout horizon; common pores and root channels, mostly vertically oriented; common worm casts; noncalcareous; neutral reaction; clear boundary.

Cca—28 to 50 inches, reddish-brown (5YR 5/4) heavy fine sandy loam, reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky and granular structure; hard when dry and friable when moist; common roots; common films and veins of calcium carbonate on the surfaces of peds and in old pores and channels; moderately alkaline; gradual boundary.

C—50 to 60 inches, yellowish-red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) when moist; hard when dry and friable when moist; common pores and old root channels; soil matrix noncalcareous, but soil material effervesces in some spots when acid is added.

The A horizon ranges from 8 to 12 inches in thickness. Texture of the B2t horizon ranges from a medium to a heavy fine sandy loam. Depth to calcareous material (Cca horizon) ranges from 28 to 60 inches. In a few areas, these soils are noncalcareous throughout the entire profile.

Spur Series

The Spur series consists of dark-colored, loamy soils on bottoms along Palo Duro and Tierra Blanca Creeks. These soils have formed in calcareous alluvial sediments washed from High Plains deposits. They are rarely flooded because an entrenched channel cuts through the bottoms and carries off most of the runoff.

The Spur soils occur with Bippus soils but are typically more calcareous in the upper part of the profile than the Bippus soils. Also, they have formed in more recent deposits than the Bippus soils and have slightly less clay in their subsoil. The Spur soils have formed in finer textured alluvium than the Lincoln soils, and they are less sandy and darker colored than those soils.

Typical profile 8 miles west and 4½ miles south of Bootleg (3,800 feet west and 2,200 feet south of the NE. corner of sec. 23, T. 2 N., R. 1 E.):

A1—0 to 17 inches, very dark grayish-brown (10YR 3/2) clay loam, very dark brown (10YR 2/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, and sticky when wet; abundant roots; a few patchy clay films; calcareous and moderately alkaline; gradual boundary.

B2—17 to 26 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak subangular blocky and granular structure; hard when dry and firm when moist; a few threads and films of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

C1—26 to 44 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) when moist; weak subangular blocky structure; hard when dry, friable when moist, and sticky when wet; common films and threads of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

C2—44 to 63 inches +, brown (7.5YR 5/4) light sandy clay loam, brown (7.5YR 4/4) when moist; weak subangular blocky and granular structure; slightly hard when dry, friable when moist, and slightly sticky when wet; contains a few films and threads of calcium carbonate; calcareous.

In a few places, the uppermost few inches of the profile is noncalcareous. When the surface layer is dry, its color ranges from dark grayish brown or very dark grayish brown to dark brown. In profiles that are slightly more clayey than the one described, the structure of the B2 horizon is moderate subangular blocky. The C horizons generally contain slightly less clay than the A and B2 horizons. When those horizons are dry, their color ranges from brown to light brown or pale brown in hues of 10YR to 7.5YR. In many places 2 to 3 inches of silt loam has been deposited on the surface.

Ulysses Series

The Ulysses series consists of soils that are calcareous to the surface and have a prominent lime zone at a moderate depth. These soils are in scattered areas around playas and along draws in the High Plains. They are mainly nearly level but are gently sloping in places.

The Ulysses soils have a thinner solum than the Pullman and Olton soils, and their B and C horizons are less clayey. Also, unlike the Pullman and Olton soils, they are calcareous to the surface. The Ulysses soils have a thicker solum than the Mansker soils but have similar horizonation.

Typical profile 3 miles west and 3 miles north of Hereford (300 feet east and 50 feet south of the NW. corner of sec. 97, block K–8):

A—0 to 12 inches, dark-brown (10YR 4/3) clay loam, dark brown (10YR 3/3) when moist; weak to moderate, subangular blocky and granular structure; slightly hard when dry and friable when moist; common worm casts and fine and medium pores; calcareous and moderately alkaline; gradual boundary.

B2—12 to 22 inches, brown (7.5YR 5.3/3) clay loam, brown (7.5YR 4.3/3) when moist; weak subangular blocky and granular structure; friable when moist and slightly sticky when wet; common to many worm casts; many fine and medium pores; a few fine, rounded concretions of calcium carbonate; calcareous and moderately alkaline; clear, smooth boundary.

Cca—22 to 45 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) when moist; weak subangular blocky structure; hard when dry, friable when moist, and sticky when wet; common very fine pores caused by old root channels; a few roots; 5 to 10 percent, by volume, is segregated soft, fine and very fine masses of calcium carbonate; calcareous and moderately alkaline; clear boundary.

C—45 to 70 inches, yellowish-red (5YR 5/6) heavy clay loam, yellowish red (5YR 4/6) when moist; weak blocky structure; about 5 percent, by volume, is calcium carbonate as soft masses, films, threads, and coatings on the surfaces of the peds; calcareous and moderately alkaline.

The A horizon ranges from 8 to 14 inches in thickness. In many places it is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) when dry. In others it is dark brown (10YR 4/3) or brown (7.5YR 4/2). The B2 horizon extends to a depth of about 23 inches, but the depth ranges from 20 to 30 inches. The structure of the B2 horizon is mostly weak granular, but it ranges to moderate subangular blocky in the profiles that are slightly more clayey than the one described.

The Cca horizon ranges from light brown to pinkish white in color. It consists of calcareous clay loam intermixed with soft masses of caliche. The content of caliche ranges from 3 to 20 percent, by volume, but it is generally about 10 percent. The color of the C horizon ranges from pale brown to reddish yellow, and the texture is loam instead of heavy clay loam in some places.

Vernon Series [6]

The Vernon series consists of reddish-brown gravelly clay loams that are very shallow over calcareous, clayey marine shales of Permian or Triassic age. These soils are on hills and ridges in the Canadian breaks and are sloping to steep. Their surface is littered with indurated white, hard, angular pebbles and fragments of caliche that are probably the remains of High Plains deposits. Pebbles and fragments of caliche are also intermixed with the uppermost few inches of soil material in the solum.

The Vernon soils are more reddish, more clayey, and less limy than the Potter and Kimbrough soils. They have a thinner solum than the Quay soils but formed in the same kind of material.

[6] The soils classified as Vernon in this county are considered to be atypical of the Vernon series. In future surveys they will probably be classified in a different series.

Typical profile of Vernon gravelly clay loam in Deaf Smith County, about 4 miles east and 3 miles south of Glenrio (2 miles southwest of headquarters on Moser ranch; 1,350 feet south of large pond, on south-facing slope of hill):

A1—0 to 6 inches, reddish-brown (5YR 5/4) gravelly clay loam, with 15 to 20 percent, by volume, hard, subangular caliche pebbles; reddish brown (5YR 4/4) when moist; moderate to strong, very fine, subangular blocky structure; hard when dry, friable when moist, and sticky when wet; common, fine and very fine, reddish-brown shale aggregates of irregular shape; roots mostly in this horizon; common, very fine, soft concretions of calcium carbonate; calcareous and moderately alkaline; clear boundary.

C—6 to 20 inches, reddish-brown (5YR 5/3), slightly shaly clay; weak platy structure breaking to fine, irregular blocky; common coatings of lime on the surfaces of the aggregates; roots common in upper part and few in lower; calcareous and moderately alkaline.

Where these soils are on the crests of hills and ridges, their surface layer is about 6 inches thick, and they have a substratum of platy, clayey shale that is only slightly weathered. Where the soils are on the lower slopes, their surface layer is generally 12 to 15 inches thick.

Zita Series

The Zita series consists of dark-colored, loamy soils that have formed in calcareous, windblown sediments. These soils are mostly on the High Plains tablelands in the western part of the county, but a few areas are in the Canadian breaks. They are nearly level or gently sloping. Their B2 horizons are friable clay loam, and their Cca horizon is soft, whitish caliche.

The Zita soils have horizons similar to those of the Olton soils, but their subsoil is more clayey and open. They have a thinner, less clayey profile than the Pullman soils and are darker and deeper than the Mansker.

Typical profile 2 miles north of Walcott (2,100 feet north and 500 feet east of the SW. corner of sec. 8, T. 4 N., R. 3 E.):

A1—0 to 9 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; weak to moderate, subangular blocky and granular structure; very hard when dry, friable when moist, and slightly sticky when wet; common worm casts and pores; neutral reaction; clear boundary.

B21—9 to 18 inches, brown (7.5YR 4/3) clay loam, dark brown (7.5YR 3/3) when moist; moderate, very coarse, prismatic structure breaking to moderate, medium, subangular blocky and granular structure; very hard when dry, friable when moist, and slightly sticky when wet; common worm casts and pores; thin, continuous clay films; neutral reaction; clear boundary.

B22ca—18 to 30 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) when moist; moderate, very coarse, prismatic and moderate, medium, subangular blocky structure; very hard when dry and friable when moist; many worm casts and pores; common films and thin veins and a few, very fine, soft masses of calcium carbonate; calcareous and moderately alkaline; gradual boundary.

Cca—30 to 50 inches, pink (7.5YR 7/3) clay loam; 20 to 30 percent, by volume, calcium carbonate as soft, coarse, irregular masses and coatings; a few fine roots; moderately alkaline and calcareous; gradual boundary.

C—50 to 60 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) when moist; similar to Cca horizon in other respects but 10 to 15 percent, by volume, is calcium carbonate.

When the A horizon is dry, its color ranges from dark brown to brown in hues of 7.5YR to 5YR, chromas of 2 to 3, and values of 4 to 5. In places the texture of the A horizon is light sandy clay loam or light clay loam. The A horizon ranges from 8 to 15 inches in thickness. The B21 horizon is sandy clay loam in some areas and ranges from 7 to 15 inches in thickness. Typically, it is noncalcareous, but it is calcareous in a few places. The color of the B22ca horizon ranges from brown or light brown to reddish brown, and the texture ranges from clay loam to sandy clay loam. The Cca horizon ranges from inconspicuous in some areas to very prominent in others. It ranges from pinkish gray (7.5YR 7/2) to pink (7.5YR 7/3) in color and from sandy clay loam to clay loam in texture. Depth to the Cca horizon ranges from 2 to 3 feet.

Chemical and Mineralogical Characteristics of the Soils

Laboratory data have not been prepared for the soils of Deaf Smith County, but data for similar soils in surrounding areas of the Texas Panhandle and western New Mexico are available. Laboratory analyses of soils on the Southwestern Great Plains Field Station, Bushland, Tex., from the soil survey of Hansford County, Tex., and from the soil survey of Curry County, N. Mex., provided the data on which the following discussion of chemical and physical properties is based.

Organic matter and potassium.—The content of organic matter in soils in grassed areas mainly ranges between 2.5 and 3 percent. In some soils on bottom lands, such as Spur and Bippus, the average is probably a little higher. Analyses of the upper 5-inch layer of Pullman clay loam showed 2.58 percent. Analyses of the surface layer of Mansker clay loam showed 2.5 percent, though these amounts decrease rapidly as depth increases. In Pullman clay loam, for example, the content of organic matter averages only about 1 percent at 12 inches below the surface and gradually decreases to about 0.5 percent at a depth of 36 inches. In the upper horizons of Mansker and Ulysses soils, the average content at a depth of 12 inches is about 1 percent, but these soils generally have 0.5 percent in the Cca horizons at a depth of 24 inches or less.

Soils lose organic matter fairly rapidly during the few years that they are first cultivated. After this, the loss in organic matter is at a much slower rate. In most cultivated soils, the plow layer is 1.5 to 2.0 percent organic matter, which is roughly 60 percent of their original level.

Apparently, enough potassium is in the soils to supply needs of crops on both irrigated and dryland soils. Data on Pullman clay loam show 400 to 550 parts per million of extractable potassium (normal neutral ammonium acetate) to a depth of 4 feet.

Phosphorus.—Data on Pullman clay loam in native vegetation show 47 parts per million of phosphorus (sodium bicarbonate soluble) per acre in the top 5 inches. Of significance, however, is the sharp drop of phosphorus in the underlying 5- to 8-inch layer. This drop is to 9 parts per million. At a depth of 12 inches, the phosphorus level is even less; the average level is about 5 parts per million.

The phosphorus level in the soils in Deaf Smith County is apparently sufficient for the needs of both irrigated and dryland crops. The surface layer furnishes most of the phosphorus needed. Except on Pullman soils, little or no response is received if phosphates are applied where the surface layer has been removed and the phosphate-deficient subsoil is exposed.

Reaction.—The soils range from slightly acid to moderately alkaline. The pH ranges from about 6.3 to about 8.2 in the surface horizons. Some of the soils are neutral to slightly acid in the surface horizons but gradually increase in alkalinity with depth. Typical of these are the Pullman and Olton soils, which are well developed soils that have been leached of lime in their upper horizons. On the other hand, many have free lime to the surface and are moderately alkaline throughout their profiles. Among these are the Mansker, Ulysses, Church, and Quay soils. Spur and Bippus soils in areas along Tierra Blanca Creek show evidence of strong alkalinity including salt efflorescences, slick spots, and alkali sacaton, but these are small areas and data are not available.

Bases.—The principal cation, calcium, makes up about 75 percent of the total bases in the soils. The remainder, listed in the most common order of decreasing amounts, are magnesium, potassium, and sodium.

The upper horizons of the soils in Deaf Smith County are largely free of sodium. Most soils, however, have small amounts in their subsoil and substratum. Exchangeable sodium in the Pullman and Mansker soils typically ranges between 1 and 3 percent, but in a few analyses, it ranges to about 10 percent.

The cation-exchange capacity of the major soils ranges from 12 to about 28 milliequivalents per 100 grams of soil. For example, the cation-exchange capacity of the surface layer of a cultivated Pullman soil that has a clay loam texture and about 2 percent organic matter ranges between 18 and 21 milliequivalents per 100 grams of soil. The subsoil of Pullman clay loams is clay textured, but it is low in organic matter and has a cation-exchange capacity ranging between 24 and 30 milliequivalents per 100 grams of soil. The Cca horizons of Mansker and Ulysses have capacities of 12 to 15 milliequivalents.

Base saturation of the clays ranges from about 70 percent in the upper horizon of Pullman and Olton soils to near 100 percent in soil horizons having free carbonates.

Clays.—The clay fraction (less than 2 microns) of the soils consists of two kinds: (1) Chemically active alumino-silicates and (2) inert carbonates.

The alumino-silicate clays have moderately high shrink-swell coefficients and moderate to high cation-exchange capacities. The principal types are montmorillonite and illite. These types comprise most of the clay fraction in the Pullman solum. The remainder is probably largely of the kaolinite type. Analysis of the cation-exchange capacities of the clays from the various horizons of Pullman soil shows a range of from 73 to 92 milliequivalents per 100 grams of soil. Silica-sesquioxide ratios of these clays were dominantly between 3 and 4, but ranged from about 2 to 4.5.

Clay-sized carbonates occur mainly in the strongly calcareous horizons, such as the B2ca and Cca horizons of Mansker and Ulysses soils, and the Cca horizons of Pullman and Olton soils. Unpublished data of the Soil Conservation Service from a Mansker clay loam profile in Carson County, Tex., show clay-sized carbonates in all horizons. The largest amount, 18 percent, was in the Cca horizon.

General Nature of the County

This section provides information for those not familiar with the county. It describes the climate and geology,

TABLE 7.—*Summary of climate at*

Month	Temperature							Precipitation		
	Average			Extremes				Average monthly	Greatest daily	
	Maximum	Minimum	Monthly	Highest recorded		Lowest recorded				
	°F.	°F.	°F.	°F.	Year	°F.	Year	Inches	Inches	Year
January	50.8	21.8	36.3	82	1950	—4	1962 [1]	0.58	2.17	1939
February	55.4	26.0	40.7	83	1962	—17	1951	.50	1.12	1956
March	62.3	30.4	46.4	92	1946	2	1960 [1]	.64	1.18	1957
April	71.4	40.1	55.8	93	1937	14	1940	1.15	1.73	1949
May	80.0	50.4	65.2	100	1939	28	1954	2.82	3.70	1947
June	89.2	59.8	74.5	105	1953	40	1946	2.50	3.24	1954
July	91.6	63.6	77.6	107	1940	53	1958 [1]	2.73	5.30	1950
August	91.0	62.4	76.7	105	1944 [1]	48	1941 [1]	2.12	3.50	1945
September	84.4	54.8	69.6	102	1945 [1]	33	1945	1.67	2.75	1941
October	74.5	44.0	59.3	93	1953 [1]	24	1939	2.15	3.57	1941
November	60.7	29.9	45.3	84	1952 [1]	0	1952	.49	3.25	1940
December	53.4	24.5	39.0	80	1939	—3	1961	.69	3.10	1943
Year	72.1	42.3	57.2	107	1940	—17	1951	18.04	5.30	1950

[1] Also on earlier dates, months, or years.
[2] Less than half a day.

discusses the history and settlement, and gives facts about the livestock, transportation, and markets.

Climate[7]

The climate of Deaf Smith County is semiarid, with an average annual rainfall of 18.04 inches. The county receives more moisture than the adjoining State of New Mexico to the west, but less than the more eastern counties of the Texas Panhandle. A summary of data on climate at Hereford, for the 26-year period, 1937–62, is given in table 7.

Monthly and annual rainfall is characterized by extreme variability, as is illustrated in table 7 by the wettest and driest years. In 1941, 38.95 inches of precipitation was recorded at Hereford, but only 7.71 inches fell during 1956, a year of extreme drought. During the 5-year drought, 1952 through 1956, the average annual rainfall was 11.77 inches. In the next 5-year period, 1958 through 1962, rainfall averaged 21.23 inches, or almost twice as much as in the preceding 5 years. Rainfall occurs more frequently in thunderstorms than in general rains. This spotty, shower-type rainfall accounts for the extreme variability in amounts. Maximum rainfall occurs during the months of May, June, and July, and 78 percent of the average annual rainfall occurs in the 6-month period, May through October. Little benefit is derived from much of the precipitation during exceptionally wet months or years, because the precipitation comes in heavy thundershowers and much of the moisture is lost in excessive runoff that causes erosion.

The extreme variations in rainfall can be seen by studying the data in table 7 for the month of October. In October, rains may be very heavy or may not occur at all. On an average, Hereford will receive, 1 year out of every 10, more than 5.0 inches of rainfall in October. The chances are equally great that Hereford will receive no rain at all during October. Periods when there is no rain for several weeks or more are fairly common, and periods of 30 days or more without measurable rain have occurred in all months of the year except May and July. No rain was reported for 2 consecutive months on several occasions.

During the winter months, the area is cut off from the moisture in the Gulf of Mexico by frequent cold fronts and precipitation is rather limited. Precipitation in winter falls as rain or snow, or sometimes as rain and snow mixed. Snowfalls are generally light, and the snow remains on the ground for only a short time. A few times in winter over a long period, snow has been heavy when moisture from the Gulf is carried northward into low pressure centers over the Texas Panhandle. During the blizzard of 1956, 26.5 inches of snow fell in a 4-day period.

In Deaf Smith County, temperature, like rainfall, shows extreme variability, especially from November through April, or during the colder 6 months of the year. Cold fronts from the northern Rocky Mountains and Plains States sweep across the plains of the Panhandle at speeds of as much as 40 miles an hour. Drops in temperature of 50 to 60 degrees within a 12-hour period are common in Deaf Smith County. Strong southwesterly winds blow in from the high New Mexico plateaus and cause rapid rises in temperature. Large fluctuations in temperature are often noted from day to day during the latter part of fall and in winter and spring. Relatively severe cold fronts may follow several weeks of mild weather and push rapidly southward late in spring. These cold fronts have a disastrous effect on new spring vegetation. A weather pattern of this kind discourages the growing of fruit trees in the area and also penalizes farmers who plant tender crops too early.

[7] By Robert B. Orton, State climatologist, U.S. Weather Bureau.

Hereford, for the years 1937–62

Precipitation—Continued							Average number of days when maximum temperature is—		Average number of days when minimum temperature is—	
Driest year (1956)	Wettest year (1941)	Precipitation that can be expected 1 year in 10		Snowfall and sleet			90° or above	32° or below	32° and below	0° and below
		Less than—	More than—	Average	Maximum					
Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Year*	*Days*	*Days*	*Days*	*Days*
0.03	0.03	0.1	1.7	1.5	8.5	1960	0	3	28	1
1.70	.28	0	1.4	2.4	26.5	1956	0	2	22	(2)
(3)	2.12	0	2.2	.3	3.0	1958 [1]	0	1	18	0
(3)	1.73	.1	1.9	.5	4.5	1938	1	(2)	5	0
1.99	8.05	.5	6.8	0	0	----------	6	0	1	0
1.40	4.24	.7	4.0	0	0	----------	17	0	0	0
.79	4.30	.3	5.0	0	0	----------	20	0	0	0
.72	1.52	.6	3.6	0	0	----------	20	0	0	0
(3)	3.93	.2	2.8	0	0	----------	8	0	0	0
1.08	11.77	0	5.0	.3	3.5	1941	1	0	2	0
0	.21	0	.9	.7	5.5	1962	0	1	18	0
0	.77	0	1.3	1.6	9.5	1943	0	2	27	(2)
7.71	38.95	11.1	25.3	7.3	26.5	1956	73	9	121	1

[3] Trace.

Because the dry air, high elevation, and usually clear skies result in much solar radiation, there is a large range between the maximum temperature during the afternoon and the minimum temperature during the early morning. This daily range averages about 28° F. Days are hot in summer and have low humidity. Nights in summer are relatively cool, for the minimum temperature is in the low 60's.

Average speeds of wind are rather high in Deaf Smith County because the high, level terrain offers little resistance to the wind. The average hourly windspeed is about 12 miles per hour. The direction of the prevailing winds ranges from south to southwest.

Humidity in this county is low compared to that of central and eastern Texas. The highest humidity occurs early in the morning, and the lowest occurs during the warmest part of the afternoon. In summer, the readings at 6 a.m. may be expected to average about 77 percent, but readings at 6 p.m. average about 40 percent.

Hail may accompany almost any thunderstorm, but damaging hailstorms are infrequent and cover only small areas. Hail is most frequent late in spring and early in summer. The growing season is fairly short. There are 185 days between the average date of the last occurrence of 32° in spring and the average date of the first occurrence of 32° in fall. The average date of the last freeze in spring is April 20. On the average, 1 year out of every 5 will have a freezing temperature after April 30; 1 year in every 20 will have a freezing temperature after May 8. The average date of the first freeze in fall is October 22. In 1 year out of every 5, on the average, a freeze will occur before October 12, and in 1 year in every 20 before October 2. The average number of days between the last occurrence of 28° in spring and the first occurrence of 28° in fall is 210 days.

Sunshine is abundant the year around. Evaporation is high, as is expected in a semiarid region. Average annual lake evaporation is approximately 67 inches. Evaporation from a Weather Bureau 48-inch pan is approximately 98 inches, of which 68 percent evaporates during the period May through October.

Geology

The origin of the High Plains is significant in the geologic history of the area (*3*). During the Permian era (roughly 200 million years ago), a large area that included nearly all of the present Panhandle of Texas, the eastern part of New Mexico, and the western part of Oklahoma was under a shallow sea. Sediments deposited in this sea formed what is known as the Permian red beds. Later, as a result of movements inside the earth, this area rose above the level of the sea. Streams began to form on the exposed rocks of the red beds. Material was washed from the higher places and redeposited along the channels of the streams. Nearly all of the surface material of Permian age in Deaf Smith County was reworked in this way, and the resulting formation is known as the Triassic red beds. Exposures of that formation can be seen along the lower part of the escarpment in the Canadian breaks. They consist of reddish-brown shale and of grayish-brown sandstone ledges.

The uplift of the Rocky Mountains during the Pliocene epoch was the next important geologic event. Swift streams, flowing from the mountains to the west, cut valleys and canyons through the red beds of Triassic age, and in some places, into the red beds of Permian age. When the mountains reached their maximum height, they began to erode more rapidly. At that time, the climate was extremely wet, and rains carried coarse, gravelly material down the slopes and eastward out onto the plains. This material made up the first deposits of the Ogallala formation, and it represents the present water-bearing material.

Finer textured sands and calcareous, loamy soil material were washed down after the coarse, gravelly material. They formed alluvial fans and outwash aprons over the Triassic red beds until the entire surface was finally covered. These deposits gradually built up to form a vast plain, the Ogallala formation, which extends several hundred miles to the east of the Rockies.

The Ogallala formation in this county ranges from about 200 to 600 feet in thickness. Exposures of that formation are along the escarpment in the Canadian breaks, and in a few areas along Tierra Blanca Creek. In most places the Potter soils have formed in these deposits.

The next important event after the material of the Ogallala formation was deposited was the formation of a mantle of loess that blankets the Ogallala formation (*4*). This mantle was deposited during about the middle of the Pleistocene epoch. The climate by this time had reversed itself and had again become dry, windy, and desiccating. The prevailing winds were from the southwest. During this period, the Pecos and other rivers were forming to the west and south. As a result of the dry climate and winds, fine-textured sediments were blown out of the river bottoms and carried to the northwest. These sediments settled on the Ogallala outwash plain, and the mantle of loess they formed built up until it is now roughly between 30 and 100 feet thick. Most of the soils of the High Plains, the Pullman, Olton, and Amarillo for example, have formed in this mantle.

The most recent geologic formations in this county are the inextensive alluvial deposits along the streams and the windblown deposits in sandy areas of the Canadian breaks. They are probably of late Wisconsin or Recent geologic age.

The source of the underground water used for irrigation is the saturated sand and gravel at the base of the Ogallala formation. This water probably accumulated during the wet, humid period when the formation was being deposited, and the underlying impervious red beds kept it from percolating to a greater depth. When the Ogallala formation was cut off from the Rocky Mountains by the Pecos River, its source of recharge water was lost. At present, there seems to be little or no recharge from rainfall, and water is pumped out faster than it is restored. Representatives of the High Plains Underground Water District are making a study of the decline of the water table by observing selected wells. They have reported that the water table in this area dropped about 4.1 feet per year during the years between 1955 and 1958.

At present, geologic forces are wearing away the edges of the High Plains tableland. Palo Duro Canyon is encroaching by headward erosion from the east; the Canadian River is encroaching from the north; and tributaries of the Pecos River are encroaching from the west. In addition, Tierra Blanca and Palo Duro Creeks and several other streams have entrenched themselves across the High Plains and are cutting downward, gradually removing the deposits.

History and Settlement

The area that is now Deaf Smith County was originally inhabited by the Comanches, Kiowas, Apaches, and members of other Indian tribes who hunted bison, deer, and antelope. Settlers began to come into the area in the 1800's. Deaf Smith County, named for Erastus (Deaf) Smith, a famous Texas scout, was created from Bexar Territory in 1876. At first, the new county was attached to Oldham County for law and court purposes, but it became independent in 1890. Eventually, the present town of Hereford became the county seat.

When the county was organized, all of it was open range. The western third was in the XIT Ranch, and the eastern part was owned by the State. In about 1898, the State land was opened to homesteaders, mostly livestock men, who soon settled the area. These early settlers were called nesters because of the fences they built to enclose their land. They were followed by farmers who broke the sod, tilled the ground, and sowed wheat and other dryland crops. These farmers replaced many of the original settlers who raised livestock. Within a few years after the eastern part of the county was settled, the XIT Ranch was divided into several smaller ranches and farms, and eventually, all of it was sold.

Agriculture gradually intensified during the next 20 years, and the county became an area of extensive dryland farming and ranching. Wheat and grain sorghum were grown on large acreages. Then, in the thirties drought struck the Great Plains. Duststorms, lack of rainfall, and low market prices forced many farmers to leave the area. Only the best farmers or farmers with enough financial backing remained.

The early forties brought a series of wet years, and irrigation from deep wells was begun about that time. Also, much had been learned during the drought period about how to farm the soils to control erosion. Irrigation, improved farming practices, and better outlets for farm products have been the main factors that have produced the stable agriculture of the present time. At present, as in earlier times, wheat and grain sorghum are the main crops, but sugarbeets and irrigated vegetables are grown on large acreages. In 1962 about 60 percent of the acreage in the county was in dryland or irrigated crops.

Livestock

Livestock is an important source of income in this county. The main kind of livestock is beef cattle, but a few farmers raise hogs or sheep. Also, most farmers have a milk cow or two and a small flock of chickens. According to figures of the U.S. Bureau of the Census, 49,926 cattle and calves, 8,473 hogs and pigs, 1,629 sheep and lambs, 39,304 chickens, and 94 turkey hens kept for breeding were on farms and ranches in the county in 1959. Owners of the larger ranches in the western part of the county also generally have a string of cow horses used in managing their herds. Most farmers own one or two riding horses.

Ranching is the main beef cattle enterprise. Some ranchers keep a herd of cows and raise calves that are sold at weaning time. Others buy steers, graze them until they weigh 800 to 1,000 pounds, and then sell them to feeders. The beef cattle are mainly of the Hereford breed, but there are several herds of Aberdeen-Angus.

The fattening of beef cattle is rapidly becoming an important enterprise. Several feedlots are located in the county. Grain sorghum and silage, grown locally, are the main feeds, but byproducts from refining sugarbeets also provide a source of feed for livestock.

Transportation and Markets

Most of the rail transportation needed for marketing vegetables and grain crops is provided by the Santa Fe Railroad. That railroad crosses the southeastern part of the county and has stations at Hereford and Dawn. The Rock Island Railroad crosses the northwestern tip of the county near Glenrio. U.S. Highway Nos. 60, 66 (Interstate 40), and 385, as well as State Route 214, also provide outlets to markets.

Hereford is the banking and commercial center of the county. Several large grain elevators and a flourmill are located there, as well as about a dozen sheds used to process vegetables. In the past, sugarbeets were shipped to refineries outside the county for processing. In the future, however, the sugarbeets from this and surrounding counties can be processed at a sugar refinery under construction at Hereford. The eggs, poultry, and milk produced in the county are marketed in Hereford and are consumed locally. The cattle and hogs are commonly trucked to markets in Amarillo, Tex., and Clovis, N. Mex. Wheat and grain sorghum grown in the county are generally sold to operators of local elevators, who transport them by rail or truck to larger markets at distant points. The baled hay and silage are fed locally.

Literature Cited

(1) American Association of State Highway Officials.
1961. Standard specifications for highway materials and methods of sampling and testing. Ed. 8, 2 v., illus.

(2) Baldwin, Mark, Kellogg, Charles E., and Thorp, James.
1938. Soil classification. U.S. Dept. Agr. Ybk., pp. 979–1001, illus.

(3) Frye, John C., and Leonard, A. Byron.
1957. Studies of Cenozoic geology along eastern margin of Texas High Plains, Armstrong to Howard counties. Univ. Tex., Bur. Econ. Geol. Rept. 32: 60 pp., illus.

(4) Lotspeich, F. B., and Coover, J. R.
1962. Soil forming factors on the Llano Estacade: parent material, time, and topography. Tex. Jour. of Sci., v. XIV, No. 1, pp. 7–17, illus.

(5) Simonson, Roy W.
1962. Soil classification in the United States. Sci. 137: 1027–1034.

(6) Soil Survey Staff.
1951. Soil survey manual. U.S. Dept. Agr. Handbook 18, 503 pp., illus.

(7) ———
1960. Soil classification, a comprehensive system, 7th approximation. U.S. Dept. Agr., 265 pp., illus. [Supplement issued in March 1967].

(8) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUP. Soil Sci. 67: 117-126.
(9) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.
1953. THE UNIFIED SOIL CLASSIFICATION. Tech. Memo. 3-357, 2 v., and app., illus.

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alkaline soil. Generally, a soil that is alkaline throughout most or all of the part occupied by plant roots. Precisely, any soil having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

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

Bench, terrace. A shelflike embankment of earth that has a level or nearly level top and a steep or vertical downhill face, constructed along the contour of sloping land or across the slope to control runoff and erosion. The downhill face of the bench may be made of rocks or masonry, or it may be planted to vegetation.

Buried soil. A developed soil that was once exposed but is now overlain by a more recently formed soil.

Calcareous soil. A soil containing calcium carbonate, or a soil that is alkaline in reaction because of the presence of calcium carbonate.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Chlorosis. A yellowing between veins on upper foliage that results from chlorophyll deficiency. Many factors, including heredity, cause chlorosis.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds that cement the soil grains together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions. Descriptive terms are as follows: Amount—*few*, less than 2 percent of volume; *common*, 2 to 20 percent of volume; *many*, over 20 percent of volume. The size measurements are: *Fine*, 1 to 2 millimeters in diameter; *medium*, 2 to 5 millimeters in diameter; and *coarse*, over 5 millimeters in diameter.

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 to moderate pressure between thumb and forefinger and can be pressed together into a lump.

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

Plastic. When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

Sticky. When wet, adheres to other material; tends to stretch somewhat and pull apart, rather than pull free from other material.

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

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

Eolian soil material. Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.

Fine-textured soils. Sandy clay, silty clay, and clay. Roughly, soil that contains 35 percent or more of clay.

Genesis, soil. The manner in which the soil originated, with special reference to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active, and it is therefore marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these characteristics. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. This layer, commonly called the soil parent material, is presumed to be like that from which the overlying horizons were formed in most soils. If the underlying material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

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

Hygroscopic water. Water that does not move in the soil, that is not used by plants, and that may exist in a state other than liquid.

Leaching, soil. The removal of soluble materials from soils or other material by percolating water.

Loam. The textural class name for a soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

Medium-textured soil. Soil of very fine sandy loam, loam, silt loam, or silt texture.

Morphology, soil. The makeup of a soil, including the texture, structure, consistence, color, and other physical, chemical, mineralogical, and biological properties of the various horizons.

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, or light yellowish brown.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Pores, soil. Open channels in the soil material caused by roots and forms of animal life, such as earthworms and insects. Following are the terms used to define soil pores: Amount—*few*, less than 5 per square inch; *common*, 5 to 25 per square inch; *many*, more than 25 per square inch. The size measurements are: *Very fine*, less than 0.25 millimeter in diameter; *fine*, 0.25 to 1.0 millimeter in diameter; *medium*, 1.0 to 3.0 millimeters in diameter; and *coarse*, 3.0 millimeters and larger.

Profile, soil. A vertical section of a soil through all its horizons and extending into the parent material. See Horizon, soil.

Reaction, soil. The degree of acidity or alkalinity of a soil expressed in pH values. In words the degrees of acidity or alkalinity are expressed thus:

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

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

Sand. Individual rock or mineral fragments that are from 0.05 to 2.0 millimeters in diameter. Sand grains are generally quartz, but they may be of any mineral composition. Sand, as a textural class name of any soil, contains 85 percent or more sand and not more than 10 percent clay.

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

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying 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, either conforming (C or R) or unconforming.

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

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. (See also Clay, Sand, and Silt.) The basic textural classes, in order of increasing proportions of fine particles are as follows: sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

GUIDE TO MAPPING UNITS

[For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs.

[See table 1, p. 7, for approximate acreage and proportionate extent of soils; table 2, p. 31, for predicted average acre yields of principal crops; and pp. 37 to 46 for information on engineering uses of soils. Dashed lines indicate soil was not placed in a range site or assigned an irrigated capability unit]

Map symbol	Mapping unit	Page	Capability unit: Dryland	Page	Capability unit: Irrigated	Page	Range site: Name	Page
Br	Bippus clay loam	6	IIIe-2	23	IIe-1	28	Deep Hardland	32
Ch	Church clay	8	IVes-1	24	IIIes-1	30	High Lime	33
DrC	Drake soils, 3 to 5 percent slopes	8	VIe-3	25	IVe-4	30	High Lime	33
DrD	Drake soils, 5 to 8 percent slopes	8	VIe-3	25	-------	--	High Lime	33
Kl	Kimbrough-Lea complex	9	VIIs-1	25	-------	--	Very Shallow	35
Ln	Lincoln soils	9	Vw-2	25	-------	--	Sandy Bottom Land	34
MkA	Mansker clay loam, 0 to 1 percent slopes	10	IVe-9	24	IIIe-10	30	Hardland Slopes	33
MkB	Mansker clay loam, 1 to 3 percent slopes	10	IVe-9	24	IIIe-10	30	Hardland Slopes	33
MkC	Mansker clay loam, 3 to 5 percent slopes	10	IVe-2	24	IVe-6	31	Hardland Slopes	33
MkD	Mansker clay loam, 5 to 8 percent slopes	10	VIe-1	25	-------	--	Hardland Slopes	33
MpD	Mansker-Potter complex, 2 to 8 percent slopes	10						
	Mansker soil	--	VIe-1	25	-------	--	Hardland Slopes	33
	Potter soil	--	VIe-1	25	-------	--	Very Shallow	35
MrC	Mobeetie fine sandy loam, 3 to 5 percent slopes	11	IVe-5	24	IVe-2	30	Mixed Land Slopes	34
MrD	Mobeetie fine sandy loam, 5 to 8 percent slopes	11	VIe-2	25	-------	--	Mixed Land Slopes	34
Mt	Montoya clay	12	IVs-1	24	-------	--	Clay Flats	32
OcA	Olton clay loam, 0 to 1 percent slopes	13	IIIce-2	22	I-1	27	Deep Hardland	32
OcB	Olton clay loam, 1 to 3 percent slopes	13	IIIe-2	23	IIe-2	28	Deep Hardland	32
Pe	Potter soils	13	VIIs-1	25	-------	--	Very Shallow	35
PmA	Pullman clay loam, 0 to 1 percent slopes	15	IIIce-1	22	IIs-1	29	Deep Hardland	32
PmB	Pullman clay loam, 1 to 3 percent slopes	15	IIIe-1	23	IIIe-1	29	Deep Hardland	32
PmB2	Pullman clay loam, 1 to 3 percent slopes, eroded	15	IVe-3	24	IIIe-2	29	Deep Hardland	32
PuA	Pullman-Ulysses complex, 0 to 1 percent slopes	15	IIIce-4	22	IIs-2	29	Deep Hardland	32
PuB	Pullman-Ulysses complex, 1 to 3 percent slopes	15	IIIe-7	23	IIIe-5	30	Deep Hardland	32
QcA	Quay clay loam, 0 to 1 percent slopes	16	IIIce-3	22	-------	--	Deep Hardland	32
QcB	Quay clay loam, 1 to 3 percent slopes	16	IIIe-3	23	-------	--	Deep Hardland	32
QcC	Quay clay loam, 3 to 5 percent slopes	16	IVe-2	24	-------	--	Deep Hardland	32
QfC	Quay fine sandy loam, 1 to 5 percent slopes	16	IVe-5	24	-------	--	Sandy Loam	35
Ra	Randall clay	17	VIw-1	25	-------	--	----------------	--
Ro	Rough broken land	17	VIIs-2	26	-------	--	Rough Breaks	34
SfB	Springer fine sandy loam, 1 to 3 percent slopes	18	IIIe-5	23	-------	--	Sandy Loam	35
Sp	Spur and Bippus soils	18	Vw-1	25	-------	--	Loamy Bottom Land	33
UsA	Ulysses clay loam, 0 to 1 percent slopes	18	IIIce-3	22	IIe-3	28	Deep Hardland	32
UsB	Ulysses clay loam, 1 to 3 percent slopes	19	IIIe-3	23	IIIe-4	29	Deep Hardland	32
Vx	Vernon-Quay complex	19						
	Vernon soil	--	VIIs-1	25	-------	--	Shallow Redland	35
	Quay soil	--	VIIs-1	25	-------	--	Deep Hardland	32
ZcA	Zita clay loam, 0 to 1 percent slopes	19	IIIce-2	22	I-2	28	Deep Hardland	32
ZcB	Zita clay loam, 1 to 3 percent slopes	20	IIIe-2	23	IIe-1	28	Deep Hardland	32

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