

Series 1956, No. 8

Issued June 1960

# SOIL SURVEY

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## Harper County Oklahoma

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

# HOW TO USE THE SOIL SURVEY REPORT

**T**HIS SURVEY will serve several groups of readers. Among others, it will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; serve as a reference for students and teachers; and add to the soil scientist's fund of knowledge.

In making this survey, soil scientists walked over the fields and native grasslands. They dug holes and examined surface soils and sub-soils; measured slopes with a hand level; noticed differences in growth of crops, weeds, and grass; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming, engineering, and related uses.

The scientists placed the boundaries of the soils on aerial photographs. Then, cartographers prepared from the photographs the detailed soil map in the back of this report. Fields, roads, and many other landmarks can be seen on the map.

## Locating the soils

Use the index to map sheets to locate areas on the large map. The index is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map is located, it will be seen that boundaries of the soils are outlined and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map. The symbol will be inside the area if there is enough room; otherwise, it will be outside the area and a pointer will show where it belongs.

Suppose, for example, an area located on the map has the symbol Ca. The legend for the detailed map shows that this symbol identifies Carey silt loam, 1 to 3 percent slopes. This soil and all others mapped in the county are described in the section, Soils on Your Farm. There is a more technical description of each soil in the section, Soil Formation and Classification.

## Finding information

Few readers will be interested in all of the soil report, for it has special sections for different groups, as well as sections that may be of value to all.

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

The soils are placed in capability units; that is, groups of soils that need similar management and respond in about the same way. For example, in the section, Soils on Your Farm, Carey silt loam, 1 to 3 percent slopes, is shown to be in capability unit IIe-2. The management suitable for this soil, therefore, will be described under the heading, Capability unit IIe-2, in the section, Management of the Soils.

The soils are in various range sites, which are areas of native pasture, each of which has a given potential production of grasses and other vegetation. Carey silt loam, 1 to 3 percent slopes, is in the Loamy range site.

If help is needed in farm planning, the local representative of the Soil Conservation Service or the county agricultural agent should be consulted. Members of the staff of the State experiment station and others familiar with farming in the county can also give assistance. This survey is a part of the technical assistance furnished by the Soil Conservation Service to the Harper County Soil Conservation District, which was established in 1939.

*Foresters and others interested in woodlands* can refer to the section, Woodlands. In that section the kinds of trees in the county are described and the factors affecting the management of woodlands are explained.

*Engineers* will want to refer to the section, Engineering Properties of Soils. A table in that section shows characteristics of the soils that affect engineering.

*Soil scientists* will find information about how the soils were formed and how they are classified in the section, Soil Formation and Classification.

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

*Newcomers in Harper County* will be especially interested in the section, General Soil Areas, which describes the broad pattern of the soils. They may also wish to read the section, General Nature of the Area, which gives additional information about the county.

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# SOIL SURVEY OF HARPER COUNTY, OKLAHOMA

Soil Survey by EARL C. NANCE, JOE D. NICHOLS, H. L. KOLLMORGEN, R. E. DANIELL, H. L. COSTILOW, and K. T. LOFTON,  
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United States Department of Agriculture in cooperation with the Oklahoma Agricultural Experiment Station



Figure 1.—Location of Harper County in Oklahoma.

**H**ARPER COUNTY is on a rolling prairie in northwestern Oklahoma (fig. 1). It is bordered on the west by Beaver County, on the north by the State of Kansas, on the northeast by Woods County, on the east by Woodward County, and on the south by Ellis and Woodward Counties. The total area of the county is 661,760 acres. In 1950 the county had a population of 5,977. Buffalo, the county seat, had a population of 1,544.

Agriculture is the basis for the economy of Harper County. Wheat, grain sorghums, and beef cattle are the main sources of farm income.

The native vegetation consisted mainly of prairie grasses, but some trees grew along the streams. Originally, the area was used by the Indians as a hunting ground for buffalo and deer.

This soil survey, a cooperative contribution of the United States Department of Agriculture and the Oklahoma Agricultural Experiment Station, was made to assist farmers and ranchers in planning improved management of their cropland and range. Fieldwork was completed in 1956. Unless otherwise indicated, all statements in this report refer to conditions in the county at that time.

## General Soil Areas<sup>1</sup>

This section provides a generalized description of the soils of Harper County. The soils have been placed in three broad soil areas, according to the kind of underlying parent material. (See figs. 2, 3, and 4.)

Within each of these broad areas is a group of soil associations. A soil association consists of two or more soils that occur in a definite pattern on the landscape.

<sup>1</sup>This section was prepared with the help of Joe D. Nichols, soil scientist, Soil Conservation Service.

The broad areas and the soil associations within each are shown on the colored map in the back of this report.

Each of the associations is made up of somewhat different soils that have formed from similar parent materials and that generally occur together on the landscape. Within the association are inextensive soils that differ from the principal soils. In general, the land-use pattern within any one association is similar from one area of that association to another.

## Soil Associations on Permian Redbeds

The soils of associations 1, 2, and 3 were formed mainly on reddish sandstones and on sandy and silty shales of the redbed formations. Together, they comprise about three-fifths of the county. The Quinlan, Woodward, Carey, St. Paul, Hollister, and Tipton soils and Rough broken land, Quinlan material, are important in these associations. A diagram indicating how some of these soils might occur on a typical landscape is shown in figure 2.

The Quinlan soils are shallow and occur on steep slopes and in shallow, gullylike drainageways. The Woodward soils are moderately deep and occur on sloping to rolling areas. The Carey soils are deep and are mainly on nearly level to gently sloping areas. The St. Paul and Hollister soils are slightly deeper and darker than the Carey soils and have formed in level to nearly level areas.

Large, deep, steep gullies and outcrops of unweathered rock are mapped as Rough broken land, Quinlan material. Some areas of Quinlan and Woodward soils are so intermingled that they have been mapped as complexes of Quinlan-Woodward or of Woodward-Quinlan loams. Areas of the Cottonwood soil, which has formed over gypsum, occur in the eastern part of the county among areas of Rough broken land, Quinlan material.

### Association 1: Woodward-Quinlan

This association is made up mainly of moderately deep, loamy soils. It covers nearly 50 percent of the county. The soils are on sloping to rolling uplands; in places the areas are dissected by large, gullylike drainageways. About one-third of the acreage consists of Woodward loams, and another third is made up of soils of the Woodward-Quinlan complexes. The rest is comprised mainly of shallow Quinlan soils and of Rough broken land, Quinlan material, which lie along the drainageways, but small areas of Carey and St. Paul soils on the smooth divides are included.

Some of these soils are suited to cultivation, and a little more than half of the association is used for crops. Inasmuch as most farms contain both moderately deep and shallow soils, the growing of small grains and the grazing

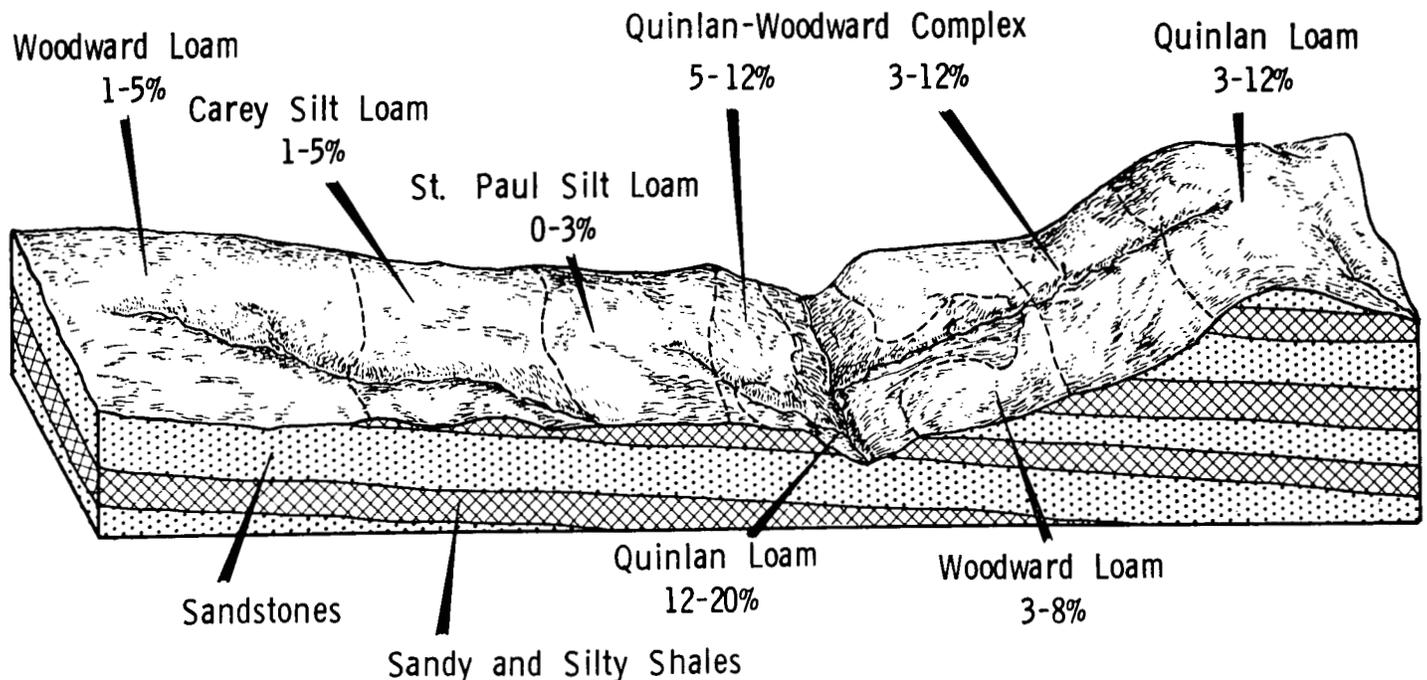


Figure 2.—A schematic drawing showing a normal pattern of soils formed over Permian redbeds. The typical slope range is given for each soil. Alternating layers of sandstone and shale underlie these soils.

of cattle are combined. The farms vary considerably in size.

Most of the tillable soils absorb water readily and can be cultivated safely under rather intensive management. Wheat is grown extensively. The average yields are low on the Woodward-Quinlan loams. They are not high on the other soils but are fairly stable. Sorghums are also grown extensively and produce fair yields. If the wheat crop fails, sorghum is sometimes grown successfully in place of it.

The principal grasses in areas used for grazing are buffalograss, blue grama, and side-oats grama. These yield well if the pastures are managed properly, but during droughts little forage is produced.

#### **Association 2: Quinlan-Woodward-Rough broken land**

This association is made up of shallow to moderately deep, loamy soils that occur on strongly sloping to steep uplands dissected by gullylike drainageways. It covers about 10 percent of the county. The principal soils are the Quinlan loams, the Quinlan-Woodward complex, and Rough broken land, Quinlan material. Included in this association is the Cottonwood soil, which has formed on beds of gypsum.

Most of the areas are unsuited to cultivation and are used mainly for grazing. Several large ranches are within this association.

The soils absorb moisture well, but much of the water runs off if a good cover of plant residues is not left on the surface. The principal grasses on the Quinlan loams and on the Quinlan-Woodward complex are side-oats grama, hairy grama, and little bluestem. These produce fair yields of forage. Little bluestem and side-oats grama predominate on Rough broken land, Quinlan material; the

yields of forage are low, and the areas are somewhat difficult for cattle to reach.

#### **Association 3: Carey-St. Paul-Tipton**

This association covers about 5 percent of the county. It is made up of deep, loamy, upland soils that have gentle slopes. The soils occur on smooth upland divides and on flats that are nearly free of deep, gullylike drainageways. The principal soils are the Carey, St. Paul, and Tipton, but included are small areas of Hollister and Woodward soils. Many small areas of this association are in the northern part of the county. One area in the northwestern part lies adjacent to the flood plain of the Cimarron River and receives deposits blown from the bottom lands by the wind. Here, the Tipton soils are developing.

The soils of this association are well suited to cultivation. They can be tilled safely if moderate conservation practices are used. Wheat is the main crop, and sorghums are next in importance. The average yields per acre on these soils are among the best in the county. Nevertheless, some crop failures occur during years of low rainfall, particularly in years that follow prolonged droughts.

#### **Soil Associations on Alluvial Plains or Windblown Sands**

This broad area comprises soils of associations 4, 5, 6, and 7. The most extensive soils in associations 4 and 5 are the Pratt, Tivoli, and Otero. The most extensive ones in associations 6 and 7 are the Spur, Lincoln, Yahola, and Loamy alluvial land. The soils of associations 4 and 5 have formed on windblown sands that originated on the flood plain of the North Canadian River, known locally as the Beaver River. The soils of associations 6 and 7 have formed in recent alluvium. In total acreage the

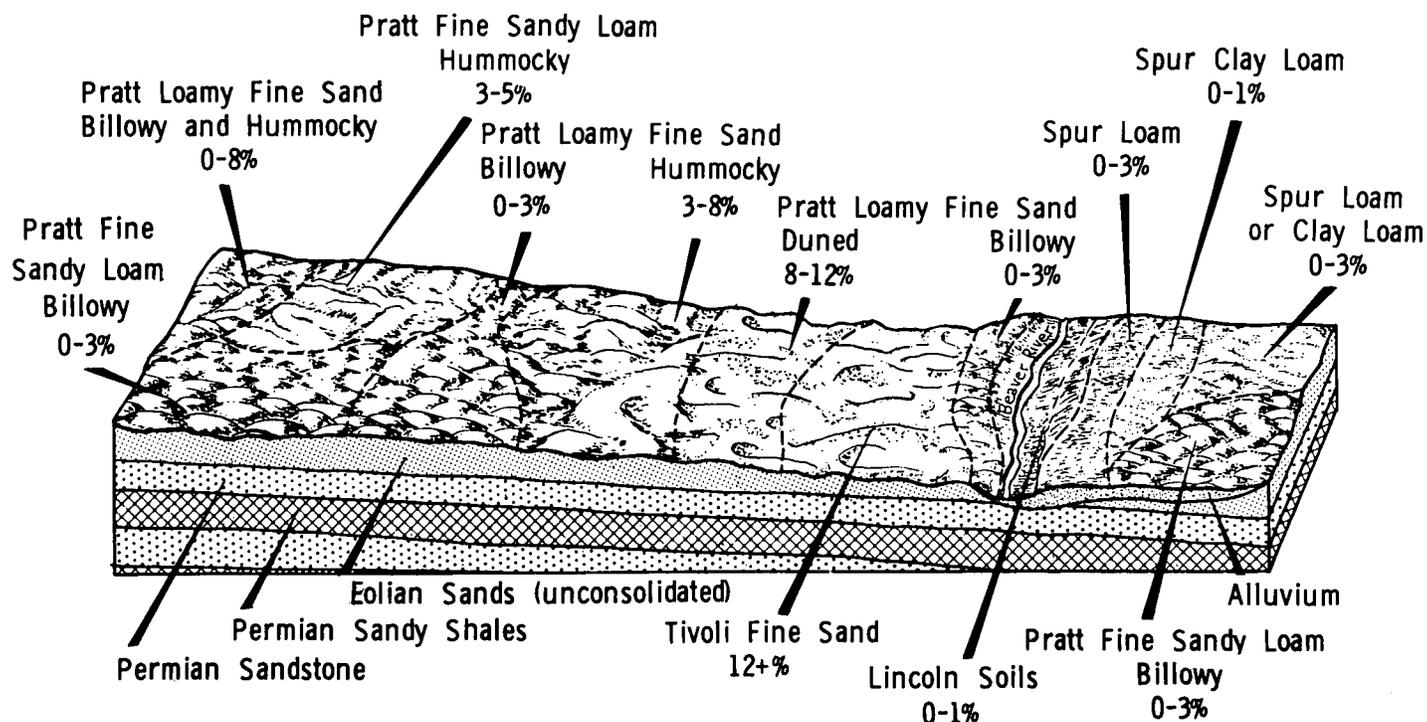


Figure 3.—A schematic drawing showing a normal pattern of soils formed on alluvial plains and on windblown sands. The typical slope range is given for each soil.

soils in this group of associations rank next to the soils in the group of associations formed over Permian redbeds. A diagram showing how some of these soils might occur on a typical landscape is shown in figure 3.

The soils of associations 4 and 5 have wavy or dunny relief. The Pratt soils have a surface soil of brown or light-brown sandy loam or loamy sand and a subsoil of brown to yellowish-brown sandy loam or loam. The Tivoli and Otero soils consist of very light colored loamy fine sand or sand to a considerable depth. In low places are spots of Dalhart-Carwile soils that have a compact subsoil of clay loam, which is slowly permeable; most of these spots occur north of the North Canadian River, but a large area is south and southeast of Laverne.

The soils of associations 6 and 7 occur on the level flood plains of streams. The surface layer of the Spur soils is dark-colored loam or clay loam, and that of the Pratt soils is brown fine sandy loam. Both soils occur on the high bottom lands above areas that ordinarily are subject to overflow. The Lincoln soils are made up of light-brown sandy materials. The Yahola soil has a surface soil of reddish-brown fine sandy loam. It occurs on bottom lands of the North Canadian and Cimarron Rivers and is subject to overflow.

All of the soils in the associations of this group take water readily, and most of them are moderately to rapidly permeable. The sandy Tivoli, Pratt, and Otero soils support bluestem, dropseed, and grama grasses; the sandier areas are infested severely with sand sagebrush. On the inextensive areas of Las Animas soils that are included in association 7, there is generally a stand of tall grasses, saltgrass, and alkali sacaton. Some areas of the Yahola and Lincoln soils, which are on the sandy and loamy bottom lands, are used for crops. Other areas have

a cover of tall grasses and dropseed grasses. In some places there are groves of cottonwood trees. Nearly all of the areas of Pratt and Spur soils of the high bottoms are used for cultivated crops.

#### Association 4: Pratt

This association is comprised of deep, sandy soils of the undulating or slightly wavy uplands. It covers about 10 percent of the county and is made up mainly of soils of the Pratt series. Most of it is on the smoother areas north of the dunny tracts that border the North Canadian River. A smaller area occurs southeast of Laverne. Most of the soils are suited to cultivation.

This association is comprised about equally of the following soils: Pratt fine sandy loams, which have a surface soil and subsoil of brown fine sandy loam; the sandier, lighter colored, more billowy Pratt loamy fine sands; and a mixture of Pratt fine sandy loams and Pratt loamy fine sands, largely under cultivation. These soils absorb moisture well but dry out quickly, and so they are subject to wind erosion.

About half of the association is used for crops. Because of the pattern of tillable and nontillable soils, on most farms there is a combination of crop farming and beef production. The size of the farms varies greatly.

The gently sloping Pratt fine sandy loams can be farmed safely if measures are used intensively to conserve soil and water. They are good soils for summer crops. If used for crops, the Pratt loamy fine sands and the steeper areas of Pratt fine sandy loams need special care because they are subject to blowing and drifting. The strongly sloping areas of Pratt soils are unsuited to continuous use for cultivated crops.

Sorghums, grown for forage, and small grains are the main crops. If stubble is left on the fields, good stands of wheat can be obtained on the Pratt fine sandy loams and good yields of rye can be made in most years on the more nearly level areas of Pratt loamy fine sands.

The principal pasture grasses are bluestem, blue grama, and sand dropseed, but the pastures are generally infested with sand sagebrush. If well managed, the soils are suitable for use as range and produce relatively high yields of forage. An adequate cover must be maintained to prevent blowing, and the infestation of sagebrush needs to be checked.

#### **Association 5: Tivoli-Pratt-Otero**

This association consists of deep, very sandy, dune soils of the uplands. It occupies about 10 percent of the county. The principal soils are the Tivoli, Pratt, and Otero, but included are areas of Quinlan soils. The largest areas lie north of the North Canadian River, along its entire course through the county, and north of the Cimarron River. In an area north of Buffalo Creek, the soils are relatively shallow over redbeds. Here, the Pratt and Tivoli soils occur in association with the Quinlan soils. The soils of this association are generally too sandy to be used for crops.

Except for the Otero soil, which has formed on limy outwash of the Tertiary age, the soils have formed on stabilized dunes deposited by the wind and derived from sandy river alluvium. Areas consisting mostly of Otero soil occur in the vicinity of Laverne.

The Tivoli soils have a surface layer of light-brown fine sand or loamy sand that is underlain by light yellowish-brown sand. The Pratt loamy fine sands are light brown and have a slightly loamy subsoil. The Otero soil consists of light-brown, calcareous loamy sand and is slightly more loamy throughout than the Tivoli soils.

All the areas of this association are used for pasture; several large cattle ranches comprise much of the acreage.

The soils absorb moisture well and are suitable for pasture if care is taken to prevent wind erosion and the encroachment of sand sagebrush. The native vegetation consisted of a moderate stand of bluestem and some sand sagebrush. Most ranges now have a thin stand of bunchgrasses, blue grama, and sand dropseed between thicker stands of sand sagebrush. The Otero soil, which has been infested less severely by sand sagebrush, is slightly more productive of range plants than the Tivoli soils.

#### **Association 6: Spur-Pratt**

This association covers about 2 percent of the county. It is composed of deep, dark, smooth soils of high bottom lands that rarely, if ever, are flooded. The principal soils are the Spur and the billowy Pratt fine sandy loam. One area lies south of the Cimarron River in the northwestern part of the county. Others are south of the North Canadian River in the southwestern part. The soils are well suited to cultivation.

About half of the acreage consists of Spur loam, which takes water well, and about one-fifth is made up of Spur clay loam, which is less permeable. The rest of the acreage is comprised of the billowy Pratt fine sandy loam.

Good yields of wheat, grain sorghums, and alfalfa are obtained on the soils of this association. Where irrigation

water is available, yields of alfalfa are good. The irrigation water is supplied through a cooperative irrigation ditch that diverts water from the Cimarron River to some of the farms. A few areas are used for pasture; yields of forage are good because of the favorable moisture conditions.

#### **Association 7: Lincoln-Yahola-Loamy alluvial land**

The soils of this association cover about 5 percent of the county. They occur on sandy and loamy bottom lands that are subject to occasional overflow. The principal soils are the Lincoln, Yahola, and Loamy alluvial land, but the Las Animas soils, though inextensive, are also important. The soils of this association are very sandy.

The Lincoln soils consist of light-colored, loamy sands that are somewhat stratified with other materials. The texture of their surface layer is extremely variable. The Yahola soil generally consists of fine sandy loam throughout; it occurs mostly in small areas along the larger creeks. Loamy alluvial land, which is similar to the Yahola soil, occupies areas that are overflowed frequently. The Las Animas soils occur along the major streams and are forming in variable alluvial sediments. They have a high water table and are generally slightly salty. Because of the high water table, the Las Animas soils are generally too wet to be used for crops. Some areas are practically bare and are subject to shifting by the wind.

Although the soils of this association are generally unsuited to cultivation, wheat and grain sorghums make good yields on the Yahola soil. Occasionally, however, a crop is lost through overflow.

The vegetation consists mostly of sand dropseed, bunchgrasses, and some sand sagebrush. Saltgrass and alkali sacaton cover the Las Animas soils and produce high yields of forage if well managed. Cottonwood trees and a poor stand of weeds are on some areas of Lincoln soils. The productivity of individual areas in the association depends upon the stability of the soil.

### **Soil Associations on Limy Outwash**

The soils of associations 8, 9, and 10 have formed on limy outwash, mainly in rolling, dissected areas that are along the margins of the High Plains. Many of them contain hard deposits of caliche in their subsoils. The Mansker, Potter, Dalhart, Richfield, and Mansic are the most important soils in these associations. A diagram showing how some of these soils might occur on a typical landscape is shown in figure 4.

The Mansker soils have a distinct layer of lime at shallow depths. The Dalhart soils are deep and have been leached of lime to greater depths than the Mansker. The Potter soils are inextensive and are generally steep and very shallow; in most places hard pieces of caliche are on the surface and at shallow depths.

The Richfield soils are nearly level and are deep and loamy. They have formed from parent material that is not so limy as that of the Mansker soils. The Mansic soils, associates of the Richfield soils, are similar to the Mansker but lack the limy layer at shallow depths. The Randall soil is clayey and has formed from alluvium. It occurs on the bottoms of shallow lakes that are wet only intermittently.

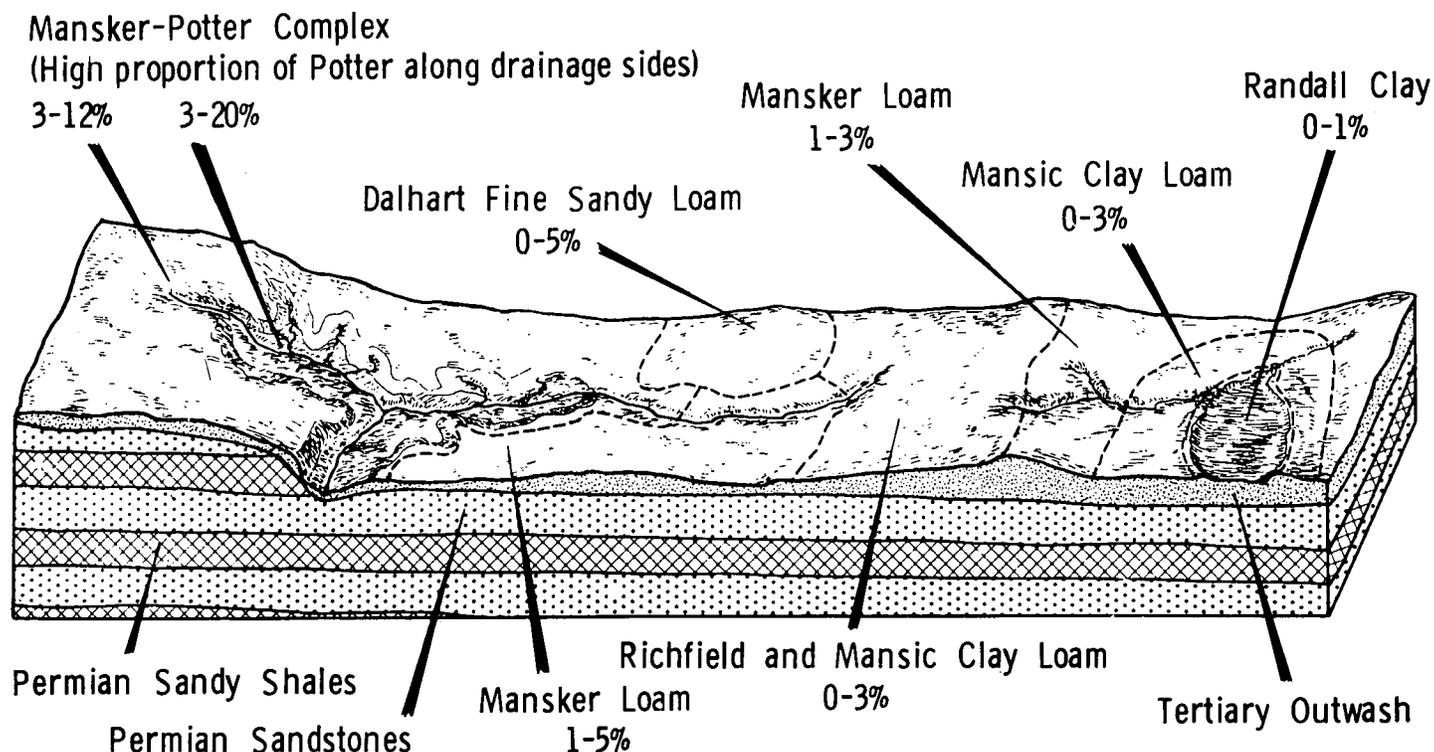


Figure 4.—A schematic drawing showing a normal pattern of soils formed on limy outwash. The typical slope range is given for each soil.

#### Association 8: *Mansker-Potter*

This association covers about 4 percent of the county. It is made up of shallow and moderately deep, loamy soils of the sloping uplands and consists principally of the soils of the Mansker-Potter complexes. The areas are mainly in the northwestern and west-central parts of the county.

About one-third of this association is under cultivation. The cultivated areas have moderate slopes and are fairly well suited to crops. In these areas are combination crop and beef-cattle farms. Sorghums grown for forage and wheat are the main crops. These crops yield fairly well, but the yields of wheat are more stable. Intensive measures to conserve soil and water are needed on cultivated areas.

The strongly sloping areas of this association are not suited to cultivation. These areas, which are dissected by gullylike drainageways, make up about half of the acreage. They are used mainly for ranching.

The predominant grasses are side-oats grama, little bluestem, and hairy grama. Sand dropseed is also common. Under good management, fair yields of forage are obtained.

#### Association 9: *Mansker-Dalhart*

This association consists of a mixture of loamy and sandy soils of the smooth to rolling uplands. It makes up about 3 percent of the county. The principal soils are the Mansker and Dalhart. Less extensive are the soils of the Mansker-Potter complexes and the Pratt soils. One area occurs on a billow to gently rolling plain east of Rosston.

Others are in the southwestern part of the county. The soils have formed principally in brown, limy loams and clay loams and, in places, in an overwash of more recent sandy loams.

About half of this association is made up of Mansker soils, which occur on gentle slopes; a third of it consists of Dalhart soils; and the rest is comprised mainly of soils of the Mansker-Potter complexes, most of which are suited to cultivation. Some Pratt soils occur in the area east of Rosston.

Nearly three-fourths of this association is used to grow wheat and sorghums. Both crops make fairly good yields, but the yields of wheat are more stable. Soils that have different management problems are intermixed considerably. The Mansker soils are fairly good for crops if practices are used rather intensively to prevent erosion by water and wind. The Dalhart soils are good for crops, but they also need intensive management because of the risk of wind erosion.

The main grasses on the Mansker soils are buffalograss, side-oats grama, and blue grama, which provide fair yields of forage under good management. Sand dropseed, blue grama, bluestems, and sand sagebrush are dominant on the Dalhart soils; yields of forage are slightly higher than on the Mansker soils.

#### Association 10: *Richfield-Mansker-Mansic*

This association is made up of deep, loamy soils on the smooth plains of the uplands. It consists mainly of the Richfield, Mansker, and Mansic soils and, to a lesser extent, of the Randall and Dalhart soils. The areas occur in the northwestern part of the county. They contain a few

wet-weather lakes and generally lack a well-defined drainage pattern.

The Richfield soils make up about two-thirds of this association, and most of the rest consists of Mansker and Mansic soils. Randall clay is on the bottoms of the wet-weather lakes. A few areas of Dalhart soils occur next to areas of Richfield and Mansic soils.

Most of the soils are under cultivation; some are irrigated from wells. Wheat, the main crop, yields well, but it generally does better on the deep, dark Richfield soils than on the Mansker and Mansic soils. Grain sorghums grow well on the Mansker and Mansic soils, but, because of droughtiness, the Mansker and Mansic soils are not so well suited to grain sorghums as the Richfield soils.

Only small areas are pastured. Farmers graze few cattle unless they control pastures in areas adjoining this association.

## How a Soil Survey Is Made

The scientist who makes a soil survey examines soils in the field, classifies the soils in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map.

**FIELD STUDY.**—The soil scientist bores or digs many holes to see what the soils are like. The holes are not spaced in a regular pattern but are located according to the lay of the land. Normally, they are not more than a quarter of a mile apart, and in some places they are much closer. In most soils such a boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. Each layer is studied to see how it differs from others in the profile and to learn the things about this soil that affect its capacity to support the growth of plants.

**Color** is usually related to the amount of organic matter in soils. The darker the surface soil, the more organic matter it contains. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

**Texture**, or the content of sand, silt, and clay, is determined by the way the soil feels when rubbed between the fingers. It is later checked by laboratory analysis. Texture determines how well the soil absorbs and holds moisture, how well it retains some plant nutrients and fertilizer, and whether it is easy or difficult to cultivate.

The texture of the soil is closely related to its fertility. Plant nutrients, such as nitrogen, phosphorus, and potassium, are necessary to make a soil fertile. These elements are stored on the surface of each particle of soil. Sands contain fewer grains than finer textured soils and, therefore, have less surface space on which to retain soil elements; in contrast, the more loamy soils have a greater number of grains and can store more elements. Consequently, they are more fertile.

**Structure** refers to the way the individual soil particles are arranged in larger grains. A soil must contain some clay before a stable structure can be formed. Sandy soils contain only a small proportion of silt and clay, and so they have little structural development. In contrast, clayey soils generally have a strongly developed structure. Structure influences the movement of air and water in the

soil and helps determine how well roots will penetrate.

Clayey and loamy soils tend to have a granular surface layer. Individual particles of sand, silt, and clay are bound together in granules the size of bread crumbs. Although granular structure is desirable, tillage constantly breaks down the structure of the granules. To help restore this granular structure, the farmer needs to add organic matter to the soil.

The structure in the subsoil of most clayey soils is blocky. The blocks range in diameter from  $\frac{1}{8}$  to 3 inches. They may be approximately square or rectangular, or they may be irregular in shape. The arrangement of the blocks somewhat resembles that of a brick wall; the top block rests on the two blocks below it. This arrangement, along with the high content of clay, slows down the rate at which air and water enter the soil and also restricts the penetration of roots. As the roots follow the natural breaks into the soil, they must travel greater distances to reach the lower part of the profile. When the clay becomes saturated with water, it expands and seals these natural breaks. Only after the surface dries and cracks can these soils again absorb air.

Sandy soils have spaces between the grains that permit good movement of air. Also, loamy and clayey soils with a granular structure have many air spaces between the grains, and so they are more permeable than soils with a clayey subsoil of blocky structure.

Although the rate at which water enters and moves through the soil is influenced by structure, it is also influenced by the clay content of the soil. Sandy soils contain only a small proportion of silt and clay and are open and porous. They do not swell and seal on wetting. As a result most of the rainwater soaks in and little is lost through runoff. At the other extreme, the clayey soils swell readily and lose much water through runoff.

**Consistence**, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

**Depth** of the soil helps determine its capacity to store moisture and the depth to which roots will penetrate. In the soil descriptions in this report, the soil depth indicates the thickness of the combined surface soil and subsoil as shown on the following list:

- Deep—More than 36 inches.
- Moderately deep—Between 20 and 36 inches.
- Shallow—Between 10 and 20 inches.
- Very shallow—Less than 10 inches.

**Slope** is expressed in percent, which is the number of feet of fall per 100 feet of horizontal distance. The steeper the slope, the greater the danger of erosion and loss of water through runoff. Strongly sloping, steep, and very steep soils are subject to severe damage through erosion from wind and water. The slope terms and numerical equivalents used in this report are as follows:

- Nearly level—Less than 1 foot of fall per 100 feet; 0 to 1 percent slopes.
- Gently sloping—1 to 3 feet of fall per 100 feet; 1 to 3 percent slopes.
- Moderately sloping—3 to 5 feet of fall per 100 feet; 3 to 5 percent slopes.
- Strongly sloping—5 to 8 feet of fall per 100 feet; 5 to 8 percent slopes.
- Steep—8 to 12 feet of fall per 100 feet; 8 to 12 percent slopes.
- Very steep—More than 12 feet of fall per 100 feet; 12 or more percent slopes.

*Other characteristics* observed in the course of the field study and considered in classifying the soil include the following: The presence of gravel or stones in amounts that will interfere with cultivation; the degree of erosion; the nature of the underlying parent material from which the soil has formed; the surface and internal drainage; and the acidity or alkalinity of the soil as measured by chemical tests.

**CLASSIFICATION.**—On the basis of the characteristics observed by the survey team or determined by laboratory tests, soils are classified by series, types, and phases.

*Soil series.*—Two or more soil types that differ in surface texture, but that are otherwise similar in kind, thickness, and arrangement of soil layers, are normally designated as a soil series. In a given area, however, it frequently happens that a soil series is represented by only one soil type. Each series is named for a place near which it was first mapped.

*Soil type.*—Soils having the same texture in the surface layers and similar in kind, thickness, and arrangement of soil layers are classified as one soil type.

*Soil phase.*—Because of differences other than those of kind, thickness, and arrangement of layers, some soil types are divided into two or more phases. Slope variations, frequency of rock outcrops, degree of erosion, depth of soil over the substratum, and natural drainage, are examples of characteristics that suggest dividing a soil type into phases.

The soil phase (or the soil type if it has not been subdivided) is the unit shown on the soil map. It is the unit that has the narrowest range of characteristics. Use and management practices, therefore, can be specified more easily than for soil series or yet broader groups that contain more variation.

*Miscellaneous land types.*—Fresh stream deposits or rough, stony, and severely gullied lands that have little true soil are not classified into types and series but are identified by descriptive names, such as Rough broken land, Quinlan material.

*Soil complex.*—When two or more soils are so intricately associated in small areas that it is not feasible to show them separately on the soil map, they are mapped together and called a soil complex. An example is the Tivoli-Quinlan complex.

*Other technical terms.*—Additional terms used in describing the soils of Harper County are defined in the glossary in the back part of the report.

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

| Soil   | Acres   | Percent |
|--|---------|---------|
| Carey silt loam, 1 to 3 percent slopes           | 25,000  | 3.8     |
| Carey silt loam, 3 to 5 percent slopes           | 3,000   | .1      |
| Cottonwood loam                                  | 6,000   | .9      |
| Dalhart fine sandy loam, 1 to 3 percent slopes   | 4,200   | .6      |
| Dalhart fine sandy loam, 3 to 5 percent slopes   | 3,300   | .5      |
| Dalhart-Carwile fine sandy loams                 | 2,500   | .4      |
| Hollister clay loam, 0 to 1 percent slopes       | 650     | .1      |
| Hollister clay loam, 1 to 3 percent slopes       | 150     | (1)     |
| Las Animas soils                                 | 10,500  | 1.6     |
| Las Animas soils, shallow over clay              | 1,400   | .2      |
| Lincoln soils                                    | 18,000  | 2.7     |
| Loamy alluvial land                              | 5,000   | .8      |
| Mansie clay loam, 0 to 1 percent slopes          | 900     | .1      |
| Mansie clay loam, 1 to 3 percent slopes          | 2,500   | .4      |
| Mansie clay loam, 3 to 5 percent slopes          | 2,000   | .3      |
| Mansker loam, 1 to 3 percent slopes              | 10,000  | 1.5     |
| Mansker loam, 3 to 5 percent slopes              | 8,000   | 1.2     |
| Mansker-Potter complex, 3 to 5 percent slopes    | 4,500   | .7      |
| Mansker-Potter complex, 5 to 20 percent slopes   | 22,000  | 3.3     |
| Otero loamy sand                                 | 10,000  | 1.5     |
| Pratt fine sandy loam, billowy                   | 17,000  | 2.6     |
| Pratt fine sandy loam, hummocky                  | 26,500  | 4.0     |
| Pratt loamy fine sand, billowy                   | 9,000   | 1.4     |
| Pratt loamy fine sand, hummocky                  | 27,000  | 4.1     |
| Pratt loamy fine sand, duned                     | 18,500  | 2.8     |
| Quinlan loam                                     | 55,000  | 8.3     |
| Quinlan loam, severely eroded                    | 500     | .1      |
| Quinlan-Woodward complex, 5 to 12 percent slopes | 100,000 | 15.2    |
| Randall clay                                     | 1,000   | .2      |
| Richfield clay loam                              | 3,300   | .5      |
| Richfield complex                                | 4,000   | .6      |
| Rough broken land, Quinlan material              | 15,500  | 2.3     |
| St. Paul silt loam, 0 to 1 percent slopes        | 10,500  | 1.6     |
| St. Paul silt loam, 1 to 3 percent slopes        | 3,500   | .5      |
| Spur clay loam                                   | 2,900   | .4      |
| Spur loam  | 8,300   | 1.3     |
| Tipton silt loam, 0 to 1 percent slopes          | 2,000   | .3      |
| Tipton silt loam, 1 to 3 percent slopes          | 3,000   | .5      |
| Tipton silt loam, 3 to 5 percent slopes          | 1,000   | .2      |
| Tivoli fine sand                                 | 39,000  | 5.9     |
| Tivoli-Quinlan complex                           | 2,500   | .4      |
| Woodward loam, 1 to 3 percent slopes             | 7,000   | 1.1     |
| Woodward loam, 3 to 8 percent slopes             | 85,000  | 12.8    |
| Woodward-Quinlan loams, 1 to 3 percent slopes    | 2,000   | .3      |
| Woodward-Quinlan loams, 3 to 8 percent slopes    | 66,000  | 10.0    |
| Yahola fine sandy loam                           | 3,000   | .5      |
| Miscellaneous uncorrelated areas—river channels  | 9,160   | 1.4     |
| Total  | 661,760 | 100.0   |

<sup>1</sup> Less than 0.1 percent.

## Soils on Your Farm

In this section the soils and miscellaneous land types of Harper County are described. A more technical description of each is given in the section, Soil Formation and Classification.

After the name of each soil or land type is the symbol that identifies it on the soil map in the back part of this report. In the description of the soil, the capability unit and range site to which it belongs are given. The approximate acreage and the proportionate extent of each soil are listed in table 1.

**Carey silt loam, 1 to 3 percent slopes (Ca).**—This deep, gently sloping soil of the uplands has formed from sandstone and sandy shale of the redbed formations. It occurs

throughout the areas underlain by redbeds. The original vegetation consisted of native grasses. The surface soil, to a depth of 15 inches, is dark-brown silt loam. Beneath this is a subsoil of reddish-brown, granular silty clay loam that takes water well.

Most of this soil is used for cultivated crops, but mainly for wheat. During seasons when there is enough moisture in the subsoil, grain sorghums are grown. Some alfalfa is grown during cycles of normal precipitation. This soil is suitable for irrigation.

Management problems consist of the crusting of the surface layer, the breakdown of structure in the surface soil, a slight hazard of erosion from wind and water, and

the formation of plowpans. (Capability unit IIe-2; Loamy range site.)

**Carey silt loam, 3 to 5 percent slopes (Cb).**—This is a deep, moderately sloping soil of the uplands. It occurs throughout the part of the county underlain by redbeds. The surface soil, to a depth of 10 to 12 inches, is dark-brown silt loam. Underlying this is a subsoil of reddish-brown, granular silty clay loam that takes water well.

About two-thirds of the acreage is used for crops, but mostly for wheat. Grain sorghums are grown during years when there is enough moisture in the subsoil.

Management problems include the crusting of the surface soil, the breakdown of structure in the surface soil, a moderate hazard of erosion from water and wind, and the formation of plowpans. (Capability unit IIIe-1; Loamy range site.)

**Cottonwood loam (Cc).**—This very shallow upland soil is subject to erosion. It occurs in the eastern part of the county in association with the Quinlan and Woodward soils. The soil has formed mainly on beds of gypsum, which outcrop in many places. The areas are moderately sloping to steeply sloping. In typical areas of Cottonwood loam, the combined thickness of the brown surface soil and the light-gray subsoil ranges from 3 to 12 inches.

This soil is suitable only for use as range pasture. (Capability unit VIIe-1; Gyp range site.)

**Dalhart fine sandy loam, 1 to 3 percent slopes (Dc).**—This is a deep, slightly billowy soil of the uplands. It is mainly in the southwestern part of the county near other areas of sandy soils. The surface soil consists of about 10 inches of dark-brown fine sandy loam. This is underlain by a subsoil of brown, granular sandy clay loam that takes water well.

This is a good all-purpose soil that is used to grow grain sorghums and wheat. If there is enough moisture, alfalfa can be grown successfully, but the stands thin out badly during droughts. This soil is well suited to sprinkler irrigation.

Management problems consist of the maintenance of organic matter, a moderate hazard of wind erosion, a slight hazard of water erosion, and the formation of plowpans. The slightly uneven, concave-convex relief also makes cultivation a problem. (Capability unit IIIe-2; Sandy plains range site.)

**Dalhart fine sandy loam, 3 to 5 percent slopes (Db).**—This is a deep, moderately sloping soil of the uplands. It occurs in the southwestern and northwestern parts of the county. The surface soil, to a depth of 7 inches, is brown fine sandy loam. This is underlain by brown, granular sandy clay loam that takes water well. In many places the subsoil contains less clay than that of Dalhart fine sandy loam, 1 to 3 percent slopes.

This is a good all-purpose soil, and most of it is used to grow grain sorghums and wheat. Yields of crops and forage are good during all but extremely dry years.

Management problems consist of the maintenance of organic matter, a moderately severe hazard of wind erosion, a slight hazard of water erosion, and the formation of plowpans. The uneven relief makes cultivation difficult. (Capability unit IVe-2; Sandy plains range site.)

**Dalhart-Carwile fine sandy loams (Dc).**—This mapping unit consists mainly of Dalhart fine sandy loam and Carwile fine sandy loam. Also included are small areas of other soils that are intermediate in characteristics be-

tween the Dalhart and Carwile soils. The soils were mapped as a complex because they occur only in such small, intermingled areas that it was not feasible to map them separately.

These soils occupy sandy areas that have uneven, slightly wavy relief. The Dalhart soil occurs in the higher positions, and the Carwile soil, on the floors of small, enclosed depressions.

The Dalhart soil is well drained. It has a permeable subsoil of sandy clay loam. The Carwile soil has a subsoil that dominantly is grayish-brown to yellowish-brown, tight sandy clay through which water infiltrates slowly. Because it occurs in enclosed depressions, the Carwile soil has no outlet for surface water, and at times the areas are ponded. Though the Dalhart soil is more extensive than the Carwile, the poorly drained spots of Carwile soil interfere with tillage of this mapping unit.

About three-fourths of the acreage is used for cultivated crops, mainly for wheat and grain sorghums. The soils are fairly well suited to sprinkler irrigation. Crops grown on low spots of Carwile soil sometimes drown out in spring.

Management problems include the slow intake of water and impeded drainage in the low spots, the maintenance of organic matter, a moderate hazard of wind erosion, and the formation of plowpans. (Capability unit IIIw-1; Sandy plains range site.)

**Hollister clay loam, 0 to 1 percent slopes (Hc).**—This deep, nearly level upland soil occurs on broad flats in the northern part of the county. The surface soil of dark grayish-brown clay loam is transitional, generally at depths of 12 to 18 inches, to a subsoil of dark grayish-brown, blocky silty clay that takes water slowly.

Most of this soil is used for cultivated crops, mainly for wheat. It is fairly well suited to border irrigation.

Management problems include surface crusting, the slow intake of water, and a slight hazard of wind erosion. (Capability unit IIc-2; Hardland range site.)

**Hollister clay loam, 1 to 3 percent slopes (Hb).**—This deep, gently sloping soil of the uplands occurs in the northern part of the county on slopes that border level areas of Hollister clay loam, 0 to 1 percent slopes. The surface soil, to depths of 8 to 12 inches, is dark grayish-brown clay loam. This is transitional, with increasing depth, to a subsoil of dark grayish-brown silty clay that takes water slowly.

This soil is limited in its suitability for crops. Nevertheless, most of it is used for cultivated crops, mainly for wheat. Management problems consist of a slight hazard of erosion from wind and water, the deterioration of structure in the surface soil, surface crusting, and the formation of plowpans. In addition, because of the slow intake of water, runoff is excessive. Erosion is a greater hazard on this soil than on Hollister clay loam, 0 to 1 percent slopes. (Capability unit IIe-1; Hardland range site.)

**Las Animas soils (Lc).**—These deep, nearly level soils of the bottom lands are subirrigated naturally by a water table that occurs at depths of 3 to 10 feet. They lie near the Cimarron and North Canadian Rivers and are subject to occasional overflow. The largest areas are in the vicinity of Laverne and also in the northwestern part of the county south of the Cimarron River.

The surface soil, to depths between 10 and 15 inches, is

grayish-brown fine sandy loam. This is transitional, with increasing depth, to slightly mottled, stratified fine sandy loam, loamy sand, and clay loam.

Surface runoff is slow and internal drainage is medium. There is some variation in drainage, however, depending on the number and thickness of the lenses of clay loam and clay.

Most areas can be cultivated, but the soils are generally more valuable as pasture because they produce a large amount of forage. Inland saltgrass, alkali sacaton, and other salt-tolerant grasses are dominant in many places. Bottom-land switchgrass does well under moderate to light grazing. (Capability unit Vw-1; Subirrigated range site.)

**Las Animas soils, shallow over clay** (lb).—These deep, nearly level soils of the bottom lands are subirrigated naturally by a water table that is at depths of 3 to 10 feet. The profile of these soils varies considerably from place to place. The surface soil generally consists of 10 to 15 inches of yellowish-brown fine sandy loam that is transitional, with increasing depth, to lighter brown, more sandy material. Beginning at depths between 24 and 30 inches is gray or grayish-brown silty clay that is slightly mottled.

Occasionally, these soils are flooded. Surface runoff is slow, and internal drainage is restricted greatly by the clay substrata.

Most of the areas are suitable for cultivation, but the soils are more valuable as pasture because they produce a large amount of forage. Inland saltgrass, alkali sacaton, and other salt-tolerant grasses are dominant, but bottom-land switchgrass does well under moderate grazing. (Capability unit Vw-1; Subirrigated range site.)

**Lincoln soils** (lc).—These are deep, nearly level to slightly hummocky soils of the bottom lands. Most of the areas are along the North Canadian and Cimarron Rivers and are subject to overflow. These soils are mainly loamy sands or sandy loams, but the texture varies considerably from place to place. The subsoil is sandy and takes water rapidly.

These soils are used primarily for pasture and should be kept in grass. The principal management problem is protecting the soil against wind erosion and droughtiness, especially during dry summers. (Capability unit VIe-1; Sandy bottom-land range site.)

**Loamy alluvial land** (ld).—This mapping unit consists of deep, nearly level and gently sloping soils of the bottom lands. The soils have formed principally in loamy sediments derived from areas of redbeds. They occur mostly along the narrow creeks that drain areas of Quinlan, Woodward, and Carey soils. The areas are dissected by meandering streams and are flooded frequently.

Little, if any, of the soil is suited to cultivation. Most of it is in native grasses. (Capability unit Vw-2; Loamy bottom-land range site.)

**Mansic clay loam, 0 to 1 percent slopes** (Ma).—This deep, nearly level soil of the uplands occurs in the shallow valleys near the margins of wet-weather lakes. The surface soil of grayish-brown clay loam is underlain by a subsoil of brown, slightly limy clay loam. This soil takes water fairly well.

Most of this soil is used to grow wheat. Management problems consist of surface crusting, the deterioration of the surface structure, a slight hazard of wind erosion, and

the hazard of runoff from higher lying areas. (Capability unit IIc-2; Hardland range site.)

**Mansic clay loam, 1 to 3 percent slopes** (Mb).—This is a deep, gently sloping soil of the uplands. The surface soil of grayish-brown clay loam is underlain by a subsoil of brown, slightly limy clay loam. This soil is associated with the Mansker soil and occurs in areas in which the Dalhart and Richfield soils are most extensive. It takes water fairly well. A considerable amount of water runs off, however, and, as a result, some soil has been lost through erosion by water and wind.

Most of this soil is used for cultivated crops, mainly for wheat. Management problems include surface crusting when the soil is bare at seeding time and looseness of the surface soil at other times; the deterioration of the surface structure; a moderate hazard of wind erosion and a slight hazard of water erosion; and uneven relief that limits the suitability for terracing. (Capability unit IIe-1; Hardland range site.)

**Mansic clay loam, 3 to 5 percent slopes** (Mc).—This is a deep, moderately sloping soil of the uplands. It is associated with the limy Mansker soils but differs from them in having a lower content of lime and a higher water-holding capacity in the subsoil. This soil takes water fairly well. There is a considerable amount of runoff, however, and more soil is lost through erosion than on Mansic clay loam, 1 to 3 percent slopes. In addition, most of the areas do not remain moist. Consequently, the hazard of wind erosion is greater.

About two-thirds of this soil is under cultivation. Management problems include surface crusting at times and looseness of the surface soil at other times; a moderate hazard of erosion by wind and water; and the deterioration of the surface structure, resulting in a greater loss of soil and moisture through runoff, even when there is a protective cover of wheat. If this soil is cultivated continuously, it needs careful management to encourage intake of water and to keep losses of soil at a minimum. (Capability unit IIIe-1; Hardland range site.)

**Mansker loam, 1 to 3 percent slopes** (Md).—This moderately deep, gently sloping upland soil has a very limy subsoil. It occurs in association with the Dalhart and Richfield soils in the western part of Harper County. To a depth of 8 or 10 inches, the soil consists of grayish-brown and brown loam; this material is underlain by a subsoil of granular clay loam. In most places chalky deposits of calcium carbonate occur at a depth of about 15 inches.

Mapped with this soil are low, light-colored knobs, representing spots of Potter soil, in which lime is close to the surface. Also included are small areas of Pratt fine sandy loams and small, intermingled areas of the less limy Mansic soils.

About three-fourths of this soil is used for cultivated crops, mainly for wheat. Management problems include surface crusting at some times and looseness of the surface soil accompanied by wind erosion, at other times; the hazard of water erosion during rainy periods; the deterioration in the surface soil structure; and uneven relief. (Capability unit IIIe-1; Loamy range site.)

**Mansker loam, 3 to 5 percent slopes** (Me).—This moderately deep, moderately sloping soil has a very limy subsoil that is at depths between 10 and 20 inches. Be-

cause of its content of lime, the subsoil has a low water-holding capacity and the soil is rather droughty. In most places the surface soil, to depths between 7 and 10 inches, consists of brown loam. This is underlain by a subsoil of brown clay loam that becomes definitely limy at depths between 10 and 15 inches.

In places the layer of lime is chalky. Scattered, light-colored spots of this soil generally indicate places where lime is close to the surface. These areas are the driest, most easily eroded parts of the fields.

About two-thirds of this soil is used for cultivated crops, mainly for wheat. Even under a close-growing crop such as wheat, however, the soil has been damaged considerably during the short time it has been farmed.

Management problems involve the uneven relief that makes contour tillage difficult; surface crusting that may hinder seedlings from emerging and, at other times, looseness of the surface soil that may result in wind erosion; the deterioration of the surface soil in cultivated areas; and a hazard of water erosion when the soil is bare. If this soil is cultivated continuously, it must be managed carefully. (Capability unit IVE-1; Loamy range site.)

**Mansker-Potter complex, 3 to 5 percent slopes (Mf).**—This complex consists of a moderately deep, limy Mansker soil and a shallow, limy Potter soil, which occur in such an intricate pattern that it was not practical to separate them on the soil map. These soils are on moderate slopes in the uneven, slightly billowy uplands of the western part of the county. The areas are made up mainly of Mansker soil, but between 5 and 25 percent is shallow Potter soil. The Potter soil occurs mostly on low knobs that restrict its suitability for cultivation.

The Mansker soil has a surface soil of brown loam. This overlies brown clay loam that is transitional to soft, limy clay loam at depths between 10 and 20 inches. The Potter soil has a grayish-brown surface soil that, in places, consists of gravelly clay loam. This material is transitional, at depths between 5 and 10 inches, to very limy material that, in many places, consists of hardened caliche.

Most of the Mansker soil absorbs water well, but the water-holding capacity is low because of the limy subsoil. Much water runs off the shallow, moderately sloping Potter soil, and so these areas are very droughty.

Nearly half of this mapping unit is used for crops, mainly for wheat. The rest is used for pastures of mid grasses and short grasses. These soils are best kept under permanent vegetation.

Management problems include the looseness of the surface soil, which causes a hazard of wind erosion in winter and early in spring; the loss of much soil through water erosion, even in areas under a cover of wheat; and the breakdown of the structure of the surface soil. (Capability unit IVE-1; Shallow range site.)

**Mansker-Potter complex, 5 to 20 percent slopes (Mg).**—This complex is made up of a moderately deep, limy Mansker soil of the shallow valleys and a shallow, limy Potter soil on low knobs on the steep, uneven slopes of the uplands. In total acreage the proportion of Mansker soil over the Potter soil is about two to one, but the areas are so intermingled and the slopes are so steep and irregular that it was not feasible to map the two soils separately. This complex is somewhat similar to the

Mansker-Potter complex, 3 to 5 percent slopes, which was described previously.

Little, if any, of this mapping unit is used for cultivation. It is best kept continuously in permanent vegetation. It supports variable stands of short grasses and mid grasses, and there are a few clumps of tall grasses in favorable spots. Droughtiness and erosion from wind and water are the principal hazards in using these soils for cultivation. About 500 acres is severely eroded (Capability unit VIe-4; Shallow range site.)

**Otero loamy sand (Oa).**—This deep, calcareous, sandy soil of the uplands occurs in hummocky areas in the western part of the county. It is associated with the Dalhart, Mansker, and Potter soils. Some small areas of Mansker and Potter soils are included in this mapping unit. In most places the profile, to depths between 5 and 10 inches, consists of grayish-brown, calcareous loamy sand. Below this is the substratum of pale-brown, limy sand.

This soil is too droughty to be used for crops, and all of it is used as rangeland. Most areas have a fair cover of short grasses and mid grasses and varying amounts of sand sagebrush and yucca. (Capability unit VIe-2; Mixed land range site.)

**Pratt fine sandy loam, hummocky (Pb).**—This deep, moderately sloping soil of the uplands occurs in low, wavy bands parallel to and generally north of the larger streams. The low spots between the hummocks are nearly flat and have no outlets for drainage water. The surface soil of brown fine sandy loam is 8 to 10 inches thick and is transitional, with increasing depth, to the subsoil of brown fine sandy loam that takes water well.

About two-thirds of this soil is under cultivation. Grain sorghums are the main crop, and wheat is next in importance. The rest of this soil is used as rangeland and has a variable cover of grama grasses, dropseed grasses, tall grasses, and some sagebrush.

Management problems include the maintenance of organic matter, a moderate to severe hazard of wind erosion, the formation of plowpans, and difficulties in tillage as the result of the uneven relief. (Capability unit IVE-2; Sandy plains range site.)

**Pratt fine sandy loam, billowy (Pa).**—This deep, gently sloping soil of the uplands has uneven, billowy relief. It lies in bands that are parallel to and generally north of the larger streams. The surface soil of dark-brown fine sandy loam is 10 to 12 inches thick. It is transitional, with increasing depth, to brown fine sandy loam that contains enough clay to be slightly sticky.

About four-fifths of this soil is used to grow grain sorghums, wheat, and alfalfa. The rest is used as range pasture consisting of tall grasses, dropseed grasses, and grama grasses, which in some places have been invaded by sand sagebrush.

Management problems include the maintenance of organic matter, a moderate hazard of wind erosion, and the formation of plowpans. (Capability unit IIIe-2; Sandy plains range site.)

**Pratt loamy fine sand, billowy (Pc).**—This deep, sandy soil of the uplands occurs on gently sloping, billowy areas that lie between the larger sand dunes. It occupies bands parallel to and north of the larger streams. The surface soil of grayish-brown loamy fine sand is about 8 inches thick and is transitional, with increasing

depth, to a subsoil of brownish-yellow loamy fine sand that takes water rapidly.

Although wind erosion is a severe hazard, about half of this soil is used for crops. Yields of grain sorghums are low but are fairly uniform from year to year. Uncultivated areas have a cover of bluestem, grama, and dropseed grasses, but many of them are severely infested with sand sagebrush.

Management problems include the maintenance of organic matter, a severe hazard of wind erosion, low fertility, and low water-holding capacity. In addition, more plowpans are forming in this soil. Because blown soil cuts off the tender seedlings, it is difficult to get good stands of crops. (Capability unit IVe-2; Deep sand range site.)

**Pratt loamy fine sand, hummocky (Pd).**—This is a deep, sandy, upland soil that occurs on irregular or choppy areas consisting of low dunes and narrow valleys. It lies in bands parallel to the larger streams. The slopes are moderate to strong. The surface soil of grayish-brown loamy fine sand is about 8 inches thick and is transitional to the subsoil of lighter brown loamy fine sand that takes water rapidly.

About one-third of this soil is under cultivation and is used mainly to grow grain sorghums. Because the soil is subject to blowing, it is difficult to get good stands of crops. As a result, yields of sorghums are low. In the long run it may be more profitable to keep this soil under a good cover of grass.

Management problems include the maintenance of organic matter, a severe hazard of wind erosion, low fertility, low water-holding capacity, limited suitability for crops, and the formation of plowpans. (Capability unit IVe-2; Deep sand range site.)

**Pratt loamy fine sand, duned (Pe).**—This deep, sandy soil of the uplands occurs on steep slopes in dune areas. It lies in bands parallel to the larger streams, mostly farther back from the streams than the very dune Tivoli fine sands. Both the surface soil and subsoil consist of loamy fine sand that is grayish brown in the upper part and brownish yellow below. The soil takes water rapidly.

This soil is unsuited to crops and is used for pasture. If managed properly, it is not likely to be damaged through wind erosion. (Capability unit VIe-3; Deep sand range site.)

**Quinlan loam (Qa).**—This shallow, moderately sloping to strongly sloping soil of the uplands has formed on weakly cemented, very fine grained sandstone and silty rocks. A few areas occur on the more clayey rock of the Dog Creek formation, which contains more fine material than other rock formations in Harper County.

The surface soil of reddish-brown or brown loam is about 6 inches thick. Below this is yellowish-red or red loam and slightly weathered sandstone that is transitional, at depths between 16 and 20 inches, to slightly more compact bedrock.

Although this soil takes water well where a good cover of plants is maintained, much water runs off the prevailing strong slopes. Erosion is likely to be severe on the steeper slopes. The areas can be protected best from erosion and made more receptive to water by maintaining a good cover of grass mulch at the end of each grazing season.

This soil is used mainly for pasture. Grama grasses,

dropseed grasses, buffalograss, and little bluestem are the principal vegetation on well-grazed pastures. (Capability unit VIe-4; Shallow range site.)

**Quinlan loam, severely eroded (Qb).**—This strongly sloping soil was once cultivated. Now, most of the surface layer has been lost and the areas have been dissected through erosion. As a result, the soil is no longer suitable for crops. Nearly all of the dark loam surface soil has been removed, and shallow gullies have cut down into the underlying bedrock. In most areas only 6 to 8 inches of weathered soil material overlies the compacted, very fine grained sandstone and silty rock.

Mapped with this soil are small areas of Woodward soil and small spots of a shallow, severely eroded soil that overlies moderately clayey bedrock. The typical vegetation consists of buffalograss, grama grasses, dropseed grasses, and some tall grasses. Many areas of this soil need to be reseeded to get a protective cover and to improve grazing.

This soil is hard to manage because much of the rain-water runs off, causing severe erosion. Although erosion is difficult to control, many areas can be protected by diverting runoff from higher lying areas. (Capability unit VIIe-2; Shallow range site.)

**Quinlan-Woodward complex, 5 to 12 percent slopes (Qc).**—Between 50 and 85 percent of this soil complex is made up of the shallow Quinlan soil, and the rest, of the moderately deep Woodward soil. These soils have formed from soft or slightly hardened, fine-grained sandstone of the redbeds. The areas are moderately sloping to steep.

The Quinlan soil occurs in the steeper areas on knobs or side slopes above narrow drainageways. The surface soil of reddish-brown, calcareous loam is 5 to 8 inches thick and is transitional, with increasing depth, to yellowish-red loam. Below this is slightly hardened sandstone. In some spots, pebbles of lime are on the surface.

The Woodward soil generally occurs on moderate slopes. The surface soil, to depths between 6 and 10 inches, is dark reddish-brown, calcareous loam. This is underlain by a subsoil of lighter colored loam that is transitional to yellowish-red, soft sandstone at depths between 20 and 30 inches.

The areas of this complex are too steep or too shallow to be suited to cultivation. Only a small acreage has been cultivated. All of the areas are now used as rangeland. They have a moderate cover of buffalograss, grama grasses, dropseed grasses, and, in areas that have been only moderately grazed, variable amounts of tall grasses.

An excessive amount of runoff and the loss of soil through erosion are the main problems on these soils. (Capability unit VIe-4; Shallow range site.)

**Randall clay (Ra).**—This clayey soil of the bottom lands occurs in low flats that have no outlets for drainage water. These areas, known as wet-weather or playa lakes, are mostly in the western and northern parts of the county and are surrounded by areas of other fine-textured soils. This soil has formed on clayey alluvium washed down from higher lying areas. It is made up mostly of grayish-brown or gray clays, which are stratified according to the kind of soil material from which they were derived.

Water moves very slowly, if at all, through this soil, and after rainy periods the areas are ponded until the water evaporates. Little, if any, useful vegetation grows,

except during dry periods when weeds and grasses, such as western wheatgrass, invade the margins of the areas.

Control of runoff from the surrounding higher lying uplands is needed to improve this soil for agriculture. If less runoff water enters the areas, the better grasses should grow. (Capability unit VIw-1; Hardland range site.)

**Richfield clay loam (Rb).**—This deep, nearly level soil of the uplands occurs in the western part of the county. The surface soil of dark grayish-brown clay loam is between 5 and 9 inches thick and is underlain by a more clayey, dark-colored subsoil that takes water slowly.

This soil is choice cropland. Nearly nine-tenths of it is used for cultivated crops, mostly for wheat. The soil is well suited to irrigation. If it is irrigated, good yields of sorghums and alfalfa can be obtained. A few small areas are in pasture of buffalograss and grama grasses. Most of the pastures are grazed heavily, and so yields of forage are rather low.

Management problems include surface crusting, the slow intake of water, the receiving of runoff water from higher lying soils, a slight hazard of erosion from wind and water, and the breakdown of the structure in the surface soil. (Capability unit IIc-2; Hardland range site.)

**Richfield complex (Rc).**—This complex of deep upland soils consists of the Richfield soil and, to a lesser extent, of the Mansic, Dalhart, and Randall soils. The relief is slightly billowy. The Richfield soil occurs in the flat areas between the knobs of Mansic and Dalhart soils. The Mansic soils consist of limy clay loam, whereas the Dalhart soils are made up of noncalcareous sandy loam. Small spots of Randall clay occur in a few, low, enclosed depressions lying within areas of Richfield soil.

In contrast to the clayey Randall soil, which occurs in low, slightly wet places, the Mansic and Dalhart soils occupy gently sloping areas. The Mansic soil takes water slowly, and some water runs off into lower areas of the Richfield soil; the Dalhart soil takes water more rapidly, and little runoff occurs.

Most areas of this mapping unit are used for cultivated crops, mainly for wheat. A few areas are in pasture, mostly of buffalograss, grama grasses, and dropseed grasses. Most of the pastures are grazed heavily, but they could produce more forage under improved management.

Management problems include surface crusting, the slow intake of water, the breakdown of the structure in the surface soil, and the hazard of erosion from wind and water. Because of the uneven slopes, contour farming is impractical. (Capability unit IIe-1; Hardland range site.)

**Rough broken land, Quinlan material (Rd).**—This mapping unit occurs in steep, canyonlike valleys and along the escarpments in strongly sloping areas of redbeds. The steepest parts consist of exposed, unweathered sandstone, and the less strongly sloping parts consist of between 10 and 20 inches of Quinlan loam over compacted rock. Mapped with this miscellaneous land type is a small amount of the deeper Woodward soil, which occurs along the foot slopes where the mantle of soil is thickest.

The vegetation is comprised mainly of buffalograss and grama, dropseed, and bluestem grasses. The bluestem

grasses grow in the wetter areas that have not been grazed excessively.

This mapping unit is suited only to limited grazing. Many parts of the areas are hard to reach, and cattle cannot graze them fully. The canyonlike areas permit only a limited access to the adjacent areas of Quinlan and Woodward soils.

An excessive amount of runoff and very severe erosion are the main hazards in using this land type for grazing. Operators must control grazing carefully to provide a protective mulch and to retain the best possible cover. (Capability unit VIIe-3; Breaks range site.)

**St. Paul silt loam, 0 to 1 percent slopes (Sd).**—This deep, nearly level soil of the uplands occurs throughout the more nearly level areas of redbeds. The surface soil, which consists of about 18 inches of brown silt loam, is transitional, with increasing depth, to the subsoil of brown silty clay loam that takes water fairly well.

This soil is valuable for use as cropland, and nearly all of it is under cultivation. Wheat is the main crop. Yields of wheat are fairly steady from year to year and generally are as high as those obtained on any other soil of the uplands. The soil is well suited to irrigation. The few, small pastures on this soil are in native grasses, mostly buffalograss, grama grasses, and dropseed grasses. Because of overgrazing, most areas are low in forage.

Management problems include surface crusting, the breakdown of the structure in the surface soil, a slight hazard of wind erosion, the formation of plowpans, and the receiving of runoff water from higher lying areas. (Capability unit IIc-2; Hardland range site.)

**St. Paul silt loam, 1 to 3 percent slopes (Sb).**—This deep, gently sloping soil of the uplands occurs around the margins of St. Paul silt loam, 0 to 1 percent slopes, in the more nearly level areas of the redbeds. The surface soil of brown silt loam is transitional, with increasing depth, to the subsoil of brown to reddish-brown silty clay loam that takes water fairly well.

This soil is valuable for use as cropland, and about 85 percent of it is cultivated. Wheat is the main crop. A few acres are in pasture, mostly of buffalograss and grama grasses. Because they have been overgrazed, many of the pastures produce little forage.

Management problems involve surface crusting, the breakdown of structure in the surface soil, a slight hazard of erosion through wind and water, and the formation of plowpans. (Capability unit IIe-1; Hardland range site.)

**Spur clay loam (Sc).**—This deep, nearly level, dark-colored soil of the bottom lands is above areas that ordinarily are flooded. Most of it occurs along the Cimarron and North Canadian Rivers. The surface soil of dark-brown clay loam and the loamy subsoil take water fairly well and have good water-holding capacity.

This soil is valuable for growing both dryland and irrigated crops. Nearly all of it is used to grow wheat, grain sorghums, and alfalfa.

Management problems include surface crusting, the receiving of excess runoff water from higher lying areas, a slight hazard of wind erosion, and the breakdown of the structure in the surface soil. A few areas along shallow drainageways and on alluvial fans below the uplands are slightly uneven and have a gradient of about 2 percent. These areas tend to erode slightly under clean

cultivation. (Capability unit IIc-1; Loamy bottom-land range site.)

**Spur loam (Sc).**—This deep, nearly level soil of the bottom lands is above areas that ordinarily are flooded. Most of it occurs along the larger streams. The surface soil and subsoil are both brown loam, and the subsoil takes water well. This soil has good water-holding capacity.

Spur loam is valuable as cropland, and nearly all of it is used to grow wheat, grain sorghums, and alfalfa. Yields are good, even under dryland farming. Some areas are irrigated.

Management problems include surface crusting, the removal of runoff water received from upland soils, a slight hazard of wind erosion, the breakdown of structure in the surface soil, and the formation of plowpans. The narrow areas lying along shallow drainageways and on alluvial fans are slightly uneven and have a gradient of about 2 percent. These areas tend to erode slightly if clean cultivation is practiced regularly. (Capability unit IIc-1; Loamy bottom-land range site.)

**Tipton silt loam, 0 to 1 percent slopes (Tc).**—This deep, nearly level soil occurs on old alluvial benches near the larger streams. It lies 20 to 40 feet above the flood plains. The surface soil, to a depth of about 24 inches, consists of brown, granular silt loam. This is underlain by a subsoil of brown silty clay loam that takes water well.

This is one of the most suitable soils for crops. Wheat is the main crop, but a considerable acreage is used to grow grain sorghums. Some alfalfa is grown during years when there is enough moisture in the soil. This soil is well suited to irrigation. With a greater amount of moisture, good yields of alfalfa and grain sorghums can be obtained. Only a few small areas are in pasture, but these commonly are grazed heavily and are low in forage.

Management problems include surface crusting, the breakdown of the structure in the surface soil, a slight hazard of wind erosion, the receiving of excess water from the sloping uplands, and the formation of plowpans. (Capability unit IIc-2; Loamy range site.)

**Tipton silt loam, 1 to 3 percent slopes (Tb).**—This deep, gently sloping soil occurs on broad alluvial benches that are between 20 and 40 feet above the flood plains of the larger streams. The surface soil, to a depth of 18 to 20 inches, consists of brown, granular silt loam. Below this is the subsoil of brown, light silty clay loam that takes water well.

This is one of the best soils for crops in the county, and about 80 percent of it is cultivated. Wheat is the main crop, but grain sorghums are grown during years when there is at least an average amount of moisture in the soil. A few small areas are in pasture that consists mostly of mid grasses and short grasses.

This soil is well suited to irrigation, and good yields of alfalfa and grain sorghums can be obtained. If the flooding method of irrigation is to be used, some areas may need leveling or bench terracing. Runoff and erosion are hazards on fields that are not irrigated carefully.

Management problems include surface crusting, a slight hazard of erosion from wind and water, the breakdown of the structure in the surface soil, and the formation of plowpans. (Capability unit IIc-2; Loamy range site.)

**Tipton silt loam, 3 to 5 percent slopes (Tc).**—This deep, moderately sloping soil occurs on the dissected margins of alluvial benches, 20 to 40 feet above the flood plains of the larger streams. The surface soil, which consists of 12 to 18 inches of brown loam or silt loam, overlies a brown, granular, loamy subsoil that takes water well. Gritty material occurs throughout the profile. Below depths of 24 to 30 inches, as much as 10 percent of the soil material consists of pebbles.

This soil is good for crops, and about two-thirds of the acreage is used for cultivated crops, mostly for wheat. A few small areas are in pasture of mid grasses and short grasses.

This soil is generally well suited to irrigation, but because of the moderate slopes, water must be applied carefully to prevent runoff and erosion. If the flooding method of irrigation is used, bench terracing will be needed. Under irrigation, good yields of alfalfa and grain sorghums can be obtained.

Management problems include surface crusting, a moderate hazard of wind erosion, a slight hazard of water erosion, the breakdown of the structure in the surface soil, and the formation of plowpans. (Capability unit IIIe-1; Loamy range site.)

**Tivoli fine sand (Td).**—This deep, very sandy soil occurs on dunelike areas that are parallel to the larger streams. The surface soil, which consists of 5 to 10 inches of light-brown fine sand, is underlain by reddish-yellow, loose fine sand that takes water very rapidly.

Most of the areas are well covered with a stand of tall grasses, mid grasses, and sagebrush, but small blowout spots are common. Unless the areas are managed carefully to prevent overgrazing, they soon lose their cover and are subject to blowing. (Capability unit VIIe-4; Dune range site.)

**Tivoli-Quinlan complex (Te).**—This soil complex consists of a mixture of Tivoli fine sand and Quinlan loam. It occurs on a dunelike, dissected terrain, mostly along the northern side of Buffalo Creek. Here, the sandy mantle of alluvium thins out and is not continuous. The shallow Quinlan soil lies in the areas between the dunes and in patches on the slopes.

The Tivoli soil is made up of deep sands that absorb water rapidly. The Quinlan soil is shallow over sandstone and absorbs water more slowly. The proportion of the two soils in individual areas varies greatly. The Tivoli soil is generally more extensive than the Quinlan. In only a few areas does it occupy less than 50 percent of the acreage.

This mapping unit is unsuited to cultivation. All of it is used as rangeland. The typical vegetation includes tall grasses, mid grasses, sand sagebrush, and sand plum. Careful management is needed to maintain a good cover. (Capability unit VIe-2; Mixed land range site.)

**Woodward loam, 1 to 3 percent slopes (Wa).**—This moderately deep, gently sloping soil of the uplands has formed under grass. It occurs throughout the redbed areas of the county. The surface soil of dark reddish-brown loam is about 10 inches thick. It is underlain by a subsoil of reddish-brown loam that is transitional to soft rock at depths between 20 and 30 inches. This soil takes water well, but its capacity for storing moisture is low.

About 80 percent of this soil is used for cultivated

crops, mainly for wheat and grain sorghums. Yields are not high. Nevertheless, they are fairly uniform from year to year, even during years of extreme drought, because the crops respond well to a small amount of rainfall. Areas that are not cultivated are used mostly for farm pastures along with areas of the more strongly sloping Woodward and Quinlan soils.

Management problems include surface crusting, a slight hazard of erosion from wind and water, the breakdown of the structure in the surface soil, and the formation of plowpans. (Capability unit IIe-2; Loamy range site.)

**Woodward loam, 3 to 8 percent slopes (Wb).**—This moderately deep, rolling soil of the uplands has formed under grass. It occurs extensively throughout the areas of redbeds. The surface soil of dark reddish-brown loam is about 8 to 10 inches thick. It is underlain by a subsoil of reddish-brown loam that is transitional to bedrock of soft sandstone at depths of 20 or more inches. This soil takes water well, but its capacity for storing moisture is low.

About two-thirds of this soil is used for cultivated crops. Wheat is the principal crop, but sorghums are also grown. Yields are not high but are fairly stable from year to year, even during periods of drought. Most areas that are not cultivated are used as rangeland or for farm pastures along with the Woodward and Quinlan soils and other soils of the redbeds.

Management problems include surface crusting, a moderate hazard of water erosion, a slight hazard of wind erosion, the breakdown of the structure in the surface soil, and the formation of plowpans. (Capability unit IIIe-1; Loamy range site.)

**Woodward-Quinlan loams, 1 to 3 percent slopes (Wc).**—This soil complex is made up of intermingled areas of Woodward and Quinlan soils that cannot be used and managed separately. The Woodward soil is moderately deep and occurs on concave foot slopes and in narrow valleys. It comprises about three-fourths of the total acreage. The Quinlan soil is shallow and occurs on low swells.

The Woodward soil has a surface layer of dark reddish-brown loam that is between 6 and 10 inches thick. Below this is a subsoil of reddish-brown loam that is transitional to soft, fine-grained sandstone at depths of 20 to 40 inches. The Quinlan soil has a surface layer of loam that is thinner and redder than that of the Woodward soils. This is transitional to slightly hardened, fine-grained sandstone. Both soils take water well, but neither has a large storage capacity.

About three-fourths of this complex is under cultivation. Wheat is the main crop, but grain sorghums do well if there is enough moisture in the subsoil. Because the terrain is uneven, it is difficult to use contour tillage and terracing. The soils can be protected best by carefully maintaining a cover of crop residues on the surface.

Management problems include a limited supply of moisture in shallow areas, a low content of organic matter, a slight to moderate hazard of erosion from wind and water, surface crusting, the breakdown of structure in the surface soil, and the formation of plowpans. (Capability unit IIIe-1; Loamy range site.)

**Woodward-Quinlan loams, 3 to 8 percent slopes (Wd).**—This soil complex consists of a moderately deep Woodward soil on side slopes and in narrow valleys and

of a shallow Quinlan soil on low hills or knobs. These soils occur in such an intricate pattern that it was not practical to map them separately.

The Woodward soil has a surface layer of dark reddish-brown loam and a subsoil of reddish loam that is transitional to weathered sandstone at depths between 20 and 40 inches. The loam surface layer of the Quinlan soil is thinner and redder than that of the Woodward soil. It is transitional to weathered, fine-grained sandstone. Both of these soils take water well, but they have only a low to moderate capacity for storing moisture.

About half of this complex is used for crops, but the acreage under cultivation is decreasing. As the result of erosion and of a decrease in the content of organic matter, yields of crops have declined. Operators need to decide whether it might be more profitable to establish a good stand of grass instead of keeping the areas under cultivation.

Management problems include the limited storage capacity for water, especially in the shallow soils; the low content of organic matter; a moderate hazard of erosion from wind and water; surface crusting; the breakdown of the structure in the surface soil; and the formation of plowpans. (Capability unit IVe-1; Loamy range site.)

**Yahola fine sandy loam (Yc).**—This deep, nearly level soil of the bottom lands is flooded occasionally. Most of it occurs along the larger creeks that drain the areas of redbeds. In general, it consists of reddish-yellow to red fine sandy loam underlain by a stratified, moderately sandy subsoil. The subsoil takes water well and has a moderate capacity for storing moisture.

Only about one-third of this fertile soil is used for crops. Wheat, grain sorghums, and alfalfa are grown. Much of the soil is not cultivated, for the individual areas are long and narrow and many of them are adjacent to areas used for range. The rangeland, consisting of tall grasses and mid grasses, produces large amounts of forage.

Management problems include the hazard of occasional overflow, the hazard of wind erosion, the maintenance of organic matter, and the formation of plowpans. (Capability unit IIc-1; Loamy bottom-land range site.)

## *Management of the Soils*

This section has six parts. The first describes general management applicable to all the cultivated soils; the second discusses irrigation; the third provides estimated yields per acre for wheat and grain sorghums under both common and improved management; the fourth explains the system the Soil Conservation Service uses in grouping soils according to their capability and places the soils of Harper County in capability units, or, as they are sometimes called, management groups; the fifth discusses range management; and the sixth discusses woodlands.

## **Management of Cultivated Soils**

Dryland farming is the prevailing type of agriculture on the cultivated soils of Harper County, but irrigation farming is practiced to some extent. Under either type of farming, it is important to select proper management practices to fit the soils and to blend these practices into

a balanced program of farming. In this section, management requirements applicable to all the arable soils are discussed.

### **Conserving moisture and controlling erosion**

Conserving moisture and controlling erosion are the principal management problems for the farmers of Harper County. These problems are made more difficult because of the limited amount of precipitation in the area. Although there is no cure-all method for eliminating duststorms and avoiding crop failures caused by droughts, the hazards of farming can be lessened by using practices to conserve soil and water.

There is always a risk of drought in Harper County, especially since the cultivated soils have become crusted and compacted. When the virgin sod was first broken out, the soils were high in organic matter, had a favorable granular structure, and water penetrated easily. During the first years under cultivation, yields of crops were high. Under continual cultivation, however, the soils lost their favorable characteristics and became more susceptible to damage through erosion from wind and water.

Harper County receives less than 23 inches of precipitation annually. Strong winds and high summer temperatures cause the rate of evaporation to be high. As a result, the surface soil is dry much of the time. This combination of factors makes the soils susceptible to wind erosion. Generally, the winds are strongest early in spring or late in winter, but they may be strong enough to cause severe damage in other seasons. All of the soils, especially the sandier ones, are subject to damage by wind.

The amount of wind erosion depends primarily on the stability of the soil when dry and on the amount of protective cover on the surface. One way of protecting the soil is to leave clods on the surface. Tillage, though necessary, destroys the cloddy structure of the soil.

Following is a discussion of practices needed to conserve moisture and to control erosion from wind and water.

**Maintenance of organic matter.**—Maintaining the content of organic matter in the soil helps to prevent excessive runoff and to control erosion. Organic matter acts like a sponge; it holds large amounts of water. It also keeps the soil open and porous and thus reduces water erosion. By binding the soil particles together into granules, the organic matter reduces wind erosion. In addition, it supplies some of the nitrogen and phosphorus needed for the growth of crops.

In Harper County the supply of organic matter can best be replenished by turning under crop residues. It is not economically feasible, however, to keep the content of organic matter up to the level of that in the virgin sod.

**Stubble-mulch tillage.**—Stubble-mulch tillage is a method of cultivating in such a way that the crop stubble is not greatly disturbed (figs. 5 and 6). To do this, sweeps, chisels, and rod weeders are used.

The soils of the county receive enough moisture almost every year to grow some kind of protective cover. If this cover is left on the surface, the loss of soil through wind erosion is reduced greatly. If the cover is removed, the bare soil is subject to blowing (fig. 7). Leaving the stubble on the surface breaks the force of the wind, acts as a cushion to break the force of falling raindrops, and makes the soil more receptive to water.



**Figure 5.**—This field on which stubble-mulch tillage has been practiced contains about 800 pounds of standing cover per acre. The soil is prepared to absorb rainfall. Spring winds did not damage the wheat crop that was planted later on this field.



**Figure 6.**—Stubble from the previous crop protects this young stand of wheat against wind erosion.



**Figure 7.**—Crop stubble was not kept on the surface of this field. As a result, the next wheat crop was blown out completely.

Farmers may be able to estimate the amount of cover needed to control wind erosion on their soils. Roughly, the extremely sandy soils need about 2,000 pounds of cover per acre, the sandy loams need about 1,000 pounds, and the clay loams need about 500 pounds. Tillage on fallow land should be avoided in fall and winter because it destroys the protective cover of crop residues.

The following are suggestions for maintaining crop residues through stubble-mulch tillage or other practices so as to control erosion and conserve moisture:

1. Support stubble-mulch tillage with other applicable conservation practices.
2. Keep the soil covered, preferably with a growing crop or a thick stubble.
3. Maintain a dense stubble for the most effective control of erosion.
4. For sorghums grown in rows, keep the stubble at a height between 10 and 14 inches.
5. Control grazing on the stubble of row crops.
6. Let wheat stubble stand until after the windy season in spring.
7. When working up stubble, adjust the one-way diskplow or other implements to cut the soil at a shallow depth so that the stubble will not be covered.

**Fallowing.**—Fallowing is a practice used to increase the supply of moisture in the soil. Substantial increases in yields have been obtained through fallowing as compared to continuous cultivation. Where fallowing is used, the soil lies idle but is kept free of weeds and other growing plants so that moisture will collect. A stubble-mulch cover is maintained to protect against wind erosion. Because of the risk of erosion in this area, clean-tillage fallow is not desirable, regardless of the amount of precipitation.

The land is fallowed in strips and cropped in alternating years. Under one system of fallowing, the soil is tilled soon after harvest so that the weeds are killed and left on the surface. The soil is tilled often enough to kill the weeds, but a stubble mulch is kept on the surface to protect against erosion and to permit water to enter the soil more easily.

A type of fallowing more widely used in this county is known as delayed tillage for summer fallow. Under this method of fallowing, the stubble is left after harvest and is not disturbed until the next spring. In the spring and summer, the soil is tilled often enough to destroy the weeds but as much stubble as possible is left on the surface. The soil is tilled less often under the delayed method, and so the cost of fallowing is reduced.

During dry years many farmers in Harper County use a cropping system that consists of fallowing and cropping in alternate years. This insures an income from the land every 2 years. Fallowing is not so necessary during periods of heavy precipitation.

**Emergency tillage for the control of wind erosion.**—Emergency tillage is used to control erosion when other methods fail to provide enough protection. Generally, the most effective method of controlling wind erosion is to produce and maintain an adequate cover of growing crops or crop residues. During dry periods, when crops fail, however, it may be necessary to plant special crops for emergency cover. If these crops do not provide

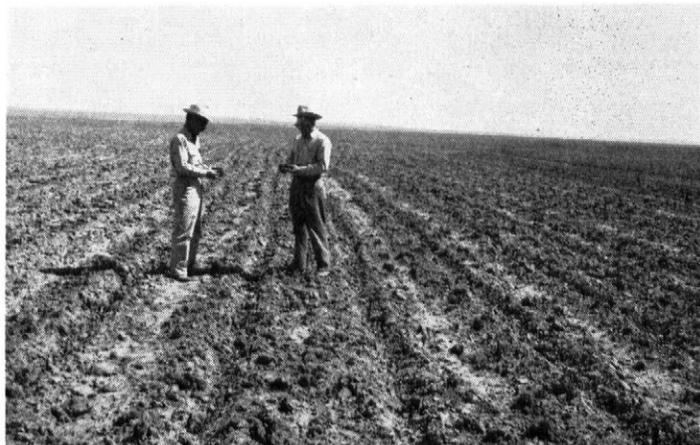


Figure 8.—Emergency tillage, which brings clods to the surface, has been practiced on this field. Even under conservation management, emergency tillage is needed occasionally to guard against wind erosion.

enough cover, emergency tillage will be needed to help reduce damage to the soils and crops (fig. 8).

Suggestions applicable to emergency tillage are as follows:

1. Keep as much cover or crop residues on the surface as possible.
2. Avoid shallow or close-spaced tillage; this tends to pulverize or loosen the surface soil.
3. Till blowout spots at the proper time to keep wind erosion from spreading to other areas. Often this may eliminate the necessity of tilling the entire field.
4. If a duckfoot attachment is used to build ridges in the fields, set it deep enough to bring up clods from below the surface, thereby permitting the loose, dry surface soil to sift downward.
5. Use a one-way diskplow, with all but every third or fourth disk removed, to throw up ridges. Set the disks deep enough and regulate the speed of the tractor so that clods are brought to the surface and formed into furrows that are deep enough to protect the soil from blowing. Deep plowing is also effective, but it is more costly than other methods of emergency tillage. Disk harrows and one-way diskplows with all the disks in place are not suitable because they pulverize the surface soil and do not bring clods to the surface.
6. Apply a thin layer of asphalt to stabilize small areas of sandy soils.
7. Add straw or manure as a mulch for the surface soil.
8. Control wind erosion by working with all of the other farmers of the community. Dust blown from one field may cover other fields and subject them to blowing.

Chiseling is one of the most effective methods of controlling wind erosion on hardlands (silty and clayey soils). The chisels are usually equipped with shovels that are between 2 and 4 inches wide and spaced 3 to 4 feet apart. Set the shovels deep enough to bring stable clods to the surface. To avoid pulverizing the soil and to get the necessary depth when the soil is first tilled, space the chisels 2 or more feet apart. This will permit further tillage, if needed, to be effective.

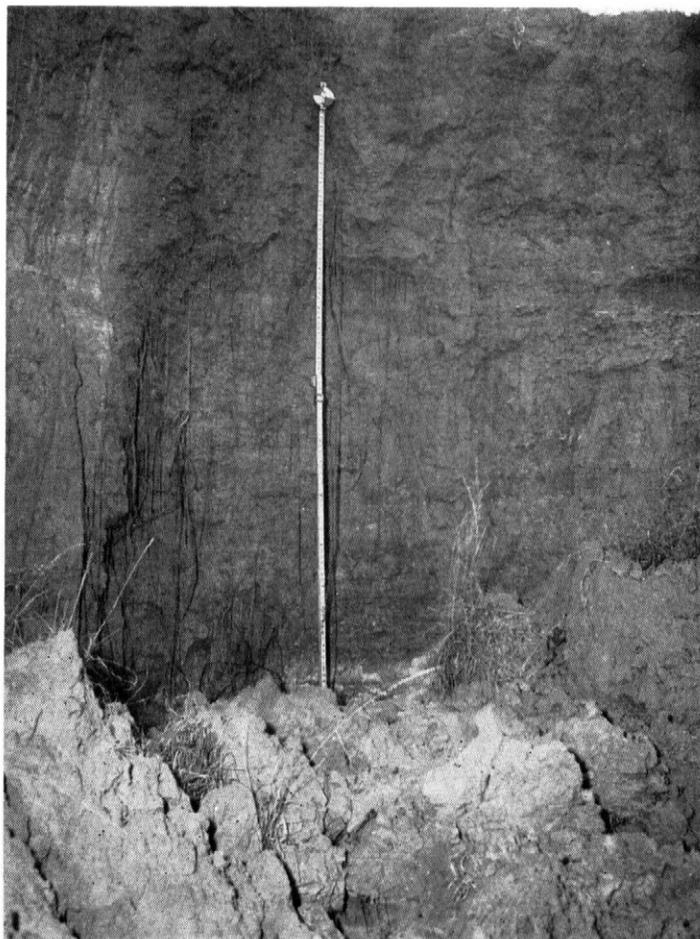
Listing is an effective method of controlling wind erosion on the Dalhart fine sandy loams, the Dalhart-Carwile fine sandy loams, the Pratt fine sandy loams, and other sandy soils. It is not suitable on the Pratt loamy fine sands. Listing is suitable only if the subsoil is moist. It provides effective control of wind erosion on hardlands in which the uppermost 3 or 4 inches of the profile is powdery. Use listers with shovels 8 to 14 inches wide. Space the listers between 38 and 46 inches apart, and penetrate the soil deep enough to bring up cloddy material.

### **Cropping systems**

The use of regular cropping systems is limited in Harper County because of the variable climate. Wheat and sorghums are grown on the uplands. Alfalfa and sweetclover are grown on the more nearly level uplands when moisture conditions are favorable. Wheat, sorghums, and alfalfa are the principal crops on the soils of the bottom lands.

The growing of legumes is limited in Harper County. Under proper management, sudangrass, wheat, and other nonlegumes can be used as soil-improving crops (figs. 9 and 10). Farmers can maintain the present fertility of their cultivated soils by using crop residues to protect the soil from erosion.

Sweetclover has been grown successfully on most of the soils. It cannot be grown regularly in the cropping system, however, because the soils are too dry more than half of the time and sweetclover requires more water per pound of plant growth than wheat or sorghums. In addition, when the residue from sweetclover is turned under, the crop that follows grows too vigorously, which is undesirable during seasons of limited precipitation.



**Figure 10.**—The roots of grasses have penetrated to a depth of 15 feet in this exposure of Yahola fine sandy loam in the bank of a creek. The roots bind the soil materials together. Using grass in the cropping system helps maintain the structure of the soil.

### **Soil amendments**

Commercial fertilizers have been used but little in Harper County. Considering the limited amount of soil moisture, the soils are generally high in fertility.

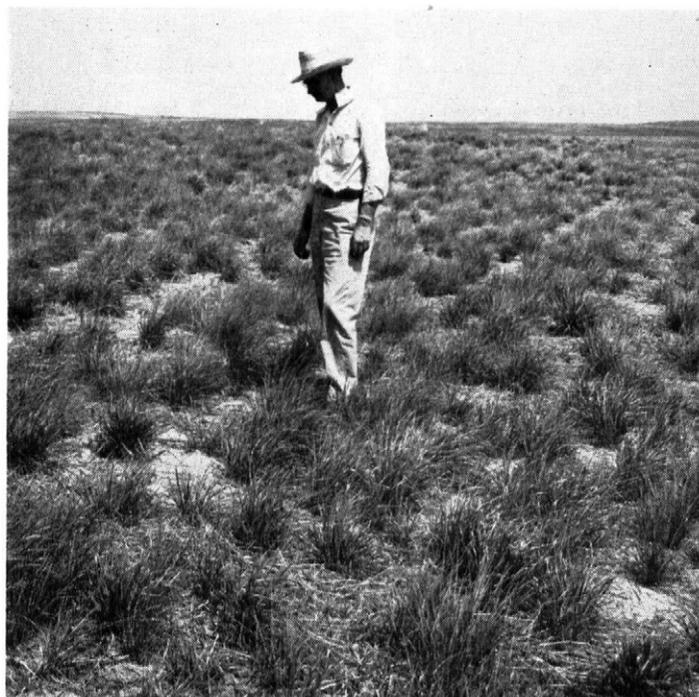
Field trials and laboratory tests indicate the crops on most of the cultivated soils will respond to nitrogen. At the present time, however, it is not economically feasible to apply nitrogen fertilizer over a long period.

Applying phosphate fertilizer to wheat pays off during years of heavy precipitation. Field trials should be conducted on small acreages over a period of several years before using more than the minimum amount of phosphate fertilizer.

Other elements needed for growing crops are abundant in the soils of the county. The soils contain enough lime (calcium carbonate) so that soil acidity is not an important problem.

### **Irrigation**

Irrigation farming, though not practiced extensively in Harper County, is becoming more prevalent. In 1954, irrigation was practiced on 21 farms, as compared to 9



**Figure 9.**—Field that once was cultivated but that has been in grass for 3 years. Grass and other soil-building crops protect the soil from erosion, maintain fertility, and improve the soil structure.

farms in 1950. The number of acres irrigated increased from 457 in 1949 to 1,665 in 1954.

Most of the irrigation water is used on small grains and forage crops. These are fed to livestock during droughty periods when pastures are poor.

**Sources of irrigation water.**—Only certain parts of Harper County contain enough underground water for irrigation. A map published by the Oklahoma Geological Survey shows the location of reservoirs of ground water in Oklahoma. This map indicates that the area north of the Cimarron River in the northwestern corner of the county has enough water for irrigation. The wells should produce between 50 and 500 gallons of water per minute. The depth to water varies, but it ranges from 25 to 100 feet.

The most extensive sources of underground water in this county are in the valley of the North Canadian River and in adjacent sandy areas. Underground water may also be available in other areas, especially in the southwestern corner of the county and in the wider valleys.

**Planning an irrigation system.**—Before investing money in irrigation equipment, the farmer needs to investigate the quantity and quality of the available water and the suitability of his soils for irrigation. Each irrigation project has special problems in layout, drainage, and management. Technicians of the Soil Conservation Service or the county agricultural agent will help the farmer plan his irrigation system.

**Available water-holding capacity and water-intake rate.**—The ideal soil for irrigation has a loamy surface layer and an open, loamy subsoil. Its capacity for storing moisture is high. Water penetrates easily, and excess water drains down through the profile. The soil is favorable for roots because the proportion of water, air, and roots is in balance.

In table 2 the soils in Harper County best suited to irrigation farming are rated according to available water-holding capacity and water intake.

Available water is the moisture in the soil that can be taken up by the plant in amounts significant to growth. For a given soil, it represents the range between field capacity, which is the maximum amount of water the soil can hold, and the level at which plants with mature root systems begin to wilt. The following ratings are based on the amount of available water that each foot of soil will store: High, 1.6 to 2.1 inches; medium, 1.1 to 1.6 inches; low, 0.6 to 1.1 inches.

The water-intake rate varies according to the condition of the soil. The water-intake rates shown in table 2 are based on soils that are moist and in good tilth. The following ratings for water intake indicate the amount of water the soil will absorb in an hour: Very slow, less than 0.2 inch; slow, 0.2 to 1.0 inch; moderate, 1.0 to 2.5 inches; moderately rapid, 2.5 to 5.0 inches; and rapid, more than 5.0 inches.

The rate of water intake is influenced by the slope, the soil texture and structure, the content of organic matter, and other characteristics of the soil; the size of the raindrops and the speed at which they fall; and the amount of protective cover on the soil. In many soils the water-intake rate depends largely on the tilth of the plowed layer, especially on the tilth of the uppermost one-fourth inch of soil.

TABLE 2.—*Water-holding capacity and water-intake rate<sup>1</sup> of the deep arable soils*

| Soil  | Available water-holding capacity | Water-intake rate             |
|---|----------------------------------|-------------------------------|
| Carey silt loam, 1 to 3 percent slopes.         | High to medium.                  | Moderate.                     |
| Carey silt loam, 3 to 5 percent slopes.         | High to medium.                  | Moderate.                     |
| Dalhart fine sandy loam, 1 to 3 percent slopes. | Medium....                       | Moderate.                     |
| Dalhart fine sandy loam, 3 to 5 percent slopes. | Medium....                       | Moderate.                     |
| Dalhart-Carwile fine sandy loams.               | Medium....                       | Slow.                         |
| Hollister clay loam, 0 to 1 percent slopes.     | High.....                        | Very slow to slow.            |
| Hollister clay loam, 1 to 3 percent slopes.     | High.....                        | Very slow to slow.            |
| Mansic clay loam, 0 to 1 percent slopes.        | High.....                        | Slow to moderate.             |
| Mansic clay loam, 1 to 3 percent slopes.        | High.....                        | Moderate.                     |
| Mansic clay loam, 3 to 5 percent slopes.        | High.....                        | Moderate.                     |
| Mansker loam, 1 to 3 percent slopes.            | Medium....                       | Moderate.                     |
| Pratt fine sandy loam, billowy.                 | Medium....                       | Moderately rapid.             |
| Pratt fine sandy loam, hummocky.                | Medium....                       | Moderately rapid.             |
| Pratt loamy fine sand, billowy.                 | Low.....                         | Rapid.                        |
| Pratt loamy fine sand, hummocky.                | Low.....                         | Rapid.                        |
| Richfield clay loam.....                        | High.....                        | Very slow to slow.            |
| Richfield complex.....                          | High.....                        | Slow.                         |
| St. Paul silt loam, 0 to 1 percent slopes.      | High.....                        | Slow to moderate.             |
| St. Paul silt loam, 1 to 3 percent slopes.      | High.....                        | Slow to moderate.             |
| Spur clay loam.....                             | High.....                        | Very slow.                    |
| Spur loam.....                                  | Medium....                       | Slow.                         |
| Tipton silt loam, 0 to 1 percent slopes.        | Medium....                       | Moderate.                     |
| Tipton silt loam, 1 to 3 percent slopes.        | High to medium.                  | Moderate.                     |
| Tipton silt loam, 3 to 5 percent slopes.        | Medium....                       | Moderate to moderately rapid. |
| Woodward loam, 1 to 3 percent slopes.           | Medium....                       | Moderate.                     |
| Woodward loam, 3 to 8 percent slopes.           | Medium....                       | Moderate.                     |
| Yahola fine sandy loam.....                     | Medium....                       | Moderate to moderately rapid. |

<sup>1</sup> Numerical limits for terms used to indicate the water-holding capacity and the water-intake rate are given in the accompanying text.

If soil is not managed properly, its structure deteriorates, the soil materials run together, and crusting follows. The crusting seals the surface and makes the soil less permeable to water and air. Much of the rainwater is lost through runoff. Consequently, depending on how well they are managed, different areas of the same kind of soil may have a water-intake rate ranging from 0.25 inch per hour to 2.0 inches per hour.

### Estimated Yields

Estimated average acre yields of wheat and grain sorghums, the principal crops grown in Harper County, are listed in table 3. These figures, based on a 20-year

Table 3.—*Estimated average acre yields of wheat and grain sorghams to be expected over a period of years on the arable soils*

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

| Soil   | Wheat  |        | Grain sorghams |        |
|--|--------|--------|----------------|--------|
|  | A      | B      | A              | B      |
| Carey silt loam, 1 to 3 percent slopes         | Bu. 12 | Bu. 14 | Bu. 15         | Bu. 17 |
| Carey silt loam, 3 to 5 percent slopes         | 9      | 11     |                |        |
| Dalhart fine sandy loam, 1 to 3 percent slopes | 10     | 12     | 18             | 21     |
| Dalhart fine sandy loam, 3 to 5 percent slopes | 8      | 10     | 14             | 16     |
| Dalhart-Carwile fine sandy loams               | 11     | 12     | 14             | 15     |
| Hollister clay loam, 0 to 1 percent slopes     | 13     | 15     |                |        |
| Hollister clay loam, 1 to 3 percent slopes     | 11. 5  | 14     |                |        |
| Mansic clay loam, 0 to 1 percent slopes        | 14     | 16     |                |        |
| Mansic clay loam, 1 to 3 percent slopes        | 11     | 13     |                |        |
| Mansic clay loam, 3 to 5 percent slopes        | 8      | 10     |                |        |
| Mansker loam, 1 to 3 percent slopes            | 11     | 13     | 15             | 17     |
| Mansker loam, 3 to 5 percent slopes            | 8      | 10     |                |        |
| Mansker-Potter complex, 3 to 5 percent slopes  | 6      | 8      | 9              | 10     |
| Pratt fine sandy loam, billowy                 | 11     | 13     | 18             | 21     |
| Pratt fine sandy loam, hummocky                | 7      | 9      | 14             | 16     |
| Pratt loamy fine sand, billowy                 |        |        | 13             | 15     |
| Pratt loamy fine sand, hummocky                |        |        | 11             | 13     |
| Richfield clay loam                            | 14     | 16     |                |        |
| Richfield complex                              | 12     | 14     |                |        |
| St. Paul silt loam, 0 to 1 percent slopes      | 14     | 16     |                |        |
| St. Paul silt loam, 1 to 3 percent slopes      | 12     | 14     |                |        |
| Spur clay loam                                 | 14     | 16     | 15             | 17     |
| Spur loam                                      | 14     | 16     | 18             | 21     |
| Tipton silt loam, 0 to 1 percent slopes        | 14     | 16     | 16             | 19     |
| Tipton silt loam, 1 to 3 percent slopes        | 10     | 13     | 14             | 16     |
| Tipton silt loam, 3 to 5 percent slopes        | 8      | 10     | 12             | 14     |
| Woodward loam, 1 to 3 percent slopes           | 11     | 13     | 15             | 18     |
| Woodward loam, 3 to 8 percent slopes           | 9      | 11     | 12             | 15     |
| Woodward-Quinlan loams, 1 to 3 percent slopes  | 8      | 10     | 13             | 15     |
| Woodward-Quinlan loams, 3 to 8 percent slopes  | 6      | 7      | 9              | 10     |
| Yahola fine sandy loam                         | 10     | 11     | 14             | 16     |

record, apply only to yields obtained under dryland farming.

Yields in columns A are those obtained under common management without the use of conservation practices. Yields in columns B are those obtained after a combination of conservation practices, such as terracing and use of waterways, contour farming, and stubble-mulch tillage, have been applied.

Management practices vary from farm to farm, and the climate fluctuates from year to year. Therefore, the estimated yields may not apply to specific tracts of land or be indicative of the yields in a particular year. At present, yields obtained under conservation farming are not much higher than those obtained under common management. Unless methods are used to conserve soil and water, however, the soils will lose an increasing amount of moisture through runoff and additional surface soil through erosion. As this happens, yields of crops will decline.

Overall figures showing yields of alfalfa are not available for this county. Records have been obtained, however, from a farmer in the valley of the Cimarron River who has recorded his alfalfa yields over a 30-year period. The alfalfa, which received some irrigation water, produced an average annual yield of 1.7 tons per acre.

### Capability Grouping

Capability grouping is a system of classification used to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the needs and limitations of the soils, on the risks of damage to them, and also on their response to management. There are three levels above the soil mapping unit in this grouping. They are the capability unit, the subclass, and the class.

The capability unit, which can also be called a management group of soils, is the lowest level of capability grouping. A capability unit is made up of soils similar in the kind of management they need, in risk of damage, and in general suitability for use.

The next broader grouping, the subclass, is used to indicate the dominant kind of limitation. The letter symbol "e" indicates that the main limiting factor is risk of erosion if the plant cover is not maintained. The symbol "w" means that excess water retards plant growth or interferes with cultivation. The symbol "s" shows that the soils are shallow, droughty, or unusually low in fertility. The symbol "c" shows that the soils are limited chiefly by a climate that is too cold or too dry.

The broadest grouping, the land capability class, is identified by Roman numerals. All the soils in one class have limitations and management problems of about the same degree, but of different kinds, as shown by the subclass. All the land classes, except class I, may have one or more subclasses.

In classes I, II, and III are soils that are suitable for annual or periodic cultivation of annual or short-lived crops.

Class I soils<sup>2</sup> are those that have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. They can be cultivated with almost no risk of erosion and will remain productive if managed with normal care.

Class II soils can be cultivated regularly, but they do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping; consequently, they need moderate care to prevent erosion. Other soils in class II may be slightly droughty, slightly wet, or somewhat limited in depth.

Class III soils can be cropped regularly but have a narrower range of use than the soils in class II. They need even more careful management.

In class IV are soils that have greater natural limitations than those in class III but that can be cultivated for some crops under very careful management.

In classes V, VI, and VII are soils that normally should not be cultivated for annual or short-lived crops but that can be used for pasture or range, as woodland, or as shelter for wildlife.

<sup>2</sup> There are no class I soils in Harper County under dryland agriculture. Soils placed in class II because of the limitation of climate would be class I soils if irrigated.

Class V soils have little or no hazard of erosion but have other limitations that are impractical to remove and that limit the use of the soils largely to pasture, woodland, or habitats for wildlife.

Class VI soils are not suitable for crops, because they are steep, droughty, or otherwise limited, but they give fair yields of forage or forest products. Some soils in class VI can, without damage, be cultivated enough so that pasture crops can be seeded.

Class VII soils provide only poor to fair yields of forage or forest products and have characteristics that limit them severely for these uses. In class VIII (none in Harper County) are soils that have practically no agricultural use. Some of them are valuable as parts of watersheds or as shelter for wildlife. Others provide attractive scenery.

The soils of Harper County have been placed in the following capability classes, subclasses, and units:

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

Subclass IIc: Soils limited chiefly by climate.

Unit IIc-1: Nearly level soils of the bottom lands.

Unit IIc-2: Nearly level, loamy soils of the uplands.

Subclass IIe: Soils that will erode if tilled and not protected.

Unit IIe-1: Gently sloping, clayey soils.

Unit IIe-2: Gently sloping, loamy soils.

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

Subclass IIIe: Soils that have a moderate or severe hazard of erosion if tilled.

Unit IIIe-1: Sloping, loamy soils.

Unit IIIe-2: Gently sloping soils.

Subclass IIIw: Soils severely affected by excess water.

Unit IIIw-1: Soils that have poor drainage.

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

Subclass IVe: Soils that have a severe or very severe hazard of erosion when tilled.

Unit IVe-1: Sloping, moderately deep, loamy soils.

Unit IVe-2: Hummocky, sandy soils.

Class V.—Soils that have little or no erosion hazard but that have other limitations that limit the kinds of plants that can be grown and prevent normal tillage

for cultivated crops. Their use is limited largely to pasture, range, or woodland, or to food and cover for wildlife.

Subclass Vw: Soils very severely affected by excess water.

Unit Vw-1: Soils that have a high water table and that occur along rivers.

Unit Vw-2: Redbed soils that are frequently flooded.

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

Subclass VIe: Soils that have a severe hazard of erosion and that are generally unsuited to cultivation.

Unit VIe-1: Sandy soils along the rivers and creeks.

Unit VIe-2: Mixed sandy and loamy soils that have low, dunny relief.

Unit VIe-3: Sandy soils that have dunny relief.

Unit VIe-4: Shallow soils on sloping lands.

Subclass VIw: Soils very severely affected by excess water.

Unit VIw-1: Clayey soils of wet-weather lakes.

Class VII.—Soils that have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to grazing or wildlife.

Subclass VIIe: Soils that have a very severe hazard of erosion.

Unit VIIe-1: Very shallow, strongly sloping soils formed on gypsum.

Unit VIIe-2: Shallow, severely eroded soils.

Unit VIIe-3: Rough broken land.

Unit VIIe-4: Extremely sandy soils on steep, dunny relief.

### *Management by capability units*

The soils of Harper County have been placed in 20 capability units. The soils of the capability units in classes II through IV are suited to cultivation. Those of capability units in classes V through VII can be used for range; some areas of these soils that are under cultivation should be returned to range.

Suggested management practices are given for the units made up of arable soils. The management of all the soils of the county, when used for grazing, is discussed in the section, Range Management.

The capability unit to which each of the soils belongs is shown in table 4. For each soil, this table also lists the principal crops, the range site, and the soil characteristics that affect management.

TABLE 4.—*Management groupings, principal crops, erodibility, and relative effectiveness of moisture-conservation practices on the soils*

| Soil  | Capability unit | Principal crops                            | Range site         | Erodibility through— |                | Effectiveness of moisture-conservation practices |
|---|-----------------|--|--------------------|----------------------|----------------|--|
|   |                 |  |                    | Wind                 | Water          |  |
| Carey silt loam, 1 to 3 percent slopes.           | IIe-2           | Wheat, grain sorghums, and native grasses. | Loamy-----         | Low-----             | Low-----       | Medium.  |
| Carey silt loam, 3 to 5 percent slopes.           | IIIe-1          | Wheat and grain sorghums.                  | Loamy-----         | Low-----             | Medium-----    | Medium.  |
| Cottonwood loam-----                              | VIIe-1          | Native grasses-----                        | Gyp-----           | Medium-----          | High-----      | Very low.  |
| Dalhart fine sandy loam, 1 to 3 percent slopes.   | IIIe-2          | Grain sorghums and wheat.                  | Sandy plains--     | Medium-----          | Low-----       | High.  |
| Dalhart fine sandy loam, 3 to 5 percent slopes.   | IVe-2           | Grain sorghums and wheat.                  | Sandy plains--     | Medium to high       | Low to medium. | Medium.  |
| Dalhart-Carwile fine sandy loams.                 | IIIw-1          | Sorghums and small grains.                 | Sandy plains--     | Medium-----          | Low-----       | Medium.  |
| Hollister clay loam, 0 to 1 percent slopes.       | IIe-2           | Wheat-----                                 | Hardland-----      | Low-----             | Low-----       | Medium.  |
| Hollister clay loam, 1 to 3 percent slopes.       | IIe-1           | Wheat-----                                 | Hardland-----      | Low-----             | Low to medium. | Medium.  |
| Las Animas soils-----                             | Vw-1            | Native grasses-----                        | Subirrigated--     | Low-----             | Low-----       | Medium.  |
| Las Animas soils, shallow over clay.              | Vw-1            | Native grasses-----                        | Subirrigated--     | Low-----             | Low-----       | Medium.  |
| Lincoln soils-----                                | VIe-1           | Native grasses and sorghums.               | Sandy bottom land. | High to medium.      | Low-----       | Medium.  |
| Loamy alluvial land-----                          | Vw-2            | Native grasses-----                        | Loamy bottom land. | Low-----             | High-----      | Low.   |
| Mansic clay loam, 0 to 1 percent slopes.          | IIe-2           | Wheat and alfalfa-----                     | Hardland-----      | Low-----             | Low-----       | High.  |
| Mansic clay loam, 1 to 3 percent slopes.          | IIe-1           | Wheat-----                                 | Hardland-----      | Low to medium.       | Low-----       | Medium.  |
| Mansic clay loam, 3 to 5 percent slopes.          | IIIe-1          | Wheat and native grasses.                  | Hardland-----      | Medium-----          | Medium-----    | Low.   |
| Mansker loam, 1 to 3 percent slopes.              | IIIe-1          | Wheat and grain sorghums.                  | Loamy-----         | Medium-----          | Low to medium. | Medium.  |
| Mansker loam, 3 to 5 percent slopes.              | IVe-1           | Wheat, native grasses, and sorghums.       | Loamy-----         | Medium to high.      | Medium-----    | Low.   |
| Mansker-Potter complex, 3 to 5 percent slopes.    | IVe-1           | Wheat, native grasses, and sorghums.       | Shallow-----       | High-----            | Medium-----    | Low.   |
| Mansker-Potter complex, 5 to 20 percent slopes.   | VIe-4           | Native grasses-----                        | Shallow-----       | Medium-----          | High-----      | Very low.  |
| Otero loamy sand-----                             | VIe-2           | Native grasses-----                        | Mixed land-----    | High-----            | Low-----       | Low.   |
| Pratt fine sandy loam, billowy----                | IIIe-2          | Grain sorghums and wheat.                  | Sandy plains--     | Medium-----          | Low-----       | Medium.  |
| Pratt fine sandy loam, hummocky--                 | IVe-2           | Sorghums and wheat-----                    | Sandy plains--     | Medium to high.      | Low to medium. | Medium.  |
| Pratt loamy fine sand, billowy----                | IVe-2           | Sorghums and native grasses.               | Deep sand-----     | High-----            | Low-----       | Medium.  |
| Pratt loamy fine sand, hummocky--                 | IVe-2           | Native grasses and sorghums.               | Deep sand-----     | High-----            | Low-----       | Medium.  |
| Pratt loamy fine sand, duned-----                 | VIe-3           | Native grasses-----                        | Deep sand-----     | High-----            | Low-----       | Medium.  |
| Quinlan loam-----                                 | VIe-4           | Native grasses-----                        | Shallow-----       | Low to medium.       | High-----      | Very low.  |
| Quinlan loam, severely eroded----                 | VIIe-2          | Native grasses-----                        | Shallow-----       | Low to medium.       | High-----      | Very low.  |
| Quinlan-Woodward complex, 5 to 12 percent slopes. | VIe-4           | Native grasses-----                        | Shallow-----       | Low to medium.       | High-----      | Very low.  |
| Randall clay-----                                 | VIw-1           | Native grasses-----                        | Hardland-----      | Low-----             | Low-----       | Low.   |
| Richfield clay loam-----                          | IIe-2           | Wheat-----                                 | Hardland-----      | Low-----             | Low-----       | Medium.  |
| Richfield complex-----                            | IIe-1           | Wheat-----                                 | Hardland-----      | Low to medium.       | Low to medium. | Medium.  |
| Rough broken land, Quinlan material.              | VIIe-3          | Native grasses-----                        | Breaks-----        | Low-----             | High-----      | Very low.  |
| St. Paul silt loam, 0 to 1 percent slopes.        | IIe-2           | Wheat-----                                 | Hardland-----      | Low-----             | Low-----       | High.  |
| St. Paul silt loam, 1 to 3 percent slopes.        | IIe-1           | Wheat-----                                 | Hardland-----      | Low-----             | Low to medium. | Medium.  |
| Spur clay loam-----                               | IIe-1           | Wheat, alfalfa, and grain sorghums.        | Loamy bottom land. | Low-----             | Low-----       | High.  |
| Spur loam-----                                    | IIe-1           | Wheat, grain sorghums, and alfalfa.        | Loamy bottom land. | Low to medium.       | Low-----       | High.  |
| Tipton silt loam, 0 to 1 percent slopes.          | IIe-2           | Wheat and grain sorghums.                  | Loamy-----         | Low-----             | Low-----       | High.  |
| Tipton silt loam, 1 to 3 percent slopes.          | IIe-2           | Wheat and grain sorghums.                  | Loamy-----         | Low-----             | Low-----       | Medium.  |



grown, and yields are fair if rainfall is well distributed throughout the growing season. During dry years the alfalfa may fail or die out. When old stands of alfalfa are turned under, plow early in spring and plant grain sorghums the first year.

To prevent overwash from higher lying, adjacent areas, construct diversion terraces. Use terracing, contour farming, and stubble-mulch tillage to conserve moisture and check erosion. Seed or sod terrace outlets with suitable grasses. Practice contour farming on unterraced areas to help conserve water.

These soils are suitable for planting trees or shrubs for use as shelterbelts.

#### CAPABILITY UNIT IIIe-1

This capability unit consists of sloping, moderately deep to deep, permeable soils. The soils take water well but lose a considerable amount of moisture through runoff. They are subject to erosion. The following soils are in capability unit IIIe-1:

|   |  |
|---|--|
| Carey silt loam, 3 to 5 percent slopes.   | Tipton silt loam, 3 to 5 percent slopes.       |
| Mansker clay loam, 3 to 5 percent slopes. | Woodward loam, 3 to 8 percent slopes.          |
| Mansker loam, 1 to 3 percent slopes.      | Woodward-Quinlan loams, 1 to 3 percent slopes. |

Wheat is the main crop grown on these soils, but sorghums are grown to a considerable extent on Woodward loam, 3 to 8 percent slopes. Use terracing, contour farming, and stubble-mulch tillage to conserve moisture and control erosion. Seed or sod all terrace outlets with suitable grasses. Practice contour farming on unterraced fields to help retain water. Where necessary, use diversion terraces to control overwash from adjacent higher lying areas. In places contour stripcropping of sorghums and small grains may be needed to help control wind erosion.

#### CAPABILITY UNIT IIIe-2

This capability unit consists of deep, sandy soils that have nearly level to slightly undulating relief. The soils take water well, and even the moisture from light rains becomes available to growing crops. Because the soils are subject to a moderate degree of blowing, the control of wind erosion is important. Conserving moisture is also a major problem. This capability unit consists of the following soils.

|   |                                 |
|---|---------------------------------|
| Dalhart fine sandy loam, 1 to 3 percent slopes. | Pratt fine sandy loam, billowy. |
|---|---------------------------------|

Sorghums and wheat are the main crops grown. Alfalfa is grown to a lesser extent.

Maintain stubble from small grains or sorghums to protect the soil during the winter and early in spring. Plow under the stubble just before planting the next crop. Run crop rows across the direction of prevailing winds. To prevent wind erosion, keep tillage to a minimum and maintain clods on the surface or use stubble-mulch tillage to maintain a mulch. In addition, seed sorghums and small grains in alternate strips. If a summer crop fails, plant small grains for emergency cover. Choose legumes and grasses according to how well they fit into the cropping system and according to how much moisture is available.

The soils of this unit are suited to sprinkler irrigation.

They can be used to plant trees or shrubs for use as shelterbelts.

#### CAPABILITY UNIT IIIw-1

This capability unit consists of deep soils that have a sandy surface layer—the Dalhart-Carwile fine sandy loams. The soils have a fine-textured subsoil that restricts the movement of water. They occur in nearly level or slightly depressed areas, within larger areas of undulating, sandy soils. Slow surface drainage and a perched water table may cause fields to remain wet during the spring and delay planting. When dry, the surface soil is subject to blowing.

Sorghums and wheat are the main crops grown. Maintain stubble from small grains or sorghums to protect the soil during the winter and early in spring. Plow under the stubble just before planting the next crop. Run crop rows across the direction of prevailing winds. To prevent wind erosion, till the fields just enough to maintain a mulch. Seed sorghums and wheat in alternate strips to control blowing. If a summer crop fails, plant small grains for emergency cover.

These soils can be irrigated, but they are limited somewhat by slow drainage. The surface drainage can be improved in some places by constructing simple ditches.

These soils are suitable for planting trees or shrubs for use as shelterbelts.

#### CAPABILITY UNIT IVe-1

This capability unit is made up mainly of moderately deep soils that are moderately sloping to strongly sloping. The material below the A horizons consists of very limy loam or soft sandstone that has a limited capacity for storing moisture for crops and is unfavorable for the growth of roots. In cultivated areas, extreme care is needed to conserve moisture and to prevent erosion from wind and water. This capability unit consists of the following soils:

|  |  |
|--|--|
| Mansker loam, 3 to 5 percent slopes.           | Woodward-Quinlan loams, 3 to 8 percent slopes. |
| Mansker-Potter complex, 3 to 5 percent slopes. |  |

Wheat and sorghums are the main crops grown. Yields are not high but are fairly stable.

Use diversion terraces to prevent overwash from the adjacent higher lying areas. Conserve moisture and check erosion through terracing, contour farming, and stubble-mulch tillage. Seed and sod terrace outlets with suitable native grasses. Practice contour farming on unterraced fields to help retain water. Keep tillage to a minimum and leave clods on the surface. Practice contour stripcropping of sorghums and small grains to help control wind erosion.

#### CAPABILITY UNIT IVe-2

This capability unit is made up of deep, sandy soils on gentle to moderate slopes that may be billowy or hummocky. The soils take water well and have low to high capacity for storing moisture. Nevertheless, conserving moisture is a serious problem. The soils are blown easily unless well protected by stubble or by a growing crop. This capability unit consists of the following soils:

|   |                                  |
|---|----------------------------------|
| Dalhart fine sandy loam, 3 to 5 percent slopes. | Pratt loamy fine sand, hummocky. |
| Pratt fine sandy loam, hummocky.                | Pratt loamy fine sand, billowy.  |

Sorghums and rye are the main crops. These soils are well suited to growing sorghums.

Seed grass on the very sandy soils on the knolls to protect them from blowing. The rest of the soils can be cultivated. During the winter and early in spring, maintain a stubble of small grains or sorghums to protect the soils. Plow under the stubble just before planting the next crop. Run crop rows across the direction of prevailing winds. To control wind erosion, keep tillage to a minimum and maintain clods on the surface or use stubble-mulch tillage to maintain a mulch. In addition, plant sorghums and small grains in alternate strips. If a summer crop fails, seed small grains for emergency cover.

The soils of this unit are fairly well suited to sprinkler irrigation. They are also suitable for planting trees or shrubs for use as shelterbelts.

#### CAPABILITY UNIT Vw-1

This capability unit consists of loamy to moderately sandy soils of the bottom lands. The soils are nearly level to gently sloping. Because of the high water table, they are not well suited to cultivation. This capability unit is made up of the following soils:

Las Animas soils.

Las Animas soils, shallow over clay.

Forage crops make high yields on these soils. Therefore, the use of the soils for grazing probably would bring greater cash returns than planting cultivated crops. The high water table provides desirable subirrigation for deep-rooted grasses. The soils are suitable for planting trees to be used as shelterbelts or for fence posts. Management of rangeland on these soils is discussed under the Subirrigated range site in the section, Range Management.

#### CAPABILITY UNIT Vw-2

This capability unit is made up of only one mapping unit, Loamy alluvial land. This occurs on loamy sediments of the redbeds along the narrow drainageways and creeks. Because of frequent flooding, the soil is unsuited to cultivation. Forage crops make high yields, and so the use of the areas for grazing probably would bring greater cash returns than could be obtained by planting cultivated crops. Management of rangeland consisting of Loamy alluvial land is discussed under the Loamy bottom-land range site in the section, Range Management.

#### CAPABILITY UNIT VIe-1

This capability unit consists of the deep, very sandy Lincoln soils, which are subject to occasional overflow. Because of the droughtiness and the severe hazard of wind erosion, the soils are unsuited to continuous cultivation.

These soils are best kept in native grasses. They are also suitable for planting trees to be used for fence posts. Management of rangeland on these soils is discussed under the Sandy bottom-land range site in the section, Range Management.

#### CAPABILITY UNIT VIe-2

The soils of this capability unit are deep and very sandy. They have undulating or dunny relief. The following soils make up this capability unit:

Otero loamy sand.

Tivoli-Quinlan complex.

The Tivoli-Quinlan complex is a mixture of the Tivoli soil, which thins out over the redbeds and is discontinuous, and the Quinlan soil of the redbeds, which occurs in valleys between dunes and in patches on the hills. Otero loamy sand is a dunny soil composed of a mixture of calcareous loamy sand and sandy loam.

The soils of this capability unit are best suited to native grasses. Management of rangeland is discussed under the Mixed land range site in the section, Range Management.

#### CAPABILITY UNIT VIe-3

This capability unit is made up of Pratt loamy fine sand, duned, which is deep and sandy. This soil occurs along the principal streams. Because of droughtiness and the severe hazard of wind erosion, it is unsuited to continuous cultivation.

Management of rangeland on this soil is discussed under the Deep sand range site in the section, Range Management.

#### CAPABILITY UNIT VIe-4

This capability unit is made up of shallow to moderately deep soils that are moderately sloping to very steep. Runoff and erosion are severe hazards. This capability unit is comprised of the following soils:

Mansker-Potter complex, 5 to 20 percent slopes.      Quinlan-Woodward complex, 5 to 12 percent slopes.  
Quinlan loam.

The soils of this unit are best suited to native grasses. Management of rangeland on these soils is discussed under the Shallow range site in the section, Range Management.

#### CAPABILITY UNIT VIw-1

This capability unit is made up of only one soil, Randall clay. This soil occurs on the level bottoms of wet-weather lakes and is high in clay. The lakes receive runoff water from the surrounding uplands, but they have no drainage outlets. Occasionally, the lakebeds are dry enough to cultivate, but it is hard to till the soil. The areas are best suited to native grasses. Whether individual areas can be cultivated depends on the amount of precipitation that falls and on the practices being used to retain rainwater in the surrounding uplands.

Western wheatgrass and vine-mesquite grow around the edges of the lake bottoms and invade the areas as the water recedes. Proper control of water on the surrounding uplands may check runoff and prevent the lakes from filling during the rainy season in spring. If the water on the surrounding uplands is controlled properly, this soil will provide better pasture during summer and fall. Management of rangeland on Randall clay is discussed under the Hardland range site in the section, Range Management.

#### CAPABILITY UNIT VIIe-1

This capability unit consists only of Cottonwood loam, a very shallow soil that has steep slopes. This soil is droughty and is highly erodible. It is suited only to permanent vegetation. Fair yields of forage can be obtained if good management is used. If a good cover of grass is not maintained, the pastures may become severely eroded. Management of rangeland on this soil is discussed under the Gyp range site in the section, Range Management.

**CAPABILITY UNIT VIIe-2**

This capability unit consists only of Quinlan loam, severely eroded. This soil is shallow and droughty. It is likely to be damaged even more through erosion.

This soil is suited only to permanent vegetation. Fair yields of forage can be obtained if good management is used. Management of rangeland on this soil is discussed under the Shallow range site in the section, Range Management.

**CAPABILITY UNIT VIIe-3**

Rough broken land, Quinlan material, a miscellaneous land type that occurs mainly in the steep parts of canyons, makes up this capability unit. It is subject to severe erosion and is best used as range.

Management of rangeland on Rough broken land, Quinlan material, is discussed under the Breaks range site in the section, Range Management.

**CAPABILITY UNIT VIIe-4**

This capability unit consists only of Tivoli fine sand, a steep soil that occurs on steep dunes of loose fine sand. The areas are droughty and are highly erodible.

This soil is best suited to permanent vegetation. Management of rangeland is discussed under the Dune range site in the section, Range Management.



**Figure 11.**—To the left of the fence, an area in the Loamy range site showing range consisting of blue grama, buffalograss, and some little bluestem that has been overgrazed. This range is in poor condition. In contrast, the range to the right of the fence has been used properly and is in excellent condition. It consists of little bluestem, sand bluestem, side-oats grama, and Canada wild rye.

## Range Management <sup>3</sup>

The grasslands in Harper County originally consisted of a mixture of warm-season and cool-season grasses along with palatable legumes and weeds. The amount of forage on a particular area depended largely upon the amount of rainfall, because most of the moisture from rainfall soaked into the soil and was used by plants. Sometimes the rainfall was not adequate to supply the needs of plants. Then, less forage was produced.

The cover of native plants on the grasslands gradually became depleted as the areas were cultivated or overgrazed. To make the grasslands productive once more, the operator must improve the cover of grasses by encouraging the superior plants. At the same time he must make a living from the land. His aim should be to develop a turf similar to the original one, which provided adequate forage for deer and buffalo throughout the year.

The amount of forage on the grasslands can be more than doubled if good range practices are applied. Such an increase in productivity would not necessarily be reflected in large increases in the numbers of livestock, especially in the numbers of breeding animals that could be carried on the range. But it would result in an increase in the amount of beef, milk, and other livestock products that could be sold. More important, it should result in a higher cash return to the operator because of lower production costs.

### Factors of range management

To use range efficiently and bring it to maximum production, a rancher should limit the number of livestock and the season of use. He should also control the distribution of grazing, eradicate brush and weeds, and seed the areas to native grasses.

<sup>3</sup> Information for this section was supplied by Jack E. Engleman, range conservationist, Soil Conservation Service.

*Proper grazing use.*—In setting up a conservation program for rangelands, it is most important to control the number of livestock on the range (fig. 11). If range plants are to thrive, about half of the yearly growth of the plants should be left ungrazed. Because of the frequent droughts in Harper County, skillful management is needed to keep the number of livestock in balance with the available supply of forage. Range that has been grazed heavily recovers much more slowly after rains than range that has been grazed lightly.

Flexible grazing management can be applied by basing the determination of the number of breeding cattle to be kept on the amount of forage available during the drier cycles. If surplus grass is available, stockers can be added in the fall. The number of livestock can be reduced in spring if it appears that the amount of moisture available for summer forage is low. Under this practice, the operator need not reduce the size of his breeding herd during dry periods and there is no serious reduction in the calf crop or in the weights of the calves.

*Deferred grazing.*—Leaving the land idle in summer helps seriously depleted range to recover more rapidly. If the operator wishes to leave a pasture idle during the summer, however, he must determine whether this will cause his other pastures to be overgrazed. The ideal situation is to keep a deferred pasture in reserve and still have the other pastures stocked at only a moderate rate. Temporary pasture or cropland can be used to permit other pastures to be left idle.

Using rangelands during the proper season is important in improving their condition. If heavy precipitation during the winter and early in spring produces abundant winter grasses and weeds on a range in poor condition, livestock can be concentrated at that point while these annuals are growing rapidly. If these grasses and weeds are grazed closely, they will compete less with the warm-season grasses that begin to grow later in the spring. Or-

dinarily, very light grazing or deferred grazing is required after the warm-season grasses become green. The deferment should extend to the middle of June or preferably for the entire growing season if the range is depleted severely.

Coarse, normally unpalatable forage should be grazed intensively when it is growing most rapidly. At this time livestock will graze it more readily. For example, ranges on the Subirrigated site that have a high percentage of inland saltgrass can be improved if this coarse grass is grazed intensively during the spring; then the livestock should be removed or reduced in number so that the more desirable switchgrass and other palatable range plants can develop fully.

*Distribution of grazing.*—Obtaining an even distribution of grazing is a problem on some pastures, especially where a pasture is in more than one range site. On pastures consisting of both bottom lands and uplands or of breaks and gently sloping uplands, it is difficult to distribute the grazing properly. Fencing the areas of different range sites into separate pastures is desirable, but whether or not to fence them must be determined on the basis of cost and on the return expected. It is especially desirable to fence areas of the Subirrigated site to permit full use of this high-producing range.

Placing farm ponds properly is helpful in obtaining a better distribution of grazing. If salt is placed in the ungrazed part of the pasture, it will also help draw the cattle away from parts that have been overgrazed.

*Control of weeds and brush.*—To increase the stand of favorable range plants, the operator needs to control the growth of weeds and brush. Generally, the best method of controlling weeds is to permit the natural succession of native plants to crowd out the undesirable plants. Unpalatable weeds, however, help to condition the trampled and packed soils of the range. They also furnish a protective litter for the surface of the soil and provide food and cover for wildlife. Consequently, it often is best not to eradicate the weeds by mowing or spraying.

On range that has a cover of sand sagebrush, skunkbrush, and other woody plants, adequate measures are needed to control the brush in addition to controlling it through natural succession. Woody plants live long and are deep rooted, and so natural succession operates very slowly. Generally, it is best to retain the cover of woody plants on steep, choppy sand dunes. Here, any kind of cover is helpful in preventing the soil from drifting.

After practices have been applied to control the brush, a pasture should be rested during the growing season. For the pasture to improve, depleted stands of grass must be allowed to grow vigorously and produce seed. After the pasture is deferred from grazing, it ordinarily is desirable to permit moderate grazing during the winter because the livestock will help distribute seed and mulch and because the removal of some of the dormant grass does not injure the stand.

*Seeding of native grasses.*—The reseeding of native grasses on the areas not suited to cultivation is an important part of the conservation program in Harper County. Before reseeding a field, the operator needs to select the mixture of native grasses best suited to the particular range site or sites that are included in the field. For example, areas of the Hardland range site produce best



Figure 12.—This field, which was formerly cultivated, was reseeded to range plants for 3 years. The seeding mixture consisted of little bluestem, side-oats grama, blue grama, and sand lovegrass. The range is now ready for winter grazing or for light grazing in summer.

when seeded to mixtures consisting principally of blue grama, side-oats grama, and buffalograss. In draws and swales, western wheatgrass does especially well. The Loamy and Sandy plains range sites are best suited to mixtures made up largely of little bluestem, side-oats grama, sand bluestem, switchgrass, and blue grama (fig. 12). Areas of the Deep sand site produce good stands containing a mixture of taller grasses, such as sand bluestem, switchgrass, Indiangrass, little bluestem, sand lovegrass, and Canada wildrye.

The reseeded fields should be enclosed by fences until they have a cover of plants similar to that in adjacent areas of native range. This should be done because cattle tend to concentrate on the reseeded areas for at least several years after the stand has been established.

#### *Range sites and range condition*

So that the range operator can understand the capabilities of his native grasses, rangelands are classified according to range sites. The vegetation on each site can be placed in range condition classes to help the operator understand the changes that occur as a result of grazing and differences in climate.

The rangelands of Harper County are in 12 range sites. Each site consists of similar soils that occur on similar relief and that are subject to about the same effects of climate. Knowing the characteristics and locations of the sites is important to the operator, especially if a large acreage of a specific site is included in his pastures. Some sites, such as the Dune site or Breaks site, may not be extensive but still may be important to range conservation because of their effect on adjacent rangeland through soil drifting or silting. The occurrence of areas of these sites may also result in overgrazing on the smoother, surrounding areas of other sites. The Subirrigated and Sandy bottom-land sites, which produce large amounts of forage, may be important even though they make up only a small acreage of a ranch.

Farmers and ranchers need to learn the kinds and amounts of grasses and other native plants the various range sites will support. To do this, they can examine areas that have not been damaged by overgrazing, wind erosion, or other disturbances. These places, sometimes called relict areas, can be compared with areas of the same range site under various grazing conditions.

By using the relict areas as an example of the ideal condition of native grasses on the range sites, it is possible to classify the degree of change that has taken place on each area of a range site. For convenience in describing the condition of the various areas of the range site, four descriptive terms, or condition classes—excellent, good, fair, and poor—are used. Rangeland in excellent condition contains between 75 and 100 percent of the best kinds of native plants the range site can support; that in good condition contains between 50 and 75 percent; that in fair condition contains between 25 and 50 percent; and that in poor condition contains between 0 and 25 percent.

In places, the condition class of the range may have been lowered one class, for example from good to fair, because of reasons other than the kinds of vegetation. A field that was cultivated formerly but that is now a part of the Sandy plains range site may have reseeded to the extent that between 50 and 75 percent of the vegetation is made up of superior range plants. Normally, this field would be classified as in good condition. If erosion is still active and many spots are bare, however, the condition of the range would be fair instead of good. As a result, this field would require more careful stocking than if it were in good condition.

The following is a discussion of each range site in the county and the condition of the vegetation on each.

#### SUBIRRIGATED RANGE SITE

This range site consists of soils that occur on the grassy lowlands, mainly along the North Canadian River north of Laverne. It also includes soils of the uplands that lie at a lower elevation than soils of the nearby Deep sand range site, which are on flats along the highway just east of Rosston. The following soils are in this range site:

Las Animas soils.

Las Animas soils, shallow over clay.

This is the most productive range site in the county because the soils retain available moisture throughout the growing season. The soils contain some alkali. Therefore, if the areas are grazed heavily over a long period, inland saltgrass is likely to increase.

If an area of this site is in excellent condition, more than 50 percent of the vegetation normally will consist of switchgrass. Alkali sacaton will be next in importance. An increase in the density and vigor of the switchgrass indicates that the condition of the range is improving.

#### SANDY BOTTOM-LAND RANGE SITE

This range site consists of deep, sandy soils that have formed on stabilized riverwash along the Cimarron and North Canadian Rivers and their larger tributaries. Many of the areas are subject to overflow. In places low dunes or ridges of sand occur. Some areas have a high water table that is within reach of the deeper rooted grasses, at least part of the time. This site is made up largely of the Lincoln soils.

Woody plants, such as baccharis, tamarix, willow, cottonwood, and sand sagebrush, often invade this site. Improvement in the condition of this site is indicated by a dense stand of sand bluestem, little bluestem, Indiangrass, and switchgrass.

#### LOAMY BOTTOM-LAND RANGE SITE

This range site is made up of loams or clay loams of the bottom lands that are subject to flooding. The following soils make up this range site:

Loamy alluvial land.  
Spur loam.

Spur clay loam.  
Yahola fine sandy loam.

These soils are deep and fertile, and they receive water from the adjacent uplands. As a result, production of forage is fairly high. Improvement in the condition of the range is indicated by dense stands of little bluestem and sand bluestem or vine-mesquite and western wheatgrass.

#### DEEP SAND RANGE SITE

This range site is made up of deep sands of the uplands. The relief is hummocky or gently rolling. Most of the low dunes have been stabilized. The following soils are in this range site:

Pratt loamy fine sand, billowy.  
Pratt loamy fine sand, hummocky.

Pratt loamy fine sand, duned.

When it is in excellent or good condition, this is the most productive of the upland range sites. On many of the ranges, sand sagebrush, skunkbush, sandplum, and other woody plants have increased because of improper grazing, and as a result the productivity has decreased greatly. Controlling the density of these woody plants is usually the first measure needed in a program to provide improved grazing.

Signs of improvement in the range are a decrease in the amount of brush and an increase in the amount and vigor of sand bluestem, little bluestem, and sand lovegrass (fig. 13). Grass growing close to and within clumps of brush is not grazed readily by cattle. Consequently, this grass produces seed and contributes to the reseeded of the range.

Among the signs of overgrazing are clumps of sagebrush broken open by cattle in search of grass; a uniform

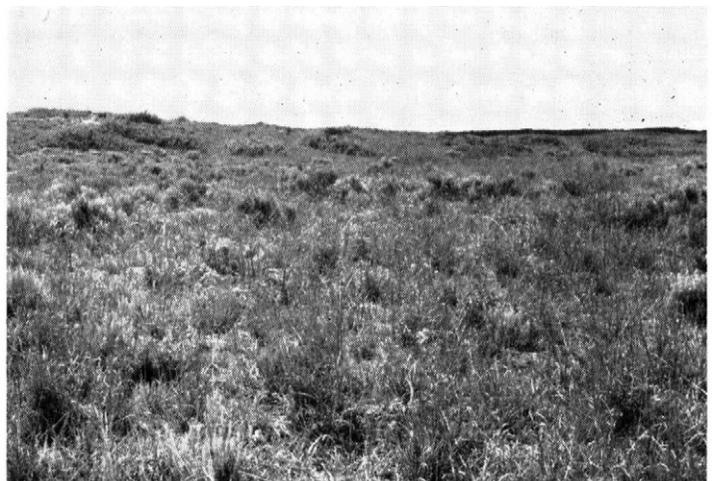


Figure 13.—Area of the Deep sand range site in good condition.

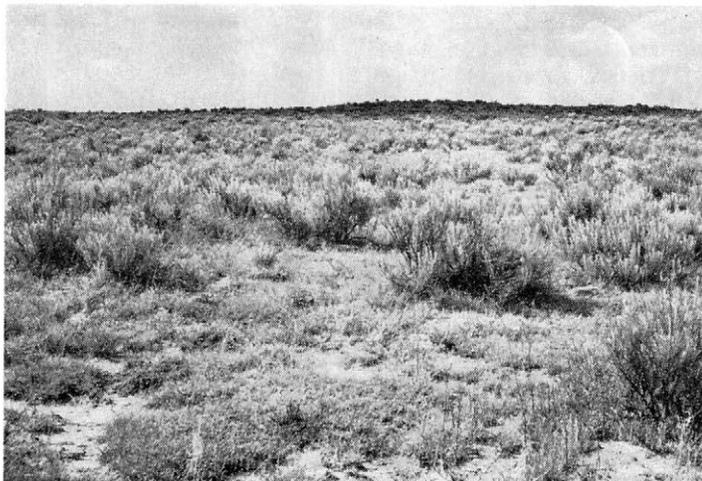


Figure 14.—Overgrazing on this area of the Deep sand range site has caused the range to deteriorate. In the foreground is evidence of erosion.

stubble of blue grama between the clumps of brush; and a few, scattered, inconspicuous clumps of taller grasses (fig. 14).

#### SANDY PLAINS RANGE SITE

This range site is made up of fine sandy loams that are smooth or gently rolling. The soils contain more clay in their subsoils than those of the Deep sand range site. Much of this site is under cultivation. It is closely associated with the Deep sand range site and is made up of the following soils:

|   |                                  |
|---|----------------------------------|
| Dalhart-Carwile fine sandy loams.               | Pratt fine sandy loam, hummocky. |
| Dalhart fine sandy loam, 1 to 3 percent slopes. | Pratt fine sandy loam, billowy.  |
| Dalhart fine sandy loam, 3 to 5 percent slopes. |                                  |

This site contains less sand sagebrush than does the Deep sand range site. Under continuous heavy grazing, blue grama becomes the dominant grass. An increase in the density of little bluestem, side-oats grama, and sand bluestem indicates that the condition of this site is improving.

#### LOAMY RANGE SITE

This range site is made up of deep, loamy, prairie soils that range from nearly level to steep. The following soils are in this site:

|  |  |
|--|--|
| Carey silt loam, 1 to 3 percent slopes.  | Tipton silt loam, 3 to 5 percent slopes.       |
| Carey silt loam, 3 to 5 percent slopes.  | Woodward loam, 1 to 3 percent slopes.          |
| Mansker loam, 1 to 3 percent slopes.     | Woodward loam, 3 to 8 percent slopes.          |
| Mansker loam, 3 to 5 percent slopes.     | Woodward-Quinlan loams, 1 to 3 percent slopes. |
| Tipton silt loam, 0 to 1 percent slopes. | Woodward-Quinlan loams, 3 to 8 percent slopes. |
| Tipton silt loam, 1 to 3 percent slopes. |  |

This site (fig. 15) is more productive than the Deep sand range site. Range in improved condition is indicated by an increase in the amount of little bluestem, sand bluestem, and side-oats grama. In addition, the blue grama is vigorous and grows in bunches instead of forming a thick, sodlike turf.

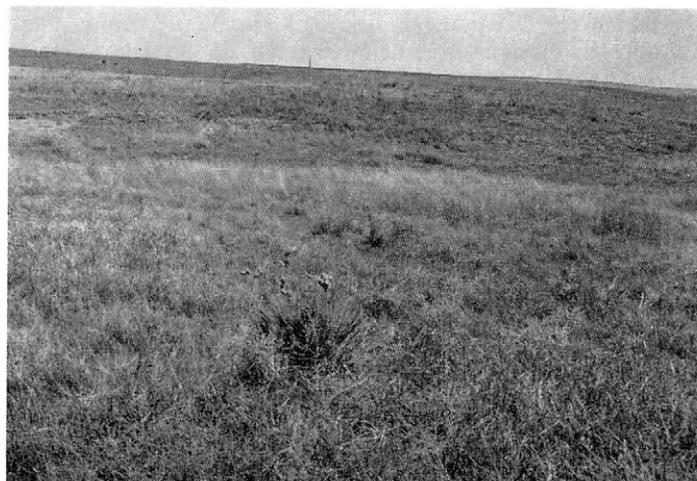


Figure 15.—Area of the Loamy range site shown in the foreground and an area of the Shallow range site in the background. Because they have been well managed, both of these sites are in excellent condition despite a drought of 3 years.

#### MIXED LAND RANGE SITE

This range site is made up of a mixture of shallow soils and of deep, sandy soils. In productivity, it is similar to the Sandy plains range site. The following soils occur on this range site:

|                   |                         |
|-------------------|-------------------------|
| Otero loamy sand. | Tivoli-Quinlan complex. |
|-------------------|-------------------------|

Improved range condition in soils that are shallow over caliche or in those on which sandrock outcrops is indicated by a vigorous stand of little bluestem and side-oats grama. A sign of improvement on the deep, sandy soils is a dense stand of sand bluestem, little bluestem, and sand lovegrass.

#### HARDLAND RANGE SITE

This range site is made up of the following medium- to fine-textured soils:

|   |  |
|---|--|
| Hollister clay loam, 0 to 1 percent slopes. | Randall clay.                              |
| Hollister clay loam, 1 to 3 percent slopes. | Richfield clay loam.                       |
| Mansic clay loam, 0 to 1 percent slopes.    | Richfield complex.                         |
| Mansic clay loam, 1 to 3 percent slopes.    | St. Paul silt loam, 0 to 1 percent slopes. |
| Mansic clay loam, 3 to 5 percent slopes.    | St. Paul silt loam, 1 to 3 percent slopes. |

Because this site is droughty, the vegetation consists of a short cover of blue grama and buffalograss and, to some extent, of side-oats grama, vine-mesquite, and western wheatgrass of medium height. Improvement in the condition of the range is indicated by a bunchy, vigorous stand of blue grama and a dense stand of grasses of medium height, especially in the draws and in areas receiving runoff water from adjacent, higher lying areas.

#### SHALLOW RANGE SITE

This range site is made up of shallow, gravelly soils that are moderately sloping to steep. Ravines, on the sides of which parent rocks are exposed, occur throughout the areas. The following soils are in this range site:

|  |   |
|--|---|
| Mansker-Potter complex, 3 to 5 percent slopes. | Mansker-Potter complex, 5 to 20 percent slopes. |
|--|---|

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

The stand of plants on this range site is more sparse and produces less forage than that on the Loamy range site. The penetration of roots is restricted by the shallowness of the soil, but there is a good soil-moisture relationship. Range in excellent condition contains a high proportion of side-oats grama and little bluestem.

#### GYP RANGE SITE

Cottonwood loam is the only soil in this range site. There are many steep-sided ravines, and in many places gypsum is exposed along the slopes adjacent to the ravines. As a result, this site produces a relatively low amount of forage, even though the deeper soil around the exposed gypsum and the ravines takes water well.

The growth of side-oats grama, little bluestem, and sand bluestem in the more suitable areas indicates that the condition of the range is improving. An increase of hairy tridens, buffalograss, and goldaster is a sign of improper grazing.

#### BREAKS RANGE SITE

This range site consists principally of Rough broken land, Quinlan material. There are many steep-sided bluffs and ravines that are either inaccessible or difficult for livestock to graze.

The production of forage is low. Superior range plants are side-oats grama, sand bluestem, and little bluestem.

#### DUNE RANGE SITE

This range site consists of Tivoli fine sand. This soil occurs on steep, choppy dunes. The dunes are generally active and difficult to stabilize, even under the best of management.

Grazing should be restricted severely to maintain the best cover possible so that the surrounding rangelands will be protected. Big sandreed, blowoutgrass, and lemon scurfpea help stabilize the dunes. Improvement in the condition of the range usually is indicated by an increase of sand bluestem.

#### Range stocking rates

No specific guide to show the safe rates for stocking livestock is given in this report because an operator's pastures may consist of a mixture of range sites. In addition, within the same site and the same pasture, the condition of the range may vary.

Production of forage varies greatly according to the cycles of precipitation. Therefore, a set rate of stocking might be too high during droughts and could result in financial loss. Range management must be flexible enough so that when moisture is more plentiful and the grass is abundant and vigorous, the number of livestock can be increased; during droughts the number can be decreased. To get good productivity from his rangelands, the operator needs to become familiar with his range sites and to learn the signs of improvement in the plant cover.

#### Woodlands

Native trees grow on only a few of the soils in Harper County. The soils on which they grow are generally sandy and are on the bottom lands along streams. Native trees also grow on upland soils that lie along the margins of the

valleys. These areas receive runoff water from higher lying areas. Here, the principal trees are cottonwood, American elm, hackberry, and redcedar. Willows grow on areas that are overflowed frequently or that are slightly wet.

Shrubby tamarix grows on the slightly saline bottom-land soils that are made up of sandy riverwash. Scattered sandplum and skunkbush grow near the drainageways. Sand sagebrush, a low woody shrub, is common on all of the sandy soils and has invaded the native grasslands.

The soils of the bottom lands are not densely wooded, and the trees are rather short and spreading. The trees, shrubs, and tall grasses in these areas provide excellent cover for game birds and small animals. The trees also furnish logs for rough construction timber. For this purpose, the cottonwoods are the best formed and most valuable. The shrubby sandplum, skunkbush, tamarix, and sand sagebrush provide escape cover for small game; some of the best hunting areas are on the sandy soils adjacent to such cover.

The soils of the bottom lands have good sites for the planting of trees to be used for fence posts. Many corners of fields and other spots isolated from areas of cropland can be planted to cedar and black locust. The best sites are on permeable, somewhat sandy soils, especially those receiving runoff from higher areas. Because of the dry climate, all trees should be cultivated in their early stages to keep down competing vegetation.

Scattered redcedars occur along ravines in the uplands, especially in rough broken areas. Locally, they are used mostly for fence posts, but many farmers have planted windbreaks of redcedar.

Field shelterbelts, or windbreaks, consisting of cottonwood, redcedar, hackberry, and Chinese elm, grow well on the Pratt and Dalhart soils of the uplands and on the soils of the bottom lands. These windbreaks break the force of the wind and help protect the loose, sandy soils from wind erosion.

Windbreaks are desirable around the homes in this open, windy area. The trees may be planted in nearly any favorable location where the soils do not contain too much clay, particularly if they can be watered when necessary. The best stands can be expected from dryland plantings on nearly level areas of the permeable Carey, Dalhart, Mansic, Pratt, St. Paul, Spur, Woodward, and Yahola soils. Trees that will provide good windbreaks for protecting cattle during the winter can be grown on Las Animas soils, Las Animas soils, shallow over clay, Loamy alluvial land, Spur clay loam, Spur loam, and on Yahola fine sandy loam of the bottom lands. These plantings will also furnish escape cover and nesting and feeding grounds for small game. They have esthetic value in breaking up the monotony of the open grassland.

#### Engineering Properties of Soils<sup>4</sup>

This section has two main parts. In the first the suitability of the soils for highway construction is described. In the second the uses of the soils in conservation engineering are discussed.

<sup>4</sup> This section was prepared with the help of R. A. Helmer, highway research engineer, Oklahoma State Highway Department.

The mapping and the descriptive report are somewhat generalized and should be used only in planning more detailed field surveys that will, in turn, be used to determine the in-place condition of the soil at the site of the proposed engineering construction.

## Soils in Highway Construction

Engineers who work with foundations and embankments constantly need to know more about soils. Information about soils that cover a large area is especially valuable in the construction of highways. This is obtained by sampling the principal soils and testing them in the laboratory. In this county 11 soils were tested (table 5), and on the basis of the results of these tests, all of the soils of the county have been rated according to the classification system used by the American Association of State Highway Officials (A.A.S.H.O.). The A.A.S.H.O. ratings, for example, A-4 and A-5, provide a quick summary of soil properties for engineers. They take into account the mechanical analysis and the liquid and plastic limits of the soils. Table 6 shows how the A.A.S.H.O. classification is derived.

In table 7 all the soils of the county are rated in descriptive terms, such as "good," "fair," and "poor;" "low," "medium," and "high;" and "suitable" or "unsuitable." These are estimates because only 11 soil profiles were actually sampled and tested. Many more laboratory tests will be needed on soils that occur throughout the

State before conclusive statements can be made about all of the soils.

Of the soils tested, the suitability of the A horizons for seeding and sodding was judged on their suitability for use as a medium for the growth of plants. In addition, the content of organic matter, the granulation of the soil, and the ability of the soil material to absorb and store moisture were analyzed. Consequently, the material in the A horizons may have a different rating from that in the C horizons, although the C horizons may have properties similar to those in the A.

Table 8 shows how the estimated ratings in table 7 were derived through the evaluation of (1) the percentage of material passing a No. 200 sieve, (2) California bearing ratio, (3) plasticity index, and (4) liquid limit.

### Definitions of terms

Because the classification and terms used in this section may not be familiar to farmers and others interested in construction, definitions are given in the following paragraphs. Engineers can refer to the glossary for definitions used in soil surveying. The engineer may also wish to read the section, How a Soil Survey is Made.

*A.A.S.H.O. classification.*—The American Association of State Highway Officials has developed a classification based on the field performance of soils. In this classification, soils are placed in seven groups designated A-1, A-2, A-3, A-4, A-5, A-6, and A-7. Some of the groups are divided into subgroups. The soils in each group are

TABLE 5.—Engineering test data for soil samples of principal soil types

| Soil type                              | Horizon              | Depth         | A. A. S. H. O. classification | California bearing ratio | Liquid limit    | Plasticity index | Particles passing |
|--|----------------------|---------------|-------------------------------|--------------------------|-----------------|------------------|-------------------|
|  |                      |               |                               |                          |                 |                  | 200-mesh sieve    |
|  |                      | <i>Inches</i> |                               |                          |                 |                  | <i>Percent</i>    |
| Carey silt loam.....                   | A <sub>1</sub> ..... | 0-7           | A-4(8)                        | 4.0                      | 28              | 5                | 90                |
|  | B <sub>3</sub>       | 22-36         | A-6(10)                       | 6.0                      | 39              | 14               | 85                |
|  | C <sub>ca</sub>      | 36-56         | A-6(9)                        | 9.3                      | 30              | 12               | 78                |
| Dalhart fine sandy loam.....           | A <sub>1p</sub>      | 0-6           | A-4(4)                        | 33.7                     | 22              | 4                | 45                |
|  | B <sub>3</sub>       | 20-35         | A-2(0)                        | 49.3                     | 21              | 4                | 30                |
|  | C                    | 35-50         | A-4(2)                        | 11.3                     | 30              | 10               | 47                |
| Lincoln loam <sup>1</sup> .....        | A <sub>12</sub>      | 3-20          | A-4(5)                        | 4.0                      | 24              | 4                | 61                |
|  | C                    | 20-50         | A-2-4(0)                      | 12.7                     | <sup>2</sup> NP | <sup>2</sup> NP  | 17                |
| Mansker loam.....                      | A <sub>1p</sub>      | 0-7           | A-4(4)                        | 9.7                      | 22              | 5                | 45                |
|  | C <sub>ca</sub>      | 15-70         | A-4(4)                        | 3.3                      | 28              | 10               | 57                |
| Pratt fine sandy loam.....             | A <sub>1p</sub>      | 0-7           | A-2(0)                        | 16.7                     | 21              | 3                | 34                |
|  | B <sub>2</sub>       | 12-35         | A-4(1)                        | 22.0                     | 25              | 6                | 38                |
|  | C                    | 35-50         | A-2(0)                        | 10.7                     | 20              | 3                | 26                |
| Pratt loamy fine sand.....             | A                    | 0-9           | A-2-4(0)                      | 14.7                     | <sup>2</sup> NP | <sup>2</sup> NP  | 18                |
|  | C <sub>1</sub>       | 18-40         | A-4(3)                        | 18.7                     | <sup>2</sup> NP | <sup>2</sup> NP  | 49                |
| Quinlan loam.....                      | A <sub>1</sub>       | 0-6           | A-2(0)                        | 12.3                     | 26              | 2                | 34                |
|  | C                    | 10-30         | A-2(0)                        | 19.0                     | 26              | 2                | 46                |
| Richfield clay loam <sup>3</sup> ..... | A <sub>1</sub>       | 0-5           | A-6(10)                       | 2.0                      | 36              | 16               | 82                |
|  | B <sub>2</sub>       | 5-26          | A-7-6(15)                     | 4.0                      | 48              | 23               | 89                |
|  | C                    | 26-60         | A-6(9)                        | 4.7                      | 34              | 12               | 74                |
| Spur loam.....                         | A <sub>1p</sub>      | 0-6           | A-4(5)                        | 7.7                      | 23              | 2                | 70                |
|  | C                    | 22-40         | A-2(0)                        | 22.3                     | 22              | 2                | 33                |
| Tivoli fine sand.....                  | A                    | 0-10          | A-3(0)                        | 9.3                      | <sup>2</sup> NP | <sup>2</sup> NP  | 9                 |
|  | C                    | 10-40         | A-3(0)                        | 10.0                     | <sup>2</sup> NP | <sup>2</sup> NP  | 3                 |
| Woodward loam.....                     | A <sub>1p</sub>      | 0-6           | A-4(8)                        | 3.7                      | 27              | 5                | 77                |
|  | C                    | 19-30         | A-4(7)                        | 5.3                      | 33              | 9                | 72                |

<sup>1</sup> Profile of one of several soils mapped together as Lincoln soils. In the sample tested, the material in the A<sub>12</sub> horizon was finer gravel than that in the normal profile for Lincoln loam. In general, the engineering properties of the material in the A<sub>12</sub> horizon in

Lincoln soils are more closely related to those of the C horizon than the tests indicate.

<sup>2</sup> Nonplastic.

<sup>3</sup> Sampled in Cimarron County, Okla.

TABLE 6.—Essentials of soil classification system of the American Association of State Highway Officials<sup>1</sup>

| General classification   | Granular materials (35 percent or less passing No. 200 sieve) <sup>2</sup> |             |                              |  |                            |                            | Silt-clay materials (More than 35 percent passing No. 200 sieve) <sup>2</sup> |  |                                      |   |   |   |
|--|--|-------------|------------------------------|--|----------------------------|----------------------------|---|--|--------------------------------------|---|---|---|
| Group classification   | A-1  |             | A-3                          | A-2  |                            |                            |   | A-4  | A-5                                  | A-6                                     | A-7   |   |
|  | A-1-a  | A-1-b       |                              | A-2-4  | A-2-5                      | A-2-6                      | A-2-7   |  |                                      |   | A-7-5   | A-7-6                                   |
| Sieve analysis:<br>Percent passing—<br>No. 10.....                           | 50 maximum.  |             |                              |  |                            |                            |   |  |                                      |   |   |   |
| No. 40.....  | 30 maximum.  | 50 maximum. | 51 minimum.                  |  |                            |                            |   |  |                                      |   |   |   |
| No. 200.....   | 15 maximum.  | 25 maximum. | 10 maximum.                  | 35 maximum.  | 35 maximum.                | 35 maximum.                | 35 maximum.   | 36 minimum.                                | 36 minimum.                          | 36 minimum.                             | 36 minimum.   | 36 minimum.                             |
| Characteristics of<br>fraction passing<br>No. 40 sieve—<br>Liquid limit..... |  |             | NP <sup>3</sup>              | 40 maximum.<br>10 maximum.                                 | 41 minimum.<br>10 maximum. | 40 maximum.<br>11 minimum. | 41 minimum.<br>11 minimum.  | 40 maximum.<br>10 maximum.                 | 41 minimum.<br>10 maximum.           | 40 maximum.<br>11 minimum.              | 41 minimum.<br>11 minimum. <sup>4</sup>                         | 41 minimum.<br>11 minimum. <sup>4</sup> |
| Plasticity index.....  | 6 maximum.   | 6 maximum.  | NP <sup>3</sup>              |  |                            |                            |   |  |                                      |   |   |   |
| Group index <sup>5</sup> .....   | 0.....   | 0.....      | 0.....                       | 0.....   | 0.....                     | 4 maximum.                 | 4 maximum.  | 8 maximum.                                 | 12 maximum.                          | 16 maximum.                             | 20 maximum.   | 20 maximum.                             |
| Stability properties.....  | Highly stable at all times.  |             | Highly stable when confined. | Stable when dry; ravel and is easily worn away by traffic. |                            | Good stability.            |   | Stable when dry; loses stability when wet. | Stability variable; hard to compact. | Fair stability when properly compacted. | Fair stability if properly compacted and kept free of moisture. |   |

<sup>1</sup> Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1; ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, A.A.S.H.O. Designation: M 145-49.

<sup>2</sup> The 200-mesh sieve separates soil fractions at about the middle of the range of very fine sand, based on the classification used by the United States Soil Conservation Service.

<sup>3</sup> NP—Nonplastic.

<sup>4</sup> Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

<sup>5</sup> General evaluations of subgrades in terms of group index are as follows: 0-1, good; 2-4, fair; 5-9, poor; 10-20, very poor. The procedure for calculating the group index is explained under Designation M 145-49 of the reference cited in footnote 1.

TABLE 7.—*Estimated ratings of soils for various kinds of construction*

[Profiles are given only for those soils sampled and shown in table 5; the characteristics of other profiles are rated by comparison with the soils sampled. For example, Cottonwood loam consists of materials with about the same engineering characteristics as Quinlan loam]

| Soils and mapping unit symbols  | Horizon         | Depth  | Shrink-swell potential | Load-supporting ability | Resistance to slope and ditch erosion | Suitability for—       |                                      |                           |                     |
|---|-----------------|--------|------------------------|-------------------------|---------------------------------------|------------------------|--------------------------------------|---------------------------|---------------------|
|   |                 |        |                        |                         |                                       | Binder for base course | Stabilization with asphalt or cement | Construction of shoulders | Seeding and sodding |
| Carey silt loam (Ca, Cb)  | A               | 0-18   | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | B               | 18-42  | Medium                 | Poor                    | Fair                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | C               | 42-60+ | Medium                 | Poor                    | Fair                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
| Cottonwood loam (Cc)<br>(See Quinlan loam.)                             |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Dalhart fine sandy loam (Da, Db)  | A               | 0-10   | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Fair                      | Fair                |
|   | B               | 10-42  | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Fair                      | Fair                |
|   | C               | 42-50+ | Low                    | Poor                    | Poor                                  | Suitable               | Suitable                             | Fair                      | Good                |
| Dalhart-Carwile fine sandy loams (Dc)<br>(See Dalhart fine sandy loam.) |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Hollister clay loam (Ha, Hb)<br>(See Richfield clay loam.)              |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Las Animas soils (La, Lb)<br>(See Spur loam.)                           |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Lincoln soils (Lc)  | A               | 0-18   | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | C               | 18-45+ | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Poor                |
| Loamy alluvial land (Ld)<br>(See Woodward loam.)                        |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Mansic clay loam (Ma, Mb, Mc)<br>(See Mansker loam.)                    |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Mansker loam (Md, Me)   | A <sub>1</sub>  | 0-7    | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Fair                      | Fair                |
|   | C               | 15-70+ | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Fair                      | Fair                |
| Mansker-Potter complex (Mf, Mg)<br>(See Mansker loam.)                  |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Otero loamy sand (Oa)<br>(See Tivoli fine sand.)                        |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Pratt fine sandy loam (Pa, Pb)  | A <sub>1</sub>  | 0-11   | Low                    | Poor                    | Fair                                  | Unsuitable             | Unsuitable                           | Fair                      | Fair                |
|   | B               | 11-26  | Low                    | Fair                    | Fair                                  | Unsuitable             | Unsuitable                           | Fair                      | Good                |
|   | C               | 26-45+ | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Fair                      | Fair                |
| Pratt loamy fine sand (Pc, Pd, Pe)                                      | A <sub>1</sub>  | 0-9    | Low                    | Fair                    | Poor                                  | Unsuitable             | Suitable                             | Poor                      | Fair                |
|   | C               | 18-40  | Low                    | Poor                    | Poor                                  | Unsuitable             | Suitable                             | Poor                      | Fair                |
|   | A               | 0-6    | Low                    | Fair                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
| Quinlan loam (Qa, Qb)   | A               | 0-6    | Low                    | Fair                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | C               | 10-20+ | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
| Quinlan-Woodward complex (Qc)<br>(See Quinlan loam.)                    |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Randall clay (Ra) <sup>1</sup>  |                 |        | High                   | Poor                    | Good                                  | Unsuitable             | Unsuitable                           | Poor                      | Poor                |
| Richfield clay loam (Rb) <sup>2</sup>                                   | A <sub>1</sub>  | 0-9    | Medium                 | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | B <sub>2</sub>  | 9-22   | High                   | Poor                    | Good                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | C               | 24-60  | Medium                 | Poor                    | Fair                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
| Richfield complex (Rc)<br>(See Richfield clay loam.)                    |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Rough broken land, Quinlan material (Rd)<br>(See Quinlan loam.)         |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| St. Paul silt loam (Sa, Sb)<br>(See Carey silt loam.)                   |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Spur clay loam (Sc)<br>(See Spur loam.)                                 |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Spur loam (Sd)  | A <sub>1</sub>  | 0-6    | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | C               | 22-40+ | Low                    | Fair                    | Poor                                  | Unsuitable             | Suitable                             | Poor                      | Fair                |
| Tipton silt loam (Ta, Tb, Tc)<br>(See Carey silt loam.)                 |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Tivoli fine sand (Td)   | A               | 0-10   | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Poor                |
|   | C               | 10-40+ | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Poor                |
| Tivoli-Quinlan complex (Te)<br>(See Tivoli fine sand.)                  |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Woodward loam (Wa, Wb)  | A <sub>1p</sub> | 0-6    | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
|   | C               | 19-30+ | Low                    | Poor                    | Poor                                  | Unsuitable             | Unsuitable                           | Poor                      | Fair                |
| Woodward-Quinlan loams (Wc, Wd)<br>(See Woodward loam.)                 |                 |        |                        |                         |                                       |                        |                                      |                           |                     |
| Yahola fine sandy loam (Ya)<br>(See Spur loam.)                         |                 |        |                        |                         |                                       |                        |                                      |                           |                     |

<sup>1</sup> Rated for whole profile; not based on specific tests. Soil material is poorly suited to most construction purposes.

<sup>2</sup> Soil sampled in Cimarron County, Okla.

TABLE 8.—Criteria for estimating physical characteristics and construction suitabilities of the soils

| Shrink-swell potential and suitability classes for earth construction | Physical tests applied to soils  |                          |                               |                              |
|---|----------------------------------|--------------------------|-------------------------------|------------------------------|
|   | Percentage passing No. 200 sieve | California bearing ratio | Plasticity index              | Liquid limit                 |
| Shrink-swell potential:   |                                  |                          |                               |                              |
| Low.....  |                                  |                          | Less than 12.....             | Less than 35.                |
| Medium.....   |                                  |                          | 12 to 20.....                 | 35 to 40.                    |
| High.....   |                                  |                          | More than 20.....             | More than 40.                |
| Load-supporting ability as subgrade:                                  |                                  |                          |                               |                              |
| Good.....   | 15 or less.....                  | More than 10.....        | 2 to 12.....                  | 2 to 35.                     |
| Fair.....   | 15 to 35.....                    | 5 to 10.....             | 12 to 20.....                 | 35 to 45.                    |
| Poor.....   | More than 35.....                | Less than 5.....         | Less than 2 or more than 20.  | Less than 2 or more than 45. |
| Resistance to erosion on slopes and in ditches:                       |                                  |                          |                               |                              |
| Good.....   | More than 50.....                |                          | More than 20.....             |                              |
| Fair.....   | 35 to 50.....                    |                          | 15 to 20.....                 |                              |
| Poor.....   | Less than 35.....                |                          | Less than 15.....             |                              |
| Seeding and sodding:  |                                  |                          |                               |                              |
| Good.....   | 10 to 50.....                    |                          | 6 to 15.....                  |                              |
| Fair.....   | 5 to 10 or 50 to 90.....         |                          | 1 to 6 and 15 to 25.....      |                              |
| Poor.....   | Less than 5 or more than 90.     |                          | Nonplastic; more than 25.     |                              |
| Soil binder for base course:  |                                  |                          |                               |                              |
| Suitable.....   | More than 50.....                |                          | 10 to 25.....                 |                              |
| Unsuitable.....   | More than 50.....                |                          | Less than 10 or more than 25. |                              |
| Stabilization of soils with asphalt or cement:                        |                                  |                          |                               |                              |
| Suitable.....   | 15 to 50.....                    |                          | Less than 10.....             |                              |
| Unsuitable.....   | Less than 15 or more than 50.    |                          | More than 10.....             |                              |

valued by means of a group index, a number that takes into account the behavior of soil and soil materials in embankments, subgrades, and subbases. The essentials of the classification are shown in table 6, which also describes, for each class, the nature and the stability of the material. Most highway engineers classify soil in accordance with this system. This system of classification is of great value to engineers because it integrates the physical tests made on the soils.

*California Bearing Ratio (CBR).*—This is a punching-shear test made on confined samples of soil at the optimum moisture content. It indicates the load-supporting value of the soil materials, expressed in percentages. The CBR equals the force needed to push a piston into compacted soil, divided by the force needed to push a piston into well-graded, compacted crushed stone.

*Liquid limit.*—The moisture content at which the soil material passes from a plastic to a liquid state.

*Plastic limit.*—The moisture content at which the soil material passes from a solid to a plastic state.

*Plasticity index.*—The numerical difference between the liquid limit and the plastic limit. The plasticity index indicates the range of moisture content within which a soil material is plastic.

**Applying engineering interpretations**

Because the alluvial soils and soil complexes are more variable than the other mapping units, they will need more careful examination at the proposed site of construction.

*Alluvial soils.*—Soils formed from alluvium vary in the stratification of the underlying sediments. The fol-

lowing alluvial soils are particularly variable and require careful study to determine suitable uses:

1. Las Animas soils: These soils have a sandy substratum. The more humpy, sandier areas are somewhat similar to areas of Lincoln soils, but the more nearly level, finer textured areas are more nearly like areas of Spur loam. The proportion of clayey and silty layers varies from place to place.
2. Las Animas soils, shallow over clay: The thickness of the loamy material over clay ranges from 1 to several feet. The soil mixture, in places, has properties similar to those of Spur clay loam, but in the more clayey areas, the material is more like that in the Randall soil.
3. Lincoln soils: These soils have a substratum of fine sand that underlies loamy sand, loam, and clay loam of varying thicknesses. Most of the clay loam occurs in the lower spots, and the loamy sand occurs on the humps. Suitable sand for building purposes can be obtained from some of the areas.
4. Loamy alluvial land: This miscellaneous land type is made up largely of sediments derived from Woodward, Carey, and Quinlan soils, but its properties more nearly resemble those of the Woodward soil than the other soils. Most of the areas are less variable in texture than areas of the Lincoln soils.
5. Yahola fine sandy loam: This soil has a moderately sandy substratum that underlies various kinds of finer textured materials. Mixtures of the soil materials have properties similar to those of Spur loam.

*Soil complexes.*—Ratings for soil complexes, which consist of mixtures of two or more soils, are based on the

characteristics of the dominant soils. The minor soils in a complex may differ considerably from the dominant ones in characteristics and in suitability for construction. The proportion of each soil in the complex varies from place to place. Consult the soil description in the section, Soil Formation and Classification, to learn the composition of each complex. There, also, you can study the characteristics of the soil of the various complexes and find the parts of the county in which each complex occurs. You can learn to identify contrasting soils fairly easily.

An example of a soil complex in this county is the Tivoli-Quinlan complex. If you study the description of this complex, you will find that the shallow, reddish Quinlan soils occur over reddish sandstone and lie within broader areas of deep, sandy Tivoli soils. Tivoli fine sand and Quinlan loam, which are also mapped separately, have somewhat similar A.A.S.H.O. classifications (see table 5) and are similar in suitability for construction purposes. Therefore, a complex of the two soils should be similar to the soils mapped separately in suitability for engineering purposes. The Tivoli soil, however, is so sandy and loose that it is rated "poor" for seeding and sodding, and the Quinlan soil is rated "fair." The Quinlan soil is the more favorable of the two for use in dressing drainage ditches along roads in areas of the Tivoli-Quinlan complex.

The soils engineer should consider the characteristics of other soil complexes in the county as he locates the soils on the maps and studies the engineering properties of each as shown in tables 5 and 7. Following are descriptions of these complexes:

1. Dalhart-Carwile fine sandy loams: The Carwile soil occurs in low, enclosed depressions. It is less desirable for construction purposes than the Dalhart soil. Its subsoil has characteristics similar to those of Richfield clay loam.
2. Mansker-Potter complexes: In the steeper areas of these complexes, the largest proportion of Potter soils occurs. The Potter soils are distinguished by a layer of hard caliche in the C horizon. The engineering properties of these soils are no poorer than those of the Mansker soils.
3. Quinlan-Woodward complex: Quinlan soil makes up about 70 percent of most areas of this complex. Because the properties of the Quinlan and Woodward soils are somewhat similar, mixtures of the two soils should have about the same qualities as either of the individual soils.
4. Richfield complex: The Richfield soil occurs in level areas within which are small depressions occupied by very clayey Randall soil. On low swells or rises are Mansic and Dalhart soils, which are generally more granular and better suited to many construction purposes than the Richfield soil. In areas of this complex, it may be possible to obtain from the Dalhart soil a material lower in volumetric shrinkage and better suited to soil stabilization and shoulder construction than that of the Richfield soil. The Richfield soil, however, may be better as a dressing to prevent erosion on slopes and ditches along parts of roads that extend across areas of Dalhart and Mansic soils.
5. Woodward-Quinlan loams: The Quinlan soils occupy between 25 and 40 percent of these complexes.

Because the properties of the Woodward and Quinlan soils are somewhat similar, the soils in these complexes are also similar in properties. An area containing about 1,000 acres occurs a few miles northeast of Buffalo. Here, the soils are more clayey than elsewhere in the county and generally have properties similar to material in the B horizon of the Carey soils.

## Soils in Conservation Engineering<sup>5</sup>

The soils of Harper County vary widely in their suitability for the construction of farm ponds, reservoirs, and farm terraces. Building these structures involves moving large quantities of earth and is expensive. If earthen structures are to perform satisfactorily, they need to be designed and planned well and built from suitable soil.

### *Earthen structures on farms*

To aid in building the principal kinds of structures, some of the methods of building them are discussed in the following pages. The second part of the section relates the methods of construction to the engineering properties of soils within eight areas in the county.

**Farm ponds or reservoirs.**—These are constructed by excavating a pit to store water. The embankments, which are formed from the excavated earth, are usually protected with grass. A spillway and graded outlet are used to carry off excess water without causing erosion. If the water is used to fill tanks for stock or for irrigation, outlets with gates are provided. If the pond is used primarily for flood control, a drawdown pipe is used to drain excess water after the pond fills up. In this way storage space is always available for additional floodwaters.

**Channel-type conservation terraces.**—These terraces are used to carry away excess water that the soil cannot absorb. They are constructed by moving earth from two sides of a field toward the center. Here, a low, broad ridge is formed. Behind it is a graded channel. This channel carries water to the end of the field and disposes of it in a waterway that leads to a natural drainageway. These terraces decrease the velocity of the water and help control erosion by serving as guides for contour farming.

**Water-impounding terraces.**—Terraces of this type are used on very gently sloping areas of cropland to impound and spread water so as to get the greatest amount of insoak. They are constructed by forming a ridge on the downhill part of the slope. Back of the ridge and extending two-thirds of the distance toward the next ridge, the land is leveled to some extent so that it will collect water during rains. The ends of the terraces are kept blocked so that water will remain on the land and soak in. If necessary, however, the ends can be opened for draining away excess water.

These terraces are probably best used on moderately permeable soils to store water in the spring for use by summer crops. On very slowly permeable soils, standing water may damage small grains and make harvesting difficult if rainfall is heavy in spring.

**Diversions, or large channel-type terraces.**—These

<sup>5</sup> This section was prepared by Robert L. Bartholic, agricultural engineer, Soil Conservation Service.

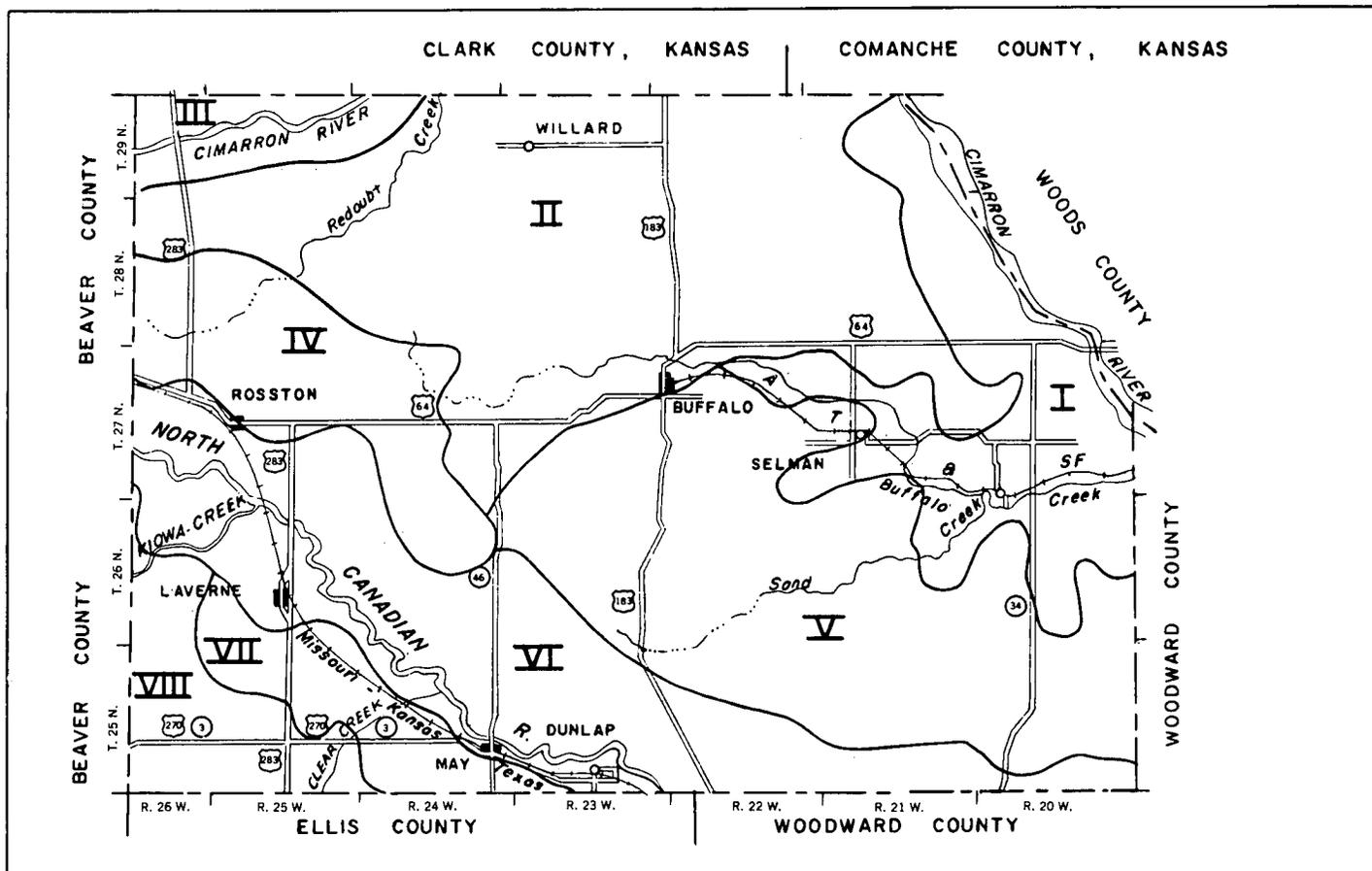


Figure 16.—Map showing the eight areas of Harper County in which the soil materials have different suitabilities for the construction of earthen structures.

terraces are constructed with a ridge that is higher than normal. They are designed to divert the runoff water from hilly areas away from cropland. Suitable waterways are needed to carry the water to natural drainageways.

#### *Suitability of soil materials for earthen structures*

The suitability of the soil materials for earthen structures generally is reflected in the various soil patterns in the county. In figure 16 Harper County is divided into eight areas, each having a definite pattern of soils. The suitability of the soil material in each area for constructing farm ponds and terraces is discussed in the text that follows. This information will help farmers, ranchers, and agricultural technicians to understand the problems involved in selecting sites for ponds and terraces in the county.

##### AREA I

This area, which is in the eastern and northeastern parts of Harper County, is generally underlain by gypsum. It extends along the western side of the Cimarron River. It also borders Buffalo Creek and extends westward to a point near Buffalo and southward as much as 5 miles. Because of the influence by gypsum, it is extremely hazardous to use the soil materials for earthen structures.

Pond dams can be constructed in places where investigations show that the pond basin and the foundation of the dam are free of gypsum. If there is gypsum in the basin, it should be covered by a blanket of clay that is at least 6 feet thick. If gypsum occurs in material to be used for the foundation of an embankment, the hazard of seepage is great.

Generally, the most favorable sites for ponds are areas not underlain by gypsum. Even in these places, however, there is a considerable amount of seepage. Several ponds in the area held water for 8 or 10 years before holes, between 2 and 24 inches in diameter, developed on the bottoms. Most of the holes were a considerable distance from the embankment, in places where not more than 3 feet of clay covered the gypsum.

Small surface structures, such as terraces and diversions, must be placed carefully if they are to function properly. In most places the rate of infiltration is high because of the gypsum in the soil. If properly located, conservation terraces function well on slopes of as much as 2 percent.

##### AREA II

This area is in the northern part of the county. It has soil materials that generally are suitable for earthen structures, and there are many good farm ponds, terraces, and diversions.

Excavated ponds or reservoirs will function satisfactorily in places where sediments do not accumulate. The construction of spillways for ponds and other structures is not so difficult in this area as in other parts of the county.

In general, this area is not suitable for conservation-type terraces. If suitable outlets can be obtained, channel-type terraces and diversions will function well.

#### AREA III

This area, which is in the northwestern corner of the county, is dissected by the Cimarron River. In places north of the river, the soil material is too sandy to be used for earthen structures to impound water. The bottom lands south of the river are generally flat and are largely under irrigation. Here, pond dams, reservoirs, terraces, and diversions will function satisfactorily. Only channel-type terraces should be used.

#### AREA IV

This area occurs in the west-central part of the county, north and east of Rosston. The soils are sandy and have a subsoil of caliche.

Some sites in this area are suitable for ponds. In these, ponds will function well if careful coring and scarifying is done at the sites of the dams. Construction of spillways is generally a problem because of the sandy surface layers of the soils.

Small structures, such as terraces and diversions, generally are not suitable in this area because of the risk of wind erosion. In places, where cultivating across the direction of the prevailing wind is not essential in controlling wind erosion, conservation terraces will function very well on slopes of as much as 2 percent. Some irrigation farming is practiced where wells provide enough water.

#### AREA V

This area lies south of Buffalo on the uplands between the North Canadian River, to the south, and Buffalo Creek, to the north. The rough terrain is underlain by red, soft sandstone and by subsidiary beds of clay.

Excellent sites and soil materials for ponds occur throughout this area. Constructing spillways is a problem, however, because of the deep, steep banks along the drainageways.

The soils in this area are likely to be damaged severely if runoff is not controlled. Channel-type terraces, the only type suitable in this area, work satisfactorily in places where suitable spillways can be constructed to handle the excess water.

#### AREA VI

This area, which is in the southern and southwestern parts of the county, is dissected by the North Canadian River. North of the river the soil material is very sandy and unsuitable for earthen structures. South of the river are bottom lands, both well drained and wet. These are unsuitable for water-impounding structures but are suitable for reservoirs built to provide water for livestock. A high water table in some of the soils makes construction a problem.

#### AREA VII

This area lies south of Laverne and south and southwest of the bottom lands of the North Canadian River. It

is suitable for pond dams and reservoirs, except that much sediment is carried into the area and deposited by drainageways originating in areas to the south. Because of the problem of sedimentation, the construction of reservoirs generally is not practical. Ponds in this area function for a much shorter period than those in area II.

Generally, there is an accumulation of sand, several feet thick, in the bottom of the drainageways. Considerable seepage may result unless care is taken in coring the dam across the drain.

Because of wind erosion, small surface structures, such as terraces and diversions, do not function well. This is especially true of those along the southern and western sides of the area. Conservation terraces are suitable in places where wind erosion can be controlled through methods other than cultivating across the direction of the prevailing winds. Terraces constructed in this area will be crooked and the fields hard to cultivate.

#### AREA VIII

This area is in the southwestern corner of the county, southeast of the North Canadian River. It is generally unsuitable as a source of material for earthen structures because the soils are deep and sandy, contain caliche in some spots, and have a severe hazard of wind erosion.

If a farm pond is planned on the finer textured soils, careful investigations are needed to locate the best soil material and to avoid extremely seepy spots. Because of the humpy terrain, terraces are generally impractical, even in places where the soil is suitable for them.

## *Soil Formation and Classification*

This section tells how the soils were formed and how they are classified. Technical descriptions are given for each of the soils mapped in Harper County.

### **How the Soils Were Formed**

Soil is produced by weathering and other factors of soil development acting on the parent materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent materials; (2) the climate under which the soil material 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 formation. They act on the parent material accumulated through the weathering of rocks and slowly change it into a natural body having genetically related horizons. The effects of climate and vegetation are conditioned by relief. The kind of parent material also affects the kind of profile that can be formed and, in extreme cases, dominates it entirely. Finally, time is needed to change the parent material into a soil profile. The time needed for horizon differentiation may be much or little. Usually, a long interval of time is needed for the development of distinct horizons.

Although the individual factors of soil formation are

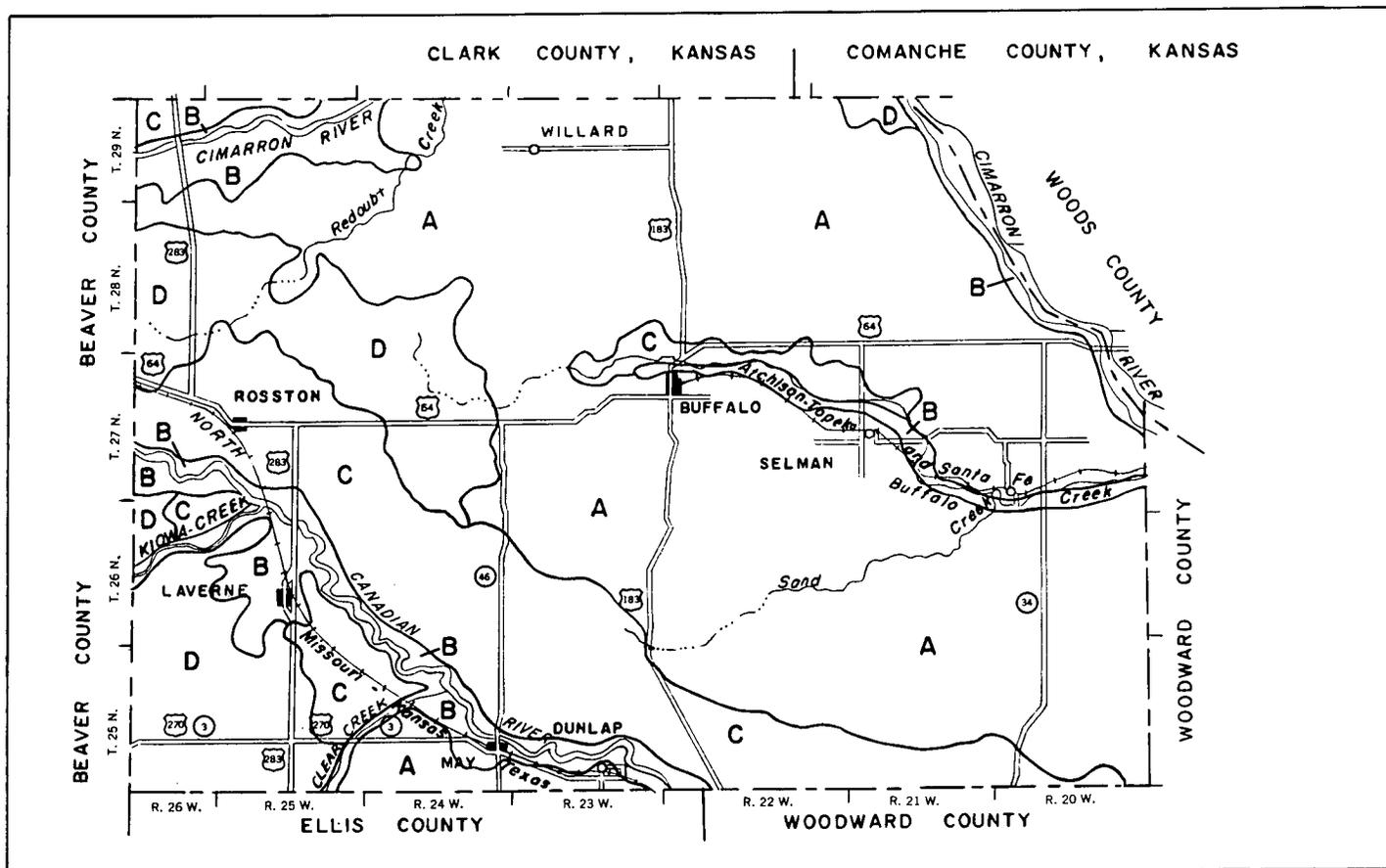


Figure 17.—Map showing the parent materials of the soils of Harper County.

A—Permian redbeds

B—Alluvium

C—Pleistocene sands

D—High Plains outwash of the Tertiary age

discussed separately in this report, it is the interaction of all of these factors that determines the characteristics of the soil profile. The interrelationship among the five factors is complex; it is difficult to isolate the effects of any one factor. In some areas the effects of four of the factors are constant or nearly so, and the effects of the fifth factor can be evaluated to some extent. Even in these areas, however, measurements of the effects are only approximations.

#### Parent materials

The soils of Harper County have formed from four different groups of parent materials. These are (1) redbeds of the Permian age, (2) alluvium, (3) sands deposited and reworked during the Pleistocene age, and (4) High Plains outwash deposited during the Tertiary age (fig. 17).

About two-thirds of Harper County is underlain by redbed material of the Permian age. Most of this material consists of weakly consolidated, soft sandstone made up of very fine sand and soft silty rocks. In the southeastern part of the county, the sandstone is differentiated into the Marlow formation and the Rush Springs member of Whitehorse sandstone. In the area north of the North Canadian River, it is undifferentiated and is recognized only as Whitehorse sandstone.

A few small remnants of Upper Day Creek dolomite occur as basal members of Cloud Chief gypsum in the area north of Buffalo. In the area bordering Buffalo Creek, the Blaine formation is important. It consists of two or three massive beds of gypsum separated by red clays and beds of dolomite. Between the Blaine gypsum and the Whitehorse sandstone are some lenses of dolomite and a narrow outcrop of Dog Creek shale, one of the most clayey beds exposed in Harper County.

The principal soils that have formed in areas of Permian redbeds are the Carey, Cottonwood, Hollister, Quinlan, St. Paul, and Woodward. The Cottonwood soil has formed on beds of Blaine gypsum.

In the western part of the county are unconsolidated or weakly cemented, limy clay loams and loams on High Plains outwash of the Tertiary age. In places, loess from these materials has been reworked and has modified the outwash. Generally, these deposits are high in lime and feldspathic minerals. In places, the outwash contains beds of caliche. The deposits of outwash are continuous in the area south and west of Laverne. In only a narrow zone do they feather out to the underlying redbeds.

North of the North Canadian River the Permian redbeds occur over a wide area. Here, the High Plains outwash caps the higher hills. It also covers the floors of the valleys but is lacking on the steeper side slopes. A typical

spot occurs west of Doby Springs. The soils formed from High Plains outwash are the Dalhart, Mansic, Mansker, Otero, Randall, and Richfield.

Sands deposited and reworked during the Pleistocene age are mostly in a large, continuous area north of the North Canadian River. The alluvium has been modified by wind. Some of the sands are siliceous and low in weatherable minerals. In some places the relief is dune-like.

The principal soils formed on these materials are the Pratt, Tivoli, and, to a lesser extent, the Carwile. The coarser textured soils generally occur nearest the streams.

Areas of recent alluvium border the North Canadian and Cimarron Rivers, and narrower areas occur in the valleys within areas of redbeds. The material along the North Canadian River is generally sandy. Here, Las Animas soils, shallow over clay, have formed. Locally, smaller areas of Spur and Yahola soils occur.

South of the Cimarron River the alluvial sediments are mostly loamy, but some comparatively recent loess has blown onto the higher alluvial benches. These benches are occupied by the Tipton soils. The principal soil of the flood plains is the Spur, but the Las Animas and Yahola soils occur to some extent. Along drainageways on Permian redbeds, the alluvium is loamy to slightly sandy and has about the same texture as the rocks at the headwaters. The Yahola is the principal soil formed from this material.

### *Climate*

The climate of Harper County is continental. It is characterized by heavy rainfall in spring; hot, dry weather in summer; and only light precipitation in fall and winter. This results in erratic and relatively shallow leaching of the soil. Because of strong winds and hot weather, the rate of evaporation is high. In most of the soils, water does not move downward through the profile, and so the basic elements are generally not leached out. The presence and depth of limestone in many of the soils indicate the average depth to which water moves. In the clayey, sloping soils, water penetrates only to a depth of a few inches. In the permeable, nearly level soils, on the other hand, it infiltrates to a depth of several feet. The very sandy soils have no distinct lime zone in the profile, whereas those formed on extremely limy materials may be limy at the surface.

### *Living matter*

Plant and animal life, both on and in the soil, are active in soil-forming processes. As plants die and decay, they add organic matter to the soil. This darkens the upper part of the soil profile. Originally, soils that supported deep-rooted tall grasses contained more organic matter and generally were darkened to greater depths than those formed mainly under a cover of buffalograss and grama grasses. Most of the nearly level and gently sloping soils absorbed a large amount of water and supported thicker stands of grass than the steep soils, and so they became darkened to considerable depths. In contrast, the steep soils contained less organic matter and were darkened to only shallow depths. If cultivated, steep soils tend to lose the darkened layer of organic matter through erosion.

Many kinds of micro-organisms are needed to transform organic remains into stable humus from which plants can obtain nutrients. Small burrowing animals and earthworms influence soil formation by mixing the organic and mineral parts of the soil and by deepening the zone in which organic matter accumulates. They also tend to keep the soils supplied with minerals by bringing unleached parent material to the surface.

Since soil life thrives in a moist, moderately warm environment, it is most active late in spring and early in fall. Plant remains decompose slowly during the hot, dry summer. For this reason, wheat farmers try to work the land immediately after harvest so that at least part of the stubble will decompose before the planting time in fall.

### *Relief*

The soils of Harper County range in relief from nearly level to very steep. The degree and type of slope determines, in part, how much water runs off, how much water infiltrates into the soil, and how much soil is likely to be lost through erosion, especially in cultivated areas.

Differences in slope usually determine the proportion of moisture and air in the soil. Normally, on slopes of more than 3 percent, more water runs off than infiltrates into the soil. The amount of water that runs off, however, also depends to a great extent on the thickness of the vegetation and soil mulch, on the fertility of the soil, on the type of slope, and on the texture of the soil material.

The profiles of the strongly sloping soils in Harper County are not well developed because there is an excessive amount of runoff and not enough movement of clay downward from the A horizon to the B horizon. The colors of the soils are similar to those of the parent materials, because the soil materials are relatively dry and contain only small amounts of organic matter. Consequently, the degree of profile development that takes place, within a given time on a particular kind of parent material and under a cover of similar plants, depends mostly on the amount of water passing through the soil.

Soil series that have formed on similar parent material and under a similar cover of plants but that differ in relief or drainage may be grouped in soil-relief sequences known as catenas. In Harper County the St. Paul, Carey, Woodward, and Quinlan soils form a catena. The soils are arranged in progressive order as to degree and type of slope, the St. Paul being the most nearly level, and the Quinlan, the most strongly sloping. The St. Paul soils generally retain the greatest amount of rainfall, and the Quinlan soils retain the least.

### *Time*

Considerable time is required for the development of a soil from the parent material. After the parent material has been deposited or has accumulated in place through weathering, the surface soil becomes darkened by the accumulation of organic matter. Calcium carbonate and other soluble minerals may be leached downward from the surface soil. The movement of clay downward from the surface soil proceeds more slowly. Generally, when clay is leached from the A horizon, there is a corresponding increase of clay in the B horizon. The rate of this

process depends, in part, on how rapidly the soil materials in the upper soil layers are weathered.

The profiles of the soils of Harper County are generally not strongly developed. The lack of strong development has been caused only partly by the factor of time. The redbed sandstones are relatively high in quartz minerals, which weather slowly. This material does not develop rapidly into well-differentiated profiles that have clayey B horizons. The loams of the Tertiary age contain a much higher content of feldspar than the sandstones of the redbeds; in this material, soils with distinct horizons form more quickly than on redbeds of similar relief and vegetation.

Little soil development occurs, regardless of the length of time, in materials consisting mostly of quartz sand. If the sand consists partly of weatherable granite, however, the development of separate horizons will proceed slowly.

In level areas of well-mixed, loamy alluvial sediments that contain large amounts of feldspathic minerals, soil formation may proceed at a moderate rate, even in the dry, subhumid climate of Harper County. On some benches, underlain by alluvium deposited in the Late Pleistocene age, soils with moderately differentiated profiles have formed in a shorter time than similar soils formed over redbeds. On the parts of these benches where the soils have been influenced by deposits of loess, the horizons may be less differentiated than in other soils and the soil may be less mature. Here, the loessal deposits accumulated long after the underlying alluvium was laid down, and the material has not had enough time to develop into mature soils. Some of the soils forming in recent alluvium on the flood plains of rivers have also been influenced by deposits of loess. Beneath successive deposits of loess and alluvium, profiles of older soils of varying degrees of maturity can be seen.

The age of a soil is not the same as the geologic age of the parent material. Although the sediments that formed the rocks of the Permian age were deposited in sea bottoms hundreds of millions of years ago, the present landscape on which the soils began to form was not developed until a time much closer to the present. The landscape developed much later than the time at which outwash deposits of the Tertiary age were laid down on the High Plains, which extend into the western part of Harper County. The Tertiary material once covered much of the county, possibly all of it, but most of it has been stripped away by the headward cutting of the Cimarron and North Canadian Rivers and their tributaries. This process required a long period of time.

## How the Soils are Classified

Soils are placed in narrow classes for the purpose of organizing them and applying knowledge about their behavior within farms or counties. They are placed in broad classes so that the soils in large areas, such as continents, can be studied and compared. The narrow classes, or lower categories of soil classification—phases, types, and series—are explained in the section, *How a Soil Survey is Made*. Briefly, a soil type consists of one or more phases and a soil series of one or more soil types. Soil types or phases are the units shown on the detailed soil map.

Soil series are also classified in a broader category, the great soil group. Each great soil group is made up of soils that have certain internal characteristics in common. The soil series of Harper County have been classified in the Alluvial, Brown, Chestnut, Planosol, Calcisol, Grumusol, Lithosol, Reddish Chestnut, and Regosol great soil groups. This classification helps to show the relationship of the soils of the county to soils in other parts of Oklahoma and throughout the United States.

Table 9 shows the great soil group for each of the soil series of Harper County. This table also gives a representative profile and important characteristics of the soils in each soil series.

## Detailed Descriptions of the Soils

In the pages that follow, each soil mapping unit is discussed. At least one representative profile of each soil series is described in some detail. Two profiles of the Spur series are described—one of Spur clay loam and another of Spur loam. The great soil group is given for each soil series for easy cross reference to table 9.

In the profile described for each soil type, the verbal and numerical descriptions for soil color are based on the Munsell color charts.<sup>6</sup> Unless otherwise specified, the numerical notations refer to the color of dry soil.

**Carey silt loam, 1 to 3 percent slopes.**—This soil belongs to the Reddish Chestnut great soil group and is a member of the St. Paul, Carey, Woodward, and Quinlan catena. It is intermediate in drainage and slope between the St. Paul and Woodward soils. Most of this soil occurs on the redbed plains, mainly in the northern part of the county. It generally occupies gentle, convex slopes on the upper parts of broad ridges, but it also is on nearly level flats. The soil has formed under a cover of grasses in soft, weakly consolidated, reddish very fine sands or loams of the redbed formations.

The following profile of Carey silt loam, 1 to 3 percent slopes (slopes predominantly about 2 percent), was observed 4 miles east and 1 mile south of Buffalo (SW $\frac{1}{2}$  sec. 14, T. 27 N., R. 22 W.):

- A<sub>1</sub> 0 to 10 inches, dark-brown (7.5YR 4/3, dry; 2.5/3, moist) silt loam; weak to moderate, medium, granular structure; friable; noncalcareous; very gradual lower boundary.
- A<sub>2</sub> 10 to 18 inches, soil material similar to that in A<sub>1</sub> horizon but slightly lighter colored (7.5YR 4/3, dry; 3/3, moist) and slightly more clayey; soil material is light silty clay loam in lower part of horizon; noncalcareous; gradual lower boundary.
- B<sub>21</sub> 18 to 29 inches, reddish-brown (5YR 5/4, dry; 3/4, moist) silty clay loam; weak, coarse, prismatic and moderate, medium, granular structure; moderately distinct clay skins; friable; contains many pores and fine tubes; calcareous and contains films of segregated calcium carbonate; very gradual lower boundary.
- B<sub>22</sub> 29 to 42 inches, red (3YR 5/6, dry; 3.5/6, moist) silty clay loam similar to material in B<sub>21</sub> horizon except that it is redder; uneven, abrupt lower boundary.
- C<sub>ca</sub> 42 to 60 inches, red (2.5YR 5/6, dry; 4/6, moist) heavy silt loam; almost structureless, but porous and permeable with many fine pores and tubes; traces of clay skins; friable; calcareous; between 5 and 10 percent of material consists of lime concretions that are as much as 1 inch in diameter; very gradual lower boundary.

<sup>6</sup> UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL SURVEY MANUAL. U. S. Dept. Agr. Handbook 18, 503 pp., illus. 1951.

Table 9.—Important characteristics of the soil series and the great soil group to which each series belongs

| Soil series | Profile description      |   |  |                         | Slope ranges of mapping units and types of slopes   | Parent material  | Great soil group  | Common associated soils   |
|-------------|--------------------------|---|--|-------------------------|---|--|-------------------|---|
|             | Depth                    | Dominant color                              | Dominant texture                               | Structure               |   |  |                   |   |
| Carey       | <i>Inches</i><br>0 to 18 | Dark brown                                  | Silt loam                                      | Granular                | 1 to 3 percent slopes, convex; 3 to 5 percent slopes, convex.                               | Soft, fine-grained silty and sandy materials from Permian redbeds. | Reddish Chestnut. | St. Paul, Woodward, and Quinlan.                                      |
|             | 18 to 29                 | Reddish brown                               | Silty clay loam                                | Prismatic and granular. |   |  |                   |   |
| Carwile     | 29 to 42                 | Red   | Silty clay loam                                | Prismatic and granular. | 0 to 1 percent slopes, concave.   | Unconsolidated sandy deposits of the Pleistocene age.              | Planosol          | Dalhart, Pratt, and Tivoli.   |
|             | 42 to 60                 | Red   | Heavy silt loam                                | Weak granular.          |   |  |                   |   |
|             | 0 to 12                  | Dark grayish brown.                         | Fine sandy loam                                | Granular                |   |  |                   |   |
| Cottonwood  | 12 to 20                 | Yellowish brown mottled with grayish brown. | Sandy clay loam                                | Subangular blocky.      | 2 to 12 percent slopes, convex.   | Gypsum and gypsiferous sandstones of the Permian redbeds.          | Lithosol          | Quinlan, Woodward, and Acme (not mapped separately in Harper County). |
|             | 20 to 42                 | Dark brown                                  | Sandy clay                                     | Subangular blocky.      |   |  |                   |   |
|             | 0 to 3                   | Brown                                       | Loam   | Granular                |   |  |                   |   |
| Dalhart     | 3 to 8+                  | Light gray                                  | Gypsiferous sandy loam and crystalline gypsum. | Weak platy.             | 0 to 3 percent slopes; 3 to 5 percent slopes, convex.                                       | Somewhat sandy, unconsolidated deposits of the Tertiary age.       | Chestnut          | Richfield, Mansker, Mansic, Carwile, and Otero.                       |
|             | 0 to 10                  | Dark brown                                  | Fine sandy loam                                | Weak granular           |   |  |                   |   |
|             | 10 to 42                 | Brown                                       | Sandy clay loam                                | Prismatic and granular. |   |  |                   |   |
| Hollister   | 42 to 50+                | Brown                                       | Sandy clay loam                                | Prismatic and granular. | 0 to 1 percent slopes, slightly concave; 1 to 3 percent slopes, convex.                     | Clayey material from Permian redbeds.                              | Reddish Chestnut. | St. Paul and Carey.   |
|             | 0 to 15                  | Dark grayish brown.                         | Light silty clay loam                          | Granular                |   |  |                   |   |
|             | 15 to 21                 | Dark grayish brown.                         | Silty clay                                     | Blocky.                 |   |  |                   |   |
| Las Animas  | 21 to 30                 | Dark gray                                   | Silty clay                                     | Blocky.                 | 0 to 1 percent slopes; level flood plains with slight depressions and wind-formed hummocks. | Moderately sandy sediments of the Tertiary age.                    | Alluvial          | Lincoln and Spur.   |
|             | 30 to 42                 | Gray  | Silty clay                                     | Blocky.                 |   |  |                   |   |
|             | 0 to 16                  | Grayish brown                               | Sandy loam                                     | Granular                |   |  |                   |   |
| Lincoln     | 16 to 45                 | Pale brown with mottles of strong brown.    | Sandy loam thinly stratified with clay loam.   | Granular.               | 0 to 3 percent slopes.  | Recent sandy alluvium.   | Alluvial          | Las Animas, Spur, Tivoli, and Pratt soils.                            |
|             | 0 to 18                  | Brown                                       | Fine sandy loam                                | Weak granular           |   |  |                   |   |
| Mansic      | 18 to 45+                | Very pale brown                             | Stratified sands and loams.                    | Structureless.          | 1 to 3 percent slopes, convex and concave; 3 to 5 percent slopes, convex.                   | Weakly consolidated, very limy clay loams of the Tertiary age.     | Chestnut          | Potter, Richfield, Mansic, Pratt, and Randall.                        |
|             | 0 to 20                  | Grayish brown                               | Clay loam                                      | Strong granular         |   |  |                   |   |
|             | 20 to 30                 | Brown                                       | Clay loam                                      | Strong granular.        |   |  |                   |   |
|             | 30 to 60                 | Pale brown                                  | Clay loam                                      | Weak granular.          |   |  |                   |   |
| Mansker     | 60+                      | Pale brown                                  | Weakly stratified clay loams.                  | Weak granular.          | 1 to 3 percent slopes, convex and concave; 3 to 5 percent slopes, convex.                   | Weakly consolidated, very limy clay loams of the Tertiary age.     | Calcisol          | Potter, Richfield, Mansic, Pratt, and Randall.                        |
|             | 0 to 6                   | Brown                                       | Heavy loam                                     | Granular                |   |  |                   |   |
|             | 6 to 13                  | Yellowish brown.                            | Clay loam                                      | Strong granular.        |   |  |                   |   |
| Otero       | 13 to 40+                | Reddish brown                               | Clay loam containing seams of chalky loam.     | Weak granular.          | 1 to 8 percent slopes, convex.  | Granitic and quartzitic sands of the Tertiary age.                 | Brown             | Mansker, Dalhart, and Pratt.  |
|             | 0 to 5                   | Grayish brown                               | Heavy loamy sand.                              | Weak granular           |   |  |                   |   |
|             | 5 to 12                  | Pale brown                                  | Loamy fine sand.                               | Single grain.           |   |  |                   |   |
|             | 12 to 40+                | Very pale brown                             | Medium sand containing some pebbles.           | Single grain.           |   |  |                   |   |

Table 9.—Important characteristics of the soil series and the great soil group to which each series belongs—Continued

| Soil series        | Profile description                        |   |   |  | Slope ranges of mapping units and types of slopes  | Parent material   | Great soil group  | Common associated soils                            |
|--------------------|--|---|---|--|--|---|-------------------|--|
|                    | Depth                                      | Dominant color  | Dominant texture  | Structure  |  |   |                   |  |
| Potter             | <i>Inches</i><br>0 to 6<br>6 to 10<br>10+  | Grayish brown<br>Grayish brown<br>White                                 | Loam<br>Clay loam<br>Hardened caliche.                              | Weak granular<br>Granular<br>Massive.                                      | 3 to 5 percent slopes, convex.   | Weakly consolidated, very limy loams containing layers of caliche.      | Lithosol          | Mansker, Mansic, and Dalhart.                      |
| Pratt <sup>1</sup> | 0 to 8<br>8 to 25<br>25 to 45+             | Grayish brown<br>Brownish yellow<br>Yellow                              | Loamy fine sand.<br>Heavy loamy fine sand.<br>Loamy fine sand.      | Single grain.<br>Single grain.<br>Single grain.                            | 0 to 3 percent slopes, billowy; 3 to 5 percent slopes, convex; 3 to 8 percent slopes, hummocky; 8 to 12 percent slopes, duned. | Sandy alluvial and eolian deposits of the Pleistocene age.              | Reddish Chestnut. | Tivoli and Carwile.                                |
| Quinlan            | 0 to 6<br>6 to 10<br>10 to 20+             | Reddish brown<br>Yellowish red<br>Yellowish red                         | Loam<br>Heavy loam<br>Soft, weathered sandstone.                    | Granular<br>Nearly massive.<br>Massive.                                    | 3 to 12 percent slopes, convex; 3 to 20 percent slopes, convex.  | Slightly hardened, fine-grained silts and sands of the Permian redbeds. | Regosol           | Woodward and Carey.                                |
| Randall            | 0 to 8<br>8 to 30<br>30 to 45+             | Dark gray<br>Very dark gray<br>Dark grayish brown.                      | Clay<br>Clay  | Subangular blocky.<br>Massive.<br>Massive.                                 | 0 to 1 percent slopes, concave.  | Clays and clay loams of playa lakebeds.                                 | Grumusol          | Richfield, Mansker, Mansic, and St. Paul.          |
| Richfield          | 0 to 9<br>9 to 15<br>15 to 30<br>30 to 40  | Dark grayish brown<br>Dark grayish brown<br>Grayish brown<br>Pale brown | Light clay loam<br>Heavy clay loam<br>Heavy clay loam.<br>Clay loam | Granular<br>Strong subangular blocky.<br>Medium blocky.<br>Medium blocky.  | 0 to 1 percent slopes  | Weakly consolidated, limy clay loams of the Tertiary age.               | Chestnut          | Dalhart, Mansker, Pratt, and Randall.              |
| St. Paul           | 0 to 18<br>18 to 26<br>26 to 33            | Dark brown<br>Brown<br>Brown  | Heavy silt loam<br>Silty clay loam<br>Silty clay loam               | Granular<br>Strong subangular blocky.<br>Moderate subangular blocky.       | 0 to 1 percent slopes; 1 to 3 percent slopes, convex.  | Soft, fine-grained silts and sands of the Permian redbeds.              | Reddish Chestnut. | Carey, Woodward, and Quinlan.                      |
| Spur <sup>2</sup>  | 0 to 15<br>15 to 25<br>25 to 45+           | Dark yellowish brown<br>Pale brown<br>Grayish brown                     | Clay loam<br>Loam<br>Stratified loams                               | Strong granular<br>Granular.<br>Granular.                                  | 0 to 1 percent slopes  | Recent alluvium of loam and clay loam.                                  | Alluvial          | Las Animas soils.                                  |
| Tipton             | 0 to 16<br>16 to 26<br>26 to 33+           | Brown<br>Brown<br>Brown   | Heavy silt loam<br>Silty clay loam<br>Silty clay loam               | Granular<br>Strong blocky.<br>Medium granular.                             | 0 to 1 percent slopes; 1 to 3 percent slopes; 3 to 5 percent slopes.   | Loamy alluvial and eolian deposits of the Pleistocene and Recent ages.  | Reddish Chestnut. | St. Paul and Carey.                                |
| Tivoli             | 0 to 8<br>8 to 45+                         | Light brown<br>Reddish yellow   | Fine sand<br>Loamy fine sand.                                       | Single grain<br>Single grain.  | 8 to 20 percent slopes, dunny.   | Siliceous eolian sands of Late Pleistocene and Recent ages.             | Regosol           | Pratt, Carwile, and Dalhart.                       |
| Woodward           | 0 to 9<br>9 to 20<br>20 to 25<br>25 to 45+ | Reddish brown<br>Reddish brown<br>Yellowish red<br>Yellowish red        | Loam<br>Loam<br>Loam<br>Seams of loam and sandstone.                | Granular<br>Prismatic and granular.<br>Nearly massive.<br>Weakly cemented. | 1 to 3 percent slopes; 3 to 8 percent slopes.  | Soft, fine-grained silts and sands of the Permian redbeds.              | Reddish Chestnut. | Carey and Quinlan.                                 |
| Yahola             | 0 to 8<br>8 to 53+                         | Yellowish red<br>Yellowish red  | Fine sandy loam<br>Stratified sandy loam and loam.                  | Weak granular<br>Weak granular.  | 0 to 3 percent slopes  | Reddish, loamy alluvium, mostly from Permian redbeds.                   | Alluvial          | Carey, Quinlan, St. Paul, and Loamy alluvial land. |

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<sup>1</sup> Profile described is of a Pratt loamy fine sand.

<sup>2</sup> Profile described for Spur clay loam.

C 60 to 80 inches+, soil material similar to that in C<sub>ca</sub> horizon except that it contains no segregated lime; massive (structureless) friable; calcareous.

To depths between 14 and 20 inches, this soil is generally dark brown to brown (7.5YR 3/2 to 4/3). The underlying subsoil is redder; it has chromas of 4 or higher.

The texture of the A<sub>1</sub> horizon ranges from silt loam to loam. The thickness of the combined A horizons ranges from 10 to 20 inches but is generally about 15 inches. The texture of the B<sub>21</sub> horizon ranges from light silty clay loam to heavy loam. The depth to free carbonates ranges from 8 to 24 inches but is generally about 18 inches. In the B horizons the clay skins on the peds range from indistinct to clearly apparent but thin. Accumulations of calcium carbonate are pronounced in only a few places, and generally they occur at a depth of about 36 inches. In a few areas that have been influenced by outwash of the Tertiary age, the soil is dark brown (10YR hues) and is darker than the typical soil.

Both surface runoff and internal drainage are medium, and moisture conditions are favorable for the growth of crops. The original vegetation consisted of tall and mid grasses, but the present cover is made up mostly of grama grasses and dropseed grasses.

Mapped with this soil are small areas of St. Paul and Woodward soils, which make up about 10 percent of the total acreage. In areas near where the redbeds join the mantle of sediments laid down in the Tertiary age, there are traces of Mansker soils.

About 80 percent of this soil is used to grow wheat. Grain sorghums and alfalfa are grown to some extent during years when there is enough moisture in the soil. Many of the pastures are small and have been overgrazed. They consist largely of buffalograss and blue grama.

**Carey silt loam, 3 to 5 percent slopes.**—This soil is somewhat similar to Carey silt loam, 1 to 3 percent slopes. A typical area is 10 miles north and 4 miles east of Rosston (SE¼ sec. 36, T. 29 N., R. 25 W.).

This soil differs from the more extensive Carey silt loam, 1 to 3 percent slopes, in the following ways: (1) The thickness of the combined A horizons ranges from 12 to 15 inches but is generally about 12 inches; (2) the color of the B horizons ranges from yellowish red to reddish brown (5YR and 2.5YR and 5/6 to 4.5/4); and (3) in some places the B horizons are more clayey, possibly because this soil has formed from rocks that contained more clay and lacked a covering of loamy soil material.

Only about two-thirds of this soil is cultivated. The rest is in native pasture of grama grasses, buffalograss, dropseed grasses, and other grasses.

**Cottonwood loam.**—This soil belongs to the Lithosol great soil group. It is in the eastern part of the county, mostly east of Selman, and is on both sides of Buffalo Creek. It occurs within larger areas of Quinlan and Woodward soils.

This soil has slopes ranging from 2 to 8 or more percent. In about three-fifths of the acreage, the slopes are 5 to 8 percent, and in most of the rest, they are between 3 and 5 percent. In a small acreage the slopes range from 8 to 12 percent.

This soil has formed principally in the outcrop of gypsum of the Blaine formation and in the remnants of clay and sandstone of the Dog Creek formation, which overlies the Blaine. The massive beds of gypsum in the Blaine

formation are separated by layers of red and gray clay and by dolomite. As the result of weathering, sinkholes and small caverns have formed in the gypsum and made the surface of the soil uneven in places. Because the gypsum and dolomite are more resistant to weathering than the clay, narrow, short breaks, or escarpments, have formed at the highest places on the landscape.

The following profile of Cottonwood loam (on a slope of 6 percent) was observed 5 miles south and 7 miles east of Selman (W½ sec. 16, T. 26 N., R. 20 W.). Many small areas of this soil occur in this half section in association with areas of Woodward and Quinlan soils.

- A 0 to 3 inches, brown (10YR 4/3, moist) loam; weak, fine, granular structure; friable; moderately permeable; noncalcareous; contains a few fragments of gypsum; abrupt lower boundary.
- C 3 to 8 inches, light-gray (2.5Y 7/3, moist) fine sandy material composed largely of gypsum particles but transitional, with increasing depth, to unweathered crystalline gypsum; platy structure; noncalcareous.

The thickness of the soil material over the gypsum ranges from a few inches to 10 inches, but it is generally about 4 inches. In areas where the soil overlies beds of clay, its color may be redder than normal and the reaction may be neutral or alkaline. Gypsum outcrops in many places.

Small areas of Woodward loam and Quinlan loam are included, but they cover less than 10 percent of the total acreage. Also included are small tracts of Acme loam, a deeper soil that occurs in pockets and along the margins of the areas of Cottonwood loam. In Harper County the areas of Acme soil are not large enough to be mapped separately.

Acme loam, a member of the Regosol great soil group, is moderately deep, and its profile has developed to about the same degree as those of the Woodward soils. It generally occurs on gently rolling to rolling uplands, mostly on slopes of between 3 and 8 percent, but long, narrow areas along the escarpments have stronger slopes. In some places, where this soil occurs along the margins of the areas of Cottonwood loam, it is transitional to the Woodward soils.

The following profile of Acme loam was observed in a depression, or pocket, that had gently sloping relief:

- A 0 to 4 inches, dark-brown (7.5YR 4/2, moist) loam; platy structure in upper part of layer; weak, granular structure in lower part; friable; permeable; noncalcareous; transitional to layer below.
- AC 4 to 18 inches, dark-brown (7.5YR 3.5/2, moist) heavy loam or silt loam; compound structure—coarse, columnar and moderate, medium, granular.
- C 18 to 22 inches+, light-gray (10YR 7/2, dry; 6/2 moist) sandy loam that contains gypsum; abrupt transition to whitish, impure gypsum.

The thickness of the profile ranges from 10 to about 24 inches. In places the soil is redder than in the profile just described.

In most areas of Cottonwood loam, surface runoff is rapid, but in some places it is slow. Some of the runoff water enters sinkholes in the gypsum. Internal drainage is medium. The water-holding capacity is low.

The native vegetation consisted of a mixture of blue-stem and grama grasses, but the present cover is made up largely of buffalograss and grama and dropseed grasses. All the areas are used as range.

**Dalhart fine sandy loam, 1 to 3 percent slopes.**—This moderately sandy soil belongs to the Chestnut great soil group. It has formed on outwash of the Tertiary age. The relief is slightly wavy and is concave-convex. Almost all of the slopes are less than 3 percent.

Most of this soil occurs in the western part of the county, adjacent to other soils that overlie Tertiary deposits. In the southwestern and west-central parts of the county, it occurs in association with the Richfield and Pratt soils. In texture, it is intermediate between soils of these two series. It is darker and finer textured throughout than the Pratt soils and is lighter colored, coarser textured, and more deeply leached of lime than the Richfield. The Pratt soils occur on younger wind-blown deposits of the late Pleistocene age.

Harper County is the eastern boundary of the Dalhart soil. In this county the soil is higher in organic matter, slightly darker, and leached of lime to a greater depth than in counties just to the west.

The following profile of Dalhart fine sandy loam, 1 to 3 percent slopes (slopes predominantly about 1 percent) was observed 5 miles south and 5 miles west of Laverne (S $\frac{1}{2}$ SW $\frac{1}{4}$  sec. 14, T. 25 N., R. 26 W.):

- A<sub>1</sub> 0 to 10 inches, dark-brown (10YR 4/3, dry; 3/3, moist) fine sandy loam; weak, medium, granular structure; friable; porous and permeable; noncalcareous; the upper part, or plow layer, is slightly lighter in color than the lower part; smooth, clear lower boundary.
- B<sub>2</sub> 10 to 42 inches, brown (10YR 5/3, dry; 4/3, moist) sandy clay loam; compound structure—coarse, prismatic and moderate, medium, granular; friable when moist, hard when dry; noncalcareous; very gradual lower boundary.
- BC 42 to 50 inches+, brown (7.5YR 4/4, moist) sandy clay loam; weak, prismatic and weak, medium, granular structure; friable to firm when moist, hard when dry; calcareous at a depth of about 45 inches, but changes little to the greatest depth sampled.

The A<sub>1</sub> horizon ranges from 6 to 12 inches in thickness and from brown to dark brown in color. The content of clay in the B<sub>2</sub> horizon ranges from about 17 to 25 percent. Locally, calcium carbonate occurs as threads or small masses, generally at a depth of more than 3 feet.

Surface runoff and internal drainage are medium. The native vegetation consisted of bluestem and grama grasses. In grazed areas the present vegetation is composed mostly of grama and dropseed grasses, but there is some bluestem in areas that have been grazed but little. About 80 percent of the acreage is used to grow wheat and grain sorghums.

**Dalhart fine sandy loam, 3 to 5 percent slopes.**—This soil is somewhat similar to Dalhart fine sandy loam, 1 to 3 percent slopes. A typical area is 4 miles north and 1 $\frac{1}{2}$  miles west of Rosston (SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 28 N., R. 26 W.). In general, this soil is on the sandy side of the textural range for the Dalhart series.

This soil differs from Dalhart fine sandy loam, 1 to 3 percent slopes, in the following ways: (1) The relief is distinctly convex instead of billowy, and concave areas are narrow and inextensive; (2) the slopes are generally about 4 percent, and most of the slopes are between 200 and 400 feet long; (3) the surface soil is somewhat lighter in color; (4) there is generally less clay in the subsoil, and in many places the B<sub>2</sub> horizon contains only 15 to 20 percent clay; and (5) in some areas the B<sub>2</sub> horizon is only about 15 inches thick.

This soil, which comprises about 40 percent of the acreage of Dalhart soils in the county, is used primarily to grow sorghums. It is likely to be damaged through wind and water erosion.

**Dalhart-Carwile fine sandy loams.**—The Dalhart soil belongs to the Chestnut great soil group, while the Carwile soil is a Planosol. The Dalhart soil has formed from eolian or alluvial sands of the Tertiary age, and the Carwile soil, from alluvium deposited during the Pleistocene age.

These soils occur in depressions between sand dunes that are north of the North Canadian River. They occupy areas below those of the associated Pratt soils and other Dalhart soils. The areas are sandy, and the slopes are uneven and slightly wavy. Dalhart, the dominant soil, occurs in the higher positions, and the Carwile soil occupies low, enclosed depressions. In areas of these soils that merge with areas of Mansker soil, the soil material contains more lime than normal.

The profile of the Dalhart soil is similar to that described for Dalhart fine sandy loam, 1 to 3 percent slopes. The following profile of Carwile fine sandy loam was observed 4 miles east and 2 miles north of Laverne (N $\frac{1}{2}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 7, T. 26 N., R. 24 W.)

- A<sub>11</sub> 0 to 6 inches, dark grayish-brown (10YR 4/2, dry; 3/2, moist) fine sandy loam; weak, fine to medium, granular structure; friable when moist, nonsticky when wet; noncalcareous; clear lower boundary.
- A<sub>12</sub> 6 to 12 inches, dark-brown (10YR 4/3, dry; 3/3, moist) heavy sandy loam; weak, fine to medium, subangular blocky structure; sticky when wet; noncalcareous; between 10 and 20 percent of exposed surface consists of medium grayish-brown (10YR 4/2) mottles; gradual lower boundary.
- B<sub>21</sub> 12 to 20 inches, yellowish-brown (10YR 5/4, dry; 4/4, moist) sandy clay loam; between 10 and 20 percent of exposed surface consists of medium, distinct, grayish-brown mottles; moderate, medium, subangular blocky structure; hard when dry, slightly sticky when wet; noncalcareous; very gradual lower boundary.
- B<sub>22</sub> 20 to 42 inches, dark-brown (10YR 4/3, moist) sandy clay mottled with yellowish brown and grayish brown; subangular blocky structure; firm and somewhat compact; calcareous; slowly permeable.

The texture of the Carwile soil ranges from loamy fine sand to sandy clay. There is much variation in the degree of mottling in the A<sub>12</sub>, B<sub>21</sub>, and B<sub>22</sub> horizons. In some places the B<sub>22</sub> horizon contains many concretions of calcium carbonate. In areas of this soil that are close to areas of Mansker soil, these concretions may begin in the A<sub>12</sub> horizon.

Surface runoff and internal drainage are medium in the Dalhart soil. Because it occurs in concave swales, the Carwile soil has no outlet for surface water. As a result, water accumulates on the soil and internal drainage is slow to very slow. The native vegetation on these soils consists of water-tolerant weeds and tall grasses.

Included in this complex, but making up less than 10 percent of the total acreage, are small areas of Pratt fine sandy loam on slopes of 0 to 3 percent and of Mansker loam on slopes of 0 to 3 percent.

About 75 percent of this soil complex is cultivated. The rest is in pastures of bluestem, grama, and dropseed grasses, with some water-tolerant grasses in the low spots.

**Hollister clay loam, 0 to 1 percent slopes.**—This soil belongs to the Reddish Chestnut great soil group, and

it is associated with the St. Paul silt loams. It occurs in the northern part of the county on nearly level to slightly concave areas in the uplands. The areas are subject to erosion.

This soil has formed in compact, calcareous clay or silty clay of the Whitehorse group of the Permian age. It is reddish below depths of 6 to 10 feet. It is more compact and clayey than the St. Paul soils because the parent material contained more clay. The total acreage of this inextensive soil is small compared to that of the St. Paul soils.

The following profile of Hollister clay loam, 0 to 1 percent slopes (slopes predominantly about  $\frac{1}{2}$  percent), was observed 6 miles east and 7 miles north of Buffalo  $N\frac{1}{2}NE\frac{1}{4}SE\frac{1}{4}SW\frac{1}{4}$  sec. 31, T. 29 N., R. 21 W.):

- A<sub>1p</sub> 0 to 7 inches, dark grayish-brown (10YR 4/2, dry; 3/2, moist) clay loam; weak, granular structure (largely destroyed by tillage); friable; noncalcareous; gradual lower boundary.
- A<sub>1c</sub> 7 to 15 inches, dark grayish-brown (10YR 3.5/2, dry; 2.5/2, moist) silty clay loam; moderate to strong, medium and coarse, granular structure; friable when moist, hard when dry; noncalcareous; a gradual, 3-inch lower boundary.
- B<sub>21</sub> 15 to 21 inches, dark grayish-brown (10YR 2.5/2, moist) silty clay; moderate, medium, irregular blocky structure with distinct clay skins; very firm when moist, very hard when dry; few visible pores; slowly to very slowly permeable; noncalcareous; gradual lower boundary.
- B<sub>22</sub> 21 to 30 inches, dark-gray (10YR 4/1, dry; 3/1.5, moist) silty clay; calcareous; in other characteristics this layer is similar to the B<sub>21</sub> horizon; very gradual lower boundary.
- B<sub>3ca</sub> 30 to 42 inches+, gray (10YR 4/1, dry; 4/1.5, moist) silty clay; weak, coarse, blocky structure with some clay skins; very firm and compact; calcareous with a few, fine concretions of calcium carbonate.

In cultivated areas there is a layer at a depth of about 6 inches that has a thick platy structure. This is the result of packing by tillage implements. Most of the plant roots extend horizontally above this compacted zone.

The thickness of the combined A horizons ranges from 12 to 18 inches, and the texture ranges from clay loam to light silty clay loam. The texture of the B<sub>21</sub> and B<sub>22</sub> horizons ranges from clay to silty clay, the content of clay being generally between 40 and 45 percent. Below a depth of 5 feet, the soil is brown to reddish brown.

Because the areas are nearly level to slightly concave, surface runoff is slow. Internal drainage is slow to very slow. The original vegetation consisted mostly of grama grasses.

More than 90 percent of this soil is used for cultivated crops, mainly for wheat. The rest is used mostly for pasture of buffalograss and blue grama.

**Hollister clay loam, 1 to 3 percent slopes.**—The profile of this soil is similar to that described for Hollister clay loam, 0 to 1 percent slopes. A representative profile can be examined at a site 7 miles north and 6 miles east of Buffalo (about 0.45 mile west and 0.45 mile north of the SE corner of sec. 31, T. 29 N., R. 21 W.).

This soil occurs on gentle slopes around the edges of Hollister clay loam, 0 to 1 percent slopes. The slopes are generally not more than 2 percent. Surface drainage is medium. In most places the combined A horizons are only 8 to 12 inches thick, as compared to about 15 inches

in Hollister clay loam, 0 to 1 percent slopes. Most of this soil is used to grow wheat.

**Las Animas soils.**—These very young Alluvial soils occur mostly on flood plains and are subject to occasional overflow. A high water table, at depths of 3 to 10 feet, favors the growth of grass.

Most of these soils are south of the Cimarron River in the northwestern part of the county and south of the North Canadian River near Laverne. The areas are nearly level but contain slight depressions and low hummocks formed by wind. Most of the alluvial sediments were derived from the mantle of moderately sandy materials of the Tertiary age that lies to the west of Harper County. Sediments of clay were of only subsidiary importance in the formation of these soils.

Although the profile of these soils differs from place to place, it is somewhat similar to that described for Las Animas soils, shallow over clay. The following profile of the Las Animas soils was observed 2 miles northeast of Laverne ( $N\frac{1}{2}$  sec. 15, T. 26 N., R. 25 W.):

The surface soil consists of weakly calcareous, grayish-brown to brownish-gray fine sandy loam that, in many places, is thinly stratified, at depths between 12 and 20 inches, with material that contains more sand or clay. Below this material is pale-brown to yellowish-brown fine sandy loam that is thinly stratified with light clay loam and is somewhat mottled with strong brown. Alluvial sediments extend to depths of many feet.

The texture of the surface layer ranges from loamy fine sand to clay loam, and the color ranges from very dark grayish brown to brown. Pale-brown spots that are slightly crusted occur in the more saline areas. In places thin bands of clay or clay loam occur throughout the profile, but in only a few places are they thick enough to affect the permeability and internal drainage of these soils. If a section of soil to a depth of 3 feet is removed and mixed together, the texture generally will be fine sandy loam or very fine sandy loam. In many level areas the profile is made up of a succession of bands of sandy loam and clay loam, the bands of sandy loam outnumbering those of clay loam by 2 to 1.

These soils occur on level flood plains marked with slight depressions and low hummocks. Surface runoff is slow. Internal drainage is generally slow but varies according to the presence or absence of bands of clay loam and clay. Typically, these soils are weakly saline, but the salts have only a slight influence on the vegetation. Only a few crusted spots are devoid of vegetation. Inland saltgrass, alkali sacaton, and bottom-land switchgrass comprise the dominant vegetation, but grama grasses and buffalograss grow to some extent on the drier hummocks.

Nearly all the areas are in pasture. The forage provides winter grazing for cattle.

**Las Animas soils, shallow over clay.**—Most of these young alluvial soils occur in a valley southeast of Rosston. They are not widely distributed, but small areas occur within larger areas of the Las Animas soils. A high water table, at depths of 3 to 10 feet, provides enough moisture in the subsoil to support a thick stand of grass. Most of the alluvial sediments were derived from the mantle of moderately sandy materials of the Tertiary age that lies to the west of Harper County. There is a large amount of clay throughout the profile.

The characteristics of the profile vary from place to place, but in areas that might be considered typical, these soils have the following characteristics: The uppermost layers consist of grayish-brown or brownish-gray fine sandy loam that is somewhat stratified with clay loam and loamy sand to depths between 20 and 30 inches; below depths of 12 to 18 inches, the soil is not so dark and is slightly mottled with strong brown. Below this and continuing to depths of 48 to 60 inches is gray to grayish-brown clay mottled with strong brown. This material is underlain by stratified sandy loam, clay loam, and clay.

The following is a typical profile, observed 1 mile east of Rosston, near United States Highway 64 (NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 20, T. 27 N., R. 25 W.):

- A<sub>1</sub> 0 to 19 inches, light yellowish-brown (10YR 7/4, dry; 6/4, moist) and light brownish-gray (10YR 7/2, dry; 6/2, moist), stratified very fine sandy loam containing thin lenses of clay loam and loamy sand; weak, medium, granular structure; nonsticky; neutral to weakly calcareous; the uppermost 2 inches is lighter colored; single grain (structureless) and slightly crusted at the surface; abrupt lower boundary.
- A<sub>b</sub> 19 to 27 inches, dark grayish-brown (10YR 4/2, dry; 3/2, moist) very fine sandy loam; weak, medium, granular structure; nonsticky; weakly calcareous; a 2-inch, clear lower boundary of thinly stratified light clay and fine sandy loam.
- C<sub>a</sub> 27 to 67 inches, grayish-brown to light brownish-gray (2.5Y 5/2 and 6/2) silty clay with a few thin bands of loamy materials; massive (structureless); very sticky when wet, very hard when dry; calcareous; between depths of 37 and 52 inches are many soft concretions of calcium carbonate; abrupt or clear lower boundary.
- C<sub>i</sub> 67 to 80 inches+, light brownish-gray to pale-yellow (2.5Y 6/2 and 7/2) very fine sand; single grain (structureless); nonsticky; noncalcareous; at the time of sampling, water table was at a depth of about 70 inches.

The combined thickness of the A<sub>1</sub> and A<sub>b</sub> horizons over silty clay is as much as 50 inches, but in places the silty clay occurs at the surface. The texture of the A<sub>1</sub> and A<sub>b</sub> horizons ranges from sand to clay loam. In places the sands have been reworked by wind and low hummocks have formed.

Surface runoff is slow, and, because of the clay in the substratum, internal drainage is very slow. The vegetation consists of inland saltgrass, alkali sacaton, and bottom-land switchgrass. On some of the low hummocks are blue grama, side-oats grama, and patches of buffalo-grass. In places there is an inconspicuous accumulation of salts, and the general vegetation indicates that the soil is slightly saline. Only a few crusted areas are devoid of vegetation.

Nearly all of the areas are used for pastures. The pastures are especially favorable for winter grazing.

**Lincoln soils.**—These soils belong to the Alluvial great soil group. They are mainly on bottom lands along the North Canadian and Cimarron Rivers and are subject to occasional overflow. Relief is level to slightly hummocky. The soils are forming in mixed alluvium derived mostly from sediments of the Tertiary age that mantled the High Plains to the west of Harper County. The areas are unstable, and they receive additional deposits of sand during floods. As a result, the profile of these soils varies greatly from place to place.

The Lincoln soils differ from the Las Animas soils in

being less stable, more sandy, and not so effectively sub-irrigated. The subsoil is sandy throughout and lacks an appreciable amount of mottling.

The following profile of a Lincoln sandy loam was observed 1 mile south and 2 miles east of Laverne (NW $\frac{1}{4}$  sec. 31, T. 26 N., R. 24 W.):

- 0 to 18 inches, brown (10YR 5/3) fine sandy loam containing lenses of sand; weak, granular structure; very friable; calcareous; permeable; abrupt lower boundary (stratified materials).
- 18 to 45 inches, very pale brown (10YR 7/4) fine sand that is stratified with loamy sand and sandy loam; very friable; calcareous; rapidly permeable.

The degree of stratification varies greatly, and it is difficult to locate two profiles that are just alike. The texture of the surface layer ranges from fine sand to clay loam. In general, the finer materials are darker. In swales, the profile contains bands of dark-colored clay loam, but generally these bands are not extensive.

Water moves downward through these soils at a rapid rate, especially in the areas in the western part of the county. Coarse grasses, scattered cottonwoods, and some sandplum and other brush comprise the natural vegetation.

These soils are used primarily for pasture. A moderate amount of forage is produced, but not so much as on the Las Animas soils.

**Loamy alluvial land.**—This miscellaneous land type is made up of dissected, somewhat unstable bottom lands. It lies adjacent to narrow creeks that drain soils that are mainly in areas of redbeds. Loamy alluvial land is flooded often enough so that the soil is altered through scouring and filling; as a consequence, farming is hazardous.

The characteristics of the profile are variable. The sediments vary considerably in texture but are dominantly loamy. A profile of this land type can be observed along a creek  $5\frac{1}{2}$  miles south of Selman (NW $\frac{1}{4}$  sec. 20, T. 26 N., R. 21 W.).

In many places the surface layer consists of brownish, calcareous fine sandy loam and is underlain by a reddish, moderately sandy subsoil. This material is stratified with loam, clay loam, and a few seams of clay. In places the subsoil is very sandy. The color of the soil material ranges from grayish brown to reddish brown, depending on the kind of material from which the sediments were derived. Most of the sediments have been deposited or shifted within the past 50 years. Although the material, to a depth of 12 inches, is slightly darkened, there is no distinct A<sub>1</sub> horizon.

The natural vegetation consists of weeds and native tall and mid grasses and an overstory of scattered cottonwoods and various woody shrubs. Little, if any, of this land type is suited to cultivation, and practically none of it is used for crops.

**Mansic clay loam, 0 to 1 percent slopes.**—This moderately dark, nearly level, calcareous soil belongs to the Chestnut great soil group. It occurs on relatively smooth, well-drained areas of the uplands in the western part of Harper County, adjacent to well-developed soils of the Dalhart and Richfield series. The areas are subject to inwash. The soil has formed in sediments deposited during the Tertiary age. These sediments were derived from the Ogallala formation of the High Plains.

This soil is similar to the Mansker soils, but it has a weakly developed, inconspicuous  $C_{ca}$  horizon that contains less than 10 percent, or generally about 5 percent, of whitish free calcium carbonate. In addition, this soil holds more water than the Mansker and is less susceptible to wind erosion.

The following profile of Mansic clay loam, 0 to 1 percent slopes, was observed 4 miles northwest of Rosston ( $S\frac{1}{2}NE\frac{1}{4}SW\frac{1}{4}$  sec. 35, T. 28 N., R. 25 W.):

- $A_{11}$  0 to 15 inches, grayish-brown (10YR 4/2, dry; 3/2, moist) clay loam; strong, fine and medium, granular structure containing many worm casts and relatively fragile granules; also coarse prismatic when dry; friable; porous and permeable; strongly calcareous; very gradual lower boundary.
- $A_{12}$  15 to 20 inches, transitional layer of material containing intermingled nests of worm casts; material is similar to that in  $A_{11}$  and  $AC_{ca}$  horizons; weak films of segregated calcium carbonate in lower part of layer; gradual lower boundary.
- $AC_{ca}$  20 to 30 inches, brown (10YR 5/3, dry; 4/3, moist) clay loam containing films of calcium carbonate; 3 percent of material consists of friable, whitish concretions of segregated calcium carbonate; compound structure—weak, prismatic and subangular blocky; no clay skins observed; friable; fine pores and open rootlet channels; strongly calcareous; very gradual, uneven lower boundary.
- $C_{ca}$  30 to 60 inches, pale-brown (10YR 6/3, dry; 5/3 moist) clay loam containing a few friable concretions of lime; massive (structureless); friable; porous and relatively permeable; strongly calcareous; gradual lower boundary.
- C 60 inches+, pale-brown clay loam that is weakly stratified with slightly more sandy or clayey materials; soil materials unconsolidated, and bedding planes very obscure.

The combined thickness of the  $A_{11}$  and  $A_{12}$  horizons ranges from 12 to 24 inches. Depth to segregated calcium carbonate ranges from 10 to 20 inches. In some places the amount of calcium carbonate is scarcely detectable, but in others it makes up as much as 10 percent of the soil. In areas that are transitional to areas of Richfield and Dalhart soils, the soil may be noncalcareous to a depth of several inches. The substratum is considerably stratified, varies in color, and contains a detectable amount of sand; the predominant texture is clay loam.

Mapped with this soil are many small areas of Mansker soils. These included areas have distinct accumulations of lime.

This soil is well drained, and the lower part of the profile is seldom, if ever, wet. The original vegetation consisted mostly of side-oats grama and bluegrass but to some extent of Torreys beardgrass and little bluestem. Most of this soil is used to grow wheat.

**Mansic clay loam, 1 to 3 percent slopes.**—This soil is somewhat similar to Mansic clay loam, 0 to 1 percent slopes. A typical area is 2 miles west and 3 miles north of Rosston ( $SE\frac{1}{4}SW\frac{1}{4}SE\frac{1}{4}$  sec. 35, T. 28 N., R. 26 W.).

This gently sloping soil differs from Mansic clay loam, 0 to 1 percent slopes, in the following ways: (1) The slopes are more convex, and there are a number of slightly lighter colored spots, particularly on low knobs; (2) the average depth to accumulations of calcium carbonate is less; (3) some areas contain a greater number of inclusions of the more limy Mansker soils; and (4) more of the surface water runs off, and so there is less moisture in the soil during the season when wheat is being grown.

Most of this soil is used for crops. Wheat is the main crop grown.

**Mansic clay loam, 3 to 5 percent slopes.**—This soil is similar to Mansic clay loam, 0 to 1 percent slopes. A typical area is 4 miles east and 2 miles north of Rosston ( $N\frac{1}{2}SW\frac{1}{4}SE\frac{1}{4}$  sec. 1, T. 27 N., R. 25 W.).

This soil differs from Mansic clay loam, 0 to 1 percent slopes, in the following ways: (1) The soil is slightly less dark, and the surface is marked with lighter colored spots that occupy low knolls; (2) the surface is somewhat uneven; and (3) the soil generally has slopes of about 4 percent, but there are many short, steeper slopes.

Many areas of this soil have been damaged appreciably through erosion, and the depth to the zone containing free carbonates may be as little as 10 inches. Mapped with this soil are small areas of Mansker soils, which have a limy subsoil.

Most of this soil is under cultivation and is used mainly to grow wheat. Yields are somewhat lower than those obtained on Mansic clay loam, 1 to 3 percent slopes. They are considerably lower than those obtained on Mansic clay loam, 0 to 1 percent slopes.

**Mansker loam, 1 to 3 percent slopes.**—This strongly calcareous, moderately deep soil occurs in the western part of Harper County in association with the Dalhart, Richfield, Potter, and Pratt soils. It is in the zone of Reddish Chestnut soils but is a member of the Calcisol great soil group.

This soil has formed in strongly calcareous, medium- and fine-textured sediments of the rolling, dissected High Plains, the eastern margin of which extends into Harper County. The areas are gently sloping, but there are a few low knobs that are mostly irregular. The surface is mainly convex, but a few concave swales occur.

Most of the sediments have been stripped from the underlying redbeds, and in many areas the lower part of the substratum is sandstone. In some of these areas, this soil is transitional to the Woodward soils.

The following is a typical profile of Mansker loam, 1 to 3 percent slopes, observed 6 miles north and 4 miles east of Laverne ( $NE\frac{1}{4}NE\frac{1}{4}$  sec. 30, T. 27 N., R. 24 W.):

- $A_{1p}$  and  $A_1$  0 to 6 inches, brown (10YR 4/3, dry; 3/3, moist) heavy loam; moderate, medium to fine, granular structure; friable when moist, slightly sticky when wet; when dry, the fine granules tend to be discrete and have little cohesion; calcareous; permeable; gradual lower boundary.
- AC 6 to 13 inches, yellowish-brown (10YR 4/4, dry; 3/4, moist) clay loam; strong, medium, granular structure; firm or crumbly when moist, sticky when wet; calcareous; many pores and wormholes; gradual lower boundary.
- $C_{ca}$  13 to 40 inches+, reddish-brown (5YR 5/4, dry; 4/4, moist) clay loam containing seams and streaks of very pale brown (10YR 7/3) chalky loam that is almost pure calcium carbonate; at a depth of 24 inches the lime comprises about 10 percent of the soil mass, and at a depth of 36 inches it comprises about 30 percent; below a depth of 40 inches the amount of free lime decreases somewhat, and it occurs as streaks or thin lenses along bedding planes and former channels of roots.

In thickness, the  $A_{1p}$  and  $A_1$  horizon ranges from 6 to 8 inches, the AC horizon ranges from 6 to 12 inches, and the  $C_{ca}$  horizon ranges from 20 to 30 or more inches.

The texture of the  $A_{1p}$  and  $A_1$  horizon ranges from heavy fine sandy loam to clay loam. In places the C horizon is pale brown or brown. The depth to the accumulation of lime ranges from 10 to 20 inches. The amount of free lime in the  $C_{ca}$  horizon ranges from about 5 percent, in areas near those of Mansic soils, to 30 or more percent. In some areas, especially those that are transitional to areas of Potter soils, the  $C_{ca}$  horizon may have hardened into caliche. In places, scattered pebbles of caliche occur on the surface. Where this soil has formed on truncated sediments that are just above the underlying redbeds, there are some pebbles of quartzite and granite.

Surface runoff is medium, except in areas of a few narrow valleys, where it is slow. Internal drainage is medium and permeability is moderate. The subsoil is drained more thoroughly than desirable, however, and it has a lower water-holding capacity than the surface soil. The native vegetation consists mostly of grama grasses and buffalograss. Little bluestem grows in areas that have been grazed lightly.

This soil is used mainly to grow wheat. Some areas are included in extensive ranches in the western part of the county and are used for grazing. These lie along the margin between the dissected High Plains and areas of material deposited in the Tertiary age.

**Mansker loam, 3 to 5 percent slopes.**—This soil is similar to Mansker loam, 1 to 3 percent slopes. A typical area is 4 miles north and 6 miles east of Rosston (NW $\frac{1}{4}$  NW $\frac{1}{4}$  sec 32, T. 28 N., R. 24 W.).

This soil differs mainly from Mansker loam, 1 to 3 percent slopes, in that it occurs on more uneven slopes that are more convex but that have no regular pattern. Generally, the depth to the limy layer is probably less than 15 inches, but in some places scattered pebbles of caliche are on the surface.

At the crests of many of the low knobs are whitish spots where limy material is exposed. A moderate amount of Potter gravelly loam (too small to be mapped separately) occurs mostly in these whitish spots and on the short, steep slopes. Also, mapped with this soil are spots of Mansic soils that lack a definite layer of lime; these spots are less extensive in this soil than in Mansker loam, 1 to 3 percent slopes.

Because of the degree of slope and the low water-holding capacity of the subsoil, much water runs off both cultivated areas and pastures. The amount of moisture in the subsoil is seldom at field capacity.

About two-thirds of this soil is cultivated. Wheat is the main crop grown.

**Mansker-Potter complex, 3 to 5 percent slopes.**—This mapping unit consists of moderately deep, calcareous Mansker soil and of shallow Potter soil. The areas are so intricately associated and the terrain so uneven that it was not feasible to map the two soils separately. The Mansker soil belongs to the Calcisol great soil group, and the Potter soil, to the Lithosol great soil group.

These soils have gently wavy relief. The areas of Mansker soil (which include some Mansic soils) occur in valleys. The Potter soil, which is loam or clay loam in texture, occurs on low, rounded knobs and on short, convex slopes of 3 to 6 percent. It makes up between 5 and 25 percent of each area. In addition to being associated with the Mansker soils, the Potter soil occurs in association with Mansic soils and lies within larger

areas of Richfield and Dalhart soils in the western part of the county.

The Mansker soil is similar to Mansker loam, 1 to 3 percent slopes. The following is a profile of a Potter loam, observed 3 miles east and 3 miles north of Rosston (NE $\frac{1}{4}$  sec. 3, T. 27 N., R. 25 W.):

- A<sub>1</sub> 0 to 6 inches, grayish-brown (10YR 5/2, dry; 4/2, moist) loam; weak, medium, granular structure; friable; calcareous; porous and permeable; gradual lower boundary.
- AC 6 to 10 inches, grayish-brown (10YR 5/2) clay loam containing a few chips and a few subangular pebbles of caliche; moderate, medium, granular structure; firm; calcareous; gradual lower boundary.
- C 10 inches+, nearly white, hardened caliche that is 24 or more inches thick.

The texture of the  $A_1$  horizon ranges from loam to clay loam; in places there are a few pebbles of caliche or other material. The depth to the C horizon ranges from a few inches to about 15 inches. In places the C horizon consists of soft, chalky material. An excessive amount of water runs off the Potter soil.

The dominant vegetation on the soils of this complex is grama grasses and buffalograss. Most of the areas are used for range.

**Mansker-Potter complex, 5 to 20 percent slopes.**—This mapping unit is similar to Mansker-Potter complex, 3 to 5 percent slopes. A typical area lies 8 miles northeast of Rosston (S $\frac{1}{2}$  sec. 5, T. 27 N., R. 24 W.).

This complex differs principally from Mansker-Potter complex, 3 to 5 percent slopes, in that it occurs on stronger slopes. The terrain is rather humpy. Low, rounded knobs occupied by Potter soil make up between 30 and 50 percent of some areas. The deeper Mansker soil occurs mostly on the lower parts of the landscape. The Mansker soil is not suitable for cultivation because the areas are dissected by the shallow Potter soil.

**Otero loamy sand.**—This soil is made up of deep, calcareous loamy sand and sand. It belongs to the Brown great soil group and is in the zone of Reddish Chestnut soils. Most of it occurs in the southwestern part of the county with the Mansker-Potter, Tivoli, and Dalhart soils. A wavy landscape of low dunes and intervening pockets is typical for this soil.

This soil has formed from a mixture of sandy outwash materials of the High Plains. These materials have been reworked by the wind. They were derived from calcareous sediments containing more feldspar and less quartz than those from which the Tivoli soils have formed.

The following is a typical profile of Otero loamy sand, observed 8 miles south of Laverne (NE $\frac{1}{4}$  sec. 32, T. 25 N., R. 25 W.):

- A<sub>1</sub> 0 to 5 inches, grayish-brown (10YR 5/2, dry; 4/2, moist) heavy loamy sand; weak, medium and fine, granular structure; very friable; calcareous; gradual lower boundary.
- AC 5 to 12 inches, pale-brown (10YR 6/3, dry; 5/3, moist) loamy fine sand; single grain; very friable; calcareous; rapidly permeable; gradual lower boundary.
- C 12 to 40 inches+, very pale brown (10YR 7/3, dry; 6/3, moist) medium sand; structureless; rapidly permeable; contains some coarse sand and many fine- to medium-sized pebbles,  $\frac{1}{4}$  to  $1\frac{1}{4}$  inches in diameter, that are mostly granite and quartzite.

The texture of the  $A_1$  horizon ranges from fine sandy loam to loamy sand; the texture of this layer is finest

in areas adjacent to Potter and Mansker soils. The thickness of the A<sub>1</sub> horizon ranges from 5 to 10 inches. The C horizon contains varying amounts of medium and coarse sand. In places concretions of calcium carbonate occur in the profile.

Both surface drainage and internal drainage are rapid. The vegetation consists mainly of grama grasses, sand dropseed, sand sagebrush, and varying amounts of yucca, tall grasses, and buffalograss. Only a small part of this soil is cultivated.

In most areas there are small spots of Potter soil. The Potter soil occurs on light-gray, limy knobs in places where the mantle of sand is thin.

**Pratt fine sandy loam, hummocky.**—This weakly developed soil is a member of the Reddish Chestnut great soil group. It has formed in sandy materials of the Late Pleistocene epoch. These materials were deposited and later reworked by wind. The soil is on an irregular, wavy plain, mainly north of the North Canadian and Cimarron Rivers. It occurs in association with the Mansker, Richfield, Dalhart, Dalhart-Carwile, and Tivoli soils and with the Pratt loamy fine sands.

The complex, eolian relief consists of low, wavy hummocks or dunes and of the lower spots between their crests. Most of the low spots are flat. They lack outlets and sufficient gradient for surface drainage. The dunes, or hummocks, are between 3 and 10 feet high. They are less than 200 feet across and have gradients of between 3 and 8 percent from the crest to the toe.

This soil has a weakly developed B horizon that contains less clay than that of the Dalhart soils with which it occurs in some places in the western part of the county. It is finer textured throughout than the Tivoli soils.

The following is a typical profile of Pratt fine sandy loam, hummocky, observed 5 miles east and 2 miles north of Rosston (E $\frac{1}{2}$ NW $\frac{1}{4}$  sec. 12, T. 27 N., R. 25 W.):

- A<sub>1</sub> 0 to 11 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) fine sandy loam; weak, medium, granular structure; friable; permeable; about neutral in reaction; gradual lower boundary.
- B<sub>2</sub> 11 to 26 inches, strong-brown (7.5YR 5/6, dry; 4.5/6, moist) fine sandy loam; weak, coarse, prismatic and weak, medium, granular structure; firm but crumbly when moist, hard when dry; noncalcareous; contains about 5 percent more clay than the A<sub>1</sub> horizon, according to field tests; gradual lower boundary.
- BC 26 to 45 inches, strong-brown (7.5YR 5/6, dry; 4.5/6, moist) fine sandy loam; weak, medium, granular structure; friable; slightly calcareous; permeable; contains about the same amount of clay as the A<sub>1</sub> horizon.

In the low places between the hummocks, the color of the soil ranges from dark brown to brown (10YR and 7.5YR hues) to depths of between 10 and 14 inches. In the spots at higher elevations the A<sub>1</sub> horizon is thinner, and in places that have been damaged more severely through wind erosion, the surface soil is light brown. The color of the B<sub>2</sub> horizon ranges from yellowish brown to strong brown. The reaction of the BC horizon ranges from slightly alkaline to weakly calcareous. In a few small areas, the soil is calcareous throughout the solum.

Surface runoff is medium, and internal drainage is medium to rapid. The vegetation consists of grama and dropseed grasses, and there are some tall grasses on sites that have not been grazed excessively. Sand sagebrush and yucca have invaded some areas.

About two-thirds of this soil is under cultivation. It is used mostly to grow grain sorghums and wheat.

**Pratt fine sandy loam, billowy.**—This soil is similar to Pratt fine sandy loam, hummocky. A typical area is 0.5 mile north of Rosston, or about 0.4 mile north and 0.15 mile west of SE $\frac{1}{4}$  sec. 18, T. 27 N., R. 25 W.

This slightly undulating soil differs from Pratt fine sandy loam, hummocky, in that it has milder slopes. It occurs on smoothly rounded rises that are less than 5 feet high. From the crest to the toe of the slopes, the gradient, in most places, is less than 3 percent. The slopes are generally more than 200 feet in length, or 400 feet from the crest of one slope to the crest of the next.

This soil occurs in long, narrow areas parallel to and well back from the larger streams. Medium-sized areas, totaling about 4,000 acres, occur on an alluvial terrace in which the alluvial soil materials have been modified by additions of windblown material. This terrace lies south of the North Canadian River, and near Laverne it is well above areas subject to overflow. Here, the terrain is also billowy and the soil profile is indistinguishable from that in larger areas that lie well back and mostly north of the river.

About four-fifths of this soil is cultivated. The rest is in pasture and range consisting mostly of grama and dropseed grasses and of tall grasses that grow in scattered clumps. Some sand sagebrush has invaded these areas, but it is not so serious a pest as on the Pratt loamy fine sands.

**Pratt loamy fine sand, billowy.**—In characteristics and distribution this soil is somewhat similar to Pratt fine sandy loam, hummocky, but it differs in the following ways: (1) It is coarser textured throughout; (2) the subsoil retains less moisture; and (3) the billowy to dune areas are more irregular and show the typical effects of sorting and reworking by wind.

This soil occurs mostly on the sandy plain north of Buffalo Creek and the Cimarron and North Canadian Rivers. Almost all of the areas lie between the sandier Tivoli soils, which border the northern sides of the major streams, and the Pratt fine sandy loams, which are farther back from the streams, near the place where the sandy plains come in contact with bedrock.

This soil occupies broad, irregular or wavy areas that have smoothly rounded rises. The rises are less than 5 feet high and have a gradient of less than 3 percent from crest to toe. Most of them are more than 200 feet in length, and the distance between one crest and the next is about 400 feet.

The soil material throughout the solum is finer textured than that of the associated Tivoli soils but is coarser textured than that of the Pratt fine sandy loams.

The following is a typical profile of Pratt loamy fine sand, billowy, observed 6 miles east of Laverne (SW $\frac{1}{4}$  NE $\frac{1}{4}$  sec. 28, T. 26 N., R. 24 W.):

- A<sub>1</sub> 0 to 8 inches, grayish-brown (10YR 5/2, dry; 4/2 moist) loamy fine sand; single grain (structureless); very friable; about neutral in reaction; gradual lower boundary.
- B<sub>2</sub> 8 to 25 inches, brownish-yellow (10YR 6/6, dry; 5/6, moist) loamy fine sand that is slightly stickier than material in the A<sub>1</sub> horizon; very friable when moist, slightly hard when dry; noncalcareous; gradual lower boundary.

BC 25 to 45 inches, yellow (10YR 8/6, dry; 7/6, moist) loamy fine sand; single grain (structureless); very friable; noncalcareous; rapidly permeable; material contains from 3 to 5 percent less clay than the B<sub>2</sub> horizon and does not become so hard when dry.

The thickness of the A<sub>1</sub> horizon ranges from 6 to 12 inches; this layer is thickest in the low spots of the landscape. The color of the A<sub>1</sub> horizon ranges from grayish brown to brown. In the B<sub>2</sub> horizon there is a narrow range in the content of clay, but in places the texture approaches fine sandy loam.

Surface drainage is medium, but an excessive amount of water drains down through the profile. The original vegetation consisted of tall and mid grasses. The present cover is made up mostly of grama and dropseed grasses and scattered clumps of tall grasses, but the areas are also infested with sand sagebrush.

Mapped with this soil are small, dune spots of Tivoli soils and low, enclosed depressions of Carwile soil. The boundaries separating this and other Pratt loamy fine sands from the Pratt fine sandy loams are diffuse, and mapping units of either of these soil types may contain inclusions of the other soil type.

About 30 percent of this soil is under cultivation. The crops are mainly grain sorghums and rye and other small grains.

**Pratt loamy fine sand, hummocky.**—This soil differs from Pratt loamy fine sand, billowy, mainly in having more uneven relief and generally stronger slopes. The areas are irregular or choppy and contain small dunes or hummocks that are from 5 to 14 feet high and have a gradient of 3 to 8 percent from crest to toe. The distance from one crest to the next is generally less than 200 feet. A typical area of this soil is in N $\frac{1}{2}$ SW $\frac{1}{4}$  sec. 21, T. 26 N., R. 24 W.

The areas of this soil that occur in swales have a darker surface layer than those on the hummocks. Fields of this soil contain more light-colored spots than fields of Pratt loamy fine sand, billowy. Wind erosion is generally active; in many blowout spots, light-brown or brownish-yellow subsoil is exposed. In places small areas of Dalhart-Carwile fine sandy loams occur in the narrow swales between the dunes.

This soil is used mainly for grazing, but some of it is used to grow crops.

**Pratt loamy fine sand, duned.**—This soil is similar to Pratt loamy fine sand, billowy, but it differs principally in relief. The areas contain dunes that are more than 14 feet high. The slopes have a gradient of more than 8 percent from crest to toe. A typical area is 3 miles east and 2 miles north of Laverne (SE $\frac{1}{4}$  sec. 12, T. 26 N., R. 25 W.). The areas lie between bands of Tivoli fine sand, which lie next to streams, and bands of Pratt loamy fine sand, which lie farther back from the streams. This soil is finer textured than Tivoli fine sand and has a somewhat darker, deeper A horizon that contains more organic matter.

Most of the areas are comprised of fairly steep dunes covered with sagebrush, tall grasses, and grama grasses. This soil probably is best used for grazing.

**Quinlan loam.**—This soil has formed on sandy, weakly consolidated Permian redbeds. It is a member of the Regosol great soil group but is in the zone of Reddish Chestnut soils. This soil is the shallow member of a

catena that consists of the Quinlan, Woodward, Carey, and St. Paul soils of the sandy and silty redbeds. The parent rock was silty or very fine grained sandstone, or packsand.

The largest areas of this soil are in the northern and eastern parts of the county. Much of this soil is on the rolling terrain just north of the sandy plain bordering the North Canadian River. A typical area is between 6 and 10 miles south of Buffalo, along United States Highway 183.

The relief is generally convex and strongly sloping. The prevailing slopes have a gradient of 5 to 20 percent, but slopes of 6 to 8 percent are most common. In a small acreage the slopes are less than 3 percent.

The following is a typical profile of Quinlan loam, observed 8 miles south and 6 miles east of Buffalo (E $\frac{1}{2}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 24, T. 26 N., R. 22 W.):

- A 0 to 6 inches, reddish-brown (5YR 5/4, dry; 4/4, moist) loam; moderate, medium, granular structure; friable when moist, nonsticky when wet; calcareous; gradual lower boundary.
- AC 6 to 10 inches, yellowish-red (5YR 5/5, dry; 4/5, moist) heavy loam containing slightly compacted seams of partly weathered sandstone; calcareous; gradual lower boundary.
- C 10 to 20 inches+, yellowish-red sandstone; slightly compacted; very fine grained; calcareous; the material in the upper part of this layer does not differ appreciably from that in the layer immediately above, and the exact depth to parent rock cannot be estimated closely; the material in the lower part of the layer is slightly more compact than that in the upper part.

The thickness of the A horizon ranges from 6 to 9 inches, and the color ranges from brown to reddish brown (7.5YR 4.5/3 to 5YR 5/4). The color of the AC horizon ranges from yellowish red to red, and the texture ranges from very fine sandy loam to silt loam. The depth to the unweathered, somewhat compact sediments of the Permian age ranges from about 8 to 24 inches, but it is generally about 18 inches.

An excessive amount of water runs off the surface. Internal drainage is medium, and the underlying sandstone has fair water-holding capacity. The original vegetation consisted of a mixture of tall and mid grasses, but the present cover is made up of grama grasses, dropseed grasses, buffalograss, and, in areas that have not been grazed excessively, scattered tall grasses.

In the western parts of many of the areas, the development of the soil has been influenced by remnants of gravelly basal deposits of the Tertiary age that have been truncated through erosion. Here, the soil is somewhat similar to the Potter and Mansker soils. In a few areas on outcrops of the Dog Creek formation, which is made up of the most clayey rocks in the county, are shallow to moderately deep, calcareous clay loams. These soils are similar to soils of the Weymouth series, which are not mapped separately in Harper County. In these areas the soil lacks the distinct C<sub>ea</sub> horizon of the Weymouth soils. Spots of Woodward soils, which have a thicker A horizon and a depth of more than 20 inches to the rock, comprise as much as 5 percent of this mapping unit. A few small canyonlike areas of Rough broken land, Quinlan material, are mapped as Quinlan loam.

Quinlan loam is used principally for grazing.

**Quinlan loam, severely eroded.**—This soil is somewhat similar to Quinlan loam. A typical area is 10 miles north

of Selman (SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 32, T. 29 N., R. 21 W.).

This soil has been damaged severely through erosion, and it is no longer cultivated. Most of the dark, loamy surface soil has been washed away, and most of the areas have been dissected by shallow gullies. Generally, only 6 to 8 inches of weathered, slightly darkened soil material overlies the compacted bedrock. In many places unweathered loamy redbeds are exposed.

Mapped with this soil are small areas of a severely eroded, moderately clayey soil that overlies the Dog Creek formation, which outcrops near the head of Buffalo Creek. Also mapped with this soil are small areas of Woodward soil.

This soil generally supports some grasses, and almost all of it is used as range. Revegetation is needed on some areas. This soil never was well suited to cultivation, and it now is completely unsuitable for crops.

**Quinlan-Woodward complex, 5 to 12 percent slopes.**—The soils of this complex are similar to Quinlan loam and Woodward loam, 1 to 3 percent slopes. A typical area occurs 10 miles south and 3 miles east of Selman (NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 11, T. 25 N., R. 21 W.).

These soils were mapped as a complex because the areas were too small and too intricately associated to be mapped separately. The shallow Quinlan soil makes up between 50 and 85 percent of the acreage, or generally about 70 percent. Most of this soil occurs on knobs on the steeper slopes. The deeper Woodward soil occurs on moderately convex slopes and on concave foot slopes. In contrast to Woodward-Quinlan loams, 3 to 8 percent slopes, this mapping unit contains a greater proportion of the shallow Quinlan soil than of the deeper Woodward soil.

The soils of this complex are unsuited to cultivation and are used as range. The cover of grasses varies greatly, but it consists mostly of buffalograss, grama grasses, and dropseed grasses. Some tall grasses grow in the areas that have been moderately grazed. Originally, the tall grasses were dominant, but now they are most prevalent in the fence rows.

**Randall clay.**—This soil belongs to the Grumusol great soil group but is in the zone of Reddish Chestnut soils. It has formed in shallow playa lakes from materials washed down from areas of Richfield, Mansker, St. Paul, and Mansic soils. The kinds of sediments deposited vary from lake to lake and even in different parts of the same lake. This clayey soil is wet during years of heavy rainfall, but it is dry during prolonged droughts.

This soil occurs mainly north of the North Canadian River in the western part of the county, but a few areas are on the redbed plain north of Buffalo. Most of it lies in depressions that are as much as 4 feet lower than the surrounding areas.

The following is a description of a typical profile of Randall clay, observed 5 miles north and 3 miles west of Rosston (NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 27, T. 28 N., R. 26 W.).

A<sub>1</sub> 0 to 8 inches, dark-gray (10YR 4/1, dry; 3/1, moist) clay; weak, fine, subangular blocky structure to massive (structureless); very firm when moist, very sticky when wet, and very hard when dry; calcareous; when surface dries out, the uppermost 1 inch of this layer tends to form a mulch; very gradual lower boundary.

AC 8 to 30 inches, very dark gray (10YR 4/1, dry; 3/1, moist) clay; nearly massive (structureless); sticky when wet, very hard when dry; calcareous; very gradual lower boundary.

C 30 to 45 inches+, dark grayish-brown (10YR 4/2, dry; 3/2, moist) clay much like the material in the AC horizon.

The texture, color, and thickness of the horizons vary greatly according to the soil from which the alluvial material was derived. The texture ranges from clay to clay loam, and the color ranges from very dark gray (10YR 3/1) to brown (7.5YR 5/4). In places, where the alluvial sediments have been influenced by deposits of the Permian age, the soil has brown hues. The thickness of the A<sub>1</sub> horizon ranges from 6 to 12 inches, and the thickness of the AC horizon ranges from 12 to 24 inches.

The playa lakes have no outlet for surface drainage, and they remain ponded for long periods. Only a small amount of water moves downward through the clay, and most of it remains on the surface until it evaporates. During wet years the vegetation consists of western wheatgrass and smartweed. Other weeds encroach as the soil dries out.

The areas of this soil are either idle or in pasture. The pastures produce little forage.

**Richfield clay loam.**—This is a typical member of the Chestnut great soil group. It has formed in fine-textured, limy sediments laid down on the High Plains in the Tertiary age. These sediments, which occur along the dissected eastern margin of the High Plains, were probably reworked during later periods and laid down as outwash plains or lakebeds. Many areas probably had a mantle of loess similar to that deposited on the flat, undissected plains to the west of the county.

This soil is in the western part of Harper County and is mostly north of the North Canadian River. It occurs farther east than the other Richfield soils, which are mainly on the High Plains to the west of Harper County. This upland soil occurs in association with the Mansker, Mansic, Dalhart, and Randall soils. It occupies smooth slopes, mostly in areas that have a gradient of less than 1 percent.

The profile of this soil is well developed, and the soil has been leached of lime to depths between 15 and 20 inches. Accumulations of calcium carbonate occur below a depth of about 30 inches. In Harper County, this soil has a surface layer that is in the darker part of the color range for the Richfield series.

The following is a typical profile of Richfield clay loam, observed 3 miles north and 2 miles west of Rosston and one-fourth mile east of the SW corner sec. 35, T. 28 N., R. 26 W.:

A<sub>1</sub> 0 to 9 inches, dark grayish-brown (10YR 4/2, dry; 3/2, moist) light clay loam or heavy silt loam; weak, granular structure in disturbed layer to a depth of 6 inches; moderate, medium, granular structure in lower part of layer; friable; noncalcareous; about neutral in reaction; gradual lower boundary.

B<sub>2</sub> 9 to 15 inches, dark grayish-brown (10YR 4/2, dry; 3/2, moist) heavy clay loam with the content of clay estimated at 35 percent; moderate to strong, medium, subangular blocky structure with continuous clay skins that are readily apparent but not pronounced; firm; noncalcareous; gradual lower boundary.

B<sub>ca</sub> 15 to 30 inches, grayish-brown (10YR 5/2, dry; 4/2, moist) heavy clay loam; moderate, medium, blocky

structure; firm; calcareous and contains threads and a few soft concretions of segregated calcium carbonate; very gradual lower boundary.

C<sub>ca</sub> 30 to 40 inches+, pale-brown (10YR 6/3, dry; 5/3, moist) clay loam; weak, medium or coarse, blocky structure that is transitional, with increasing depth, to massive, porous material; moderately friable; calcareous, with films and a few friable concretions of segregated calcium carbonate.

The texture of the A<sub>1</sub> horizon varies. In some places it is clay loam, and in others it is silt loam, loam, or silty clay loam. In color, the A<sub>1</sub> horizon ranges from dark grayish brown to grayish brown, and in thickness, from 7 to 10 inches. The texture of the B<sub>2</sub> horizon is generally heavy clay loam, but in some areas it is a light clay. In areas where the subsoil contains more clay than normal, the A<sub>1</sub> horizon is generally thin.

Both surface drainage and internal drainage are slow, and moisture is about optimum for growing wheat in this area. The native vegetation consisted mostly of mid grasses. Most of the pastures now contain a large amount of buffalograss.

Mapped with this soil are a few, brown, calcareous spots, which are similar to areas of Mansic soils, and small spots of the somewhat sandier, brown Dalhart soils. Small areas of the more clayey Randall soil occur in some of the low spots.

About nine-tenths of this soil is used to grow wheat. Some of it is pastured, but most of the pastures are small.

**Richfield complex.**—This soil complex is made up of approximately 65 percent Richfield soil, 20 percent Mansic soil, 14 percent Dalhart soil, and 1 percent Randall soil. In each area, however, the proportion of the individual soils varies considerably. The percentage of Mansic and Dalhart soils is greatest in the more undulating areas.

The soils of this complex are similar to Richfield clay loam, the Mansic clay loams, the Dalhart fine sandy loams, and Randall clay. A typical area of this soil complex is 4½ miles north and 1 mile west of Rosston (S½NW¼ sec. 25, T. 28 N., R. 26 W.).

The Richfield soil occurs in level areas, and the Mansic and Dalhart soils are on intermingled, low, subdued knolls or rises. A few, very shallow swales, 1/10 of an acre to 5 acres in extent, are occupied by Randall soil.

Most of this complex is used for cultivated crops, and wheat is the principal crop grown. A few areas are in native pasture consisting mostly of grama grasses and buffalograss. Although the relief is generally level, most of the areas are modified by undulations or low knolls. As a result, it is not practical to till on the contour.

**Rough broken land, Quinlan material.**—This miscellaneous land type occurs in rough canyonlike areas and along the faces of escarpments. It occupies areas of redbeds consisting of slightly compacted sandstone and silty rock. The dominant slopes are steep, and the soil material is mostly very shallow; some of the foot slopes and narrow divides have milder slopes, and on these the layer of soil material is thicker. An area of this land type can be observed in the N½NW¼ sec. 34, T. 25 N., R. 20 W.

The Quinlan soil material is between 10 and 20 inches thick over compacted sandstone. Mapped with this land type are moderately deep Woodward soils on the foot slopes and Loamy alluvial land on the narrow areas at

the bottoms of canyons. The soil materials are similar to those of the Quinlan loams, the Woodward loams, and Loamy alluvial land. About 25 percent of most of the areas consists of barren, exposed, unweathered rock lying on steep slopes that are actively eroding. Except for the areas that are actively eroding, most areas have a fair cover of grass.

**St. Paul silt loam, 0 to 1 percent slopes.**—This soil belongs to the Reddish Chestnut great soil group. It is the most nearly level, darkest colored member of a catena that occurs on loamy redbeds. In order of increasing degree of slope and increasing loss of moisture through runoff, the soils of the catena rank as follows: St. Paul, Carey, Woodward, Quinlan.

The St. Paul soil occurs on nearly level uplands on an erratic, discontinuous, partly obscured mantle of somewhat reddish silty loess deposited during the Pleistocene epoch. Mineralogically, these deposits resemble the residuum from the underlying rock. In some areas the soil has formed from loess, and in others it has formed from residuum from the underlying rock. In mapping, it is difficult to differentiate between areas of the soil formed from the two different kinds of parent material.

This soil is on the smoothest parts of the redbeds that extend northward from the valley of Buffalo Creek. One area lies close to the valley of the Cimarron River in the northern part of the county. The soil is generally nearly level (slopes between ½ and 1 percent and the slopes weakly convex).

The A horizons and the upper part of the B horizon are darker and less reddish in this soil than in the Carey soils. As mapped in Harper County, the subsoil of this soil seems to include all of the textural variations that are allowable for a soil series.

A profile of St. Paul silt loam, 0 to 1 percent slopes, located 8 miles north and 2 miles east of Buffalo and 0.4 mile south of the NE corner sec. 32, T. 29 N., R. 22 W., is described as follows:

- A<sub>1p</sub> 0 to 7 inches, brown (7.5YR 5/2, dry; 3/2, moist) heavy silt loam; weak, medium, granular structure; friable; noncalcareous; abrupt lower boundary.
- A<sub>1</sub> 7 to 18 inches, dark-brown (7.5YR 4/2, dry; 2.5/2, moist) heavy silt loam or light silty clay loam; strong, medium, granular structure; friable; about neutral in reaction; gradual lower boundary.
- B<sub>21</sub> 18 to 26 inches, brown (7.5YR 4/4, dry; 3/4, moist) medium silty clay loam; strong, medium, subangular blocky structure; weak clay skins on peds; moderately firm; many fine pores and open channels of rootlets; noncalcareous; gradual lower boundary.
- B<sub>ca</sub> 26 to 33 inches+, brown (7.5YR 5/4, dry; 4/4, moist) medium silty clay loam; moderate, medium to coarse, subangular blocky structure; firm; calcareous; contains films and fine concretions of segregated calcium carbonate; lower part of layer is slightly more reddish and may be made up of weathered silty material of the Whitehorse group, which consists dominantly of soft, very fine grained sandstone.

The profile just described represents the darker, or browner, side of the range for St. Paul soils. The combined A horizons are dark brown (chromas of not more than 3) to a depth of more than 15 inches and in places to a depth of 20 inches. The combined B horizons consist of medium to heavy silty clay loam to a depth of 24 inches; below this, the structure, in many places, is blocky. The B horizons generally occupy plane to very weakly convex surfaces. The lighter colored profiles have

redder B horizons, generally with slightly convex surfaces; the subsoil is less clayey and firm and is likely to lack continuous clay skins on the peds. These profiles are somewhat similar to those of the Carey soils.

The zone of calcium carbonate generally is indistinct. In places it contains a few, fine, soft concretions and a few threads of lime. In other places this zone has distinct films of lime on the surfaces of the peds; between 2 and 5 percent of the free lime occurs in the form of soft, whitish masses. In most places the zone of calcium carbonate begins at depths between 24 and 40 or more inches, but in places it is lacking. The color of the substratum ranges from brown to yellowish red, but the brown colors are predominant.

Areas of this soil near areas of Richfield and Dalhart soils have been influenced somewhat by the sandier outwash material of the High Plains. These areas are brown to grayish brown (10YR hues) and are similar to the Richfield soils. In some of these places, the subsoil is mottled.

Surface drainage is slow and internal drainage is medium. Therefore, the soil has a good capacity for storing moisture so that wheat, the principal crop, and other crops can be grown. The original vegetation consisted of a mixture of buffalograss, little bluestem, and grama grasses. A few areas are now in pasture of buffalograss and grama grasses.

Mapped with this soil, but making up no more than 15 percent of its total acreage, are small spots of Carey, Hollister, Richfield, and Woodward soils.

**St. Paul silt loam, 1 to 3 percent slopes.**—This soil is similar to St. Paul silt loam, 0 to 1 percent slopes. A typical area is 9 miles north and 4 miles west of Buffalo (E $\frac{1}{2}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 28, T. 29 N., R. 23 W.).

This soil occurs around the margins of areas of St. Paul silt loam, 0 to 1 percent slopes, and along shallow drainageways. Most of the areas are long and narrow, and the total acreage is not large. This soil differs mainly from St. Paul silt loam, 0 to 1 percent slopes, in occurring on stronger, more convex slopes, which have more rapid runoff. Also, the A horizon is thinner, or only 12 to 16 inches thick. In many places the lower part of the subsoil is redder. This soil is transitional to the Carey soils, but it has a browner, less reddish A horizon and a less reddish, slightly more clayey B horizon.

**Spur clay loam.**—This calcareous soil of the bottom lands is a member of the Alluvial great soil group. It receives runoff water from areas of Reddish Chestnut soils, but it is flooded only occasionally. This is a moderately fine textured, dark-colored soil. It is forming mostly in sediments of High Plains outwash mixed, in places, with material derived from the redbeds.

Most of the areas are on the low, nearly level benches south of the Cimarron River in the northwestern part of the county and south of the North Canadian River near Laverne and May. About two-thirds of this soil occurs on benches slightly above areas that are overflowed frequently. The rest of it is on slightly corrugated, uneven areas along shallow drainageways or on alluvial fans along the margins of valleys. These areas have slopes of as much as 2 percent and are used, without great risk, in the same way as the adjacent level areas.

This soil is darker and finer textured than the adjacent Spur loam, which occurs on convex areas of natural

dikes. Associated with this soil, but generally in lower positions and more frequently flooded, are the sandier Yahola and Lincoln soils.

A representative profile of Spur clay loam occurs in the northwestern corner of Laverne in the SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 21, T. 26 N., R. 25 W. Another typical profile, observed 10 miles due north of Rosston in the NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 32, T. 29 N., R. 25 W., is described as follows:

- A<sub>1p</sub> 0 to 6 inches, dark-brown (10YR 4/3, dry; 3/3, moist) clay loam; strong, medium, granular structure; firm when moist, slightly sticky when wet; calcareous; gradual lower boundary.
- A<sub>1</sub> 6 to 15 inches, dark yellowish-brown (10YR 4/4, dry; 3/4, moist) light clay loam; strong, medium to fine, granular structure; firm when moist, slightly sticky when wet; calcareous; clear gradual lower boundary.
- AC 15 to 25 inches, pale-brown (10YR 6/3, dry; 5/4, moist) very fine sandy loam or loam; moderate, medium to fine, granular structure; friable; calcareous; clear lower boundary.
- A<sub>1b</sub> 25 to 32 inches, grayish-brown (10YR 5/2, dry; 4/2, moist) loam; calcareous; very gradual lower boundary.
- AC<sub>b</sub> 32 to 45 inches+, pale-brown (10YR 6/3) very fine sandy loam; weak, fine, granular structure; nonsticky; calcareous; transitional, with increasing depth, to brown or pale-brown, stratified clay loam and loam.

The color, texture, and thickness of the horizons vary considerably as a result of differences in stratification. This also accounts for buried soils, identified by their slightly darker surface horizons, at a depth of more than 2 feet. In many places the entire profile consists of clay loam but the material below a depth of 16 inches is lighter colored and somewhat higher in lime. In some profiles there are saline horizons at a depth of about 24 inches.

Surface drainage is slow in the nearly level areas; this is ideal for the maximum amount of water to infiltrate. Internal drainage is medium to slow. Tall and mid grasses and, in the low areas, spots of saltgrass comprised the original vegetation.

Mapped with this soil are small areas of Yahola and Lincoln soils; a few areas of Las Animas soil, shallow over clay; a reddish, permeable soil in small areas along the Cimarron River; and some spots in which the soil has been affected adversely by salts.

Although nearly all of the areas are under cultivation, there are a few small pastures of switchgrass, grama grasses, bluestems, and other native grasses.

**Spur loam.**—This soil is similar to Spur clay loam, but it occurs at slightly higher elevations. It is mostly on natural dikes adjacent to the streamward side of low, broad benches. As a result, drainage water moves more freely from the surface downward through the soil than it does in Spur clay loam.

This soil is south of the Cimarron and North Canadian Rivers. In most of the areas there are weakly convex slopes of between  $\frac{1}{2}$  and 2 percent, but a few spots have stronger slopes. More than 60 percent of this soil is nearly level. The rest occurs along shallow drainageways or on alluvial fans that are slightly dissected or on which the sediments have been deposited unevenly. The more sloping areas are only slightly more likely to be damaged through erosion than the other areas, and they, therefore, can be used and managed in the same way as the nearly level areas.

The following is a typical profile of Spur loam observed 11 miles north and 2½ miles east of Rosston near the Cimarron River (SW¼SW¼ sec. 23, T. 29 N., R. 25 W.):

- A<sub>1p</sub> 0 to 4 inches, brown (7.5YR 5/2, dry; 4/2, moist) loam; weak, medium, granular structure; friable; about neutral in reaction; abrupt lower boundary.
- A<sub>1</sub> 4 to 22 inches, brown (7.5YR 4/2, dry; 3/2, moist) loam; moderate, medium, granular structure; friable; alkaline but noncalcareous; gradual lower boundary.
- AC 22 to 40 inches+, dark yellowish-brown (10YR 4/4, dry; 3/3.5, moist) loam; weak, medium, granular structure; friable and permeable; calcareous; transitional, with increasing depth, to stratified loam and light clay loam.

There is considerable variation in the thickness, texture, and color of the horizons. In many areas, especially along local drainageways that have cut into the redbeds, the soil is more reddish than that described. These spots border low natural dikes consisting of redder material derived wholly from the redbeds. Some of this reddish soil resembles the Yahola soil. In areas made up of older deposits, the soil contains an enriched A horizon.

Surface drainage and internal drainage are medium. Because this soil absorbs water well, it is well suited to crops. The original vegetation consisted of tall and mid grasses, but most of the areas are now used for cultivated crops, mainly wheat.

**Tipton silt loam, 0 to 1 percent slopes.**—This weakly developed soil, a member of the Reddish Chestnut great soil group, has formed on slightly reddish, unconsolidated alluvium or on alluvium mantled with loess. Most of it is on benches that are between 20 and 40 feet above the flood plains of the Cimarron River.

The relief is nearly level, and some spots have slightly concave slopes. In areas near the uplands, this soil is transitional to gently sloping St. Paul and Carey soils. Small areas of this soil along the North Canadian River are associated with large areas of the Dalhart and Pratt soils.

The following is a typical profile of Tipton silt loam, 0 to 1 percent slopes, observed on a high bench above the Cimarron River, 11 miles north and 3 miles east of Selman (S½NE¼NE¼ sec. 27, T. 29 N., R. 21 W.):

- A<sub>1p</sub> 0 to 7 inches, brown (7.5YR 5/2, dry; 3/2, moist) heavy silt loam; noncalcareous; abrupt lower boundary
- A<sub>1a</sub> 7 to 16 inches, dark-brown (7.5YR 4/2, dry; 2.5/2, moist) heavy silt loam or light silty clay loam; strong, medium, granular structure; friable; noncalcareous; about neutral in reaction; gradual lower boundary.
- B<sub>22</sub> 16 to 26 inches, brown (7.5YR 4/4, dry; 3/4, moist) medium silty clay loam; strong, medium, subangular blocky structure; contains clay skins; moderately firm; many fine pores and open rootlet channels; noncalcareous; gradual lower boundary.
- B<sub>ca</sub> 26 to 33 inches+, brown (7.5YR 5/4, dry; 4/4, moist) medium silty clay loam; moderate, medium to coarse, subangular blocky structure; firm; calcareous with films and fine concretions of segregated calcium carbonate.

The profile of this soil is relatively uniform. The thickness of the combined A horizons ranges from 18 to 30 inches. In areas mantled with loess, darker layers of buried soils occur at depths of 18 to 36 inches. The depth to free carbonates, in the form of threads or small masses, ranges from 30 to 40 inches. A few lenses of gravel may occur at depths of more than 24 inches.

Surface drainage is slow to medium, and internal drainage is medium. Nearly all of the areas are under cultivation. In the areas not cultivated, overgrazing has caused the original vegetation of mid and tall grasses to be replaced by short grasses.

Mapped with this soil, but making up less than 5 percent of the total acreage, are nearly level areas of the St. Paul, Pratt, and Dalhart soils.

**Tipton silt loam, 1 to 3 percent slopes.**—This soil is similar to Tipton silt loam, 0 to 1 percent slopes. A typical area is 11 miles north and 2 miles west of Buffalo (NE corner of NE¼NW¼ sec. 15, T. 29 N., R. 23 W.).

Like Tipton silt loam, 0 to 1 percent slopes, this soil is on alluvial benches modified by loess, but it is on stronger slopes. Most of the slopes are convex. The surface drainage is medium.

In places the combined A horizons are thinner and the plow layer has a slightly lighter color (1 value greater) than that of Tipton silt loam, 0 to 1 percent slopes. Also, the material below a depth of about 36 inches is lighter colored (about 1 value greater). In some areas the texture of the surface layer is loam. In places the subsoil is calcareous at a depth of about 24 inches. In some areas as much as 5 percent of the subsoil is made up of fine pebbles.

About 80 percent of this soil is used to grow wheat.

**Tipton silt loam, 3 to 5 percent slopes.**—This soil is similar to Tipton silt loam, 0 to 1 percent slopes. A typical area is 11 miles north and 2 miles east of Selman (SW¼NW¼SW¼ sec. 26, T. 29 N., R. 21 W.).

This soil differs from Tipton silt loam, 0 to 1 percent slopes, mainly in the following ways: (1) The plow layer and the subsoil are lighter colored, and the subsoil contains more gravel; (2) there is considerably more grit or sand throughout the profile; (3) and the profile is largely loam instead of silt loam in texture.

This soil is on the narrow, dissected margins of the alluvial benches occupied by the other Tipton soils. It makes up about one-sixth of the total acreage of Tipton soils in Harper County.

The texture of the surface layer ranges from silt loam to loam. The subsoil is as much as 10 percent pebbles. Generally, it is calcareous at depths below 24 inches, but in places it is calcareous below depths of 20 inches.

About two-thirds of this soil is used for cultivated crops. The rest is in pastures of short and mid grasses.

**Tivoli fine sand.**—This weakly developed soil is a member of the Regosol great soil group. It has formed on deposits of the Late Pleistocene epoch and in deep sands that have been laid down more recently. It is on uplands that border and are generally north of the North Canadian River and other large streams. Some areas occur along Buffalo Creek, and others are north of the Cimarron River in the northwestern corner of the county. The topography is distinctly dune, with narrow swales between the dunes. The slopes generally range from about 6 to 20 percent, but in some places they are steeper.

Most of this soil is in bands that are fairly continuous, but some of it occurs on the sandy mantle within larger areas of Pratt loamy fine sands. A few rather small areas are made up of active dunes that are shifted about by the wind, but most of the areas have been stabilized by tall and mid grasses and sand sagebrush.

The following is a typical profile of Tivoli fine sand (slopes of about 10 percent) observed 2 miles north and 1 mile east of May (W $\frac{3}{4}$  sec. 7, T. 25 N., R. 23 W.):

- A<sub>1</sub> 0 to 8 inches, light-brown (7.5YR 6/4, dry; 5/4, moist) loose fine sand; noncalcareous; gradual lower boundary.
- C 8 to 45 inches+, reddish-yellow (7.5YR 8/6, dry; 6/6, moist) loose fine sand or loamy fine sand; very friable and rapidly permeable; noncalcareous.

The A<sub>1</sub> horizon is 6 to 12 inches thick and ranges from light brown to yellowish brown in color. Small blowout spots that lack an A<sub>1</sub> horizon are common, however, even in areas with a fairly good cover. In places the substratum consists of reddish-yellow to strong-brown fine sand or loamy fine sand that has a low water-holding capacity. In the narrow swales between the dunes, the soil is slightly darker and more loamy than the profile described and is similar to the Pratt loamy fine sands.

This soil absorbs nearly all the precipitation that falls, but internal drainage is very rapid. Tall bunch grasses, grama grasses with an overstory of sand sagebrush, plum bushes, and skunkbush comprise the typical vegetation. All the areas are used for range. The proportion of tall grasses to other vegetation varies greatly, depending on how intensively the areas have been grazed. Tall grasses are more common on lightly grazed rangeland than elsewhere.

Mapped with this soil are small areas of Pratt loamy fine sands, which make up between 1 and 3 percent of the total acreage.

**Tivoli-Quinlan complex.**—This soil complex is made up of a mixture of Tivoli and Quinlan soils. The Tivoli soil is similar to Tivoli fine sand, and the Quinlan soil, to Quinlan loam. A typical area is 1 mile northeast of Buffalo (E $\frac{1}{2}$ NW $\frac{1}{4}$  sec. 6, T. 27 N., R. 22 W.).

These soils occur on dune, dissected areas that are suitable only for range. Most of the acreage is in a strip north of Buffalo Creek and to the east of Buffalo. Here, the areas of dune Tivoli soil, which occur on a mantle of loose sand, thin out and become discontinuous. The underlying redbeds are exposed in places. The red sandstone in the areas between the dunes and the red patches on the slopes indicate spots of Quinlan soil.

The degree of slope ranges from 2 to 20 or more percent. In general, the proportion of the Tivoli soil is greater than that of the Quinlan soil, but the percentage of either soil in individual areas ranges from 15 to 85 percent. In only a few areas, however, does the Tivoli soil make up less than 50 percent of the acreage.

**Woodward loam, 1 to 3 percent slopes.**—This is a moderately deep, calcareous soil of the Reddish Chestnut great soil group. It is a member of a catena of grassland soils that, in order of decreasing loss of moisture through runoff, rank as follows: Quinlan, Woodward, Carey, and St. Paul.

This soil has formed in red, slightly consolidated sediments of very fine sandy loam or silt loam, often referred to as sandstone or packsand. It occurs on the redbeds, largely north of the North Canadian River and east of Rosston. It is associated with the Quinlan and Carey soils.

This gently sloping, well-drained upland soil occupies low swells and long, weakly concave foot slopes. The

slopes range from 1 to 3 percent, but most of them are between 2 and 3 percent.

The Woodward soil resembles the Quinlan soils more closely than others, except that it has a thick, more strongly developed A<sub>1</sub> horizon and a greater depth to unaltered, soft bedrock. It lacks the textural B horizon and the deep profile that characterize the Carey soils. The Woodward soil has smoother, concave slopes and occurs in areas, such as accumulations of slope colluvium, where the parent material is only slightly consolidated; in contrast, the Quinlan soils are on steeper, more convex slopes and occupy areas in which the parent rock is more consolidated or compact.

The following is a typical profile of Woodward loam, 1 to 3 percent slopes, observed 3 miles west and 1 mile south of May (W $\frac{1}{2}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 29, T. 25 N., R. 24 W.):

- A<sub>1</sub> 0 to 9 inches, dark reddish-brown (5YR 4/4, dry; 3/4, moist) loam; weak to moderate, medium, granular structure; friable; calcareous; gradual lower boundary.
- A<sub>3</sub> 9 to 20 inches, reddish-brown (5YR 5/4 dry; 4/4, moist) loam; compound structure—weak, coarse, prismatic and moderate, medium, granular; friable; calcareous; porous and permeable; very gradual lower boundary.
- C<sub>1</sub> 20 to 25 inches, yellowish-red (5YR 5/7, dry; 4/7, moist) loam with seams of loosely cemented, very fine grained sandstone; calcareous; very gradual lower boundary.
- C<sub>ca</sub> 25 to 45 inches+, seams of yellowish-red (5YR 5/8, dry; 4/8, moist) loam and weakly cemented sandstone; about 5 percent consists of concretions of calcium carbonate.

The thickness of the A<sub>1</sub> horizon ranges from a few inches to 10 or more inches, and the color ranges from dark brown (7.5YR 4/3) to reddish brown (5YR 4/4). In places the reaction of the A<sub>1</sub> horizon is basic. The depth to consolidated parent rock generally ranges from 20 to 40 inches, but on some colluvial foot slopes, it is 60 inches. In general, the texture throughout the solum is loam or silt loam. About 75 percent of the material is loam, and about 25 percent is silt loam. The silt loam material is related to material of the Dog Creek formation, which outcrops in the valley of Buffalo Creek east of Buffalo. In areas near sandy soils, the A<sub>1</sub> and A<sub>3</sub> horizons contain a large amount of sand. In places the A<sub>3</sub> horizon contains 5 percent more clay than the A<sub>1</sub> horizon, but this is barely perceptible through field tests.

Surface drainage and internal drainage are medium. The original vegetation consisted of tall grasses and grama grasses. It now consists largely of grama grasses and buffalograss and a considerable amount of dropseed grasses.

More than 80 percent of this soil is used for crops, mainly for wheat. Grain sorghums also are grown if there is enough moisture in the subsoil. Uncultivated areas are used mostly for farm pastures.

Small areas of other soils, principally Carey and Quinlan, are included with this mapping unit. They make up less than 15 percent of the total acreage. In all areas the Carey soils are more extensive than the Quinlan.

**Woodward loam, 3 to 8 percent slopes.**—This soil is similar to Woodward loam, 1 to 3 percent slopes. A typical area is 2 miles east and 1 mile south of Buffalo (NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 17, T. 27 N., R. 22 W.).

This soil resembles Woodward loam, 1 to 3 percent slopes, except that it is on stronger slopes, most of which

have a gradient of 4 or 5 percent; some slopes are less than 200 feet long and have a gradient of 7 or 8 percent. A typical landscape is made up of a narrow drainageway, 300 feet wide and having 3 percent slopes; a side slope, between 400 and 800 feet long and having 5 or 6 percent slopes; and a rather narrow, convex ridgetop, 300 or more feet wide and having 3 percent slopes. This sequence of slopes repeats itself from place to place, but the length and gradient of the side slopes vary.

This soil is much more extensive than Woodward loam, 1 to 3 percent slopes, and, consequently, it is more important for agriculture. About two-thirds of it is used for crops. Wheat is the main crop, but grain sorghums are grown extensively during years when there is enough moisture in the subsoil. Areas that are not cultivated are used for farm pastures or range, along with the soils of the Woodward-Quinlan complexes and other sloping soils of the redbed areas. The typical vegetation consists of buffalograss, grama grasses, dropseed grasses, and scattered clumps of tall grasses.

**Woodward-Quinlan loams, 1 to 3 percent slopes.**—This soil complex consists of a moderately deep Woodward and a shallow Quinlan soil, so intricately associated that they cannot be mapped or used separately. The profile of the Woodward soil is similar to that described for Woodward loam, 1 to 3 percent slopes, and that of the Quinlan soil is similar to the profile described for Quinlan loam. A typical area is 4 miles west of May (SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 29, T. 25 N., R. 24 W.).

These soils have gentle slopes. The Woodward soil is on long, concave foot slopes, and the Quinlan soil is mainly on low swells. Some of the Quinlan soil occupies low knobs, which indicates that the underlying sandstone is more consolidated than that on which the adjacent Woodward soil has formed. The complex is not extensive, and most of it is associated with the Woodward loams. In general, the Quinlan soil makes up about 25 percent of the acreage in the individual areas.

About three-fourths of this complex is used for crops, and the rest is pastured. Because the slopes are uneven, contour tillage and terracing are difficult.

**Woodward-Quinlan loams, 3 to 8 percent slopes.**—This soil complex is made up of a moderately deep Woodward soil and a shallow Quinlan soil, so intricately associated that they must be used and managed as a unit. As a result, these soils were mapped as a complex. The Woodward soil is similar to Woodward loam, 1 to 3 percent slopes, and the Quinlan soil is similar to Quinlan loam. An area of this complex is 1.5 miles southeast of Buffalo (SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 18, T. 27 N., R. 22 W.).

The relief of this complex is similar, but slightly more uneven, than that of Woodward loam, 3 to 8 percent slopes. The Woodward soil, more extensive in this complex than the Quinlan, is on side slopes and concave foot slopes. The Quinlan soil, which comprises between 30 and 40 percent of the total acreage, occurs mainly on knobs. These knobs of Quinlan soil reflect the presence of underlying layers of more consolidated sandstone and siltstone than that on which the surrounding areas of Woodward soil have formed. Much of the complex occurs in association with the Woodward and Quinlan loams that are mapped separately.

About 1,000 acres consists of finer textured soils formed on the outcrop of the Dog Creek formation, the most

clayey rock of the Permian epoch exposed in Harper County. Woodward silt loam is on the slopes, and a variant of Weymouth clay loam, lacking a pronounced accumulation of calcium carbonate, is on the knobs. Neither of these soils is mapped separately in Harper County. A typical area of the fine-textured variant of the Weymouth series occurs 3 miles east and 2 miles north of Buffalo (NW $\frac{1}{4}$  sec. 34, T. 28 N., R. 22 W.).

About half of the complex is used for crops, but the acreage under cultivation is decreasing. The uneven terrain makes contour tillage and terracing impractical, and losses through erosion are considerable under less intensive management. Much of the acreage is used for farm pastures or as range.

**Yahola fine sandy loam.**—This soil, a member of the Alluvial great soil group, occurs in nearly level areas or on low ridges and in swales on the flood plains of the larger creeks. Some of it occurs in association with the Lincoln and Las Animas soils on the flood plains of the North Canadian and Cimarron Rivers. The coarser textured soil is on the low ridges and natural dikes nearer the streams, and the finer textured soil is on flats and in low swales. Although the areas are subject to occasional overflow, this does not limit their use for crops.

This soil has formed on reddish, calcareous sediments derived from areas of redbeds. In places these sediments are mixed with those derived from the mantle of sediments of the Tertiary age. The Yahola soil is redder and not so sandy as the Lincoln soils. It is redder and somewhat sandier than the Spur soils, and in places it has formed on more stratified sediments.

The following typical profile of Yahola fine sandy loam was observed in the southeastern part of Harper County along Sleeping Bear Creek (E $\frac{1}{2}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 15, T. 25 N., R. 20 W.):

AC 0 to 53 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) fine sandy loam; weak, medium, granular structure; friable; weakly calcareous; permeable; weakly stratified with thin layers of loam and sandy loam to the lowest part of the profile; the uppermost 8 inches is very slightly darkened but not enough to be described by a different color.

The surface soil is commonly fine sandy loam but ranges in texture from fine sandy loam to clay loam. In many places the surface soil is weakly developed and is primarily reddish brown (5YR 5/3 or 5/4 to 5YR 6/3 or 6/4). The substratum is stratified with loamy sand, loam, and clay loam.

Surface drainage is medium, but internal drainage is rapid. Originally, the vegetation was mostly tall grasses and scattered cottonwood, hackberry, and elm trees.

About one-third of this soil is under cultivation, and the rest is used for pasture. More of it could be used for crops, except that the areas are small and narrow and are adjacent to areas of other soils that are used principally for range.

## General Nature of the Area

Harper County is on a dissected plain. Most of it is underlain by redbeds of soft, weakly consolidated, reddish sandstone and silty or loamy rock. The broad areas north of the North Canadian River have a mantle of sand.



Figure 18.—Remains of a sod house built by the early settlers.

Other large areas in the western part of the county have a cover of limy, sandy materials similar to those that underlie the High Plains to the west; these areas range from billowy to dunny.

In general, the relief is hilly, but there are many valleys containing nearly level soils well suited to cultivation. A wide valley occurs in the western part of the county, and another is along Buffalo Creek in the eastern and central parts.

The county is drained by the Cimarron and North Canadian Rivers. In approximately two-thirds of the county, the drainage waters flow north and east to the Cimarron River. In approximately one-third, they flow south and east to the North Canadian River.

From east to west, the elevation in the county increases approximately 19 feet per mile. Buffalo is 1,791 feet above sea level.

## Settlement

When the first settlers arrived in Harper County, each received 160 acres of land, which was provided by the Homestead Act of 1893. Life was rigorous; many of the pioneers lived in sod houses (fig. 18). Because most of the settlers had large families, they had to plow much of the marginal land to gain a livelihood. For a long time, greater returns were expected from the land than it was capable of producing. As the productivity of the soils declined and as the hazards of droughts and erosion became greater, the population of the county became smaller and larger farms were needed to provide a living for the farm families.

Many changes have taken place in recent years as the result of the increased use of conservation methods. Much of the marginal land has been returned to grass. Improved methods are being used by many farmers, but effective conservation of soil and moisture depends on the participation of the community as a whole.

## Transportation

Harper County has adequate transportation facilities. State Highway 34 extends along the eastern side of the county and joins United States Highway 64 in the north-

eastern part. United States Highway 64 extends east to west, passing through Buffalo and Rosston. Extending from north to south through the center of the county is United States Highway 183. United States Highway 283, which extends from north to south in the western part of the county, connects Rosston and Laverne. In the southwestern part of the county, United States Highway 270 and State Highway 3 extend from east to west.

A branch of the Santa Fe Railroad serves Selman and Buffalo. The Missouri-Kansas-Texas Railroad extends through May, Laverne, and Rosston.

## Agriculture

The agriculture of Harper County is based mainly on the growing of wheat and grain sorghums and on the raising of beef cattle. Wheat is the main cash crop. Most of the grain sorghums are fed to cattle, but some of the crop is marketed.

Most of the farmland is sloping and can be farmed safely only if practices are used to conserve soil and water. Dryland farming is predominant, but by 1954, 1,665 acres<sup>7</sup> of farmland was irrigated.

In 1954, there were an estimated 694 farms in the county as compared to 1,204 farms in 1930. In the same year the average-sized farm contained 912.2 acres as compared to 494.0 acres in 1930. The approximate number of tractors on farms during the same period increased from 598 to 1,318. These figures show that although the number of farms has decreased, the average size of the farms has increased greatly and the farms have become more mechanized.

**Crops.**—Wheat and grain sorghums are the principal crops. Oats, barley, rye, broomcorn, cotton, corn, sweetclover, and alfalfa are grown to a lesser extent. The approximate acreage of these crops is shown in table 10.

TABLE 10.—Acreage of principal crops in stated years

| Crop   | 1929             | 1939             | 1949     | 1954             |
|--|------------------|------------------|----------|------------------|
| Sorghums for all purposes except sirup:              |                  |                  |          |                  |
| Harvested for grain or seed                          | 21, 668          | 12, 909          | 5, 044   | 2, 438           |
| Hogged, or grazed, or cut for silage, hay, or fodder | 20, 891          | 17, 742          | 17, 330  | 38, 922          |
| Small grains threshed:                               |                  |                  |          |                  |
| Wheat  | 178, 967         | 65, 022          | 182, 257 | 121, 621         |
| Oats   | 1, 162           | 2, 270           | 1, 097   | 722              |
| Barley   | 1, 518           | 4, 965           | 666      | 4, 117           |
| Broomcorn  | 2, 928           | 381              | 143      | 135              |
| Cotton   | 147              | ( <sup>1</sup> ) | 47       | ( <sup>1</sup> ) |
| Corn for all purposes                                | 14, 125          | 1, 827           | 300      | 134              |
| Alfalfa:   |                  |                  |          |                  |
| Seed harvested                                       | 428              | 497              | 2, 822   | 1, 297           |
| Cut for hay  | 1, 306           | 709              | 4, 778   | 7, 188           |
| Sweetclover seed harvested                           | ( <sup>1</sup> ) | 47               | 521      | 112              |

<sup>1</sup> Not reported.

**Livestock.**—Cattle are the dominant kind of livestock in Harper County. Table 11 shows the number of livestock on farms at stated intervals since 1930.

<sup>7</sup> Statistics used in this section were taken from records of the United States Bureau of the Census.

TABLE 11.—Number of livestock on farms in stated years

| Livestock              | 1930                  | 1940                 | 1950                 | 1954                 |
|------------------------|-----------------------|----------------------|----------------------|----------------------|
| Cattle and calves..... | 35, 272               | <sup>1</sup> 26, 258 | 44, 008              | 46, 816              |
| Milk cows.....         | 5, 232                | 4, 668               | 3, 141               | 2, 623               |
| Horses and mules.....  | 7, 685                | <sup>1</sup> 3, 149  | 1, 393               | 839                  |
| Sheep and lambs.....   | 2, 893                | <sup>2</sup> 2, 529  | 836                  | 4, 793               |
| Hogs and pigs.....     | 7, 365                | <sup>3</sup> 2, 254  | 2, 330               | 2, 021               |
| Chickens.....          | <sup>1</sup> 120, 644 | <sup>3</sup> 54, 334 | <sup>3</sup> 43, 056 | <sup>3</sup> 32, 239 |

<sup>1</sup> Over 3 months old.   <sup>3</sup> Over 4 months old.  
<sup>2</sup> Over 6 months old.

**Climate**

The climate of Harper County is continental. Temperatures vary greatly and are likely to change rapidly. During the summer, the temperature often rises to between 100° F. and 105° F. Because of the low humidity, the heat is not too oppressive and the nights are generally cool. In winter the temperature occasionally drops to -15° F., but extremely cold spells seldom last for more than a few days. Table 12, compiled from records of

TABLE 12.—Temperatures and precipitation at Buffalo, Harper County, Okla.

[Elevation, 1,800 feet]

| Month          | Temperature <sup>1</sup> |                  |                  | Precipitation <sup>2</sup> |                    |                     |                  |
|----------------|--------------------------|------------------|------------------|----------------------------|--------------------|---------------------|------------------|
|                | Average                  | Absolute maximum | Absolute minimum | Average                    | Driest year (1954) | Wettest year (1941) | Average snowfall |
|                | ° F.                     | ° F.             | ° F.             | Inches                     | Inches             | Inches              | Inches           |
| December.....  | 36. 9                    | 84               | -9               | 0. 90                      | 0. 28              | 0. 35               | 2. 7             |
| January.....   | 36. 0                    | 84               | -17              | . 67                       | . 06               | 1. 79               | 2. 6             |
| February.....  | 39. 7                    | 87               | -13              | . 91                       | . 06               | 1. 45               | 3. 4             |
| Winter.....    | 37. 5                    | 87               | -17              | 2. 48                      | . 40               | 3. 59               | 8. 7             |
| March.....     | 48. 9                    | 99               | -8               | 1. 28                      | . 23               | 1. 33               | 2. 9             |
| April.....     | 56. 3                    | 97               | 15               | 1. 95                      | 1. 22              | 2. 57               | . 4              |
| May.....       | 66. 3                    | 103              | 25               | 3. 12                      | 5. 58              | 5. 57               | ( <sup>3</sup> ) |
| Spring.....    | 57. 2                    | 103              | -8               | . 635                      | 7. 03              | 9. 47               | 3. 3             |
| June.....      | 76. 9                    | 111              | 35               | 3. 42                      | . 30               | 4. 35               | 0                |
| July.....      | 82. 8                    | 112              | 46               | 2. 12                      | . 56               | 1. 31               | 0                |
| August.....    | 81. 8                    | 115              | 43               | 2. 49                      | . 40               | 1. 84               | 0                |
| Summer.....    | 80. 5                    | 115              | 35               | 8. 03                      | 1. 26              | 7. 50               | 0                |
| September..... | 73. 4                    | 109              | 29               | 2. 50                      | . 23               | 5. 96               | 0                |
| October.....   | 61. 4                    | 100              | 12               | 1. 68                      | 2. 19              | 8. 80               | ( <sup>3</sup> ) |
| November.....  | 47. 6                    | 89               | 0                | 1. 16                      | ( <sup>3</sup> )   | . 49                | . 5              |
| Fall.....      | 60. 8                    | 109              | 0                | 5. 34                      | 2. 42              | 15. 25              | . 5              |
| Year.....      | 59. 0                    | 115              | -17              | 22. 20                     | 11. 11             | 35. 81              | 12. 5            |

<sup>1</sup> Average temperature based on a 49-year record, through 1955; highest temperature based on a 44-year record and lowest temperature based on a 43-year record, through 1952.

<sup>2</sup> Average precipitation based on a 49-year record, through 1955; wettest and driest years based on a 37-year record, during the period 1914-1955; snowfall based on a 43-year record, through 1952.

<sup>3</sup> Trace.

the United States Weather Bureau station at Buffalo, near the center of Harper County, gives monthly, seasonal, and annual temperatures and precipitation. The temperatures and precipitation at Buffalo are believed to be typical of those throughout the county.

As shown in table 12, more than 13 inches, or about 62 percent of the average annual precipitation, falls from May through September. About a third of the yearly precipitation falls as light rain that adds little if any moisture to the subsoil. Approximately a fourth falls as heavy, dashing rains that total 1 or more inches. Winters are uniformly dry.

The pattern of annual precipitation is somewhat irregular in Harper County (fig. 19). Both the amount and the distribution of precipitation affect agriculture. The low amount of annual precipitation, especially the low amount that fell during the 1930's, makes the conservation and proper use of moisture an important factor if crops are to be grown.

The frost-free season lasts for approximately 190 days. The average date of the last killing frost in spring is April 13, and that of the first in fall is October 20. Killing frosts have occurred as late as May 8 and as early as September 29.

Almost every summer there are destructive hailstorms. Most of these are local storms, so the probability of a particular farm being damaged is not great.

The prevailing winds are from the southwest. There is enough wind to operate nearly all of the windmills in the county every day of the year. The hot, dry winds in summer are a hazard and often result in decreased yields of crops. They evaporate the moisture from the leaves so fast that it does not reach the roots. Occasionally, the wind parches the leaves beyond recovery. Another windy season may occur during the spring. Unless the soil is well protected by a growing crop or a good stubble, a considerable amount of soil may be lost through wind erosion (fig. 20).

Damage from wind erosion is greatest during years of low precipitation, when there is not enough plant growth or stubble to protect the soil. During these times erosion is especially severe on the sandy soils. Each year Harper County is subject to at least one damaging wind of more than 40 miles per hour.

Fall-sown wheat and grain sorghums sown late in spring are the principal crops suited to the climate of Harper County. Wheat is planted in the fall near the end of the rainy season so that it can use moisture stored in the soil. The wheat remains semidormant during the comparatively dry winter, and it matures after the rains that fall late in spring and early in summer.

Grain sorghums are resistant to drought and are generally able to use summer moisture. Usually, the crop matures despite the hot, dry winds and periods of drought. During dry periods the leaves roll up and remain dormant.

Except for a few days after rain or snow has fallen, farmwork can be done at almost any time of the year. Livestock farms, which have a more diversified type of farming, require more work during winter than do wheat farms.

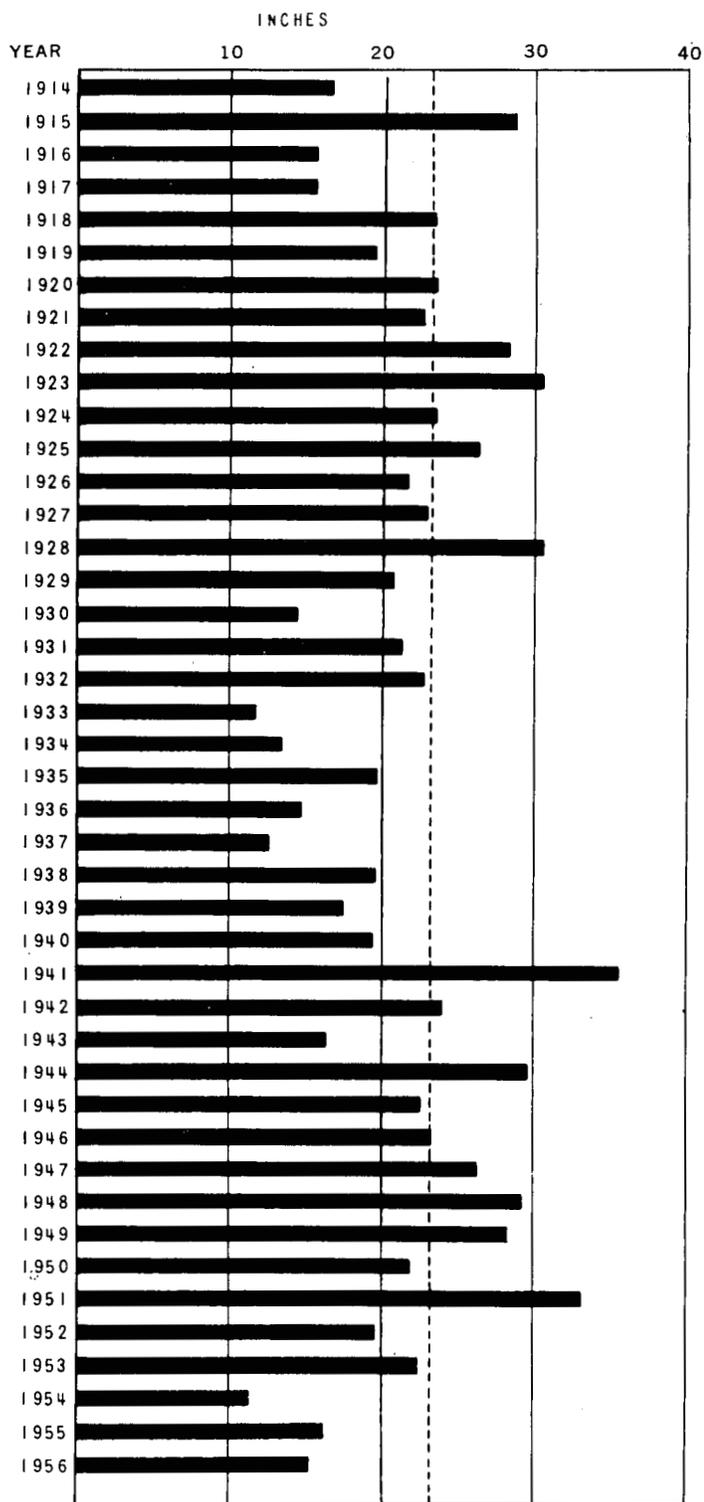


Figure 19.—Diagram showing variations in annual precipitation, as recorded at the U.S. Weather Bureau Station at Buffalo from 1914 through 1956. Average for the period is shown by a vertical broken line.

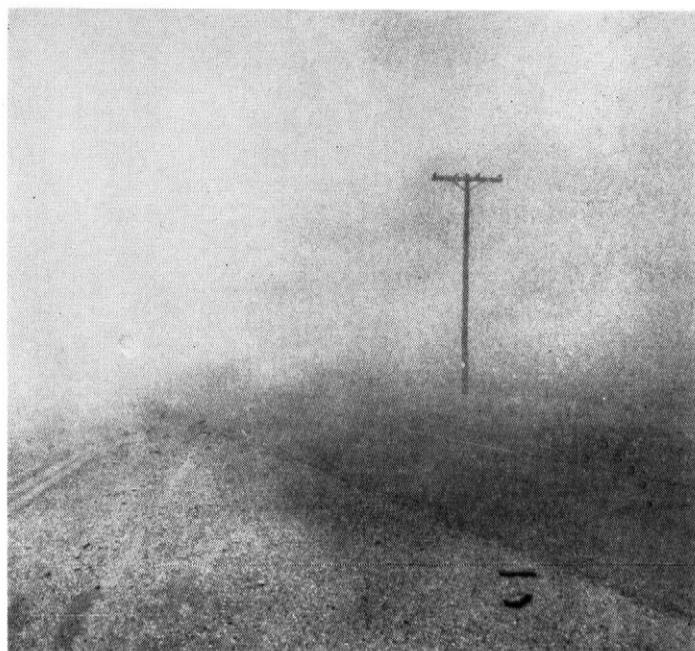


Figure 20.—Wind erosion has resulted in a "black blizzard" on this unprotected soil.

### Glossary

- Alluvium.** Soil or rock material, such as gravel, sand, silt, or clay, deposited on land by streams.
- Calcareous soil.** A soil that contains calcium carbonate, or a soil alkaline in reaction because of the presence of calcium carbonate. A soil that contains enough calcium carbonate to effervesce (fizz) when treated with dilute hydrochloric acid.
- Caliche.** A broad term for the more or less cemented deposits of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. When it is very near the surface or exposed by erosion, the material hardens.
- Catena, soil.** A group of soils formed from similar parent materials but differing in profile characteristics because of differences in relief or drainage.
- Chlorosis.** A condition in plants resulting from the failure of chlorophyll (the green coloring matter) to develop, usually because of a deficiency of an essential nutrient such as iron. Leaves of chlorotic plants range from light green through yellow to almost white.
- Colluvium.** Mixed deposits of soil material and rock fragments near the bases of rather steep slopes. The deposits have accumulated through soil creep, slides, and local wash.
- Concave slopes.** Slopes that are curved like the interior of a circle or hollow sphere. On level soils, concave spots may be swale-like or may resemble a saucer.
- Concretions.** Hard grains, pellets, or nodules from concentrations of compounds in the soil that cement the soil grains together. The composition of some concretions is unlike that of the surrounding soil. Concretions can be of various sizes, shapes, and colors.
- Convex, relief.** Land surface that is curved or rounded and resembles the outer surface of a sphere.
- Consistence, soil.** The combination of properties of soil material that determine its resistance to crushing and its ability to be molded or changed in shape. Consistence depends mainly on the forces of attraction between soil particles. The following are terms commonly used to describe consistence:  
*Compact.*—Dense and firm but without cementation.

**Firm.**—Resistant to forces tending to produce rupture or deformation.

**Friable.**—Readily ruptured and crushed with application of moderate force; nonplastic.

**Hard.**—When dry, soil is moderately resistant to pressure; barely breakable between thumb and forefinger.

**Indurated.**—Very strongly cemented; brittle and does not soften under prolonged wetting; so extremely hard that for breakage a sharp blow with a hammer is required; hammer generally rings as a result of the blow.

**Loose.**—Noncoherent.

**Plastic.**—When wet, soil is readily deformed by moderate pressure but is cohesive; wire formable.

**Soft.**—Weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.

**Ferruginous.** Iron-bearing; usually refers to material that has a comparatively high content of iron oxide.

**High Plains outwash.** Soil material from the Rocky Mountains that has washed down and spread out.

**Noncalcareous, soil.** Soil that lacks free lime (calcium carbonate).

**Ped.** An individual natural soil aggregate, such as a crumb, prism, or block, in contrast to a clod, which is a mass of soil brought about by digging or other disturbance.

**Permeability, soil.** The quality of a soil horizon that enables water or air to move through it. It can be measured quantitatively in terms of rate of flow through a unit cross section in unit time under specified temperature and hydraulic conditions. Values for saturated soils usually are called hydraulic conductivity. The permeability of a soil may be limited by the presence of one nearly impermeable horizon, even though the others are permeable.

**Permian epoch.** A period of geologic time between 185 and 210 million years ago; refers to geologic materials deposited during the Permian epoch.

**Pleistocene epoch.** The latter part of the Quaternary age; a period of geologic age between 25 thousand and 1 million years ago; refers to geologic material deposited during this time.

**Pinholes.** Refers to very fine holes in the soil profile; usually closely related to soil porosity.

**Quaternary age.** A period of geologic time occurring between the present time and 1 million years ago; refers to geologic material deposited during this time.

**Reaction, soil.** The degree of acidity or alkalinity of the soil mass, expressed in pH values or in words, as follows:

|                         | 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 |

|                             | pH              |
|-----------------------------|-----------------|
| Moderately alkaline.....    | 7.9 to 8.4      |
| Strongly alkaline.....      | 8.5 to 9.0      |
| Very strongly alkaline..... | 9.1 and higher. |

**Structure, soil.** The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The following are the principal forms of soil structure:

**Blocky, angular.**—Aggregates are shaped in the form of blocks; most of the ped faces are flat or slightly concave and angle vertices are sharp.

**Blocky, subangular.**—Aggregates have some rounded and some plane surfaces; vertices are rounded.

**Columnar.**—Aggregates are prismatic and are rounded at the upper ends.

**Crumb.**—Generally soft, small, porous aggregates; irregular but tending toward a spherical shape, as in the A<sub>1</sub> horizons of many soils. Crumb structure is closely related to granular structure.

**Granular.**—Roughly spherical, firm, small aggregates that may be either hard or soft, but they are generally firmer than crumb and without the distinct faces of blocky structure.

**Platy.**—Soil particles are arranged around a plane, usually horizontal.

**Prismatic.**—Soil particles are arranged around a vertical line; aggregates have flat vertical surfaces.

The following terms are used to indicate a lack of definite structure:

**Single grain.**—Each grain by itself, as in dune sand (structureless).

**Massive.**—Large, uniform masses of cohesive soil, sometimes with irregular cleavage, as in the C horizons of many heavy clay soils (structureless).

**Subsoil.** The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plow layer (or its equivalent of surface soil) in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when "soil" was conceived only as the plowed soil and that beneath it as the "subsoil."

**Substratum.** Any layer beneath the solum or true soil. The term is applied both to parent material and to other layers unlike the parent material, below the B horizon or the subsoil.

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

**Tertiary age.** A geologic period of time between 1 and 60 million years ago; refers to geologic material deposited during that time.

**Texture, soil.** The relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically, it refers to the proportions of sand, silt, and clay.





# Accessibility Statement

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This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at [ServiceDesk-FTC@ftc.usda.gov](mailto:ServiceDesk-FTC@ftc.usda.gov). For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at <http://offices.sc.egov.usda.gov/locator/app>.

## Nondiscrimination Statement

### Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

### To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (<http://directives.sc.egov.usda.gov/33081.wba>) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at [http://www.ascr.usda.gov/complaint\\_filing\\_file.html](http://www.ascr.usda.gov/complaint_filing_file.html).

### To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at [http://www.ascr.usda.gov/complaint\\_filing\\_cust.html](http://www.ascr.usda.gov/complaint_filing_cust.html) or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to [program.intake@usda.gov](mailto:program.intake@usda.gov).

### Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for

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program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

**Supplemental Nutrition Assistance Program**

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (<http://directives.sc.egov.usda.gov/33085.wba>).

**All Other Inquiries**

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (<http://directives.sc.egov.usda.gov/33086.wba>).