Series 1961, No. 20

Issued February 1965

Soil Survey

Armstrong County, Texas

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

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Armstrong County will help farmers and ranchers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; serve as a reference for students and teachers; and add to our knowledge of soils.

Locating the soils

Use the index to map sheets to locate areas on the detailed soil map. The index is a small map of the county numbered to show what part of the county is represented on each sheet of the detailed soil map. When the correct sheet of the detailed map is found, it will be seen that the soil areas are outlined and that each is designated by a symbol. All areas marked with the same symbol are the same kind of soil. Suppose, for example, an area located on the map has the symbol PuA. The legend for the detailed map shows that this symbol identifies Pullman silty clay loam, 0 to 1 percent slopes. This soil and all others mapped in the county are described in the section "Descriptions of the Soils."

Finding information

Special sections of the report will interest different groups of readers, and some sections will be of interest to all.

Farmers and ranchers can learn about the soils on their farms in the section "Descriptions of the Soils." They can then turn to the section "Use and Management of the Soils," to learn how these soils can be managed and what yields can be expected. Those interested in improving habitats for wildlife will find pertinent information in the subsection "Wildlife."

Range conservationists and others interested in rangeland can refer to the subsection "Management of the Soils for Range." In that section the soils of the county are placed in range sites, and factors affecting the management of rangeland are explained.

The "Guide to Mapping Units," which is at the back of the report, gives the map symbol for each soil, the name of the soil, and the capability unit and range site in which it has been placed.

Engineers will want to refer to the subsection "Engineering Applications." Tables in that section show soil characteristics that affect engineering.

Soil scientists and others who are interested will find information about how the soils formed and how they are classified in the section "Genesis, Classification, and Morphology of the Soils."

Students, teachers, land appraisers, and other users will find various parts of the report useful, depending on their particular interest.

Newcomers in Armstrong County and others not familiar with the county will be interested in the section "Soil Associations," in which broad patterns of soils are described. They may also be interested in the section "Additional Facts About the County," which describes the climate, discusses the public facilities, and gives some statistics on agriculture.

* * * * *

This soil survey was made as part of the technical assistance furnished to the Staked Plains Soil Conservation District and the Swisher County Soil Conservation District. Through these districts farmers and ranchers receive technical help from the Soil Conservation Service in planning for the use and conservation of their soils.

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

Cover Picture: Area of Mixed Land Slopes range site.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

Contents

	Page
How soils are named, mapped, and classified	3
Soil associations	4
The High Plains	4
1. Pullman-Randall association	4
The Rolling Plains	5
2. Abilene-Wichita association	5
3. Berthoud-Mansker-Potter association	5
4. Miles-Olton association	5
5. Broken lands-Quinlan-Weymouth association	6
Descriptions of the soils	6
Abilene series	8
Berthoud series	9
Berthoud-Mansker soils	9
Berthoud-Potter soils	10
Bippus series	10
Gravelly broken land	12
Likes series	12
Loamy alluvial land	12
Lofton series	13
Mansker series	13
Miles series	14
Olton series	15
Potter series	17
Pullman series	17
Quinlan series	18
Randall series	19
Roscoe series	19
Rough broken land	20
Rough broken land, gypsiferous	21
Sandy alluvial land	21
Ulysses series	22
Vernon series	23
Vona series	23
Weymouth series	23
Weymouth-Vernon soils	24
Wichita series	24
Woodward series	25
Zita series	26
Use and management of the soils	27
Capability groups of soils	27
Management by capability units	28
General management practices	35
Predictions of crop yields	36
Use and management of the soils—Continued	
Management of the soils for range	38
Current use of grassland	38
Range sites and condition classes	38
Descriptions of range sites	39
Practices for rangeland	43
Wildlife	45
Engineering applications	45
Engineering classification systems	45
Engineering properties of the soils	52
Engineering interpretations of the soils	52
Geology	56
Genesis, classification, and morphology of the soils	57
Factors of soil formation	59
Climate	59
Living organisms	59
Parent material	59
Relief	59
Time	60
Classification of the soils by higher categories	60
Morphology and classification of the soils in Armstrong County	64
Zonal order	64
Chestnut soils	64
Reddish Chestnut soils	68
Brown soils	70
Intrazonal order	70
Calcisols	70
Grumusols	72
Azonal order	73
Lithosols	73
Regosols	74
Additional facts about the county	75
Climate	75
Agriculture	77
Crops	77
Livestock	78
Farm power and mechanical equipment	78
Farm tenure and size of farms	78
Public facilities	78
Literature cited	79
Glossary	79
Guide to mapping units	Following 80

Series 1961, No. 20

Issued Feburary 1965

SOIL SURVEY OF ARMSTRONG COUNTY, TEXAS

BY LOUIS L. JACQUOT, LUTHER C. GEIGER, BILLY R. CHANCE, VERLE D. WOODS, DONALD A. LEATH, AND LYNDON C. IMKE, SOIL CONSERVATION SERVICE

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

ARMSTRONG COUNTY covers 583,040 acres, or 911 square miles, in the central part of the Texas Panhandle (fig. 1). Growth and development of the county have depended almost entirely on agriculture. Nearly a third of the acreage is under cultivation. The major crops are dry-farmed winter wheat and sorghum. Scattered small acreages are irrigated from deep wells. Most of the land not cultivated is grazed by beef cattle, a major source of income.

The distribution of cropland and grazing land in the county generally conforms with the two major physiographic areas, the High Plains and the Rolling Plains. The soils, agriculture, and general economy of the county are better understood if these two major areas are studied along with figure 2, which shows these areas and some of the major soils that occur within them.

HIGH PLAINS AREA.—Almost all the cultivated land is in the High Plains physiographic area. It covers the northwestern part of the county and a small area south of Palo Duro Canyon. It is mostly a nearly level treeless plain, a part of a vast apron of material that was washed from the Rocky Mountains, mainly during the Pliocene epoch. These deposits, known as the Ogallala formation, were later mantled with the windblown, or eolian, sediments that produced the present smooth, gradually sloping plain.

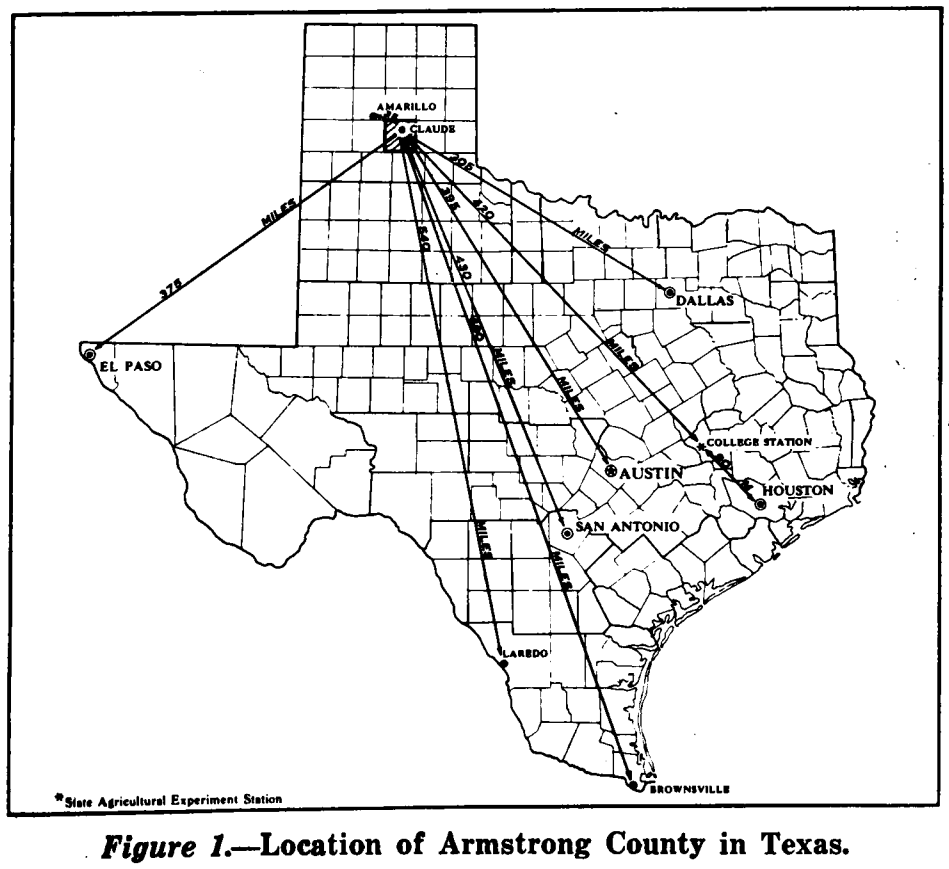

Figure 1.—**Location of Armstrong County in Texas.**

This treeless plain in Armstrong County is only a part of the High Plains, which in turn is part of the Great Plains, a strip roughly 200 to 500 miles wide that parallels the eastern side of the Rocky Mountains from Canada to the Texas Panhandle. The Great Plains region was once a short-grass paradise for buffalo, but in less than half a century much of it was brought under cultivation. It now produces mostly wheat and sorghum.

In Armstrong County, the High Plains area is marked by distinct, prominent escarpments where it borders the Palo Duro Canyon, which runs diagonally southeastward across the county. The escarpment is less clearly defined in the northeastern part of the county than elsewhere. The drainage system of the Salt Fork of the Red River starts in that part of the county and extends southeastward.

The elevation of the High Plains ranges from 3,530 to 3,280 feet above sea level. The surface is remarkably smooth except where it is pitted by many depressions, or playas. The average slope is less than 10 feet per mile toward the southeast. Thus, surface drainage is poorly defined. Runoff water flows into the depressions and forms the intermittent lakes, or playas. A playa has no definite outlet. When a small playa fills, any additional water must drain to a larger playa at a lower elevation. Overflow from the playas provides the water that starts Mulberry Creek, Happy Creek, and the Salt Fork of the Red River.

The extensive soils of the High Plains are uniform, deep, moderately fine textured, and fertile. The minor soils are those in the large depressions, or playas, and scattered areas of limy soils that lie within or bordering the High Plains and along the major draws reaching back into the plain.

ROLLING PLAINS AREA.—Geologic erosion of land that was once part of the High Plains has produced the physiographic area known as the Rolling Plains. These plains are the watershed for the Salt Fork and the Prairie Dog Town Fork of the Red River. The stream pattern is dendritic, or branching, and flow is generally to the southeast. Stream erosion, and perhaps some wind erosion, have formed the Palo Duro Canyon, a scenic, rugged, much dissected area fronted in many places by

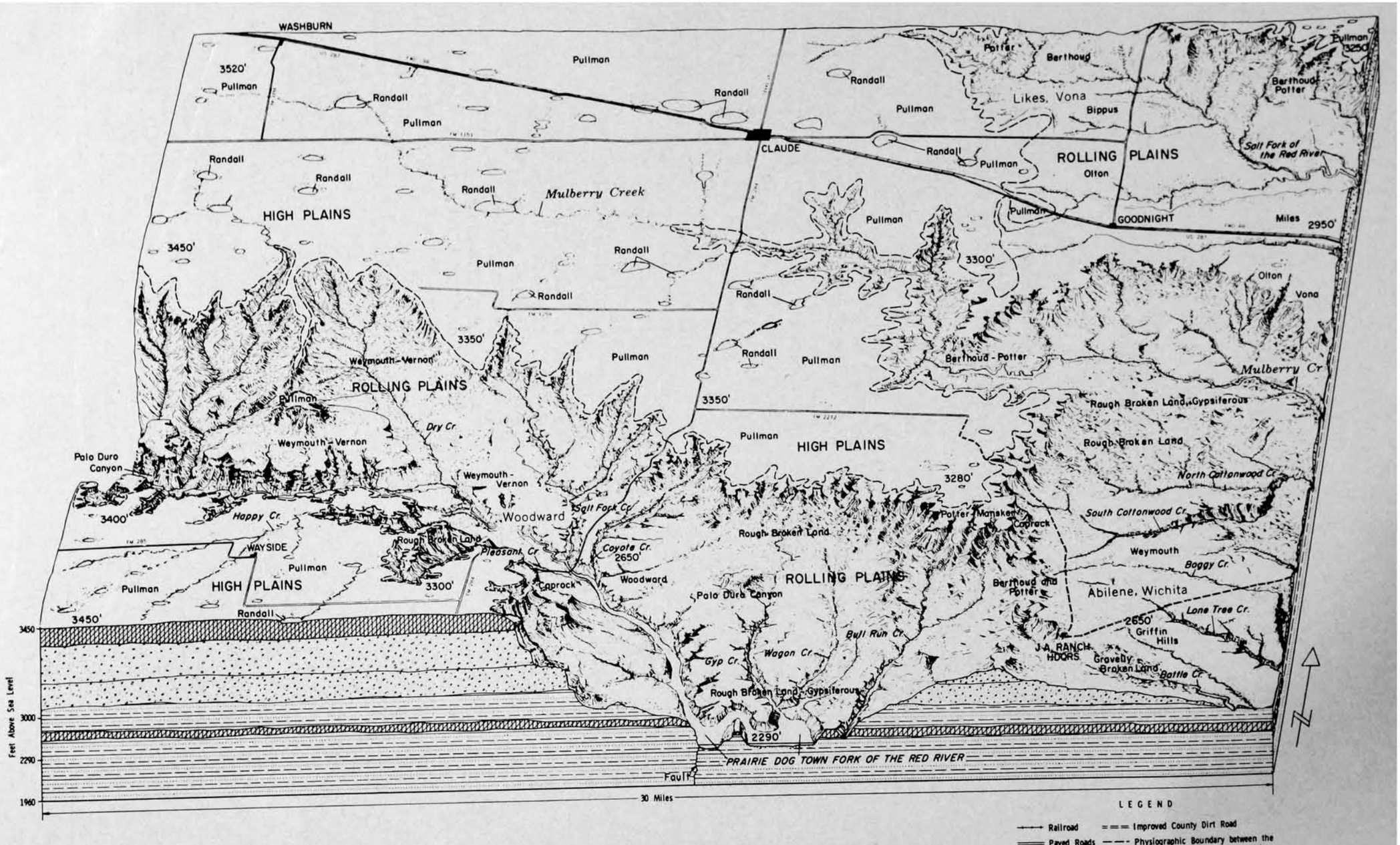

Figure 2.—Physiographic areas, soils, and major drainageways in Armstrong County. Relief is exaggerated, and elevations are approximate. See figure 27 for geologic formations underlying the county.

caliche or by red-bed escarpments. Some of these escarpments, or breaks, are not accessible to livestock.

The Prairie Dog Town Fork of the Red River, Mulberry Creek, and their tributaries drain the Palo Duro Canyon. Along these streams geologic erosion has exposed materials of three geologic eras. First removed were the High Plains deposits of the Cenozoic era; then the colorful Triassic deposits of the Mesozoic; and finally the oldest deposits, Permian materials, laid down in an inland sea in the Late Paleozoic. Along this canyon, elevations range from about 2,290 to 3,280 feet above sea level.

Within the Rolling Plains area, around the headquarters of the J. A. Ranch in the extreme southeastern part of the county, there is an old alluvial terrace. This terrace consists of material washed from the red-bed formation and from High Plains material. This nearly level to gently sloping terrace is dissected by North Cottonwood Creek, Boggy Creek, and Lone Tree Creek. These intermittent streams flow to the southeast. The elevation of this old terrace ranges from 2,650 to 2,700 feet above sea level.

Soils of the Rolling Plains are mostly deep to very shallow and loamy, though some are deep to very shallow and sandy. The dominant parent material is sediment washed from the High Plains. Most of the area is still covered with native grass. A few trees grow along the watercourses and near waterholes. The whole area is used mainly for grazing. Some fields in the northeastern part of the county are cultivated, mainly to sorghum, sudangrass, and small grain to feed livestock.

Except around the community of Goodnight, in the northeastern part of the county, the population is sparse.

How Soils Are Named, Mapped, and Classified

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

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Mansker and Pullman, for example, are the names of two soil series in Armstrong County. All the soils in the United States having the same series name are essentially alike in natural characteristics, but soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

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

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Mansker loam, 1 to 3 percent slopes, is one of several phases of Mansker loam, a soil type that in this county has a slope range of 1 to 5 percent.

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

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

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed or occur in such small individual tracts that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it. An example in Armstrong County is Weymouth-Vernon complex. Also, in most mapping, there are areas to be shown that are so rocky, so shallow, or so frequently worked by wind and water that they are too variable to be classified into soil series. These areas are shown on the soil map, but they are given descriptive names, such as Gravelly broken land or Sandy alluvial land, and are called land types.

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

Only part of the soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled.

The mass of detailed information is then organized in such a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. The soil scientists set up trial groups based on the yield and practice tables and other data and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultations. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

Soil Associations

Soils occur in patterns on the land. As one travels over a county or other large tract, it is easy to see differences from place to place. There are many obvious differences in type of surface drainage; in the width of valleys; in kind of native plants; and in kind of agriculture. With these more obvious differences there are less easily noticed differences in the patterns of soils.

By delineating the boundaries of the different patterns of soils on a small scale map, one obtains a map of soil associations. Such a map is useful to those who want to compare different parts of the county for purposes of planning the development and protection of natural resources. It indicates, broadly, the areas appropriate for native range, dry-farmed crops, irrigated crops, and many other present or potential uses. Such a map is not detailed enough, however, for use in planning the management of a single farm or ranch.

The soil associations of this county are shown on the colored map at the back of this report. Each association has a recurring proportional pattern of soils and is named for the soils dominant in this pattern. The soils that occur in one soil association may occur in another, but in a different proportion and pattern. The soils in any one association may be much alike or very different.

Following are descriptions of the five soil associations in this county. First described is the one soil association on the High Plains, and then the four soil associations on the Rolling Plains.

The High Plains

This broad, treeless, short-grass prairie is so uniform that only one soil association covers its entire extent in this county.

1. Pullman-Randall association

Nearly level to gently sloping, deep, fine and moderately fine textured, very slowly permeable soils

The pattern of soils in this association is Pullman soils on the extensive smooth uplands; Randall, Roscoe, Lofton, Zita, and Mansker soils in and bordering the playa basins (fig. 3); and scattered bands of Olton and Ulysses soils on uplands bordering the intermittent streams. This association occupies about 285,000 acres.

Pullman soils make up about 73 percent of this association. They are on the smooth uplands and surround the soils of the numerous playa basins. Pullman soils are deep, dark, productive soils that have a silty clay loam surface layer and a subsoil that is very slowly permeable when it is wet. These are by far the most extensive cultivated soils in the county. About 15 per-

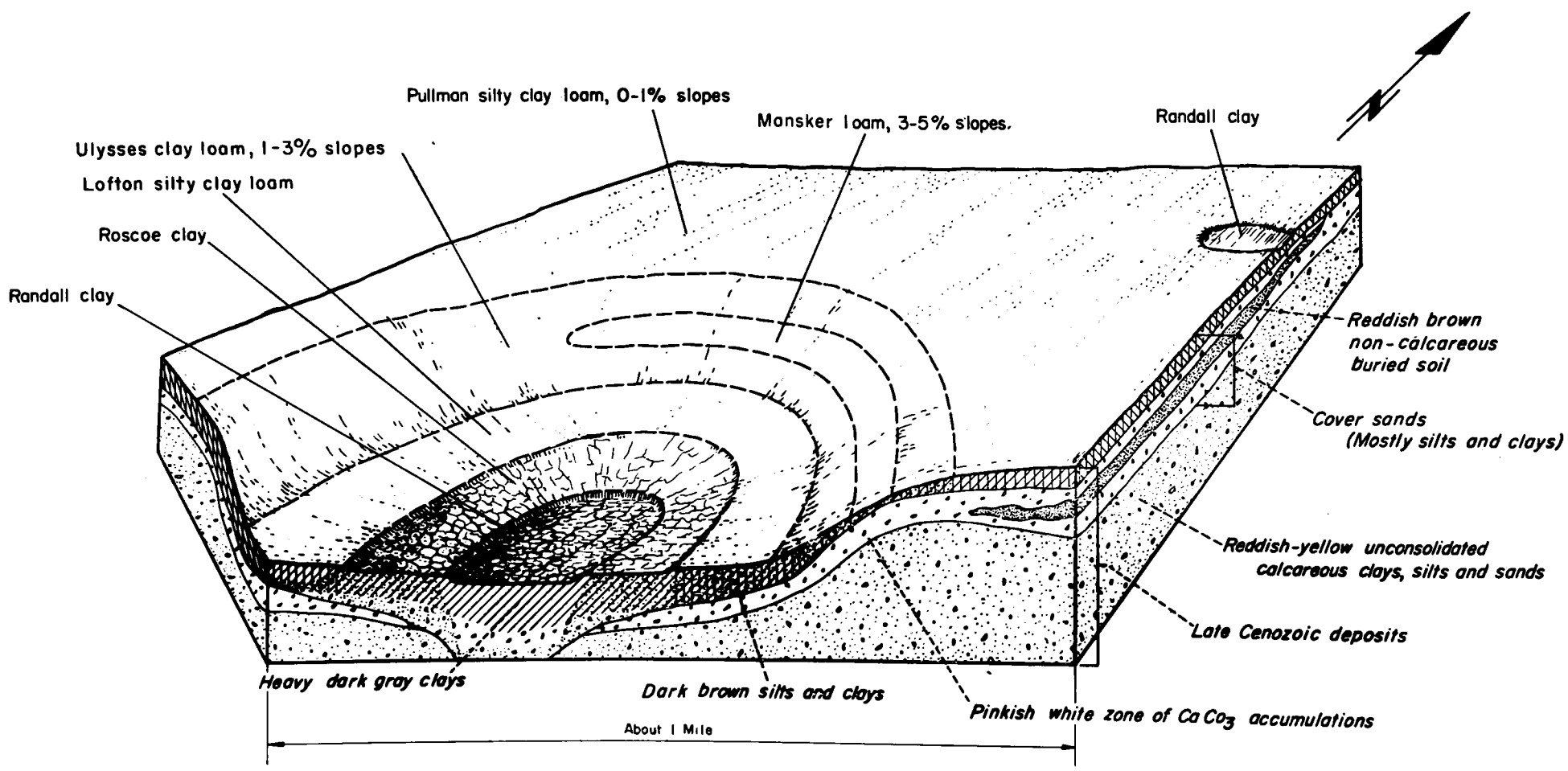

Figure 3.—Typical soil pattern in association 1.

cent of their cultivated acreage is under irrigation. Small grains are the main crops.

Soils of the playa basins, which together occupy about 18 percent of the association, occur in typical positions, as shown in figure 3. At the bottom of the larger playas are the Randall soils. These level, deep, poorly drained clays are ponded for long periods during wet years and are flooded for a short time in most dry years. Randall soils are good habitats for wildlife. Sedges growing in some of the playas, or grasses that get a start in dry years and survive until the playa is ponded again, provide limited grazing.

The deep, calcareous, somewhat poorly drained, clayey Roscoe soils are on the lower playa benches above the Randall soils. In some areas those soils can be cultivated, but crops are sometimes lost in wet years.

The Lofton soils are on the higher playa benches. These are very dark colored, deep, clayey, very slowly permeable soils that have clearly defined structure. They receive extra water from the surrounding higher areas and, if properly managed, produce high yields of cultivated crops.

The Zita soils, less extensive than others in the playas, lie adjacent to the basin rims above the Lofton soils and below the Ulysses or Mansker soils.

The Ulysses and Mansker soils are on the basin rims. They are shallow to moderately deep, calcareous soils that are moderately susceptible to wind and water erosion.

The Olton soils occur with Ulysses soils in scattered areas and narrow bands bordering the edges of the High Plains and the intermittent streams within it.

The Olton and Ulysses soils are productive, deep or moderately deep, and slowly permeable to moderately permeable. Most of their acreage is cultivated, chiefly to wheat and sorghum. About 4 percent of the cultivated land is irrigated.

Except for the cultivated Pullman, Olton, and Ulysses soils previously mentioned, all of this soil association is used for grazing. Conservation of moisture and control of erosion are the main problems in managing these soils, but plowpans form and tilth becomes poor if the soils are not cultivated carefully. Farms or ranches on this association average about 1,200 acres, but the irrigated farms are much smaller than average.

The upland soils of this association—the Pullman, Olton, and Ulysses—present no serious limitations to urban developments or the building of roads.

The Rolling Plains

More than half of this county is in the Rolling Plains. The soils are mainly deep to very shallow and loamy, though some are deep to very shallow and sandy, and they are covered mostly with native grass. There are four soil associations in the Rolling Plains.

2. *Abilene-Wichita association*

Nearly level to moderately sloping, deep, medium to moderately fine textured, slowly permeable to moderately permeable soils

This association occupies about 21,000 acres in the southeastern part of the county. Abilene soils make up about 60 percent of the association; Wichita soils about 26 percent; and Miles and Weymouth soils about 14 percent.

Abilene soils are nearly level to gently sloping, deep, dark, moderately fine textured soils on uplands. Their subsoil is slowly permeable. Except for a few cultivated patches, all of the acreage is in range, but these soils could be used to grow crops. Buffalograss and blue grama grow well. In some places there is a heavy infestation of mesquite shrubs and trees.

Wichita soils generally occupy slightly stronger slopes than Abilene soils. They normally lie between Abilene and Miles soils. They are nearly level to moderately sloping, deep, reddish-brown, moderately permeable soils on uplands. Wichita soils are lighter-colored than Abilene soils, and their subsoil is lighter textured. They are slightly darker-colored and heavier textured than Miles soils. They are well suited to winter wheat and sorghum and are excellent producers of native grasses. They are now used for range in which the main forage is blue grama.

3. *Berthoud-Mansker-Potter association*

Gently sloping to steep, deep to very shallow, medium to moderately coarse textured, moderately permeable soils

The pattern of soils in this association is Berthoud soils on the foot slopes; Mansker and Potter soils on the steeper slopes; and minor areas of Bippus soils along the flood plains of the larger streams. Berthoud and Bippus soils formed in calcareous materials washed from the High Plains. Mansker and Potter soils formed in calcareous residual deposits of the High Plains. They occupy about 87,280 acres along and below the caliche escarpments bordering the High Plains.

The moderately deep, calcareous, friable Berthoud soils dominate in this association (fig. 4). They are scattered on colluvial-alluvial foot slopes below the Potter and Mansker soils. Less than one-fourth of their acreage is cultivated. Areas not cultivated support a good cover of short grasses, such as buffalograss, blue grama, and side-oats grama. Mesquite is common in most areas. On the sandier Berthoud soils, the vegetation is mostly blue grama and little bluestem, and mesquite trees are fewer than on the less sandy Berthoud soils.

Mansker and Potter soils are on the stronger slopes above the Berthoud soils. The Mansker soils have a fair cover of grama grasses and a minor amount of buffalograss. The Potter soils support a sparse growth of side-oats grama, hairy grama, and three-awn, scattered patches of catclaw, and a few thickets of shinnery oak.

4. *Miles-Olton association*

Nearly level to gently sloping, deep, moderately coarse to moderately fine textured, moderately permeable to slowly permeable soils

This association, the smallest in the county, covers about 9,760 acres. It is in the upper part of the transitional area between the High Plains and the Rolling Plains, in the vicinity of Goodnight.

Miles soils make up about 55 percent of this association. They are deep, well-drained, reddish-brown, nearly level to gently undulating soils that have a moderately permeable subsoil. Whether dry farmed or irrigated, Miles soils are among the most suitable soils in the county for row crops. Grain sorghum, winter wheat, and some cotton are grown.

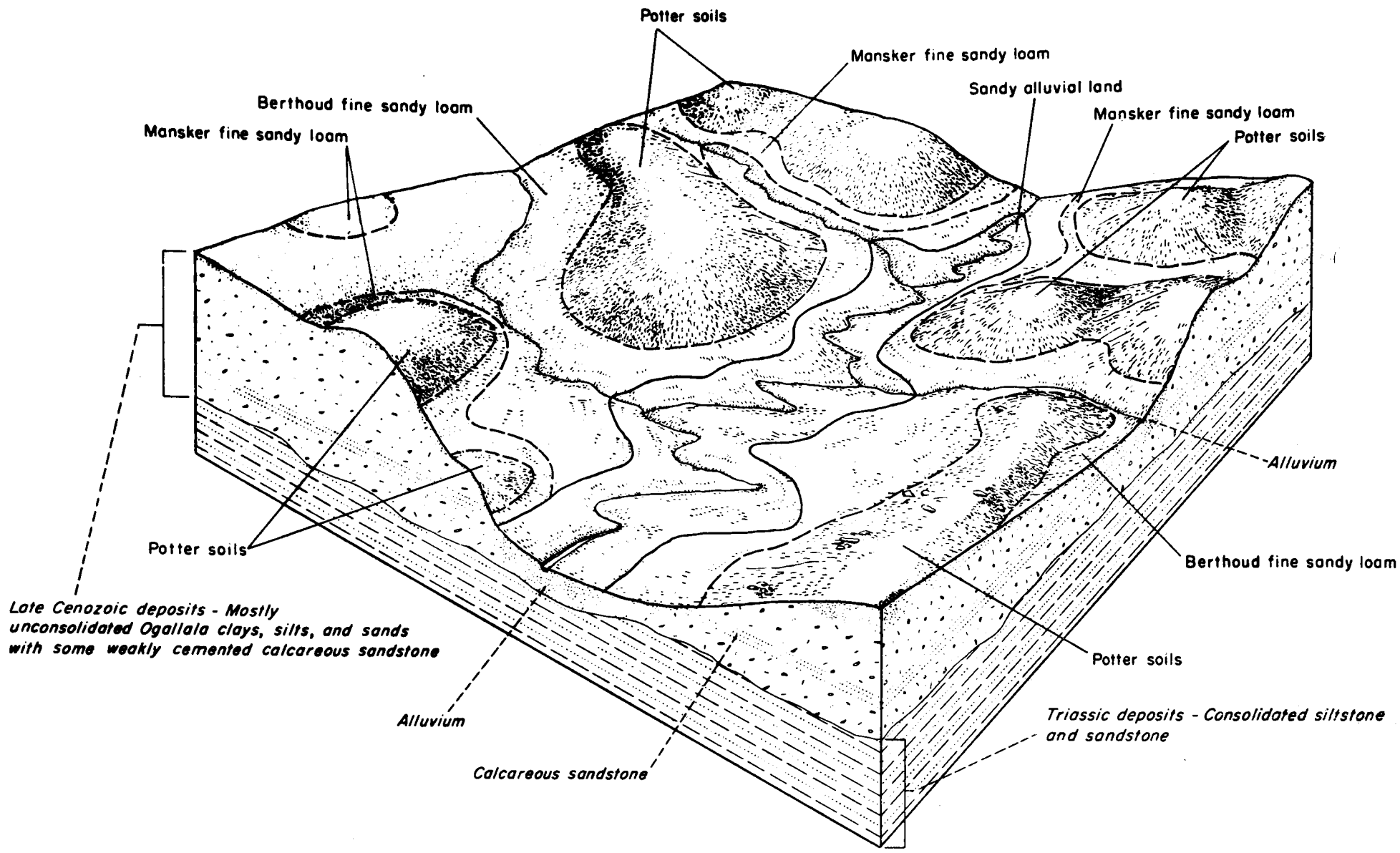

Figure 4.—**Typical soil pattern in association 3.**

About 45 percent of the association consists of Olton soils. They are mainly on the smooth, nearly level uplands bordering the western edges of the Miles soils. Olton soils are productive, deep, dark colored, slowly permeable, and moderately fine textured. Most of their acreage is cultivated, chiefly to wheat and grain sorghum.

5. *Broken lands-Quinlan-Weymouth association*

Rough lands and dissected, shallow to moderately deep soils

The pattern of land types and soils in this association is Rough broken land and Gravelly broken land on the breaks or escarpments that border and extend into Palo Duro Canyon, and Vernon, Quinlan, Woodward, and Weymouth soils on the smoother red-bed terraces. This association is in the Palo Duro Canyon and contains about 180,000 acres.

Rough broken land makes up about two-thirds of this association (fig. 5). It consists of steep, strongly dissected caliche breaks and red-bed breaks that border and, in some places, extend into the canyon. The red beds are made up of sandstone, siltstone, gypsum, and shale. In most places little or no soil has developed. The native vegetation is generally sparse and consists mostly of side-oats grama, hairy grama, little bluestem, and three-awn, and a scattering of yucca, catclaw, shinnery oak, and juniper shrubs. Some areas are not accessible to livestock but are habitats for wildlife.

About one-third of this association is made up of the very shallow to moderately deep Vernon, Quinlan, Weymouth, and Woodward soils. These soils occupy the smoother, less eroded red-bed terraces within the canyon.

Most all of the acreage is used for grazing. The native vegetation is sparse on the shallow Vernon soils but is fair to good on the Quinlan and Woodward soils. Scattered patches of buffalograss, clumps of the grama grasses, three-awn, needlegrass, and some juniper shrubs grow on the Vernon soils. The vegetation on the Quinlan and Woodward soils consists mainly of black grama, blue grama, side-oats grama, and bluestem grasses and yucca, juniper, and catclaw shrubs. Blue grama is the main vegetation on the Weymouth soils, but there is some side-oats grama. Mesquite shrubs have invaded many areas.

For the most part, the nearly level to gently sloping Weymouth and Woodward soils are arable, but because they are dissected by a number of deep canyons or valleys, they are not cultivated. These are the best grassland soils in the association.

Descriptions of the Soils

The descriptions of soil series and mapping units in this section of the report are designed to be useful to you if you are interested principally in the agricultural uses of the soils. Accordingly, emphasis is placed on the characteristics that help you identify the soils in the field and

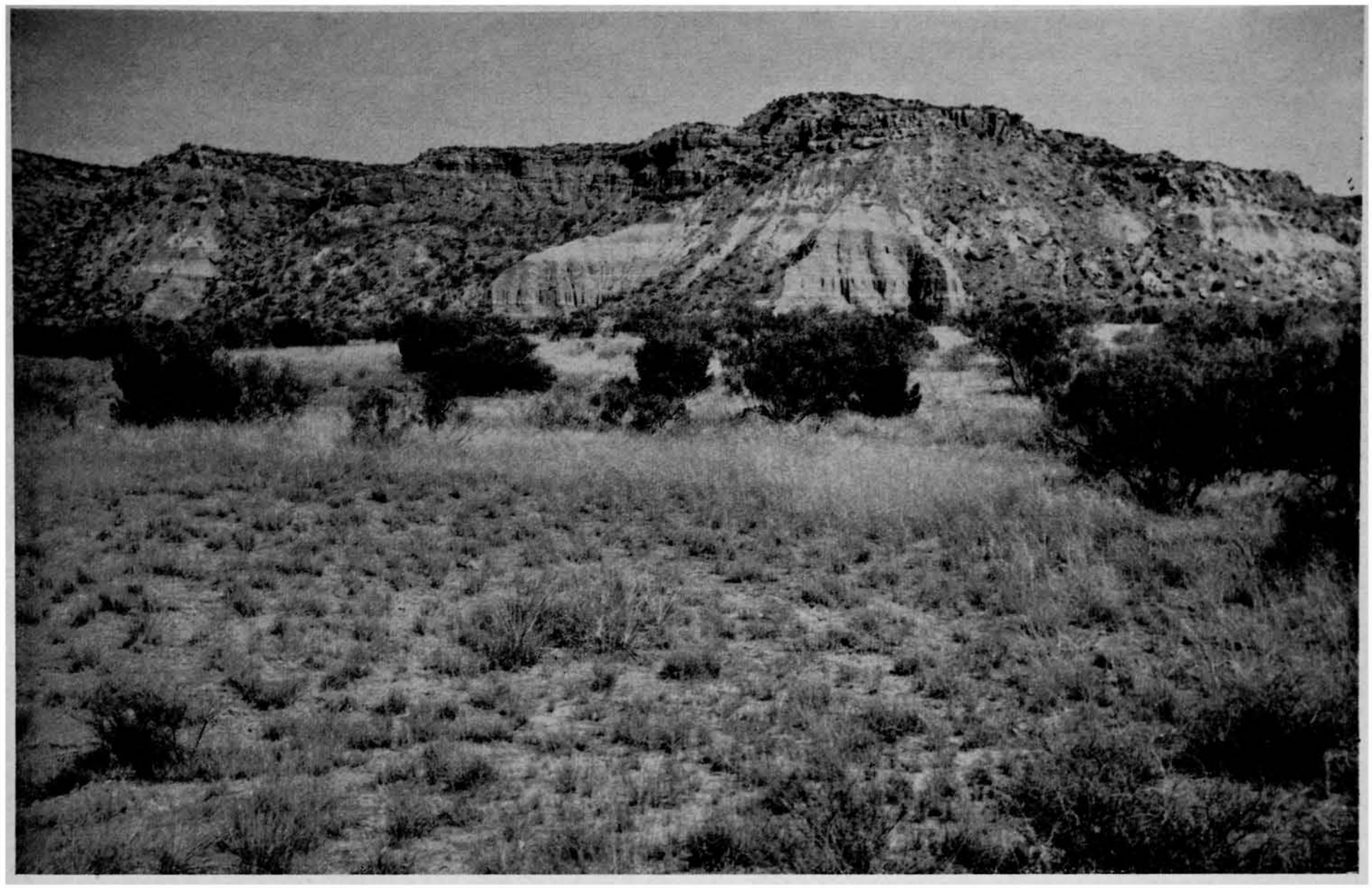

Figure 5.—**Typical landscape in association 5.**

those that affect their suitability for agriculture. Familiar and nontechnical terms are used so far as practical. Technical terms that have to be used because there are no accurate substitutes are defined in the Glossary. Soil scientists commonly use symbols composed of letters or combinations of letters and numbers to identify the various layers of soils, and you will find some such symbols used on the illustrations in this section. These symbols have special meanings that concern soil scientists and others who want to make a special study of soils. Most readers need to remember only that all symbols beginning with "A" identify the surface soil and subsurface soil; all those beginning with "B" identify the subsoil; and all those beginning with "C" identify the substratum, or parent material. The small letters "ca" indicate an accumulation of calcium carbonate.

Color, texture, structure, and consistence of the soils are among the important characteristics described in this section.

The color of the soil usually is related to the organic-matter content. A dark-colored surface layer is usually an indication of high organic-matter content. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

The texture of the soil, or its content of sand, silt, and clay, is determined in the field by the way the soil feels when it is rubbed between the fingers. This is checked from time to time by laboratory analysis. Texture determines how well the soil retains moisture and plant nutrients and whether it is easy or difficult to cultivate. Each mapping unit is identified by a textural name—clay loam, for example—which refers to the texture of the surface layer.

The soil structure is the arrangement of the individual soil particles into larger grains, or aggregates, and the amount of pore space between grains. Structure gives clues to the ease or difficulty with which the soil is penetrated by plant roots, moisture, and air.

The 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.

Other characteristics significant in agriculture are the depth of the soil over bedrock or compact layers; the presence of gravel or stones in amounts that will interfere with cultivation; the steepness and pattern of slopes; the degree of erosion; the nature of the underlying rocks or other material from which the soil was derived; and the acidity or alkalinity of the soil as measured by chemical tests.

A more technical and detailed description of each soil series is included in the section "Genesis, Classification, and Morphology of the Soils." Information on the use and management of each soil is given in the section "Use and Management of the Soils."

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The approximate acreage and proportionate extent of each soil mapped in the county are given in table 1. The location and distribution of each soil are shown on the detailed map at the back of this report.

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

Soil	Area	Extent
	Acres	*Percent*
Abilene clay loam, 0 to 1 percent slopes	10,585	1.8
Abilene clay loam, 1 to 3 percent slopes	1,015	.2
Berthoud-Mansker fine sandy loams, 3 to 8 percent slopes	26,270	4.5
Berthoud-Mansker loams, 3 to 8 percent slopes	15,150	2.6
Berthoud-Potter sandy loams	39,025	6.7
Bippus clay loam, 0 to 1 percent slopes	1,075	.2
Bippus clay loam, 1 to 3 percent slopes	5,495	.9
Bippus clay loam, 3 to 5 percent slopes	2,775	.5
Bippus fine sandy loam, 1 to 3 percent slopes	2,065	.4
Gravelly broken land	8,170	1.4
Likes loamy fine sand	1,350	.2
Loamy alluvial land	5,035	.9
Lofton silty clay loam	10,615	1.8
Mansker fine sandy loam, 1 to 3 percent slopes	760	.1
Mansker loam, 1 to 3 percent slopes	960	.2
Mansker loam, 3 to 5 percent slopes	14,870	2.6
Mansker loam, 3 to 5 percent slopes, eroded	280	(1)
Miles fine sandy loam, 0 to 1 percent slopes	2,150	.4
Miles fine sandy loam, 1 to 3 percent slopes	4,845	.8
Miles fine sandy loam, 3 to 5 percent slopes	560	.1
Olton clay loam, 0 to 1 percent slopes	5,830	1.0
Olton clay loam, 1 to 3 percent slopes	10,130	1.7
Olton clay loam, 3 to 5 percent slopes	360	.1
Potter soils	12,910	2.2
Pullman silty clay loam, 0 to 1 percent slopes	167,850	28.8
Pullman silty clay loam, 1 to 3 percent slopes	39,465	6.8
Pullman silty clay loam, 1 to 3 percent slopes, eroded	1,350	.2
Quinlan complex	19,645	3.4
Randall clay	15,940	2.7
Roscoe clay	6,765	1.2
Rough broken land	52,195	9.0
Rough broken land, gypsiferous	19,685	3.4
Sandy alluvial land	2,720	.5
Ulysses clay loam, 0 to 1 percent slopes	1,645	.3
Ulysses clay loam, 1 to 3 percent slopes	8,390	1.4
Vona fine sandy loam, 3 to 5 percent slopes	490	.1
Weymouth clay loam, 1 to 3 percent slopes	2,035	.3
Weymouth clay loam, 3 to 5 percent slopes	1,835	.3
Weymouth-Vernon complex	37,235	6.4
Wichita loam, 0 to 1 percent slopes	775	.1
Wichita loam, 1 to 3 percent slopes	3,210	.5
Wichita loam, 3 to 5 percent slopes	925	.1
Woodward loam, 1 to 3 percent slopes	950	.2
Woodward loam, 3 to 5 percent slopes	6,330	1.1
Woodward loam, 5 to 8 percent slopes	3,580	.6
Zita clay loam, 0 to 1 percent slopes	530	.1
Zita clay loam, 1 to 3 percent slopes	170	(1)
Barren riverbeds and creekbeds (sands and gravel)	5,765	1.0
Water areas	1,280	.2
Total	583,040	100.00

[1] Less than 0.05 percent.

Abilene Series

In the Abilene series are deep, slowly permeable soils on uplands. These soils have a dark grayish-brown clay loam surface layer and a very dark grayish-brown, heavy clay loam subsoil. These soils developed in calcareous, loamy outwash under a cover of native grasses. They occur mainly in the southeastern part of the county, on the Rolling Plains. Slopes range from smooth and nearly level to convex and gently sloping.

The surface layer is about 8 inches of neutral, dark grayish-brown clay loam that ordinarily contains an appreciable amount of organic matter. This layer is friable, but it pulverizes to dust if overtilled when dry, and it compacts if tilled when too moist. Where low in organic-matter content, it crusts easily when it dries.

The subsoil is about 35 inches thick and is slowly permeable. The upper part is very dark grayish-brown, neutral, heavy clay loam. This part has a moderate, medium, prismatic structure that breaks to moderate, medium, blocky or granular. The middle part is a dark grayish-brown light clay that has a strong blocky structure. It contains more clay, is more compact, and is less permeable than the part above or below. The lower part of the subsoil contains less organic matter than the middle part and is slightly lighter colored. It is a strongly calcareous clay loam that has a moderate blocky structure.

Most Abilene soils have, at a depth of 30 to 60 inches, a layer in which calcium carbonate has accumulated. The parent material below this layer is a mixture of strongly calcareous, reworked, old red-bed material and outwash sediments from the High Plains. This parent material is massive and contains less calcium carbonate than the layer above.

The thickness of the surface layer of Abilene soils ranges from 6 to 9 inches, and the texture from loam to silty clay loam. The thickness of the subsoil ranges from 25 to 50 inches. Surface drainage ranges from slow in the more nearly level areas to medium in the gently sloping areas.

The Abilene soils retain more water, are darker colored, and contain more organic matter than the associated less clayey Wichita soils. They have more distinct layers and are less permeable than the Weymouth soils.

Most of the acreage occupied by the Abilene soils is still in native grass pasture.

Abilene clay loam, 0 to 1 percent slopes (AbA).—This is a nearly level, dark-colored, slowly permeable soil. It is smooth, deep, and fertile. Its moisture-holding capacity is high, but the range of moisture content within which it is suitable for tillage is only moderate. The soil crusts easily and is slightly susceptible to wind erosion.

Mapped with this soil are clayey spots 10 to 30 feet in diameter that are vegetated with lake sedges and western wheatgrass. These spots stay wet longer than the surrounding soils; they are indicated on the map by the symbol for depressions.

Nearly all of this soil is in native grasses, mostly buffalograss and blue grama. A few or many mesquite trees have invaded, and so has some pricklypear cactus.

When moisture is favorable, good to excellent yields of dryland winter wheat and grain sorghum can be produced. Water for irrigation is not now available. If it were, this soil would produce excellent yields of wheat, sorghum, cotton, alfalfa, and vegetables. (Capability unit IIce-4, dryland; Deep Hardland range site)

Abilene clay loam, 1 to 3 percent slopes (AbB).—Most of this gently sloping soil borders nearly level Abilene and Wichita soils or lies along the natural drainageways that pass through nearly level areas. It has a slightly thinner

surface layer than Abilene clay loam, 0 to 1 percent slopes, and is subject to more loss of water and to more erosion because of its stronger slopes, but it is otherwise similar to that soil.

Included with this soil in mapping are small areas of Miles loam, 3 to 5 percent slopes, and minor areas of Weymouth soils. The inclusions make up 12 to 15 percent of the acreage.

This soil is nearly all in native grass, but it is suited to cultivation. When moisture is favorable, good yields of winter wheat and grain sorghum can be obtained. Water is not now available, but the soil is capable of producing high yields of cotton, alfalfa, or similar crops under irrigation. (Capability unit IIIe–2, dryland; capability unit IIIe–3, irrigated; Deep Hardland range site)

Berthoud Series

Soils of the Berthoud series are moderately sloping, medium in depth, brown to grayish brown, and calcareous (fig. 6). They are well-drained, friable soils that formed in water-laid material on foot slopes in areas transitional from the High Plains to the Rolling Plains. Geologic erosion has produced shallow, receding scarps, called catsteps. The number of these scarps increases with increase in slope. In this county Berthoud soils are mapped only in complexes with nonarable soils.

Figure 6.—**Profile of Berthoud fine sandy loam.**

The surface layer is brown to grayish-brown, calcareous, friable loam to fine sandy loam and is about 9 inches thick. It has weak granular and prismatic structure. Many worm casts are present.

The subsoil is brown to light brownish gray and loamy. It contains slightly more clay than the surface layer and has a granular and prismatic structure; the granules are mostly worm casts. This layer is about 20 inches thick. When it is moist, plant roots easily penetrate it and go into the underlying parent material.

The texture of the surface layer ranges from loam to sandy loam and the thickness from 7 to 15 inches. The texture of the subsoil ranges from loam to sandy clay loam and the thickness from 12 to 25 inches.

Berthoud soils are more calcareous and lighter colored than the closely related Bippus soils, which have more organic matter in their surface layer. They are slightly darker colored and more clayey than the Likes soils.

Berthoud soils are used almost entirely for native pasture consisting of blue grama, side-oats grama, sand dropseed, and other native mid grasses, with minor amounts of little bluestem, a scattering of yucca, and a little sand sagebrush in the sandier spots. Cultivated areas are used only to grow sorghum that is used as supplemental forage for livestock.

Berthoud-Mansker Soils

Berthoud and Mansker soils are mapped together as a complex in small, moderately sloping to sloping areas where the two kinds of soil occur in such patterns that they cannot be shown separately on the map. These soils are in the sloping and rolling areas transitional between the High Plains and the Rolling Plains. The landscape is one of rolling foot slopes, knolls, hills, and hogbacks.

Berthoud-Mansker fine sandy loams, 3 to 8 percent slopes (BfD).—Berthoud fine sandy loam makes up about 65 percent of this complex. It is on concave, colluvial-alluvial foot slopes below the Mansker soils and above the milder concave slopes of the Bippus soils and the nearly level areas of Loamy alluvial land. The native vegetation on this soil is dominantly blue grama but includes some side-oats grama, forbs, and yucca.

Mansker fine sandy loam, occupying the remaining 35 percent of this complex, is a shallow residual soil. Typically, it is on slopes above the Berthoud soil, near the summit of ridges, knolls, and other strongly sloping areas. The Mansker soil supports mainly native mid grasses. Dominant are side-oats grama and blue grama, but little bluestem and also some forbs are included. Yucca is common, and there is a scattering of catclaw shrubs. This soil has stronger slopes and is shallower than Mansker fine sandy loam, 1 to 3 percent slopes, which is described under the heading "Mansker Series," but in other characteristics it resembles that soil.

The percentage of either soil in this complex may vary as much as 20 percent from place to place. Also, in most areas, 10 to 15 percent of the acreage consists of Potter soils that were included in mapping.

This complex is unfit for cultivation because it has complex slopes and is shallow, limy, and subject to severe erosion. It is a good producer of grass if grazing is well

managed. (Capability unit VIe–2; Mixed Land Slopes range site)

Berthoud-Mansker loams, 3 to 8 percent slopes (BmD).—This complex consists of small areas of moderately sloping to sloping Berthoud loam mingled with sloping Mansker loam in such a pattern that the soils cannot be shown separately on the soil map. It occurs on sloping and rolling areas between the High Plains and the Rolling Plains. The landscape is one of smooth valley foot slopes, hogbacks, and hills.

Berthoud loam occupies about 65 percent of the acreage. It is on concave colluvial-alluvial foot slopes below the Mansker soils and above the Bippus soils and Loamy alluvial land. The Berthoud soil in this complex is shallower and less clayey than that described for the Berthoud series. On the Berthoud soil, geologic erosion has produced shallow, receding scarps, called catsteps, which are characteristic of sloping soils covered by grass. The number of scarps apparently varies with the slope.

The Berthoud soils, if properly managed, generally support a moderate to good cover of mid and short native grasses. The main grasses are side-oats grama, blue grama, and buffalograss. Yucca, cactus, and mesquite grow in some places.

The Mansker soil, occupying about 35 percent of the complex, is a shallow residual soil near the tops of ridges, knolls, and other sloping areas. It is similar to the soil described for the Mansker series. It supports chiefly short and mid grasses, such as side-oats grama, hairy grama, blue grama, and some buffalograss. There are some forbs and scattered patches of catclaw. Where this soil is heavily grazed, buffalograss replaces some of the grama grasses.

The proportion of Berthoud and Mansker soils in this complex varies by as much as 25 percent from place to place. Included in the complex are small areas of Potter soils that, in places, make up as much as 10 percent of the Mansker part of the complex.

The soils of this complex are unfit for cultivation because they are strongly sloping, shallow, and limy. They are good producers of native grasses when correctly grazed. If they are misused, they will gully and blow. (Capability unit VIe–1; Hardland Slopes range site)

Berthoud-Potter Soils

In transitional areas between the High Plains and Rolling Plains, Berthoud and Mansker soils occur in small areas so intermingled that they cannot be shown separately on the soil map. The landscape is one of smooth, moderately sloping to strongly sloping foot slopes and hills. The soils of this complex have profiles like those described for the Berthoud and Potter series. Here, however, the Berthoud soil is shallower and more sloping.

Berthoud-Potter sandy loams (Bo).—About 55 percent of this mapping unit is Berthoud soil, 30 percent is Potter, and 15 percent is Mansker. The proportions of these soils in the complex vary as much as 25 percent from place to place. Slopes range from 5 to 12 percent or more. This complex contains more Potter soil than the complex of Berthoud-Mansker fine sandy loams or Berthoud-Mansker loams. It includes minor areas of Likes soils and of Gravelly broken land.

The Potter soil is confined mostly to the tops of ridges and knolls. The Berthoud soil is on the smoother, lower side slopes of the valley walls, hogbacks, and hills. The Mansker soil occurs mainly between the Potter and Berthoud soils, but in many areas it is intermixed with both the Potter and Berthoud soils. (See fig. 28, p. 61.)

The Berthoud soil supports a good cover of short and mid grasses, such as blue grama, side-oats grama, and some bluestem. There are scattered mesquite shrubs and, in the sandier spots, some sand sagebrush. The Potter soils have a thin cover of native vegetation, mainly mid and short grasses. Side-oats grama, three-awn, and hairy grama grow on this soil, and also some forbs, yucca, and catclaw. In a couple of areas south of Goodnight, along the rim of Palo Duro Canyon, there are dense patches of shin oak. The Mansker soil supports a fair stand of grasses consisting mainly of side-oats grama and blue grama but including minor amounts of bluestem. Yucca is common, and there is a scattering of catclaw.

The soils of this complex are used only as native pasture for livestock or wildlife. If misused they are likely to wash, gully, and blow. (Berthoud soil: capability unit VIe–2; Mixed Land Slopes range site. Potter soil: capability unit VIIs–1; Shallow range site)

Bippus Series

The Bippus series consists of deep, gently sloping to moderately sloping soils that have a surface layer of dark grayish-brown clay loam to fine sandy loam and a subsoil of grayish-brown clay loam to heavy loam (fig. 7). These soils are on local outwash deposited on foot slopes, aprons, and fans below the High Plains escarpment or remnants of that escarpment.

The surface layer is about 13 inches thick where the texture is clay loam and 16 inches thick where the texture is fine sandy loam. This layer is neutral in reaction and friable to very friable. The plow layer in areas that have been tilled still has its excellent granular structure.

The subsoil is about 25 inches of friable clay loam. It contains slightly more clay than the surface layer and is normally calcareous. Fine to medium nodules of caliche are few to common and are distributed throughout this layer. This layer has fine and medium granular and prismatic structure; most of the granules are worm casts.

The parent material, 10 feet or more thick in places, consists of strongly calcareous local sediments that have been washed from the higher lying, weathered soils of the High Plains. This material is friable, contains considerable lime, and is easily penetrated by plant roots when moist. In most places, however, this material appears to be dry most of the time.

The surface layer of Bippus soils ranges from 10 to 24 inches in thickness, and the subsoil from 10 to 40 inches.

Bippus soils are well drained. Surface drainage is medium to slow, and the subsoil is moderately permeable. These soils receive runoff from adjacent slopes.

Bippus soils are less calcareous than Berthoud soils. They receive more runoff water and are darker colored because they contain more organic matter. They contain more organic matter than Likes soils, are much darker colored, and contain much more clay. They are not stratified like the lower lying Loamy alluvial land, since their parent materials are local sediments, not sediments

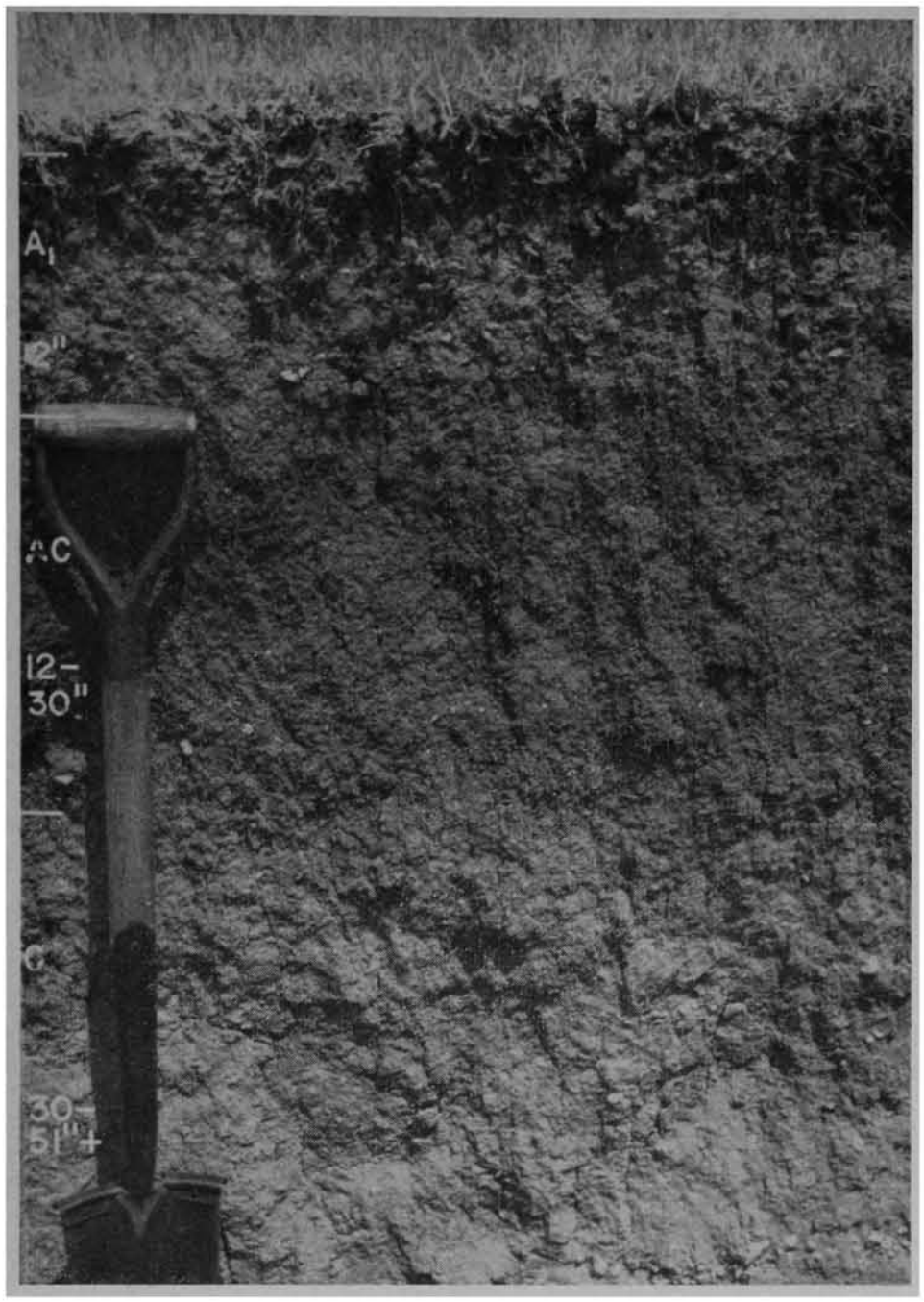

Figure 7.—**Profile of Bippus clay loam.**

brought from great distances, as are those of Loamy alluvial land and Sandy alluvial land.

About one-fourth of the acreage of Bippus soils is cultivated. The use of these soils for crops is determined largely by the size and shape of the soil areas and their accessibility for farming. These soils are mostly on large cattle ranches where nearly all the land is used as native range.

Bippus clay loam, 0 to 1 percent slopes (BrA).—This is a smooth, nearly level, deep, dark-colored, friable, granular soil. It occurs mostly as irregular bands between lower lying Loamy alluvial land and higher lying Berthoud loam.

Included with this soil in mapping are small areas of Loamy alluvial land and some narrow areas transitional to Bippus clay loam, 1 to 3 percent slopes.

This soil is fertile; it has a moderate to moderately wide range of moisture content within which it is suitable for tillage; and it takes and stores water and releases it to plants as needed. Under cultivation, however, it is moderately susceptible to wind and water erosion.

If it is properly managed, this soil is highly productive of either the dryland or the irrigated crops commonly grown in the area. It is a good producer of native grasses because it holds much of the water it receives. The acreage not in grass is used to produce supplemental feed for livestock. (Capability unit IIIce–2, dryland: capability unit IIe–2, irrigated: Deep Hardland range site)

Bippus clay loam, 1 to 3 percent slopes (BrB).—This is a smooth, gently sloping, dark-colored, friable, granular soil. It occurs as areas of irregular width on foot slopes in the range areas of the county. Less than 30 percent of it is farmed.

Included with this soil in the areas mapped are small areas of Bippus clay loam, 0 to 1 percent slopes.

This soil has a moderately wide range of moisture content within which it can be worked. It takes and stores water and releases it to plants. Under cultivation, it is moderately susceptible to wind and water erosion unless it is carefully managed. Under good management, it is productive cropland and an excellent producer of short native grasses. (Capability unit IIIe–2, dryland: capability unit IIIe–3, irrigated: Deep Hardland range site)

Bippus clay loam, 3 to 5 percent slopes (BrC).—This soil is similar to Bippus clay loam, 1 to 3 percent slopes, but it is on stronger, concave slopes, is slightly less clayey, and is not so dark colored or so thick in the surface layer. Because it has stronger slopes, it loses more water through runoff. The susceptibility to water erosion is moderately severe, and the danger of wind erosion is moderate. At its lower boundaries, this soil normally blends with Bippus clay loam, 1 to 3 percent slopes.

Included with this soil in mapping are spots of Berthoud soils and of soils transitional to Berthoud soils, which make up as much as 10 percent of some areas.

Nearly all of this soil has a cover of short native grasses, chiefly blue grama but including lesser amounts of buffalograss and sand dropseed. There are scattered mesquite trees. Less than a tenth of the acreage is used to grow winter wheat and sorghum. (Capability unit IVe–1, dryland or irrigated: Deep Hardland range site)

Bippus fine sandy loam, 1 to 3 percent slopes (BpB).—This is a deep, gently sloping, granular soil that has a surface layer of fine sandy loam and a subsoil of moderately permeable clay loam. It occurs as irregular bands adjoining the bottom lands in the sandier parts of the Rolling Plains.

Included in mapping are a few small areas transitional to Berthoud-Mansker fine sandy loams, 3 to 8 percent slopes. These inclusions make up as much as 10 percent of a few areas.

This is a fertile soil. It has a wide range of moisture content within which it is suitable for tillage. It takes water readily and releases it easily to plants. Its moisture-holding capacity is moderate. When tilled, it is moderately susceptible to wind erosion and slightly susceptible to water erosion.

About an eighth of this soil is cultivated, mainly to dryland sorghum and winter wheat, which are used as supplemental feed for livestock. In years of favorable moisture, grain is grown for sale. If it is properly used, this soil produces a good cover of blue grama, some sand dropseed and little bluestem, and a scattering of forbs and mesquite. (Capability unit IIIe 4, dryland: capability unit IIe–5, irrigated: Sandy Loam range site)

Gravelly Broken Land

Gravelly broken land occupies areas below the High Plains escarpment but above the red-bed erosional plains in the Palo Duro Canyon. The landscape is one of a chain or cluster of fairly smooth, gravel-capped, dome-shaped hills 100 feet or more high.

Gravelly broken land (Gr).—This land type is locally called "gravelly hills." Geologic erosion has removed the finer sediments and has left a mantle of quartzitic gravel and cobblestones. This mantle varies in thickness, but it is thickest and most effective in retarding erosion at the top of hills. It feathers out at or near the base of hills. The slope range is 5 to 60 percent or more, but the slope is most commonly about 25 percent. Miniature landslides are common on slopes of more than 50 percent and in areas bordering streams.

In the swales between the hills is Likes loamy fine sand. In mapping, however, these spots of Likes soil were included with Gravelly broken land and make up about 15 percent of its acreage.

This land type is smoother than Rough broken land and is more accessible to cattle. It supports a sparse, but uniform, cover of mid and tall native grasses, mainly little bluestem, blue grama, and side-oats grama, and also scattered redberry juniper and catclaw shrubs. The vegetation provides partial refuge for some species of wildlife. (Capability unit VIIs–3; Gravelly range site)

Likes Series

In the Likes series are deep, moderately sloping to strongly sloping soils that have a surface layer of brown loamy fine sand and a subsoil of light-brown loamy fine sand (fig. 8). These soils are on valley foot slopes and in draws on the Rollings Plains.

The surface layer is about 10 inches of neutral, and in some places weakly calcareous, very friable or loose loamy fine sand that is slightly darkened by organic matter. It has a very weak, granular structure, but in some places it is nearly structureless. The soil material is held together by fibrous grass roots.

The subsoil is pale-brown, loose, structureless loamy fine sand and is about 25 inches thick. It is strongly calcareous and contains a few scattered fine nodules of hard caliche.

The parent material, about 2 to 15 feet thick, is strongly calcareous, structureless loamy sand that has been washed or blown from the higher areas. In most places there are some scattered fine nodules of caliche.

The surface layer of Likes soils ranges from 8 to 15 inches in thickness, and the subsoil from 8 to 25 inches or more.

The Likes soils are lighter colored and coarser textured than the Berthoud soils. They have fewer and less distinct layers than the Vona soils and are much more calcareous.

All of the acreage is in mid and tall native grasses and is used for range.

Likes loamy fine sand (Lk).—This is a moderately sloping to strongly sloping, very porous, coarse-textured soil. It takes water readily, but it has low fertility and when tilled is subject to severe wind erosion.

Included with this soil in mapping are some sandy mounds and ridges and narrow areas transitional to Miles and Berthoud soils.

Figure 8.—**Profile of Likes loamy fine sand.**

This soil is used entirely for range. It supports a fair to good cover of mid and tall native grasses, such as blue grama, side-oats grama, bluestem, and sand lovegrass. There are a few yucca plants and some sand sagebrush and skunkbrush. (Capability unit VIe–6; Sandy Land range site)

Loamy Alluvial Land

Loamy alluvial land consists of moderately permeable, calcareous sediments deposited by streams. It occurs as narrow, irregular flood plains, mostly on the Rolling Plains. It is flooded after each heavy rainfall, and it is susceptible to deep, vertical channel cutting and to bank sloughing. In places the soil material is stratified and the layers range in texture from clay loam to sandy loam. The parent material consists of friable, calcareous alluvium derived mainly from the High Plains but including some red-bed material. Drainage is good. Both surface drainage and internal drainage are medium.

Loamy alluvial land is darker colored, more clayey, and less permeable than Sandy alluvial land.

Cultivation of these areas is not practical, because they

include old scar channels, streambanks, and areas dissected by active meandering drainage channels. The cover of native vegetation is heavier than on similar soils on uplands, because of the extra moisture added by floods.

Loamy alluvial land (Lm).—This miscellaneous land type consists of loamy sediments deposited on the narrow flood plains along Mulberry Creek, the Salt Fork of the Red River, and the Prairie Dog Town Fork of the Red River.

Included in the areas mapped are small areas of Bippus clay loam, 0 to 1 percent slopes, and small areas transitional to Bippus clay loam, 1 to 3 percent slopes.

Thin lenses of sand and of quartzitic and caliche gravel commonly occur in the lower part.

This land type is not suited to cultivation, but it is a good producer of short and mid grasses, such as blue grama, buffalograss, and western wheatgrass, and of vine mesquite. It remains in good condition longer under heavy grazing than Sandy alluvial land, but it responds less readily to management once it has deteriorated. A few cottonwood and chinaberry trees grow around the waterholes along the channels of intermittent streams. (Capability unit Vw–1; Loamy Bottom Land range site)

Lofton Series

In the Lofton series are nearly level, very dark grayish-brown soils that have a surface layer of silty clay loam and a subsoil of compact, dark or very dark grayish-brown clay. These soils occur in depressions within areas of Pullman soils on the High Plains. They are mostly on the higher benches of large playas, but some are on the bottom of slight depressions.

The surface layer is very dark grayish-brown silty clay loam and is about 7 inches thick. The structure is moderate or strong, granular or subangular blocky in areas that are in native grass, and weak granular in areas that have been tilled for some time. This layer crusts if tilled when dry, and it compacts if tilled when too moist. The reaction is neutral.

The subsoil is about 45 inches thick. It contains more clay and is more compact in the upper part than in the lower part. The upper part is neutral, dark to very dark grayish-brown clay. It has a strong, medium, blocky structure when dry, but it is massive when wet.

In most places there is a layer in which calcium carbonate has accumulated. Depth to this layer ranges from 40 to 70 inches but is commonly about 50 inches.

The parent material consists of calcareous, clayey sediments derived from the surrounding higher areas of the High Plains. This material is firm and massive, and it contains some scattered pockets of chalky caliche and a few krotovinas ranging from about 1 to 11 inches in diameter.

The surface layer of the Lofton soils ranges from 5 to 10 inches in thickness, and the subsoil from 35 to 60 inches. Buried soils occur in some places.

Surface drainage is slow, and the subsoil is very slowly permeable when wet.

Lofton soils receive and retain more water and are darker colored than the associated higher lying Pullman and Ulysses soils. They are deeper and are less permeable than Zita soils. They have more distinct layers and are better drained than the lower lying Roscoe and Randall soils.

Lofton silty clay loam (Lo).—This soil is fertile. It is dark colored because it is high in organic-matter content. When wet, it takes water very slowly, and it can be worked only within a fairly narrow range of moisture content. It is slightly susceptible to wind erosion. In very wet seasons it is flooded occasionally.

Included with this soil in mapping are narrow areas transitional to Roscoe clay and Randall clay. The inclusions make up as much as 15 percent of some areas, but generally they make up less than 5 percent.

This soil is well suited to either dryland or irrigated crops. It is highly productive if moisture is favorable, but some areas should not be cultivated unless outside water is diverted. (Capability unit IIIce–1, dryland; capability unit IIs–1, irrigated; Deep Hardland range site)

Mansker Series

The Mansker series consists of very friable, strongly calcareous, grayish-brown, shallow soils that have a surface layer of loam to sandy loam and a subsoil of light grayish-brown clay loam to sandy clay loam (fig. 9).

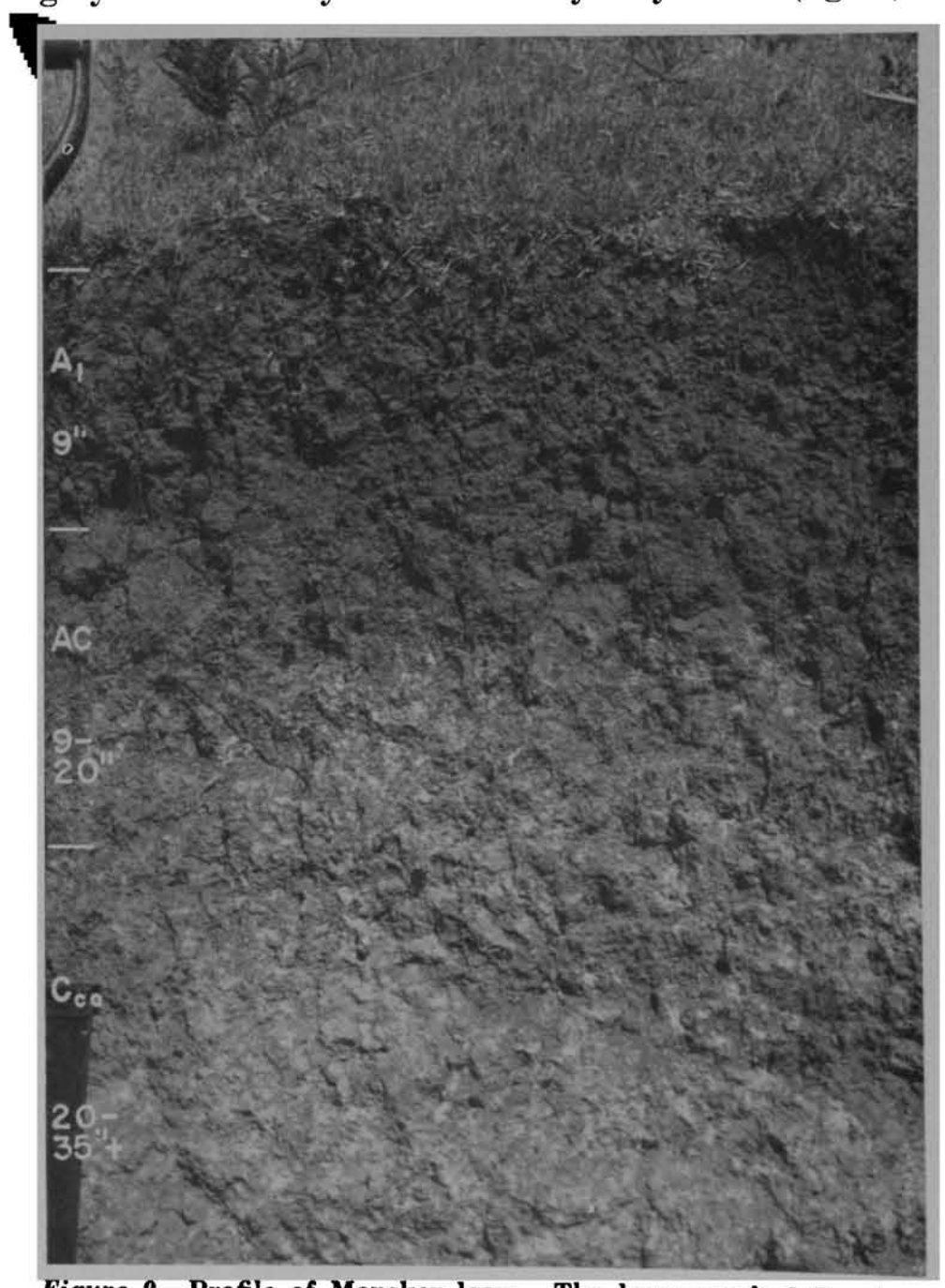

Figure 9.—**Profile of Mansker loam. The layer marked Cca is a zone of lime accumulation.**

Mansker loam is on southern and southwestern exposures on playa rims and side slopes of draws on the High Plains. Mansker fine sandy loam is mainly in the transitional area between the High Plains and the Rolling Plains.

The surface layer is strongly calcareous, grayish-brown, very friable, granular loam to sandy loam and is about 8 inches thick. The loam is darker colored than the fine sandy loam or sandy loam. This layer is highly susceptible to wind erosion if tilled and left unprotected.

The subsoil is about 9 inches of friable, grayish-brown loam to sandy clay loam. It contains slightly more clay than the surface layer. It has a moderate, fine, granular structure. Most of the granules are worm casts. Fine fragments of caliche are distributed throughout this layer. Plant roots easily penetrate this layer when it is moist.

At a depth of 12 to 20 inches, there is an 8- to 24-inch layer in which lime has accumulated. Soft and hard lime concretions make up 20 to 60 percent of this layer.

The parent material is a mixture of strongly calcareous old outwash and sediments deposited and reworked by the wind.

The surface layer is 6 to 11 inches thick, and the subsoil 7 to 13 inches.

Drainage is good. Surface runoff is moderate to rapid, and permeability is moderate.

Mansker soils are more calcareous and lighter colored than the deeper, less sloping, closely related Ulysses soils. They occur on smoother, less complex slopes than Potter soils, and they are deeper and less calcareous.

Nearly all of the acreage is in native range consisting of mid and short grasses, such as side-oats grama and blue grama, minor amounts of bluestem and forbs, and scattered patches of broom snakeweed and catclaw. Yucca is common on the sandier soils in the heavily grazed areas, and buffalograss on the more clayey soils.

Mansker fine sandy loam, 1 to 3 percent slopes (MaB).—This is a smooth, shallow, calcareous, gently sloping soil that has a subsoil of moderately permeable sandy clay loam and, within 20 inches of the surface, a layer of soft to hard caliche.

Included in the areas mapped are a few small areas of Potter soils.

This soil contains an excessive amount of lime. It takes water readily, but its water-holding capacity is low. If tilled and left unprotected, it is in severe danger of blowing. Fertility is low.

About a third of the acreage is cultivated, mainly to feed sorghum and winter wheat, which are used as supplemental feed and forage for livestock. (Capability unit IIIe–8, dryland; capability unit IIIe–10, irrigated; Mixed Land Slopes range site)

Mansker loam, 1 to 3 percent slopes (MkB).—This shallow, calcareous soil occurs within large areas of Ulysses soils and on the long, gentle side slopes of playas and draws on the High Plains. It has a subsoil of moderately permeable clay loam and, at a depth of less than 20 inches, a layer of soft to hard caliche.

This soil has fairly low fertility and contains an excessive amount of lime. It takes water easily, but its water-holding capacity is fairly low. Under cultivation, it is moderately susceptible to wind and water erosion.

Nearly all of this soil has a cover of native grasses, chiefly blue grama, side-oats grama, and buffalograss. There are scattered patches of broom snakeweed and catclaw shrubs. About a tenth of the acreage is cultivated with the surrounding Ulysses soils. (Capability unit IVe–9, dryland; capability unit IIIe–10, irrigated; Hardland Slopes range site)

Mansker loam, 3 to 5 percent slopes (MkC).—This is a shallow, calcareous, moderately sloping soil that has a moderately permeable clay loam subsoil. Below the subsoil, at a depth of 20 inches or less, is a layer of soft to hard caliche. Typically, this soil is on the southern and southwestern exposures of playa rims, on side slopes of drainageways, and on ridges. The smooth, convex slopes are from 200 to 800 feet long. The slopes of playa rims are commonly about 300 feet long, and those of drainageways and ridges about 500 feet.

Nearly all of this soil is in native range consisting mostly of side-oats grama and blue grama but including lesser amounts of buffalograss and some patches of broom snakeweed and catclaw shrubs. There are scattered patches of catclaw and in some places a few dwarf mesquite shrubs. (Capability unit VIe–1, dryland; capability unit IVe–6, irrigated; Hardland Slopes range site)

Mansker loam, 3 to 5 percent slopes, eroded (MkC2).—The surface layer of this soil is a stronger brown than that of a representative uneroded Mansker soil. It is mostly clay loam and is ordinarily about 4 inches thick. About half of the original surface layer has been lost through wind and water erosion. Shallow, crossable gullies are common. A few gullies are deep enough that the parent material is exposed.

Included with this soil in the areas mapped are spots, less than 5 acres in size, of Ulysses clay loam and Potter loam.

About a third of the acreage of this soil still is farmed with the deeper and more productive associated soils. The rest has been reseeded to native grasses. Cultivation is no longer profitable. Native grasses can be reestablished and will protect the soil from further erosion. A mixture of side-oats grama, blue grama, and buffalograss can be planted in dead litter, preferably in residues from close-drilled sorghum. Annual weeds probably will need to be mowed to reduce competition with the grass seedlings. Grazing can be permitted after the grass is well established. (Capability unit VIe–1; Hardland Slopes range site)

Miles Series

In the Miles series are deep, smooth, undulating soils that have a surface layer of brown or dark-brown fine sandy loam and a subsoil of reddish-brown sandy clay loam (fig. 10). These soils occur on the Rolling Plains.

The surface layer is about 9 inches of neutral fine sandy loam. The upper part has a granular structure or, where it has been overtilled, is structureless. The lower part has a coarse to very coarse prismatic structure. In places that have been cultivated, the wind has blown away some of the silt and clay particles, and the texture now is loamy fine sand. A plowsole forms in this layer if the soil is tilled repeatedly to the same depth or is tilled when too moist.

The subsoil is about 45 inches thick and consists of three layers. The upper layer and the middle layer are neutral, reddish-brown sandy clay loam that has a coarse or very coarse prismatic structure. Permeability is

moderate to moderately rapid. In most places there are a few waterworn, lime-coated quartz pebbles and cobblestones in the uppermost layer. The middle layer contains more clay and is more compact than the layers above and below. The lowest layer is yellowish-red, calcareous, heavy sandy loam to sandy clay loam that has a slightly weaker structure than the other two layers. Waterworn, lime-coated quartz pebbles and cobblestones are common in this layer. In places, the lowest part includes a buried soil.

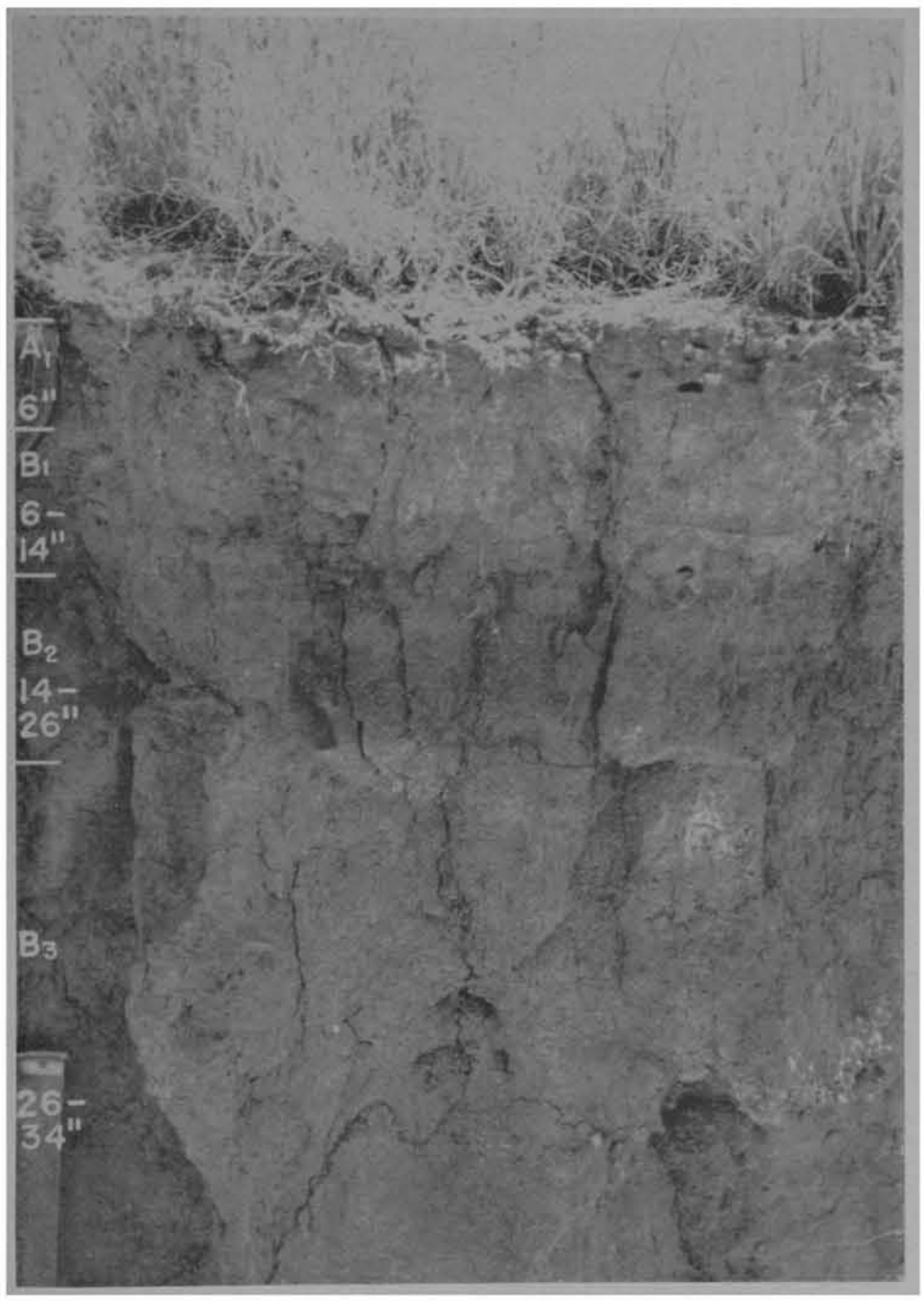

Figure 10.—**Profile of Miles fine sandy loam.**

The parent material consists of old, calcareous outwash of loam to light sandy clay loam texture. Generally, it contains a few lenses of waterworn quartz and caliche gravel at a depth of 3 to 5 feet. It is friable and is easily penetrated by plant roots when moist.

The surface layer ranges from 6 to 14 inches in thickness, and the subsoil from 30 to 70 inches. The subsoil is neutral or mildly alkaline and weakly calcareous. Buried soils are fairly common at a depth of 3 to 5 feet or more.

Most Miles soils are slightly or moderately susceptible to water erosion, and the sandier Miles soils are highly susceptible to wind erosion if unprotected.

Miles soils are more porous, more permeable, and lighter colored than Abilene and Wichita soils. They have more distinct layers and are deeper than the more calcareous Weymouth and Woodward soils.

About half of the acreage is cultivated to sorghum, winter wheat, and some cotton, and the rest is in native range consisting of mid and short grasses, a scattering of forbs, and some mesquite.

Miles fine sandy loam, 0 to 1 percent slopes (MsA).—This is a deep, nearly level soil that has a moderately permeable subsoil of sandy clay loam.

This soil is porous and easily worked. It readily takes water and releases it to plants.

If its fertility is maintained, this is one of the most dependable soils in the county for sorghum and cotton. Under irrigation it produces good yields of all crops commonly grown in the county. Most of the acreage east of Goodnight is tilled. The rest is in the Palo Duro Canyon and is used for native range consisting mostly of mid and short grasses, such as blue grama, feather bluestem, and little bluestem. (Capability unit IIIe–4, dryland; capability unit IIe–4, irrigated; Sandy Loam range site).

Miles fine sandy loam, 1 to 3 percent slopes (MsB).—This is a gently sloping and slightly undulating soil that has a surface layer of fine sandy loam and a subsoil of moderately permeable sandy clay loam. This is the most extensive of the arable Miles soils in the county. It is porous and easily worked, and it readily takes water and releases it to plants. When cultivated, it is moderately susceptible to wind erosion and slightly to moderately susceptible to water erosion.

Included in mapped areas of this soil are spots of Miles fine sandy loam, 3 to 5 percent slopes, and also some spots of Miles loamy fine sand that are in old cultivated fields.

About two-fifths of the acreage is used as native range. If the moisture supply is adequate and management is good, this soil is a good producer of dryland or irrigated crops, including sorghum, cotton, wheat, and other crops commonly grown in the county. (Capability unit IIIe–4, dryland; capability unit IIe–5, irrigated; Sandy Loam range site)

Miles fine sandy loam, 3 to 5 percent slopes (MsC).—This is a moderately sloping and undulating soil that has a subsoil of moderately to moderately rapidly permeable, light sandy clay loam. This soil is fairly fertile and is easy to work. It readily takes water and releases it to plants. If it is cultivated and left unprotected, there is a moderately severe hazard of wind erosion and a moderate hazard of water erosion.

Mapped with this soil are spots of loamy fine sand less than 5 acres in size.

Most of the acreage is in native range consisting of mid and tall grasses. A small acreage is cultivated, mainly to sorghum. (Capability unit IVe–4, dryland; Sandy Loam range site)

Olton Series

In the Olton series are deep, friable soils that have a surface layer of dark-brown clay loam and a subsoil of reddish-brown, heavy clay loam (fig. 11). These soils occur as spots and bands on side slopes of drainageways that border the High Plains. Slopes range from smooth and nearly level to convex and moderately sloping.

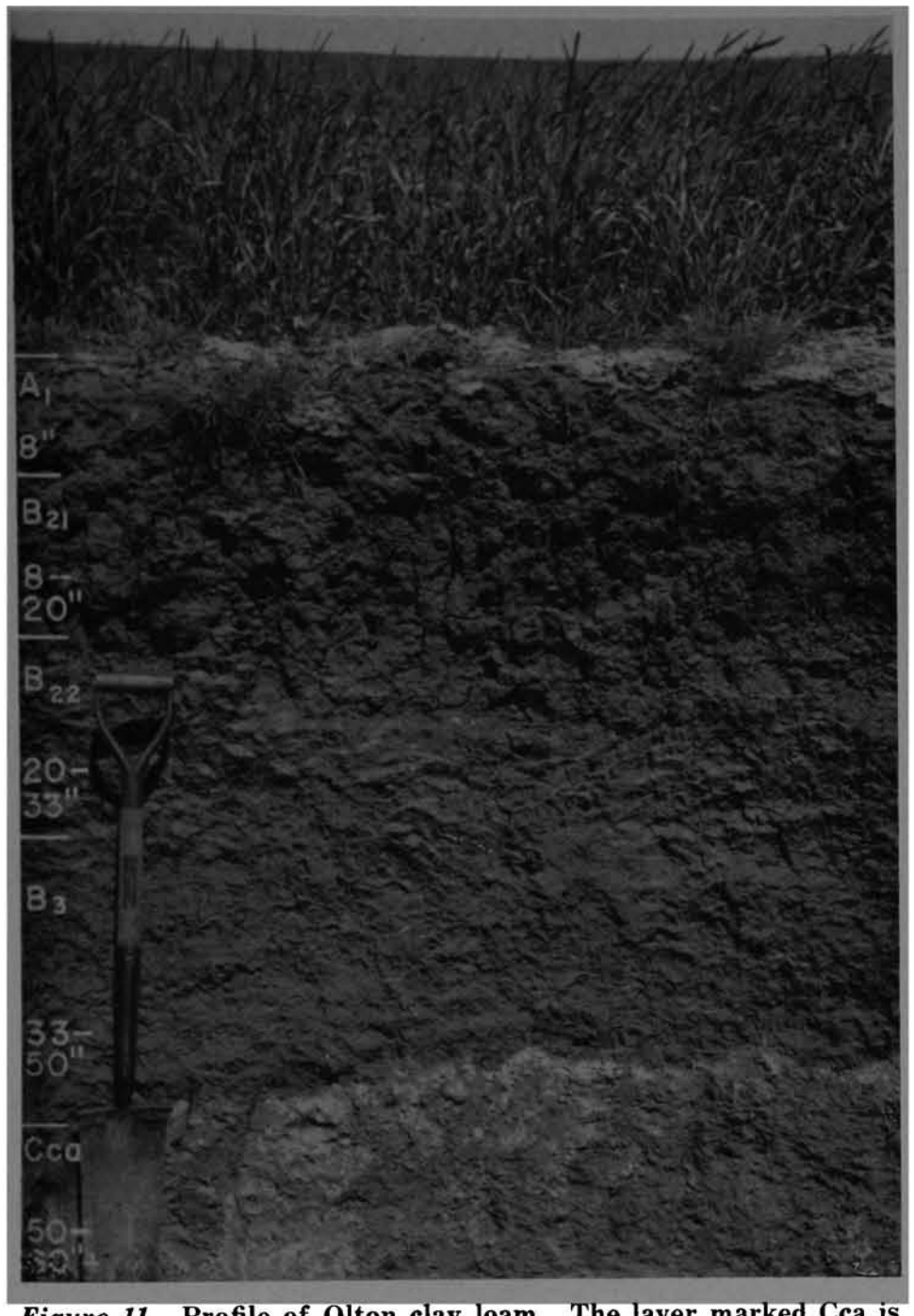

Figure 11.—**Profile of Olton clay loam. The layer marked Cca is a zone of lime accumulation.**

The surface layer is about 8 inches of dark-brown, neutral clay loam. Before it was tilled, this layer had a fine granular structure. Where it has been overtilled, the plow layer is nearly structureless and is low in organic-matter content. Below the plow layer, the structure is granular or subangular blocky.

The subsoil is about 35 inches thick. The upper part is a slowly permeable, neutral, dark reddish-brown, heavy clay loam that has a blocky structure. It contains more clay and is slightly more compact than the part below. The lower part is a weakly calcareous, reddish-brown to yellowish-red, heavy clay loam that has a moderate, blocky structure. The subsoil consists of the same kind of material as the buried soils that underlie the nearly level Pullman and Zita soils.

Most Olton soils have a well-developed pink or pinkish-white layer at a depth of 30 to 64 inches but most commonly at about 45 inches. About 20 to 50 percent of this layer, by volume, is chalky calcium carbonate.

The parent material is reddish-yellow, strongly calcareous, fairly friable earthen material that contains scattered pockets of chalky caliche. This material is easily penetrated by plant roots when moist, but it appears to be dry most of the time. It is occasionally wet for short periods during unusually wet weather.

The thickness of the surface layer ranges from 7 to 11 inches. The texture ranges from loam to silty clay loam, but it is most commonly clay loam. The thickness of the subsoil ranges from 20 to 50 inches.

Olton soils are well drained. Surface runoff is moderate to slow, and the subsoil is slowly permeable.

Olton soils are lighter colored, more permeable, and less droughty than Pullman and Lofton soils. They are lighter colored and less permeable than Zita soils.

Olton soils are suited to the crops commonly grown in the county, but less than half of the acreage is cultivated. A large acreage is still in native range.

Olton clay loam, 0 to 1 percent slopes (OcA).—This is a deep, smooth, nearly level soil. It borders areas of Pullman silty clay loam, 0 to 1 percent slopes.

Included with this soil in mapping are transitional areas of the adjoining Pullman and Ulysses soils. These inclusions make up 8 to 10 percent of some areas but less than 3 percent of most areas.

This soil is fertile. It takes water slowly, but its water-holding capacity is moderately high, and the range of moisture content within which it can be worked is favorable. Under cultivation it is slightly susceptible to wind erosion.

About half of this soil is cultivated, and the rest is in native range. Good to excellent yields of winter wheat, grain sorghum, barley, and other crops commonly grown in the county can be produced if the natural moisture supply is adequate or if the soil is irrigated. (Capability unit IIIce–2, dryland; capability unit IIe–1, irrigated; Deep Hardland range site)

Olton clay loam, 1 to 3 percent slopes (OcB).—This is a deep, fertile soil. It takes water slowly, but its water-holding capacity is moderately high, and the range of moisture content within which it is suitable for tillage is moderately wide. Under cultivation this soil is slightly susceptible to wind erosion and moderately susceptible to water erosion.

Included with this soil in mapping are narrow areas transitional to the adjoining Pullman silty clay loam, 1 to 3 percent slopes. These inclusions make up as much as 8 percent of some areas but less than 5 percent of most areas.

Nearly half of the acreage is cultivated, and the rest is in range consisting of short native grasses. If the moisture supply is favorable, or if this soil is properly managed under irrigation, good to excellent yields of the crops commonly grown in the county are produced. (Capability unit IIIe–2, dryland or irrigated; Deep Hardland range site)

Olton clay loam, 3 to 5 percent slopes (OcC).—This soil is slightly more shallow than Olton clay loam, 1 to 3 percent slopes. It is moderately sloping and slowly permeable. In tilled areas there is a slight hazard of wind erosion and a moderately severe hazard of water erosion.

Included in mapped areas of this soil are a few areas of Pullman soils. These inclusions make up as much as 10 percent of some areas but less than 5 percent of most areas.

Most of this soil is in range consisting mainly of blue grama but including some buffalograss. Some mesquite

trees have invaded. (Capability unit IVe–1, dryland or irrigated; Deep Hardland range site)

Potter Series

The Potter series consists of strongly calcareous, very shallow, light-brown to grayish-brown loamy soils that are underlain by pinkish-white caliche. These soils are adjacent to the jagged caliche caprock escarpment that borders the High Plains. Strong to steep slopes predominate, but a few areas are gently sloping.

The surface layer is about 7 inches of grayish-brown, very strongly calcareous loam, gravelly loam, or fine sandy loam that has a weak, fine and medium, granular structure. This layer ranges in thickness from 2 to 10 inches. The underlying caliche is 2 or 3 feet or more in thickness. It is partly weathered, and it becomes soft and chalky with increasing depth. This caliche, which is 40 to 70 percent calcium carbonate, probably was deposited by underground water.

These soils are excessively drained. Because of steep slopes, most of the rainfall is lost through runoff and the substratum is permanently dry.

Potter soils are lighter colored and shallower than the closely related Mansker soils, and they usually have steeper, more complex slopes. They are lighter colored and shallower than Berthoud soils.

Potter soils (Ps).—These gently sloping to steeply sloping soils are strongly calcareous and very shallow. They have a loam to gravelly loam texture. The water-holding capacity is low, and fertility is low. If not protected by vegetation, these soils blow, wash, and gully severely.

Included in the areas mapped are areas of Mansker and Berthoud soils less than 20 acres in size. These inclusions make up about 15 percent of some areas.

These soils are suitable only for range or for wildlife habitats. They support a thin cover of native grasses, such as three-awn, side-oats grama, hairy grama, and little bluestem. There are scattered patches of broom snakeweed and catclaw shrubs. Dense stands of shinnery oak grow in a few areas along the rim of the Palo Duro Canyon in the eastern part of the county. (Capability unit VIIs–1; Shallow range site)

Pullman Series

The Pullman series consists of deep, nearly level to gently sloping soils that have a surface layer of dark grayish-brown silty clay loam and a subsoil of dark-brown clay (fig. 12). These soils are on the High Plains. Except for areas surrounding intermittent lakes and draws, relief is flat or nearly so.

The surface layer is neutral, dark grayish-brown silty clay loam and is about 7 inches thick. This layer compacts easily if tilled when too moist, and it crusts when dry. The plow layer is nearly structureless, but generally tillage brings up some small clods and clayey fragments from the upper part of the subsoil. The lower part of the surface layer is compact and has a strong, blocky structure.

The subsoil is about 48 inches thick. The upper part contains more clay and is more compact than the lower part. The upper part is neutral, dark-brown clay. When dry, it has a strong, medium, blocky structure, but

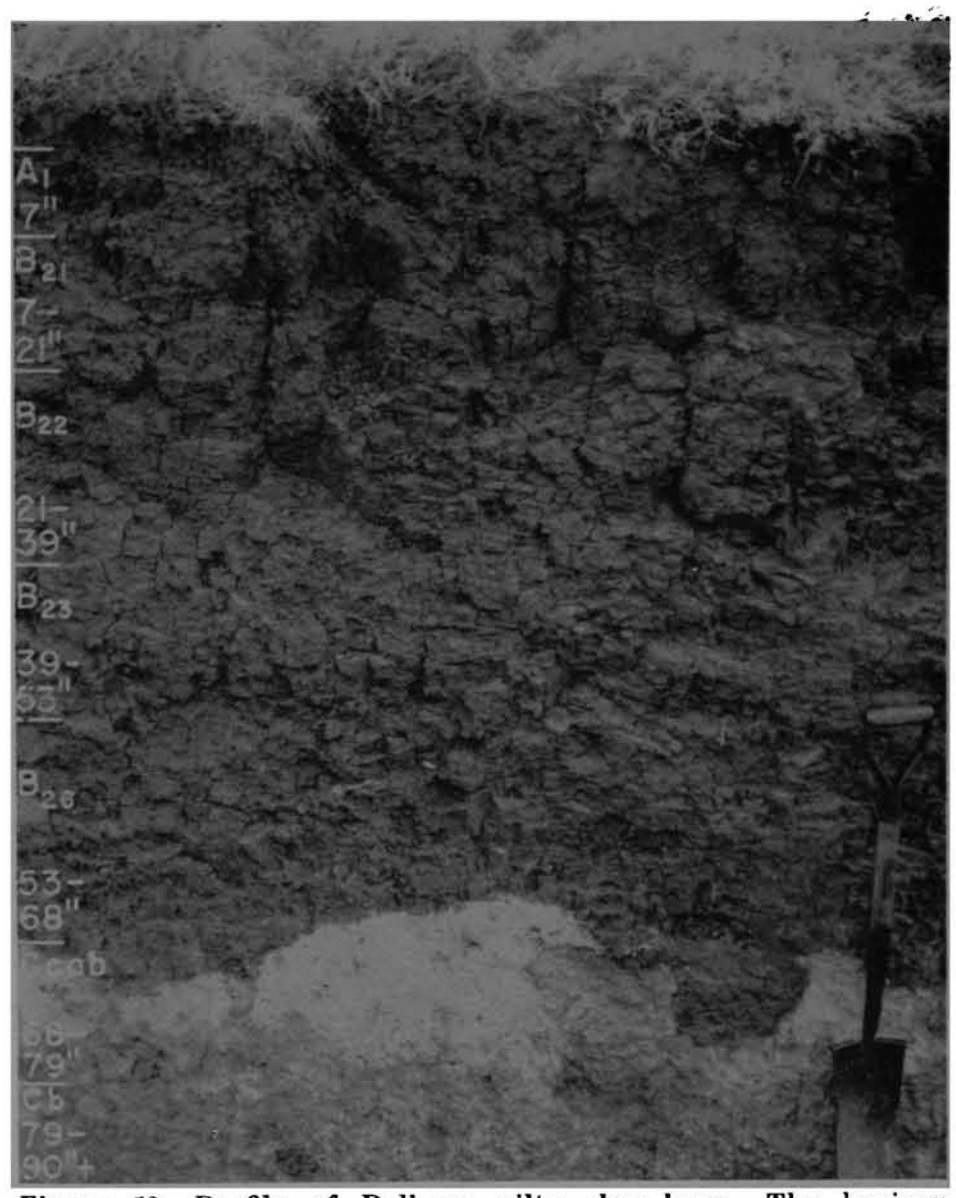

Figure 12.—**Profile of Pullman silty clay loam. The horizon marked Ccab is a zone of lime accumulation; the one marked Cb is a buried soil.**

it is temporarily tight and massive when moist. Tillage commonly causes the formation of a plowsole, or plowpan, that limits the moisture available to plants and prevents normal development of roots. The lower part of the subsoil is weakly calcareous, dark-brown to yellowish-red clay to silty clay that has a moderate, blocky structure when dry. This part is very slowly permeable when wet.

Most Pullman soils have a layer in which calcium carbonate has accumulated. Depth to this layer ranges from about 30 to 70 inches but is most commonly between 50 and 55 inches.

The parent material is strongly calcareous, wind-laid material that is fairly friable, contains much lime, and is easily penetrated by plant roots when moist. This material is dry, except for a short time during extremely wet periods.

The texture of the surface layer ranges from clay loam to silty clay, but in most places it is silty clay loam. The thickness ranges from 3 to 8 inches. The differences in thickness result from wind and water erosion. The thickness of the subsoil ranges from 20 to 70 inches or more. In most places, especially in the nearly level areas, one or more layers of a buried soil underlie the subsoil.

Surface drainage ranges from slow, in the nearly level areas, to medium, in the convex, gently sloping areas.

Pullman soils are lighter colored than the lower lying Lofton soils. They have more distinct layers and are less permeable than Zita and Ulysses soils.

Soils of the Pullman series are important in agriculture. They are suited to winter wheat, sorghum, and short native grasses. They are very productive if the moisture supply is adequate or if they are properly irrigated. Most of the acreage is cultivated.

Pullman silty clay loam, 0 to 1 percent slopes (PuA).—This is a smooth, nearly level soil. The subsoil has a strong, blocky structure when dry, but it is nearly massive when moist. This soil is fertile. It takes water very slowly when wet, but it has a high water-holding capacity and a moderate range of moisture content within which it is suitable for tillage. When tilled, it is slightly susceptible to wind erosion.

Included with this soil in mapping are small areas, less than 5 acres in size, of Ulysses, Olton, and Zita clay loams and of transitional soils; areas of Pullman silty clay loam, 0 to 1 percent slopes, less than 3 acres in size, that are on long, very gentle slopes and are indicated on the map by the symbol for spot erosion; and scattered areas of Randall clay, less than 4 acres in size, that stay wet longer than the soil surrounding and are indicated on the map by the symbol for depressions. These inclusions make up about 5 percent of the acreage.

This is the most extensive soil in the county. About nine-tenths of the acreage is cultivated, and the rest is in range consisting chiefly of buffalograss and blue grama. When moisture is favorable, yields of dryland crops are good to excellent. Yields are also good to excellent if the soil is properly managed under irrigation. (Capability unit IIIce–1, dryland; capability unit IIs–1, irrigated; Deep Hardland range site)

Pullman silty clay loam, 1 to 3 percent slopes (PuB).—This soil occupies convex slopes and gently sloping areas that drain into the playas and draws on the High Plains. It is deep and fertile. It takes in water very slowly when wet, but its water-holding capacity is high, and the range of moisture content within which it is suitable for tillage is moderate. When tilled, it is slightly susceptible to wind erosion and moderately susceptible to water erosion.

The surface layer is about 6 inches thick. The clay subsoil is about 30 inches thick. It has a strong, blocky structure when dry, but when wet it is massive.

Mapped with this soil are areas of Pullman silty clay loam, 1 to 3 percent slopes, eroded. These areas are less than 4 acres in size, and they are indicated on the detailed soil map by spot-erosion symbols. Small areas of Zita, Ulysses, and Olton clay loams are also included in the areas mapped. All of these inclusions make up less than 10 percent of the acreage.

About half of the acreage is cultivated, and the rest is in range consisting mostly of blue grama and buffalograss. When moisture is favorable, good crops can be produced under dryland farming. Crop yields are good to excellent if the soil is well managed under irrigation. (Capability unit IIIe–1, dryland or irrigated; Deep Hardland range site)

Pullman silty clay loam, 1 to 3 percent slopes, eroded (PuB2).—This soil is on convex slopes around playas, on low ridges, and on the sides of the drainageway of Mulberry Creek. Generally, the slopes are 300 to 700 feet long.

In a few places areas of eroded Ulysses soils, less than 4 acres in size, are mapped with this soil.

The surface layer is dark-brown to dark grayish-brown light clay to silty clay. It is only 1 to 5 inches thick and is most commonly about 3 inches thick. About half of the original surface layer has been lost, mainly through sheet erosion. In places tillage has mixed part of the heavy clayey subsoil with the original surface soil, and in these places the texture of the present surface layer is silty clay. Shallow, crossable gullies are common. In a few places gullies have penetrated into the parent material.

About two-thirds of the acreage is cultivated, and the rest is in pasture of native grasses. This soil should be managed to prevent further erosion. Some areas can be seeded to a permanent cover of native grasses if grazing is well managed. (Capability unit IVe–3, dryland or irrigated; Deep Hardland range site)

Quinlan Series

In the Quinlan series are friable, shallow, reddish-brown soils overlying weakly cemented, fine-grained sandstone and packsand. These soils are on the Rolling Plains. They occur on the red-bed terraces in the Palo Duro Canyon. Slopes are convex. The slope range is 2 to 20 percent, but the gradient is most commonly about 8 percent. The landscape is one of knolls, mesas, and hogbacks. In this county Quinlan soils are mapped only in a complex with Woodward and Vernon soils and Rough broken land.

The surface layer is fine sandy loam or very fine sandy loam that has a weak, granular structure. This layer ranges from 2 to 15 inches in thickness but is most commonly 6 inches thick. It ranges from reddish brown to yellowish red in color. In most places it is slightly redder in the lower part than in the upper part.

The parent material consists mostly of silty and sandy deposits of ancient marine origin. In places it contains interbedded crystalline gypsum.

These soils are excessively drained. Surface runoff is medium to rapid, and permeability is rapid.

Quinlan soils are less clayey and more permeable than Vernon soils. They are more shallow and more permeable than Woodward soils.

Because these soils are shallow and are low in fertility, they are unfit for cultivation. They support a thin cover of black grama, blue grama, side-oats grama, hairy grama, sand dropseed, and bluestem grasses, and a scattering of yucca and redberry juniper.

Quinlan complex (Qc).—This is a complex of shallow and very shallow, reddish soils intermixed with Rough broken land. It is extensive in the Palo Duro Canyon. The soils are more severely dissected than the soils on the lower lying red-bed plains. Slopes are variable.

This complex is about 35 percent Woodward soils, 40 percent Quinlan and Vernon soils, and 25 percent red, rough, broken sandstone material. The proportion of each of these varies as much as 30 percent or more from place to place.

Quinlan very fine sandy loam is on the rough erosional red-bed plains where the parent material contains much packsand. It supports a sparse cover of black grama, side-oats grama, bluestem, needlegrass, and some yucca and juniper.

Woodward very fine sandy loam formed on the sloping red beds of the erosional plains. Its supports a fair to good cover of native mid grasses, mostly bluestem, drop-

seed, and the grama grasses. There are some herbs and forbs and scattered juniper trees.

The Vernon soil is a very shallow, red to reddish-brown clay loam over red-bed shale. It supports a sparse cover of native grasses, such as hairy grama, side-oats grama, buffalograss, and three-awn. There are also scattered yucca and dwarfed juniper shrubs.

The red, rough, broken sandstone material is in the extremely dissected or gullied areas of the erosional plains. This part of the complex includes minor areas of nearly barren badlands. It is suitable only for wildlife habitats. The sheltered areas support a fair to good stand of native vegetation.

The Woodward, Quinlan, and Vernon soils are suitable for both range and wildlife habitats. They need management that will help to control water and wind erosion.

This complex has a rougher landscape and consists of shallower and sandier soils than those of the Weymouth-Vernon complex. (Quinlan and Vernon soils: capability unit VIIs–1; Shallow Redland range site. Woodward soil: capability unit VIe–4; Mixed Land range site. Rough broken land: capability unit VIIs–2; Rough Breaks range site)

Randall Series

The Randall series consists of very poorly drained, gray to dark-gray clayey soils. These soils are in depressions or playa bottoms and are from 2 to 50 feet or more below the level of the surrounding plains (fig. 13). These areas are circular, and they range from less than an acre to several hundred acres in size.

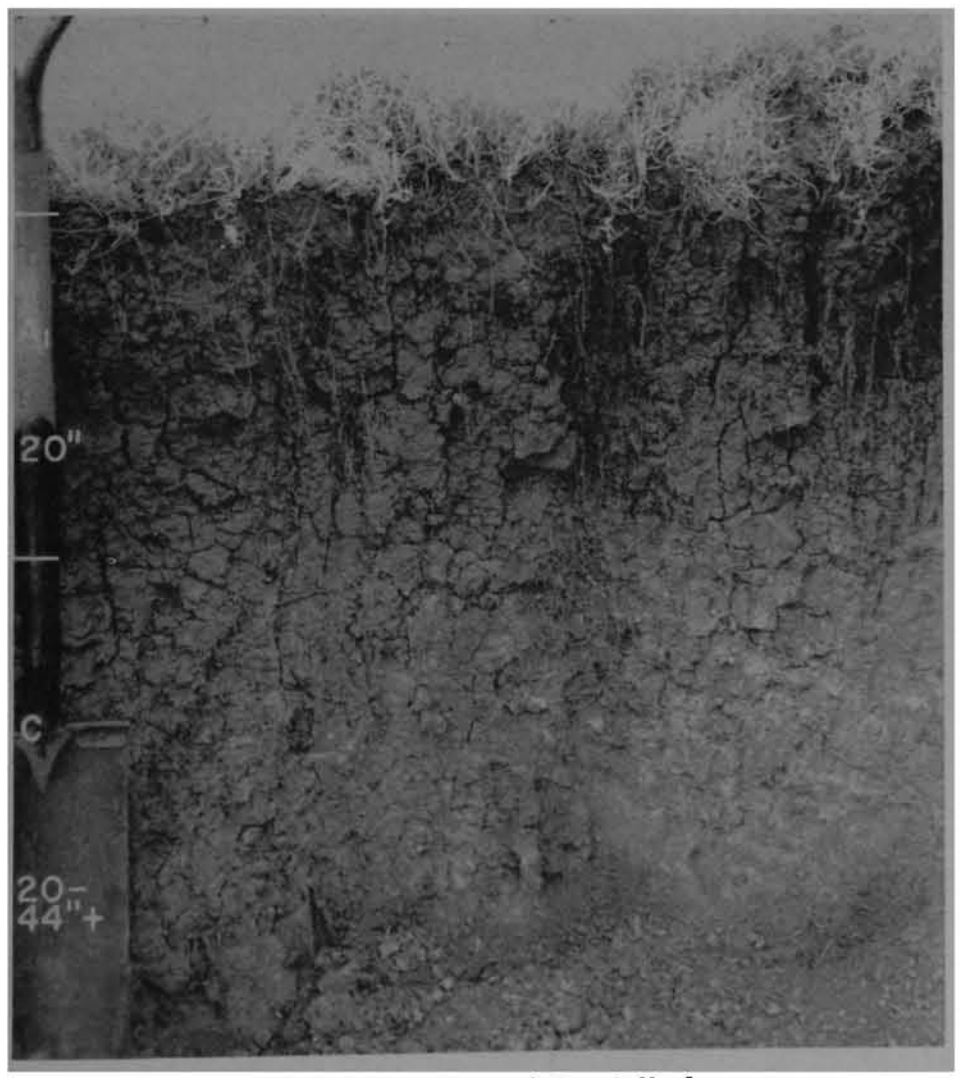

Figure 13.—**Profile of Randall clay.**

The surface layer is about 20 inches of slightly acid to mildly alkaline, dark-gray clay. The range of moisture content within which it is suitable for tillage is very narrow. Generally, this layer is either gummy and stiff or very hard.

The subsoil of stiff, gray clay is about 20 inches thick. It has blocky structure or is massive. This layer has a swampy odor after it has been wet for some time.

The parent material is very slowly permeable, stiff, sticky clay washed or blown from the surrounding Pullman, Ulysses, Mansker, and Lofton soils. The clay content ranges from 50 to 80 percent.

The surface layer of Randall soils ranges from 8 to 30 inches in thickness, and the subsoil from 20 to 70 inches.

Randall soils are darkly stained with organic matter. They are very poorly drained. After heavy rains they are ponded for extended periods. Most of the water is removed by evaporation because there is no surface drainage and very slow internal drainage. During the longer periods of ponding, nearly all the vegetation dies except sedges and smartweed.

When the soil is dry, cracks several feet deep and as much as 4 inches wide form. Part of the crumbly, dry surface soil sloughs, washes, or falls into these cracks. When the soil is wet, the cracks close; when it dries again, more surface soil falls into the cracks. Thus, there is slow circulation of the entire soil mass.

Randall soils are grayer, more clayey, less open, and more poorly defined than Roscoe and Lofton soils. They occur in lower positions on the landscape than Roscoe soils and are less well developed structurally.

Randall clay (Ra).—This level soil is fertile. It takes water very slowly when moist, and the range of moisture content within which it is suitable for tillage is very narrow. This soil blows easily as soon as the ponded water has evaporated in the places where the vegetation has been drowned out.

Included with this soil in mapping are transitional areas and other small spots of Roscoe soils that make up as much as 15 percent of some areas.

Most of the acreage is used as native pasture or as wildlife habitats. These soils are not suitable for cultivation unless runoff from the surrounding soils is diverted or the playas are drained.

Randall clay does not have a range site classification. It is generally included in the same range site as the adjoining areas. (Capability unit VIw–1)

Roscoe Series

In the Roscoe series are calcareous, somewhat poorly drained, nearly level soils that have a dark-gray clayey surface layer and a grayish-brown clay subsoil (fig. 14). These soils are on the lower playa benches, below the Lofton soils and above the Randall soils, in the larger playas throughout the High Plains.

The surface layer is generally calcareous and mildly alkaline, dark-gray clay or silty clay and is about 18 inches thick. In some places the reaction is neutral throughout this layer. This layer crusts, air slacks, powders, and blows if excessively tilled and left unprotected.

The subsoil is sticky, dark grayish-brown to grayish-brown clay and is about 35 inches thick. It is neutral to alkaline and in most places is strongly calcareous. This

layer has a medium or coarse, blocky structure when dry, but it readily air slacks to very fine, angular blocky aggregates that are erodible when exposed to the weather.

***Figure 14.*—Profile of Roscoe clay. The horizon marked Cca is a zone of lime accumulation. A 4-inch layer of loose material has accumulated on the surface.**

The parent material is heavy, calcareous, grayish-brown clay that has been washed or blown from the surrounding and higher lying Pullman, Ulysses, Mansker, and Lofton soils within the watershed of the individual playas.

The thickness of the surface layer ranges from 12 to 25 inches. The color is very dark gray to gray but is most commonly dark gray. The color is determined mostly by the organic-matter content. The subsoil ranges from 12 to 50 inches in thickness and from neutral to alkaline in reaction. It is most commonly a calcareous, grayish-brown heavy clay, though in places it is gray or dark-gray clay.

In areas that are covered by native grasses and sedges, the surface is characterized by small mounds.

Roscoe soils are somewhat poorly drained. Surface drainage is slow at best, and in some places there is none. Internal drainage is very slow.

Roscoe soils are more permeable and better drained than Randall soils. They are less clayey and less well drained than Lofton soils, and they have less distinct layers.

Some crops can be grown on Roscoe soils in other than extremely wet or extremely dry years.

Roscoe clay (Rb).—This somewhat poorly drained, level soil is fertile. It takes water very slowly when moist, and the range of moisture content within which it is suitable for tillage is narrow.

Mapped with this soil are a few small alkaline spots, and also some transitional areas of Randall and Lofton soils. These inclusions make up as much as 15 percent of some areas. The alkaline spots are highly susceptible to wind erosion if tilled.

About a third of the acreage is cultivated, mainly to small grain. If the moisture supply is favorable, good yields are obtained. In extremely wet years crops are sometimes lost. The acreage not cultivated has a cover of short native grasses, chiefly western wheatgrass, buffalograss, and blue grama. Saltgrass is dominant on the alkaline spots. (Capability unit IIIce–1, dryland; capability unit IIs–1, irrigated; Deep Hardland range site)

Rough Broken Land

Rough broken land occurs below the gently sloping soils of the High Plains and along the rims and flanks of the Palo Duro Canyon. The upper edge of the caliche escarpments and the lower lying Permian plains are the boundaries of this land type in Armstrong County. The relief is strongly sloping to steep. In some areas elevations range from 500 to 800 feet within a horizontal distance of 100 to 300 feet. Nearly barren caliche escarpments and sandstone cliffs are prominent but not extensive (fig. 15).

A typical area of this land type is on the north side of the Palo Duro Canyon, in the area where farm-to-market road 284 enters the canyon.

Rough broken land (Ro).—This miscellaneous land type is about 55 percent Rough broken land, 20 percent Berthoud soils, 13 percent badlands, and 12 percent unclassified very shallow gravelly soils and alluvial land. The proportion of each may vary 40 percent or more from place to place. Rough broken land differs from Rough broken land, gypsiferous, in that it consists of Pleistocene deposits from the High Plains and of Triassic deposits from the Rolling Plains. It includes minor areas of Potter soils and of Permian sandstone and shale that do not contain gypsum.

About a third of the acreage of Rough broken land borders the Rolling and the High Plains, and the rest is on the multicolored red beds within the Rolling Plains. Most of the escarpments are vertical. The vegetation consists mainly of a thin cover of little bluestem, side-oats grama, and hairy grama, but some black grama and juniper shrubs grow on the red-bed slopes. Yucca, catclaw, and dwarfed mesquite are scattered throughout.

Berthoud soils are in sheltered spots below the caliche escarpments and above the sandstone cliffs. These soils are as much as 3 feet thick. They have slopes of 3 to 15 percent. They support a good to excellent cover of grasses, mostly blue grama and bluestem. There are some mesquite trees and a few juniper shrubs.

In some areas geologic erosion removes weathered material as fast as it forms. Deep, V-shaped gullies are com-

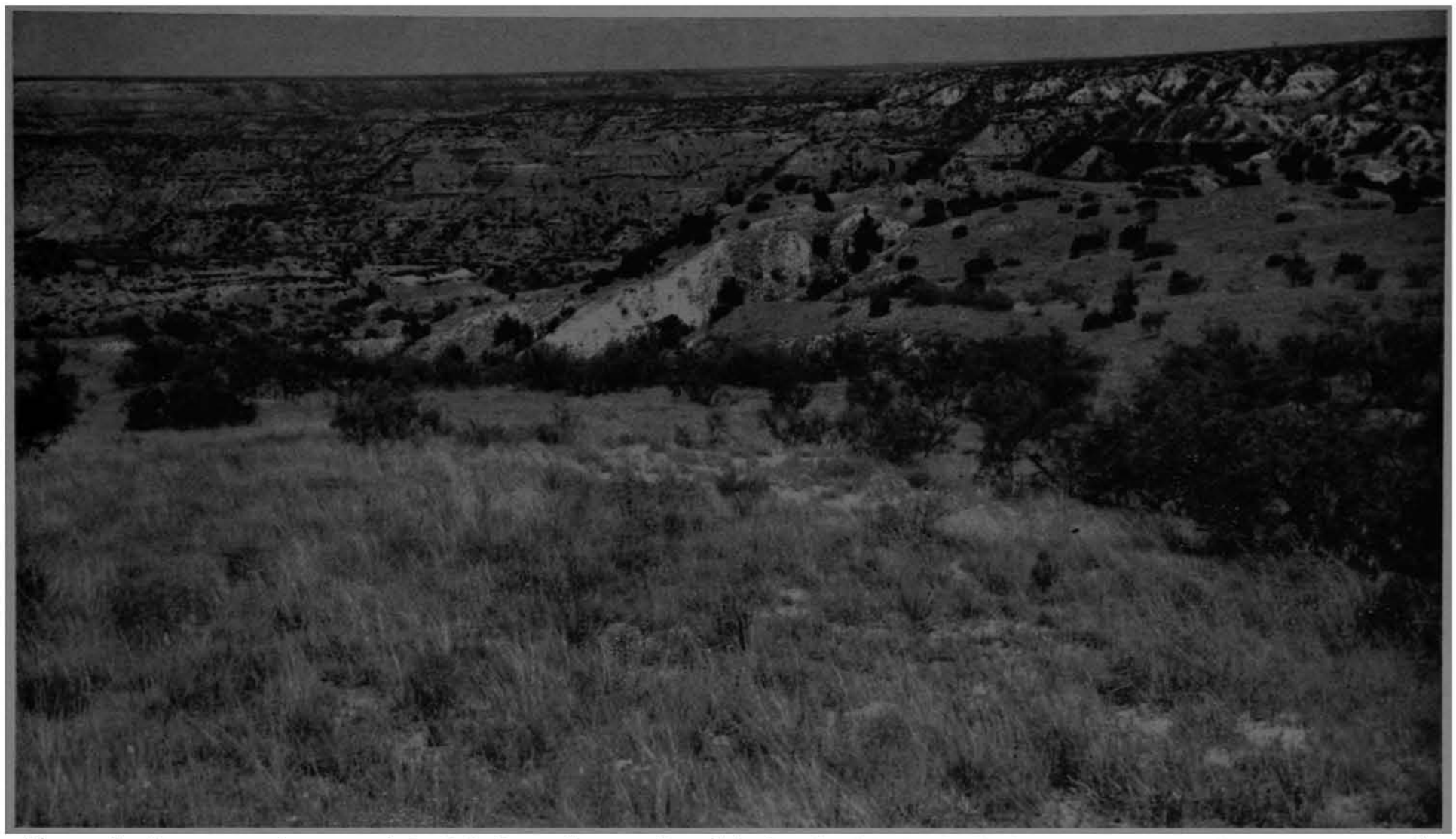

Figure 15.—**Representative area of the Palo Duro Canyon. Rough broken land is in the background, and Mansker and Potter soils are in the foreground.**

mon on these spots, which are called badlands. Little or no vegetation grows on the badlands, and they make some other areas that are suitable for range inaccessible to cattle. The badlands provide natural habitats for deer and Barbary sheep. (Rough broken land: capability unit VIIs–2; Rough Breaks range site. Berthoud soils: capability unit VIe–2; Mixed Land Slopes range site)

Rough Broken Land, Gypsiferous

Rough broken land, gypsiferous, is known locally as the red-bed breaks. It occurs in the Palo Duro Canyon. The landscape is one of jagged gypsum escarpments, barren gypsum hills and flats, gypsum ledges, canyons, and dissected red-bed plains. Between the hills and on sheltered flats, very shallow soils have formed over the gypsum beds.

Typical areas of this land type are along Salt Creek, Coyote Creek, Bull Run Creek, and Mulberry Creek, 4 to 8 miles upstream from the Prairie Dog Town Fork of the Red River.

Rough broken land, gypsiferous (Rs).—This land type is more sandy and more sparsely vegetated than Rough broken land, which is at higher elevations in the Palo Duro Canyon.

Included in the areas mapped are small bands of Sandy alluvial land on the bottom of canyons that have nearly vertical walls. Also included are talus materials consisting mostly of boulders, slabs, and fragments of gypsum and sandstone, interbedded in some places in fine sandy loam red-bed material.

Those areas in which a little soil has formed support a fair cover of short grasses, mainly the grama grasses and some mid grasses, mainly bluestem. In other places vegetation is sparse. The badlands have little value as range, but they provide natural habitats for wildlife. (Capability unit VIIs–4; Rough Breaks range site)

Sandy Alluvial Land

This land type consists of recently deposited alluvium, mostly calcareous and gypsiferous sand and loamy sand. It occurs on the Rolling Plains, as narrow bands of irregular width along the larger streams, only a few feet higher than the stream channel.

A representative area of this land type is on the flood plains of Mulberry Creek about 5.5 miles south and 2.5 miles west of Goodnight.

The surface layer is pale brown loamy fine sand stratified with thin layers of very pale brown fine sand to coarse sand. The underlying material is calcareous, light-colored fine sandy loam and coarse sand in layers of varying thickness. In some places there is a layer of waterworn quartz and caliche gravel at a depth of more than 36 inches (fig. 16).

Drainage is somewhat excessive. Surface drainage is medium to slow, and internal drainage is rapid.

Sandy alluvial land is more permeable, lighter colored, less stratified, and much sandier than Loamy alluvial land.

Sandy alluvial land (Sa).—This land type is flooded after heavy rains, which happen two or three times a year.

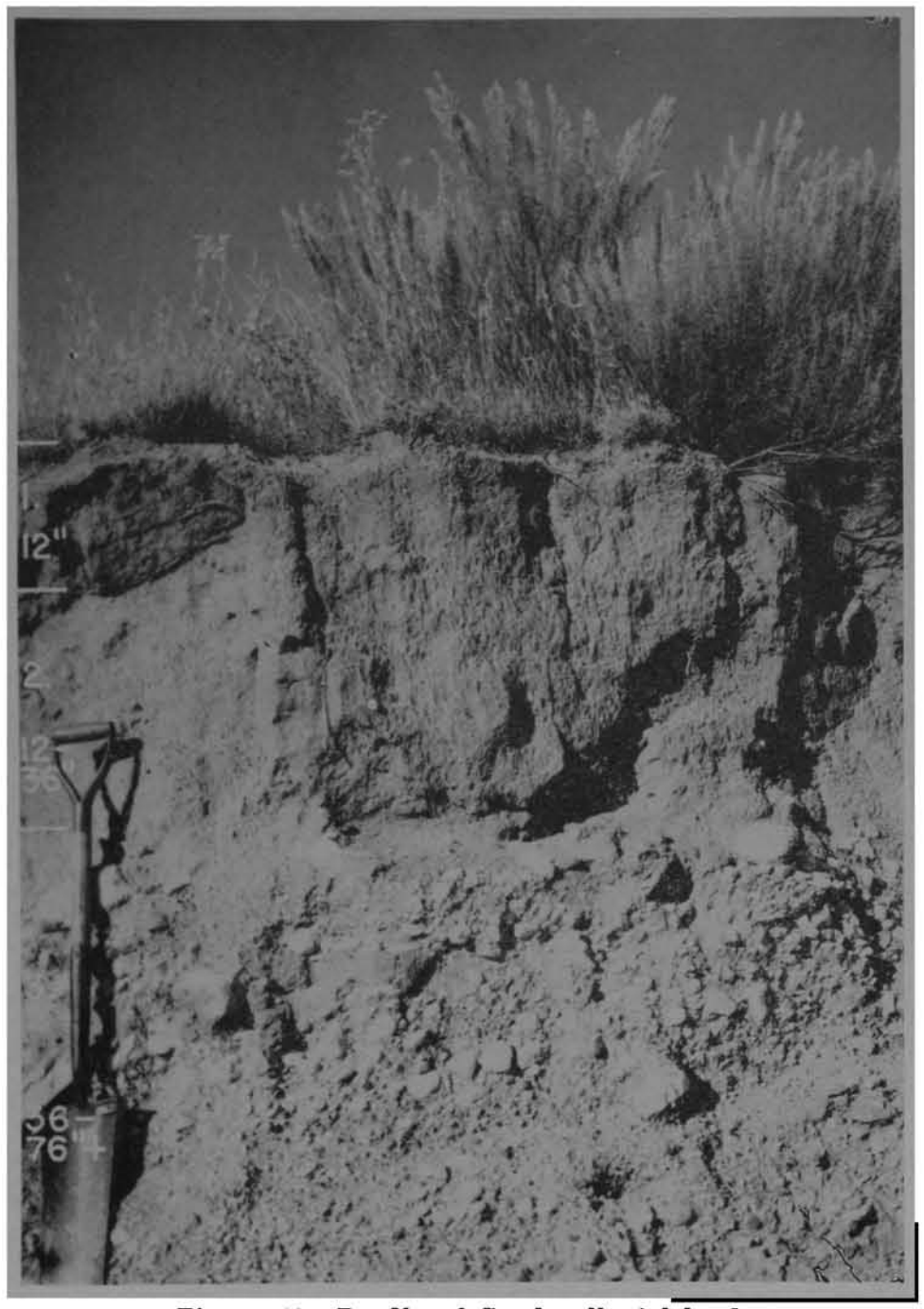

Figure 16.—**Profile of Sandy alluvial land.**

During droughts, it may be dry for several months. Some areas are subject to severe channel cutting and sloughing, and others to deposition of sterile sand.

Included in the areas mapped are spots of nearly level Bippus soils and of Likes soils. The inclusions make up about 15 percent of the acreage.

This land type is not suited to cultivation, but it is a good to excellent producer of tall native grasses, herbs, and shrubs. The dominant grasses are bluestem, Indiangrass, and switchgrass. Sand sagebrush is also common. (Capability unit Vw-2; Sandy Bottom Land range site)

Ulysses Series

The Ulysses series consists of well-drained, nearly level to gently sloping soils. These soils have a surface layer of clay loam and a subsoil of slightly heavier clay loam. They formed mainly in wind-laid deposits. They occur as scattered areas on the High Plains, mostly on low knolls surrounded by Pullman soils, along the rims of playas, and on the side slopes of drainageways.

The surface layer is about 8 inches of weakly calcareous, dark grayish-brown clay loam that has granular structure. The plow layer, in areas that have been tilled for some time, is grayish-brown clay loam that has weak granular structure. Below the plow layer is a calcareous layer that has granular or subangular blocky structure.

The subsoil is calcareous, grayish-brown, friable clay loam and is about 16 inches thick. It has a weak, subangular blocky and prismatic structure that breaks to granular. Most of the granules are worm casts. When moist this layer is easily penetrated by plant roots. Ordinarily, at a depth of about 25 inches there is a layer in which lime has accumulated.

The parent material is strongly calcareous, wind-laid material that contains less lime than the subsoil. When moist, this material is easily penetrated by plant roots.

The color of the surface layer ranges from dark grayish brown to grayish brown, the texture from clay loam to heavy clay loam, and the thickness from 7 to 12 inches. The thickness of the subsoil ranges from 10 to 24 inches. The depth to the layer of lime ranges from about 20 to 35 inches.

Ulysses soils are similar to Mansker soils in color and reaction, but they are smoother, deeper, and less sloping, and show slightly more structural development in the subsoil. They are more permeable, lighter colored, less clayey, and less well developed structurally than Pullman or Lofton soils.

Most of the smoother, less sloping Ulysses soils are cultivated. They are suited to winter wheat and sorghum.

Ulysses clay loam, 0 to 1 percent slopes (UcA).—This is a moderately deep, nearly level soil that is transitional between Zita and Mansker soils.

As much as 4 percent of some of the areas mapped consists of minor areas of Zita and Pullman soils.

This soil is friable, is easily tilled, and takes water readily. Under cultivation, it is moderately susceptible to wind erosion if not protected by crop residues and surface roughness.

Most of the acreage is cultivated to wheat and sorghum. The rest is in native pasture, consisting mainly of blue grama and buffalograss and including some side-oats grama, herbs, and shrubs. When moisture is favorable, good crop yields are obtained under dryland farming. If the soil is properly managed under irrigation, crop yields are good to excellent. In some seasons iron deficiency causes chlorosis of sorghum and corn and reduces yields. (Capability unit IIIce–3, dryland; capability unit IIe–3, irrigated; Deep Hardland range site)

Ulysses clay loam, 1 to 3 percent slopes (UcB).—This is a gently sloping, moderately deep, calcareous soil. It is friable, is easy to till, and takes water readily. If tilled and not protected by crop residues and surface roughness, it is moderately to severely susceptible to wind and water erosion.

Included with this soil in mapping are small areas of Mansker soils which make up as much as 6 percent of some areas.

All of this soil is used to grow winter wheat, sorghum, and short native grasses, mainly blue grama, side-oats grama, and buffalograss. (Capability unit IIIe–3, dryland; capability unit IIIe–4, irrigated; Deep Hardland range site)

Vernon Series

The Vernon series consists of very shallow, red to reddish-brown, clayey soils that are weakly formed on shaly clay and siltstone residuum of the red beds (fig. 17). These soils are on the Rolling Plains. They occur on flats, knobs, knolls, and hogbacks within the Palo Duro Canyon. In this county they are mapped only in complexes with Quinlan and Weymouth soils.

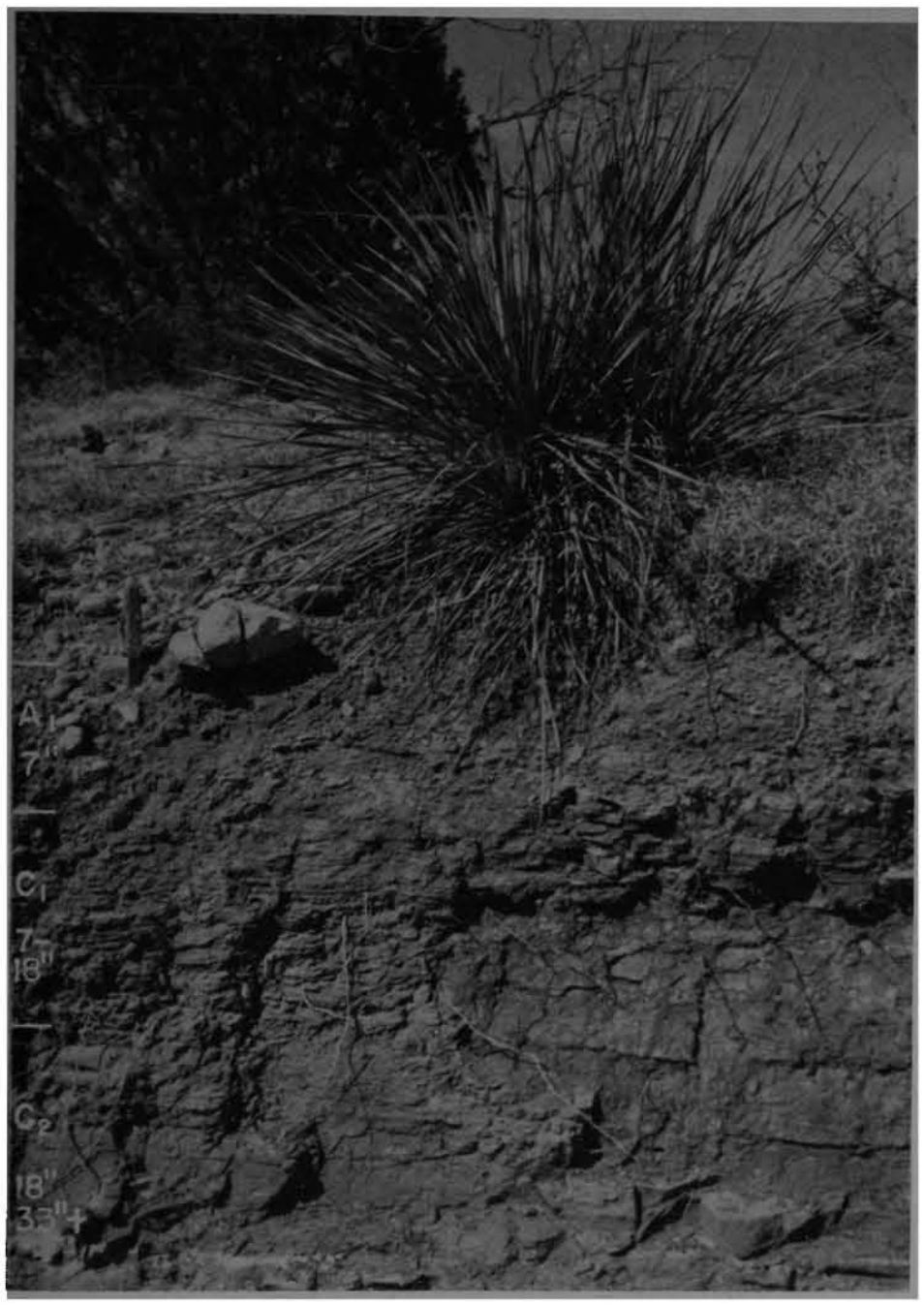

Figure 17.—**Profile of Vernon clay loam.**

The surface layer is about 5 inches of reddish-brown, friable clay to clay loam that has a weak, granular structure. It is darkened somewhat by organic matter. This layer is underlain by partly weathered red siltstone, shaly clay, and very fine red sandstone. In most places at low elevations in the Palo Duro Canyon, this material is strongly gypsiferous, and in places there are lenses and beds of semihard white gypsum.

The surface layer is 1 to 12 inches thick. The slope ranges from 1 to 15 percent but is most commonly 7 percent.

Vernon soils are excessively drained. Surface runoff is rapid, and internal drainage is slow to very slow. Small areas that are exposed to the prevailing winds and to excessive runoff are severely eroded.

Vernon soils are shallower and more clayey than Weymouth soils.

Shallowness and low fertility limit the use of Vernon soils to range and to wildlife habitats. A thin cover of native grasses, such as hairy grama, side-oats grama, buffalograss, and three-awn, grow on these soils. There are scattered yucca plants and dwarf redberry juniper shrubs.

Vona Series

The Vona series consists of deep, brown soils that have a surface layer of fine sandy loam and a subsoil of friable, heavy fine sandy loam. These soils are in the northeastern part of the county on the Rolling Plains. They occur along draws and on undulating flats between Mulberry Creek and the Salt Fork of the Red River. They have convex to slightly billowy surface relief.

The surface layer is about 10 inches of neutral, brown fine sandy loam. The plow layer is structureless, but the layer below has weak, coarse, prismatic structure that easily breaks to granular.

The subsoil is about 30 inches thick and contains slightly more clay than the surface layer. It is brown fine sandy loam that has a moderate, very coarse, prismatic structure that easily crumbles to granular. The upper part is neutral, but the lower part is mildly alkaline and weakly calcareous.

The parent material is material recently deposited by wind and water and reworked by the wind. Moisture and plant roots easily penetrate this material.

The thickness of the surface layer ranges from 8 to 16 inches. The color is dark brown to grayish brown but is most commonly brown. The subsoil is slightly lighter colored than the surface layer, and it ranges from 15 to 45 inches in thickness.

Permeability is moderately rapid; consequently, very little water runs off.

Vona soils have more distinct layers and are more permeable than the calcareous Likes soils.

All of the acreage is in range of mid and tall native grasses, such as blue grama, bluestem, Indiangrass, lovegrass, and sand dropseed. There is some sand sagebrush and some skunkbush.

Vona fine sandy loam, 3 to 5 percent slopes (VoC).—This is a deep, moderately sloping soil that has a subsoil of friable fine sandy loam. The subsoil has moderately rapid permeability.

Included with this soil in mapping are a few minor knolls of Mansker soils.

This is a fairly fertile soil that can be tilled throughout a wide range of moisture content. It takes water rapidly and has a moderate to moderately low water holding capacity. When tilled, it is highly susceptible to wind erosion unless an adequate cover of vegetation is maintained. Overgrazing will weaken and thin out desirable grasses and cause serious blowing. (Capability unit IVe-4, dryland: Sandy Loam range site)

Weymouth Series

This series consists of shallow to moderately deep, gently sloping to moderately sloping, loamy and clayey soils on the Rolling Plains. These soils occur as scattered areas on the old erosional red-bed plains in the Palo Duro Canyon. The relief is nearly level to convex.

The surface layer is about 9 inches of weakly calcareous, reddish-brown clay loam that has a moderate, fine, granular structure.

The subsoil is about 14 inches thick. It consists of moderately permeable, calcareous, reddish-brown clay loam. The structure is granular or subangular blocky.

The parent material is a mixture of calcareous red-bed sediments and sediments from the High Plains. This material is friable and is easily penetrated by plant roots when moist.

The texture of the surface layer ranges from loam to clay loam, the color from dark reddish brown to light reddish brown, and the thickness from 5 to 11 inches. The texture of the subsoil ranges from silty clay loam to loam, the color from light reddish brown to yellowish red or reddish yellow, and the thickness from 7 to 15 inches.

Weymouth soils are well drained. Surface drainage is medium to rapid, and permeability is moderate.

Weymouth soils are deeper, lighter colored, and less clayey than Vernon soils. They are shallower, lighter colored, and less clayey than Abilene soils, and they have less distinct layers. They are deeper than Quinlan soils, and they are less sandy than Quinlan and Woodward soils.

Weymouth clay loam, 1 to 3 percent slopes (WcB).—This is a calcareous, shallow to moderately deep, gently sloping soil that has a moderately permeable and granular subsoil.

Included in the areas mapped are a few areas of Weymouth clay loam, 3 to 5 percent slopes, and transitional and fringe areas of Miles soils. The inclusions make up about 7 percent of the acreage.

This soil is easily tilled, but it is fairly low in natural fertility. It takes water readily, but its water-holding capacity is low. When tilled, it is moderately susceptible to wind and water erosion.

All of the acreage is in short native grasses, chiefly the grama grasses and some buffalograss. A few or many mesquite trees have invaded. (Capability unit IIIe–7, dryland; Deep Hardland range site)

Weymouth clay loam, 3 to 5 percent slopes (WcC).—This soil is shallow and calcareous. The subsoil is granular and moderately permeable.

Included with this soil in mapping are gravelly knolls, small areas of Vernon soils, and areas transitional to Miles soils. The inclusions make up about 15 percent of the acreage.

This soil is fairly easy to work, but it is low in fertility. It takes water readily, but its water-holding capacity is low. The hazards of wind erosion and water erosion would be moderately severe if any of the acreage were cultivated.

All of this soil is in native short grasses, mostly blue grama, side-oats grama, and hairy grama. Some three-awn and buffalograss are included and there are some dwarfed mesquite and redberry juniper shrubs. (Capability unit VIe–8; Deep Hardland range site)

Weymouth-Vernon Soils

Weymouth and Vernon soils are mapped together as a complex because they are so intermingled that they cannot be shown separately on the soil map. These soils are on the Rolling Plains. They occupy smooth, broad, gently sloping to sloping red-bed terraces or erosional plains in the Palo Duro Canyon.

Weymouth-Vernon complex (Wf).—About 65 percent of this complex is Weymouth soil, 20 percent is Vernon, and 15 percent is Woodward and other soils. The proportions vary as much as 30 percent from place to place. The soils are smoother, deeper, and more clayey than those in the Quinlan complex.

Weymouth clay loam is on the moderately smooth, gently sloping terraces. It supports a good cover of short and mid grasses, such as blue grama, side-oats grama, and buffalograss, and a scattering of little bluestem. Mesquite trees are common.

Vernon clay loam is a very shallow soil that occurs on the gently sloping floors of valleys in the red beds, and on knolls, ridges, and other strongly sloping areas. The knolls and ridges are 5 to 20 feet high and 50 to 300 feet or more in diameter. This soil has a sparse cover of side-oats grama, hairy grama, black grama, three-awn, yucca, catclaw, and dwarf juniper.

The soils of this complex are highly susceptible to water erosion. They are unfit for cultivation, but they are fair to good producers of native grasses if grazing is well managed. (Weymouth soil: Capability unit VIe–8; Deep Hardland range site. Vernon soil: Capability unit VIIs–2; Shallow Redland range site)

Wichita Series

This series consists of deep, smooth, nearly level to weakly undulating, dark-brown loamy soils on the Rolling Plains. The subsoil is moderately permeable, reddish-brown clay loam to sandy clay loam (fig. 18). These soils of the uplands occur mostly in the Palo Duro Canyon.

The surface layer is about 8 inches thick. It ranges from loam to sandy clay loam but is most commonly loam. The structure is granular, and the reaction is neutral.

The subsoil is about 40 inches thick. It has medium or coarse, prismatic structure that breaks to subangular blocky, blocky, or granular fragments. The upper part of the subsoil contains more clay and has more distinct horizonation than the lower part.

The parent material is a 3- to 10-foot deposit of old, calcareous outwash. Its texture is loam or clay loam, and it contains scattered waterworn quartz pebbles. This material is friable, and when moist it is easily penetrated by plant roots.

The surface layer of Wichita soils ranges from 6 to 11 inches in thickness, and the subsoil from 25 to 60 inches. The subsoil is either neutral or mildly alkaline and calcareous. In areas that have slopes of less than 2 percent, buried soils commonly occur at a depth of 2 to 4 feet.

Wichita soils are lighter colored, less clayey, and more permeable than Abilene soils. They are darker colored, more clayey, and less permeable than Miles soils.

Most of the acreage is used as range. Only a few patches are cultivated. Dryland sorghum is the main cultivated crop.

Wichita loam, 0 to 1 percent slopes (WhA).—This deep, nearly level soil has a moderately permeable subsoil of sandy clay loam. This soil is fertile and is easily worked. It takes, stores, and releases water in a manner favorable

for plant growth. When tilled, it is slightly susceptible to wind erosion.

Included in the areas mapped are a few spots of Abilene soils and of soils transitional to Abilene soils.

Nearly all of this soil has a cover of short and mid native grasses, chiefly blue grama, buffalograss, and sand dropseed. Mesquite trees have invaded most areas.

When moisture is favorable, this soil produces good to excellent yields of the dryland crops commonly grown in the area. (Capability unit IIce–4, dryland; Deep Hardland range site)

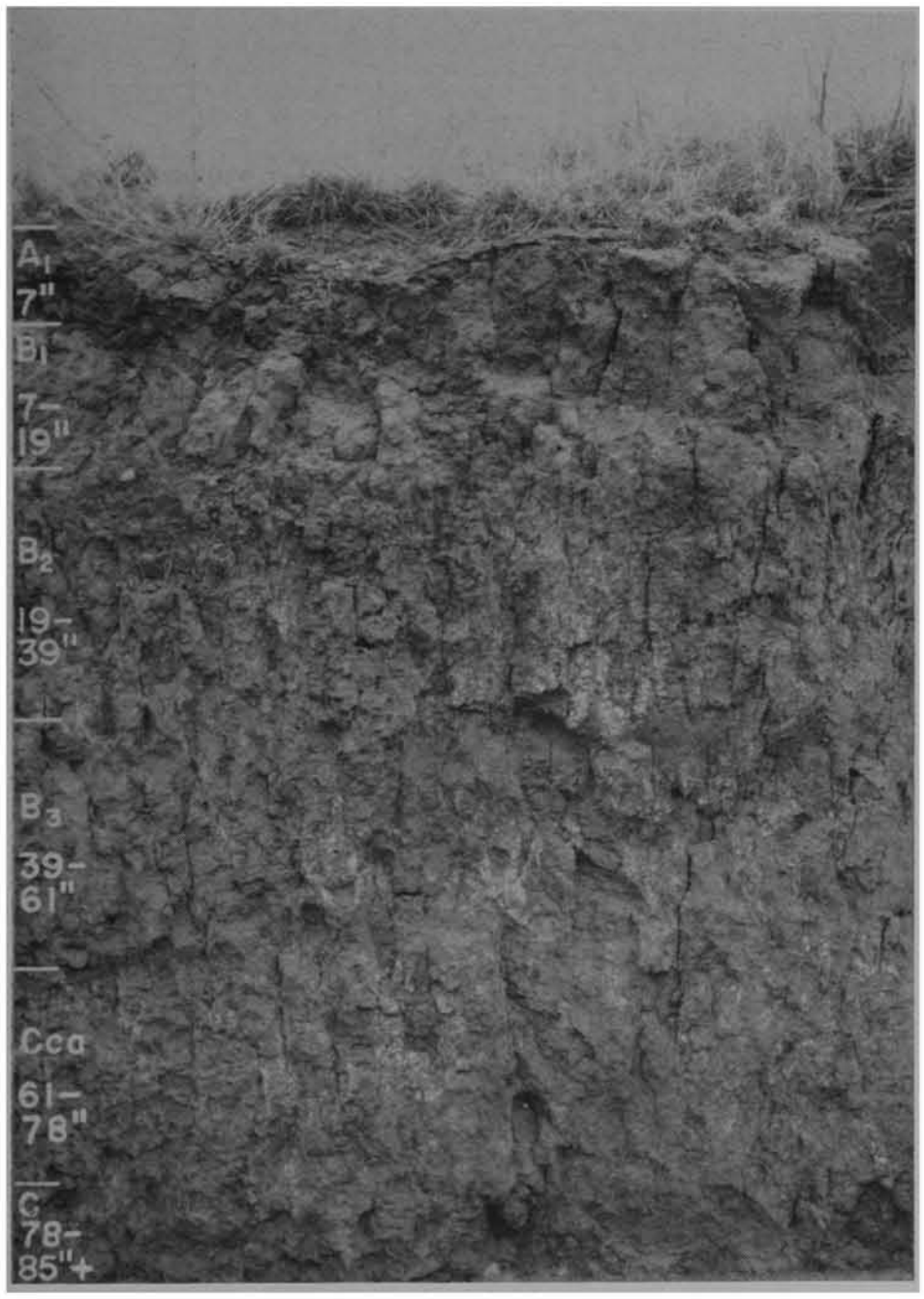

Figure 18.—**Profile of Wichita loam. The horizon marked Cca is a zone of lime accumulation.**

Wichita loam, 1 to 3 percent slopes (WhB).—This is a deep, gently sloping or gently undulating soil that has a subsoil of moderately permeable sandy clay loam. It is fertile and productive, is easy to work, and stores a large amount of water for plants. When tilled, it is slightly susceptible to wind erosion and moderately susceptible to water erosion.

Included with this soil in mapping are minor areas of Weymouth soils and of soils transitional to Weymouth soils.

Although this soil is suitable for all the tilled crops commonly grown in the county, little of it is cultivated. Most of it is in an area dominated by large cattle ranches and consequently is used as range. It is a good producer of short native grasses. (Capability unit IIIe–2, dryland; capability unit IIIe–3, irrigated; Deep Hardland range site)

Wichita loam, 3 to 5 percent slopes (WhC).—This undulating and moderately sloping soil occurs in the Palo Duro Canyon. The subsoil is moderately permeable sandy clay loam. This soil is fertile and is easily worked. It takes water readily. If it is cultivated, the wind erosion hazard is moderate and the water erosion hazard is moderately severe.

Included with this soil in mapping are a few areas of Weymouth and Miles soils, less than 5 acres in size, and a few knolls mantled with quartz gravel and cobblestones. These inclusions make up as much as 10 percent of some areas.

This inextensive soil is used only as native range. Under cultivation it is less productive and more difficult to manage than Wichita loam, 1 to 3 percent slopes. (Capability unit IVe–1, dryland or irrigated; Deep Hardland range site)

Woodward Series

The Woodward series consists of shallow to moderately deep, reddish-brown loamy soils on the Rolling Plains. These soils occupy the smooth areas of the erosional red-bed plains in the Palo Duro Canyon.

The surface layer is 7 to 15 inches thick. The texture ranges from loam to very fine sandy loam, but it is most commonly loam.

The subsoil is slightly redder than the surface layer. It ranges from about 4 to 16 inches in thickness.

A 3- to 10-inch, yellowish-red to red layer of lime has accumulated below the subsoil. In some places this lime zone is barely evident.

The parent material is compact, calcareous, weathered red-bed siltstone and, in the lower part, very fine-grained gypsiferous sandstone.

Because these soils have moderately rapid permeability, little water runs off.

Woodward soils are deeper, less sandy, smoother, and less eroded than Quinlan soils, and they have more distinct layers. They are more sandy throughout than Weymouth soils and are deeper, smoother, and less clayey than Vernon soils.

Because of the scattered pattern in which Woodward soils occur within the moderately rough landscape of the Quinlan complex, they are unfit for cultivation, but if well managed they are good producers of native grasses. Larger and smoother areas are arable, but deep canyons make them inaccessible for farming.

Woodward loam, 1 to 3 percent slopes (WoB).—This is a calcareous, shallow to moderately deep, gently sloping soil. The subsoil is moderately permeable, light clay loam.

Included with this soil in mapping are minor areas of Woodward loam, 3 to 5 percent slopes, and areas transitional to Miles fine sandy loam, 1 to 3 percent slopes. These inclusions make up about 10 percent of the acreage.

This soil is easy to till, and it takes water readily, but it has fairly low fertility, and its water-holding capacity is fairly low. Under cultivation it is moderately susceptible to wind and water erosion.

All of this soil has a cover of short and mid native grasses, chiefly the grama grasses but also little bluestem, sand dropseed, and buffalograss. Yucca, catclaw, and mesquite shrubs grow in some places. (Capability unit IIIe-7, dryland; Mixed Land range site)

Woodward loam, 3 to 5 percent slopes (WoC).—This is a calcareous, shallow, moderately sloping soil that has a moderately permeable subsoil.

About 12 percent of the acreage consists of minor areas of moderately sloping Quinlan soils and small areas of gravelly knobs.

This soil is easily tilled but is low in fertility. It takes water readily, but its water-holding capacity is low. The hazards of wind erosion and water erosion would be moderately severe if any of the acreage were cultivated.

All of this soil is in short and mid native grasses, mainly the grama grasses. Some little bluestem, sand dropseed, and three-awn are included, and there are some yucca and mesquite shrubs. Overgrazing thins and eventually eliminates the little bluestem and the grama grasses. (Capability unit IIIe-7, dryland; Mixed Land range site)

Woodward loam, 5 to 8 percent slopes (WoD).—This calcareous, strongly sloping soil is susceptible to both wind and water erosion. It has a moderately permeable subsoil. It takes water readily, but its water-holding capacity is low. Fertility is low.

Included in the areas mapped are minor areas of Quinlan soils and gravelly knobs. These inclusions make up about 15 percent of the acreage.

This soil is used only as native range. Under good range management, it produces a good cover consisting of blue grama, side-oats grama, and black grama, lesser amounts of little bluestem and sand dropseed, a scattering of yucca and mesquite shrubs, and forbs. (Capability unit VIe-4; Mixed Land range site)

Zita Series

In the Zita series are dark-colored, friable, nearly level to gently sloping soils that have a surface layer of clay loam and a subsoil of silty clay loam (fig. 19). These soils are on the High Plains. They occur in nearly flat and slightly concave areas and in some of the larger playas, between areas of Ulysses and Lofton soils.

The surface layer is about 15 inches of neutral, dark grayish-brown clay loam. This layer is easily tilled. In most places the plow layer is structureless, but in some places it has a weak, granular structure. The lower part of this layer has a moderate, fine to medium, granular structure.

The subsoil is friable, granular and subangular blocky, grayish-brown to brown, heavy clay loam. It is about 15 inches thick. The upper part is weakly calcareous, and the lower part is strongly calcareous.

The parent material is strongly calcareous, wind-laid earthen material of clay loam texture. It is friable, contains pockets of lime, and is easily penetrated by plant roots. In playas, this layer of parent material is lacking; apparently all of it has become part of the soil.

The texture of the surface layer ranges from loam to silty clay loam, the color from brown to very dark grayish brown, and the thickness from 8 to 25 inches. The texture of the subsoil ranges from clay loam to silty clay loam, the color from grayish brown to very dark grayish brown, and

Figure 19.—**Profile of Zita clay loam. The horizon marked Cca is a zone of lime accumulation.**

the thickness from 10 to 25 inches. A prominent lime layer begins at 22 to 50 inches from the surface, but most commonly at a depth of 25 to 36 inches. This layer is 12 to 28 inches thick. It is 25 to 60 percent dispersed chalky lime and segregated lime. Old, filled, rodent channels, 1 to 12 inches in diameter, are few to common in this layer and in the upper part of the parent material. The color of the parent material ranges from reddish brown to reddish yellow.

Zita soils are shallower, less clayey, and more permeable than Pullman and Lofton soils. They are lighter colored than Lofton soils. They are darker colored than Ulysses soils and are less limy in the subsoil.

Zita clay loam, 0 to 1 percent slopes (ZcA).—This is a smooth, deep, dark-colored, granular, nearly level soil.

Included with this soil in mapping are small areas of, and narrow areas transitional to, Pullman, Ulysses, and Lofton soils. These inclusions make up as much as 10 percent of a few areas.

This soil is fertile and easily tilled. It takes, stores, and releases water readily. Under cultivation, however, it is slightly susceptible to wind erosion.

Most of the acreage is cultivated. The remaining acreage is in range consisting of short native grasses. When

moisture is favorable, good to excellent yields of dryland crops can be produced. Good to excellent yields are also obtained if the soil is properly managed under irrigation. (Capability unit IIIce–2, dryland; capability unit IIe–2, irrigated; Deep Hardland range site)

Zita clay loam, 1 to 3 percent slopes (ZcB).—This is a smooth, dark-colored, granular, gently sloping soil. It is slightly lighter colored and has a thinner surface layer than Zita clay loam, 0 to 1 percent slopes.

Included in the areas mapped are narrow areas transitional to Ulysses and Pullman soils. In two separate areas these inclusions make up as much as 12 percent of the acreage.

This soil is fertile and is easily worked. It takes and stores moisture and releases it readily to plants. When tilled, it is moderately susceptible to wind and water erosion.

About two-thirds of the acreage is cultivated, and the rest is in native grass. When moisture is favorable, good crops are produced under dryland farming. If the soil is properly managed under irrigation, crop yields are good to excellent. (Capability unit IIIe–2, dryland; capability unit IIIe–3, irrigated; Deep Hardland range site)

Use and Management of the Soils

In this section the system of land capability classification used by the Soil Conservation Service is briefly explained. The soils are placed in capability groups, and the management for each group is discussed. General management is also discussed, and estimated average acre yields on seeded acreage are given for the arable soils under two levels of management. Management of rangeland and management of wildlife areas also are included.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable they are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, grazing, or wood products. There are no class I or class VIII soils in Armstrong County.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIIe. The letter *e* shows that the main limitation is risk of erosion; *w* means that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

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

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

Soils are classified in capability classes, subclasses, and units according to the degree and kind of their permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils, and without consideration of possible but unlikely major reclamation projects. The eight classes in the capability system and the subclasses and units in Armstrong County are described in the list that follows. Soils suitable for irrigation are grouped in capability units for that purpose, but no separate discussions of management under irrigation are given. In groupings for either dryland farming or for irrigation, the capability subclass shows the dominant kind of limitation. Capability unit IIs–1, irrigated, for example, contains soils that under irrigation are limited chiefly by the clay loam texture and the risk that a plowpan will form.

Class I.—Soils that have few limitations that restrict their use. No soil of Armstrong County is in class I.

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

- Subclass IIce.—Soils that have some limitations because of climate and risk of erosion.
  - Unit IIce–4, dryland.—Deep, nearly level soils on uplands; slowly permeable to moderately permeable subsoil.

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

- Subclass IIIce.—Soils limited by low rainfall and a moderate risk of erosion.
  - Unit IIIce–1, dryland; IIs–1, irrigated.—Deep, nearly level soils on uplands; compact, very slowly permeable, heavy clay subsoil.
  - Unit IIIce–2, dryland; IIe–1 or IIe–2, irrigated.—Deep, nearly level soils on uplands; slowly permeable to moderately permeable, heavy clay loam subsoil.
  - Unit IIIce–3, dryland; IIe–3, irrigated.—Moderately deep, calcareous, nearly level soils on uplands.
- Subclass IIIe.—Soils subject to moderate erosion if they are not protected.
  - Unit IIIe–1, dryland or irrigated.—Deep, gently sloping soils on uplands; very slowly permeable, blocky, heavy clay subsoil.

Unit IIIe-2, dryland; IIIe-2 or IIIe-3, irrigated.—Deep, gently sloping soils on uplands; slowly permeable to moderately permeable subsoil.

Unit IIIe-3, dryland; IIIe-4, irrigated.—Deep, calcareous, gently sloping soils on uplands; moderately permeable subsoil.

Unit IIIe-4, dryland; IIe-4 or IIe-5, irrigated.—Deep, nearly level to gently sloping soils on uplands; moderately permeable sandy clay loam to clay loam subsoil.

Unit IIIe-7, dryland.—Shallow to moderately deep, calcareous, gently sloping soils on uplands; moderately permeable subsoil.

Unit IIIe-8, dryland; IIIe-10, irrigated.—Shallow, gently sloping, calcareous soils on uplands; moderately permeable clay loam or sandy clay loam subsoil.

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

Subclass IVe.—Soils that have moderately severe susceptibility to wind and water erosion if not protected.

Unit IVe-1, dryland or irrigated.—Deep, moderately sloping soils on uplands; slowly permeable to moderately permeable subsoil.

Unit IVe-3, dryland or irrigated.—Deep, gently sloping soils on uplands; very slowly permeable subsoil.

Unit IVe-4, dryland.—Deep, moderately sloping soils on uplands; friable, moderately rapidly permeable subsoil.

Unit IVe-9, dryland; IIIe-10, irrigated.—Shallow, gently sloping, calcareous soils on uplands; moderately permeable clay loam subsoil.

Class V.—Soils subject to little or no erosion hazard but having other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass Vw.—Soils that are subject to frequent overflow.

Unit Vw-1.—Moderately permeable loam and clay loam on bottom lands.

Unit Vw-2.—Moderately rapidly permeable to rapidly permeable sandy soils on bottom lands.

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

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

Unit VIe-1; IVe-6, irrigated.—Shallow to moderately deep, moderately permeable, calcareous, moderately sloping and strongly sloping soils on uplands.

Unit VIe-2.—Shallow, moderately permeable, calcareous, moderately sloping and strongly sloping soils on uplands.

Unit VIe-4.—Shallow to moderately deep, strongly sloping soils on uplands.

Unit VIe-6.—Deep, calcareous, rapidly permeable, undulating soils on uplands.

Unit VIe-8.—Very shallow to moderately deep, moderately sloping, loamy and clayey soils on uplands; moderately permeable subsoil.

Subclass VIw.—Soils severely limited in use because of excess water.

Unit VIw-1.—Deep, poorly drained, fine-textured soils in playas.

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

Subclass VIIs.—Soils or land types very severely limited by physical characteristics.

Unit VIIs-1.—Very shallow, very strongly calcareous, strongly sloping to steep soils on uplands.

Unit VIIs-2.—Stony, gravelly, flaggy, rough, broken areas.

Unit VIIs-3.—Gravelly and cobbly hills.

Unit VIIs-4.—Rough broken land and gypsiferous soil material.

Class VIII.—Soils and landforms that have limitations that preclude their use, without major reclamation, for commercial production of plants and restrict their use to recreation, wildlife, water supply, or esthetic purposes. No soil of Armstrong County is in class VIII.

Management by Capability Units

In this subsection the soils of Armstrong County have been placed in capability units. Each unit is described, the soils in each are listed, and management is suggested for the soils suitable for dryland farming and for irrigated farming. The management of rangeland is described in the section "Management of the Soils for Range."

Capability unit IIce-4, dryland

This unit consists of dark-colored, deep, nearly level soils on uplands. These soils have a slowly permeable to moderately permeable subsoil. They are—

Abilene clay loam, 0 to 1 percent slopes.
Wichita loam, 0 to 1 percent slopes.

These soils take water slowly, but they have a high capacity to hold both water and plant nutrients and to release them readily to plants. They are slightly susceptible to wind and water erosion, and they tend to crust at the surface. The chief requirements are maintaining and improving productivity and tilth, preserving soil structure, conserving moisture, and controlling wind erosion.

About 90 percent of the acreage is in short native grasses and is used as range; about 10 percent is dry farmed. Forage sorghum is the chief crop.

Winter wheat and sorghum are the dryland crops best suited to these soils. Stubble mulching and other uses of crop residues help to control wind erosion, maintain the organic-matter content, slow runoff, and conserve moisture. If crops fail to make a good stand in a dry year, and the residues are insufficient to keep the soil from drifting, the surface soil should be roughened by chiseling and listing. Tillage operations should be limited to the minimum essential for preparation of a seedbed and for control of weeds. Farming on the contour and terracing the long slopes help to conserve moisture.

Lack of moisture, not lack of fertility, is the factor limiting production on these soils. Because of the tendency of the surface to crust and of the soil structure to deteriorate, careful management is needed to obtain moderate to high yields.

These soils are suited to irrigation, but water is not now available.

Capability unit IIIce-1, dryland; IIs-1, irrigated

This unit consists of smooth, deep, nearly level soils on uplands. These soils have a heavy clay subsoil that is compact and very slowly permeable. They are—

Lofton silty clay loam.
Pullman silty clay loam, 0 to 1 percent slopes.
Roscoe clay.

These soils have a high capacity to hold moisture and plant nutrients but release them slowly to plants. They are slightly susceptible to wind erosion, and they tend to crust at the surface. The very slowly permeable subsoil restricts the movement of water and the growth of roots. The chief management requirements are controlling wind erosion, preserving soil structure, conserving moisture, and utilizing irrigation water properly.

If tilled when too moist, or if tilled continuously at the same depth, these soils develop a plowpan or compacted layer. Excessive tillage breaks down the structure of the soils and destroys the effectiveness of crop residues. Consequently, it is important to limit tillage operations to the minimum essential for the preparation of a seedbed and the control of weeds. If moisture conditions are favorable, these soils are productive. Careful management is needed for continued moderate to high yields. Winter wheat, grain sorghum, and feed sorghum are the chief crops.

Dryland farming.—Winter wheat and grain sorghum are the dryland crops best suited to these soils. Wheat can be grown if the soil is wet to a depth of 2 feet or more at seeding time and is adequately protected with crop residues (*2*).[1] If the soil is too dry for wheat but is adequately protected with residues, it should be fallowed so that the moisture supply will build up. Sorghum can be grown if the soil is both too dry for wheat and inadequately protected with residues. Other suitable cropping systems are the following: (1) Small grain and occasional delayed fallow; (2) sorghum and occasional fallow or delayed fallow; (3) wheat, then grain sorghum, then fallow or delayed fallow.

If drought lasts several years, it may not be possible to produce enough cover to control blowing, and emergency tillage then may be necessary to roughen the surface and produce clods.

Lack of moisture, not lack of fertility, is the factor that limits production. Field diversions, grassed outlets, and terraces may be needed to retard runoff. Contour farming also helps to conserve water. Dryland crops generally do not respond to commercial fertilizer.

Irrigated farming.—If properly managed under irrigation, these soils produce high yields of all crops commonly grown in the county (fig. 20). A surface, or gravity, system of level borders and level or graded furrows is suitable. Irrigation runs should be longer than for any other cultivated soils in the county. Compacted soils require longer sets or more frequent applications of water. The cropping system should include a soil-improving crop, and crop residues should be utilized to improve tilth and help maintain fertility. Commercial fertilizer, in amounts based on soil and crop requirements, is necessary to maintain high yields. Because of slow permeability in the subsoil, the surface soil needs to be loosened by tillage, so as to increase its capacity for temporary storage of water.

***Figure 20.*—Harvesting wheat grown on Pullman silty clay loam, 0 to 1 percent slopes.**

Capability unit IIIce-2, dryland; IIe-1 or IIe-2, irrigated

This unit consists of deep, nearly level soils on uplands. These soils have a slowly permeable to moderately permeable, heavy clay loam subsoil. They are—

Bippus clay loam, 0 to 1 percent slopes.
Olton clay loam, 0 to 1 percent slopes.
Zita clay loam, 0 to 1 percent slopes.

These soils hold water and plant nutrients and release them readily to plants. Under cultivation they are slightly or moderately susceptible to wind erosion. The chief requirements are maintaining or improving productivity and tilth, conserving moisture, controlling erosion, and using irrigation water properly.

Most of the acreage is used to produce winter wheat and grain sorghum. The rest is in range consisting of short native grasses, chiefly blue grama and buffalograss.

Dryland farming.—Management should include contour farming, stubble mulching, constructing terraces or other diversions, and seeding drainageways to grasses. Chiseling or listing to make the surface rough and cloddy may be necessary if the amount of cover produced is not enough to keep the soil from blowing or to trap drifting soil. A regular crop or a catch crop should be planted each growing season, as soon as there is enough moisture.

Irrigated farming.—Under irrigation, the Bippus and Zita soils of this group are in capability unit IIe-2, but the Olton soil is in unit IIe-1. These soils are good producers of winter wheat, sorghum, alfalfa, and cotton. Sweetclover, rye, and sudangrass can be grown for green manure and can also be used for temporary pasture. Yields can be increased by applying barnyard manure

[1] Italic numbers in parentheses refer to "Literature Cited," p. 79.

and commercial fertilizer in amounts based on soil and crop needs.

Capability unit IIIce-3, dryland; IIe-3, irrigated

This unit consists of Ulysses clay loam, 0 to 1 percent slopes, a moderately deep, calcareous, nearly level soil on uplands. The subsoil is moderately permeable.

This soil is easily tilled. It is friable and takes water readily, and it has a moderate capacity to hold water and plant nutrients. It is moderately susceptible to wind erosion. The main requirements are maintaining or improving productivity and tilth, conserving moisture, and using irrigation water properly.

Most of the acreage is used to produce winter wheat and grain sorghum. In some seasons iron deficiency causes chlorosis of young sorghum and corn plants, and yields are reduced even if the plants are saved by rain or by treatment with a special spray.

Dryland farming.—A dryland cropping system should include a high-residue crop and a cover crop. The stubble and residues can be utilized to help control wind erosion. If the cover produced is not sufficient to keep the soil from blowing, chiseling or listing may be necessary to make the surface rough and cloddy so drifting soil will be trapped. A crop should be planted each growing season, as soon as there is enough moisture. Contour farming, terracing to break long slopes, and seeding drainageways to grasses help to conserve moisture and to control erosion.

Irrigated farming.—This soil generally produces high yields of winter wheat and grain sorghum if conservation irrigation is practiced. Some feed sorghum, field corn, and cotton can also be grown. Commercial fertilizer is necessary to maintain high yields. The kind and amount of fertilizer to be applied should be based on soil and crop needs. Irrigation runs can be shorter than on less permeable soils.

Capability unit IIIe-1, dryland or irrigated

This unit consists of Pullman silty clay loam, 1 to 3 percent slopes, a deep, gently sloping soil on uplands. The subsoil is very slowly permeable, blocky, heavy clay.

This soil has a high capacity to hold water and plant nutrients, but the clay subsoil impedes the movement of water and, in places, the development of roots. The hazard of water erosion is moderate, and the hazard of wind erosion is slight. The chief management requirements are controlling erosion, preserving structure, conserving moisture, and retarding runoff.

If moisture conditions are favorable, this soil is a good producer of winter wheat, grain sorghum, and short native grasses.

Dryland farming.—Dryland cropping systems can be about the same as those suggested for the soils of capability unit IIIce-1, but management requirements are somewhat more exacting. Installing terraces and farming on the contour help to slow runoff and to increase infiltration of water. Deep chiseling temporarily breaks up compacted layers caused by excessive tillage or by tillage when the soil is too wet. Stubble mulching helps to prevent crusting of the surface, to control erosion, and to reduce evaporation. A cover of growing crops or of crop residues is the best means of controlling wind erosion. Tillage to roughen the surface may be necessary if the cover of vegetation is inadequate.

Irrigated farming.—Under irrigation this soil produces high yields of all crops commonly grown in the county. If properly managed and fertilized, it produces as much as 45 or 50 bushels of winter wheat per acre and from 4,000 to 5,000 pounds of hybrid grain sorghum per acre.

Because of the stronger slope, water erosion is a greater problem on this soil than on the soils of capability unit IIs-1; consequently, more grading and other preparation are required before irrigation. The management practices and cropping systems suggested for the soils in capability unit IIs-1 are applicable.

A gravity irrigation system is suitable, but, with the same head of water, the graded-furrow runs should be longer than those on the Olton and Ulysses soils. They need not be so long as those on the similar, but more nearly level, Roscoe and Lofton soils.

Capability unit IIIe-2, dryland; IIIe-2 or IIIe-3, irrigated

This unit consists of deep, gently sloping soils on uplands. The subsoil is slowly permeable to moderately permeable. These soils are—

Abilene clay loam, 1 to 3 percent slopes.
Bippus clay loam, 1 to 3 percent slopes.
Olton clay loam, 1 to 3 percent slopes.
Wichita loam, 1 to 3 percent slopes.
Zita clay loam, 1 to 3 percent slopes.

These soils have a high capacity to hold water and plant nutrients and to release them to plants. They are slightly to moderately susceptible to wind erosion and, because of their slope, are moderately susceptible to water erosion. The chief requirements are maintaining or improving productivity, controlling erosion, conserving moisture, and using irrigation water properly.

Most of the acreage is cultivated, and the rest is in short native grasses and is used as range. Winter wheat, grain sorghum, and feed sorghum are the main crops.

Dryland farming.— Dryland cropping systems can be about the same as those suggested for capability unit IIIce-1, but, because of the stronger slope, the soils in this unit need more intensive management. Requirements include farming terraced land on the contour, establishing grassed outlets, and stubble mulching.

Irrigated farming.—Under irrigation, the Abilene, Bippus, Wichita, and Zita soils of this group are in capability unit IIIe-3, but the Olton soil is in unit IIIe-2. These soils produce good to excellent yields of winter wheat, grain sorghum, cotton, alfalfa, and other crops commonly grown in the county. Yields are higher when barnyard manure and commercial fertilizer are used. The amount of fertilizer to be applied should be based on soil and crop needs. The Abilene and Wichita soils are not irrigated, because water is not available.

Capability unit IIIe-3, dryland; IIIe-4, irrigated

Ulysses clay loam, 1 to 3 percent slopes, is the only soil in this unit. It is a deep, gently sloping, calcareous soil on uplands. The subsoil is moderately permeable.

This soil has a moderate capacity to hold water and plant nutrients. It is easily tilled. Because it contains lime, it is friable and blows readily. It is moderately

susceptible to both wind and water erosion. The main management requirements are maintaining and improving productivity and tilth, controlling erosion, conserving moisture, and using irrigation water efficiently.

About half the acreage is cultivated. Winter wheat and grain sorghum are the chief crops. The rest of the acreage is in native grasses, mainly blue grama and some side-oats grama and buffalograss. In some seasons young sorghum and corn plants show symptoms of chlorosis. The plants sometimes recover and produce fair yields after a rain or irrigation or a special spray treatment.

Dryland farming.—If the soil is dry farmed, practices that will help to conserve moisture should be used. Stubble-mulch tillage and contour cultivation of terraced fields help to control erosion and to maintain structure. A crop should be planted each growing season, as soon as there is enough moisture. If the cover produced is not sufficient to keep the soil from blowing, chiseling or listing may be necessary to roughen the surface so that drifting soil will be trapped.

Irrigated farming.—Good yields of winter wheat, sorghum, cotton, and corn have been produced on this soil. Higher yields are obtained when barnyard manure and commercial fertilizer are applied according to soil and crop requirements.

Capability unit IIIe-4, dryland; IIe-4 or IIe-5, irrigated

This unit consists of deep, nearly level to gently sloping soils on uplands. These soils have a subsoil of moderately permeable sandy clay loam to clay loam. They are—

Bippus fine sandy loam, 1 to 3 percent slopes.
Miles fine sandy loam, 0 to 1 percent slopes.
Miles fine sandy loam, 1 to 3 percent slopes.

These soils are easily tilled. They take water readily, and they have a moderate capacity to hold moisture and plant nutrients and to release them to plants. They are slightly to moderately susceptible to wind erosion. The gently sloping soils are slightly susceptible to water erosion. The chief requirements are maintaining and improving productivity and tilth, controlling erosion, conserving moisture, and using irrigation water efficiently.

Most of the acreage of the Miles soils and a small acreage of the Bippus soil is cultivated. The remaining acreage is in native grasses, mostly blue grama and bluestem. These soils are among the least droughty of the arable soils in the county. In years of normal seasonal rainfall, they produce moderately high yields of feed and grain sorghum, cotton, and winter wheat. Even in the drier years, they can be counted on to produce some crops.

Dryland farming.—If these soils are dry farmed, practices to conserve moisture and to control wind erosion are needed. Some practices common in the gently sloping areas are terracing, contour farming, stubble mulching, and establishing grassed outlets. Except when it is protected by a cover of growing crops or crop residues, the surface should be kept rough and cloddy by chiseling or listing, in order to trap drifting soil. A crop should be planted each growing season, as soon as there is enough moisture.

Irrigated farming.—Under irrigation. Miles fine sandy loam, 0 to 1 percent slopes, is in capability unit He-4, but the other Miles soil and the Bippus soil are in unit IIe-5. All of these soils are good producers of winter wheat, grain sorghum, cotton, and alfalfa. Some sweetclover, rye, and sudangrass are grown for pasture or green manure.

Crop residues, if properly managed, help to maintain or to increase the organic-matter content and to control wind erosion. Commercial fertilizer is necessary for continued high yields. The amount to be applied should be determined by soil and crop requirements.

The Miles soils, which have a high water-intake rate, can be irrigated more efficiently by sprinkler systems than by gravity systems. Considerable land shaping and conditioning is generally needed to prepare these soils for gravity-flow irrigation, and because of the high water-intake rate, runs must be short.

Capability unit IIIe-7, dryland

This unit consists of shallow to moderately deep, calcareous, gently sloping soils on uplands. The moderately permeable subsoil is underlain by caliche and fine-grained red-bed material at a depth of 20 to 30 inches. These soils are—

Weymouth clay loam, 1 to 3 percent slopes.
Woodward loam, 1 to 3 percent slopes.
Woodward loam, 3 to 5 percent slopes.

These soils are easily tilled, but they have a moderately low capacity to hold water and plant nutrients. They are moderately susceptible to water erosion and slightly susceptible to wind erosion. They require management that will maintain and improve productivity and tilth, control erosion, and conserve moisture.

Most of the acreage is in short native grasses and is used as range. The main grasses are blue grama and side-oats grama, but some buffalograss and three-awn are included.

These soils are capable of producing fair to good yields of winter wheat and feed sorghum. Contour farming and stubble mulching help to save moisture and to reduce water and wind erosion. If the amount of cover produced is not sufficient to control erosion, listing or chiseling may be necessary to prevent blowing or to trap drifting soil. A crop should be planted each growing season, as soon as there is enough moisture.

No water is available for irrigating these soils.

Capability unit IIIe-8, dryland; IIIe-10, irrigated

This unit consists of Mansker fine sandy loam, 1 to 3 percent slopes, a shallow, gently sloping, calcareous soil on uplands. The subsoil is moderately permeable clay loam or sandy clay loam underlain by soft or hard caliche at a depth of less than 20 inches.

This soil is highly susceptible to wind erosion, and water erosion causes some damage. The chief requirements are maintaining or improving productivity and tilth, conserving moisture, controlling erosion, using a cropping system to suit the soil, and using irrigation water efficiently.

Chlorosis of sorghum and corn seedlings is common. This is evidence of iron deficiency, which reduces yields even if the plants are saved by rain or by treatment with a special spray.

Dryland farming.—Crops that resist drought and leave much residue should be grown on areas farmed as dryland. Sudangrass, rye, and winter wheat are grown for supplemental feed and pasture. Because it is shallow, this soil

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never produces high yields, but if properly managed it will produce some winter wheat even in extremely dry years. Contour farming and stubble mulching are needed to control erosion.

Irrigated farming.—This soil is suited to sprinkler irrigation. Alfalfa, a lime-loving plant, grows well on this soil but requires large amounts of water. A bermudagrass pasture, properly irrigated, fertilized, and grazed, has produced as much as 600 pounds of beef per acre.

Capability unit IVe-1, dryland or irrigated

This unit consists of deep, well-drained, moderately sloping soils on uplands The subsoil is slowly permeable to moderately permeable. These soils are—

Bippus clay loam, 3 to 5 percent slopes.
Olton clay loam, 3 to 5 percent slopes.
Wichita loam, 3 to 5 percent slopes.

These soils take and store water and release it readily to plants, but they are highly susceptible to water erosion. The chief requirements are maintaining or improving productivity and tilth, controlling erosion, and conserving moisture.

Most of the acreage is in native grasses and is used as range. Because of their slope, these soils are better suited to range than to cultivated crops. If moisture is adequate, they are productive, but if they are not properly managed, erosion and loss of water reduce crop yields.

Dryland farming.—Growing only high-residue crops, such as wheat or closely spaced sorghum, stubble mulching and other use of crop residues, contour farming, and terracing are practices that help to control erosion and to conserve moisture in dry-farmed areas. Emergency tillage may be necessary if the amount of cover produced is not sufficient to control erosion. Excessive tillage and tillage when the soil is too wet breaks down the structure of the soil and destroys the effectiveness of crop residues.

If cropped areas are returned to native grasses, a mixture of blue grama and buffalograss can be seeded in a cover of sorghum litter. These areas should not be grazed until the grass stand is well established. Mowing may be necessary to control the weeds during this period.

Irrigated farming.—If properly managed under irrigation, these soils are good producers of sorghum and winter wheat. Sweetclover, rye, and sudangrass can be grown to be used as pasture or green manure. Crop residues, if properly managed, help to control wind erosion and to maintain or to increase the organic-matter content of the soils. Commercial fertilizer is necessary for continued high yields. Applications should be based on soil and crop requirements. The Wichita soil is not irrigated, because water is not available.

Capability unit IVe-3, dryland or irrigated

The one soil in this unit is Pullman silty clay loam, 1 to 3 percent slopes, eroded. It is a deep, gently sloping soil on uplands. The subsoil is very slowly permeable.

This soil tends to crust at the surface. Water erosion is moderately severe, and wind erosion is evident. Much of the area has been affected by sheet, rill, and gully erosion. About half of the original surface layer has been lost. The chief requirements are maintaining or improving productivity and tilth, controlling erosion, conserving moisture, shaping and preparing the land properly for irrigation, and using irrigation water efficiently.

This soil is better suited to native range than to crops.

Dryland farming.—Terracing and contour farming, growing only winter wheat or closely spaced sorghum, and managing the residues properly will largely control erosion of dry-farmed areas. Emergency tillage to roughen the surface may be necessary if the cover of vegetation is inadequate. Overtillage and tillage when the soil is too wet will cause surface crusting and compaction. This destroys the natural structure of the soil, causes loss of water and soil, and reduces crop yields.

Irrigated farming.—Irrigation of this soil is costly because much grading and other land preparation are needed. High yields of wheat and grain sorghum are possible if a gravity irrigation system is installed and commercial fertilizer and crop residues are efficiently used.

Capability unit IVe-4, dryland

This unit consists of deep, moderately sloping soils on uplands. The subsoil is friable and moderately rapidly permeable. These soils are—

Miles fine sandy loam, 3 to 5 percent slopes.
Vona fine sandy loam, 3 to 5 percent slopes.

These soils take water readily and make the moisture from even a light rainfall available to crops. Their capacity to hold water and plant nutrients is moderate to moderately low. The hazard of wind erosion is moderate to moderately severe, and the hazard of water erosion is moderate. The chief requirements are conserving moisture and controlling wind erosion by maintaining a cover or keeping the soil rough and cloddy.

Most of the acreage is used for range consisting of native mid grasses. About 35 acres is used for row crops.

The soils of this group are among the least droughty of the arable soils in the county. If rainfall is normal, they produce good yields of feed and grain sorghum, sudangrass, winter wheat, and cotton under dryland farming. Even in dry years, they can be counted on to produce some crops. A cover should be kept on these soils at all times. Terracing, contour farming, and stubble mulching are needed to help control erosion. Varying the depth of tillage prevents the formation of a plowpan.

No water is available for irrigating these soils.

Capability unit IVe-9, dryland; IIIe-10, irrigated

This unit consists of Mansker loam, 1 to 3 percent slopes, a shallow, gently sloping, calcareous soil on uplands. The subsoil is moderately permeable clay loam. The capacity of this soil to hold water and plant nutrients is low. The hazard of wind and water erosion is moderately severe. The chief requirements are controlling erosion, conserving moisture, selecting a suitable cropping system, and using irrigation water efficiently.

This is a marginal soil for crops. Yields are limited even under careful management. Some winter wheat is produced even during the drier years.

Iron deficiency causes chlorosis of sorghum and corn seedlings and reduces yields. The plants may recover after rain or irrigation or after treatment with a spray that contains iron and manganese.

Dryland farming.—If dry farmed, this soil can be pro-

tected by planting only close-grown, high-residue crops, farming on the contour, and stubble mulching. All crop residues are needed as a mulch to protect the soil during the windy season. If the cover produced is not sufficient to prevent blowing, chiseling or listing may be necessary to roughen the surface so that drifting soil will be trapped. A crop should be planted each year, as soon as moisture and growing conditions are favorable.

Irrigated farming.—Alfalfa, sweetclover, and bermudagrass are grown under irrigation and used for pasture. Green manure, humus, and frequent light applications of commercial fertilizer are needed for good yields of other crops. The kind and amount of fertilizer should be based on soil and crop requirements.

Capability unit Vw-1

This unit consists of Loamy alluvial land, a land type on the bottom lands of the Rolling Plains. This land type is made up of nonarable, moderately permeable loam and clay loam.

This land type receives runoff from the surrounding, higher lying soils on the uplands. It is cut up by scar channels and is frequently flooded by intermittent streams. Under good range management, there is only slight erosion, chiefly the cutting of stream channels. Channel gullying is becoming a serious problem in a few watersheds where heavy grazing is permitted. Improper practices in some of the tilled areas have caused excessive runoff and soil damage.

This land type is not suitable for cultivation and should remain in range. Do not burn pastures to control woody plants, because fire kills the desirable grasses and leaves the ground bare. For further discussion, see the description of the Loamy Bottom Land range site.

Capability unit Vw-2

This unit consists of Sandy alluvial land, a land type made up of nonarable, moderately rapidly to rapidly permeable sandy sediments on bottom lands along the larger streams.

These areas are dissected and frequently flooded by intermittent streams, and they receive runoff from the uplands. This extra moisture results in a thicker stand of grass than grows on upland soils of similar texture. Under good range management there is little erosion, chiefly channel cutting and bank sloughing. Runoff from improperly managed tilled areas in the uplands also causes some erosion.

This land type is not suitable for cultivation and should remain in range. Allow about half of each year's growth to remain, to permit the grass to store food for growth early in spring and to reduce the danger of erosion in winter and early in spring. For further discussion, see the description of the Sandy Bottom Land range site.

Capability unit VIe-1; IVe-6, irrigated

This unit consists of shallow to moderately deep, moderately sloping and strongly sloping, moderately permeable, calcareous soils on uplands. These soils are—

Berthoud-Mansker loams, 3 to 8 percent slopes.
Mansker loam, 3 to 5 percent slopes.
Mansker loam, 3 to 5 percent slopes, eroded.

The principal management requirements of these soils are control of erosion, conservation of moisture, and efficient use of irrigation water. Erosion can be controlled by maintaining a cover of vegetation or by keeping the surface rough and cloddy.

Mansker loam, 3 to 5 percent slopes, is the only soil of this group suitable for cultivation, and it is suitable only if irrigated. Because of shallowness, slope, and the severe hazard of wind and water erosion, the other soils are used only for range.

If properly managed, these soils generally produce a fair to good stand of native grasses. Irrigated pasture of bermudagrass appears to do well in the smoother areas. An annual production of 500 pounds of beef per acre is possible when the pastures are irrigated, fertilized, and properly grazed. Reseed overgrazed pastures with desirable grasses, and defer grazing for at least one season. Construct ponds in drainageways to help keep livestock distributed over the range. For further discussion, see the description of the Hardland Slopes range site.

Capability unit VIe-2

This unit consists of shallow, moderately permeable, calcareous, moderately sloping and strongly sloping soils on uplands. These soils formed on moderately coarse textured, strongly calcareous sediments from the High Plains. They are—

Berthoud-Mansker fine sandy loams, 3 to 8 percent slopes.
Berthoud soil in Berthoud-Potter sandy loams.
Berthoud soil in Rough broken land.

These soils are too shallow and steep for cultivation. They are highly susceptible to wind erosion. They are best used as range or as wildlife habitats. Although they support a fair to good cover of native grasses, careful management is necessary to control erosion. Control grazing to allow desirable grasses to reseed. Construct stock water ponds in drainageways, to help keep livestock distributed in large pastures. Allow about half of each year's growth to remain, in order to maintain a vigorous stand, reduce runoff, and increase infiltration. For further discussion, see the description of the Mixed Land Slopes range site and the Shallow range site.

Capability unit VIe-4

This unit consists of shallow to moderately deep, strongly sloping soils on uplands. These soils are—

Woodward loam, 5 to 8 percent slopes.
Woodward soil in Quinlan complex.

Because these soils are shallow, steep, and highly susceptible to wind erosion, they are not suitable for cultivation. They are best used as range or as wildlife habitats. Although they have a good cover of native short and mid grasses, careful management is necessary to control erosion. Establish cover on bare areas by spreading hay containing mature seed. Reseed overgrazed pastures with mixtures of desirable native or tame grasses. Do not burn pastures to control weeds and woody plants, because fire kills the desirable grasses and leaves the ground unprotected against erosion. For further discussion, see the description of the Mixed Land range site.

Capability unit VIe-6

This unit consists of Likes loamy fine sand, a deep, calcareous, rapidly permeable, coarse-textured soil on up-

lands. It occurs on concave to undulating relief on the Rolling Plains.

Because of its severe susceptibility to wind erosion and its steep, uneven slopes, this soil is not suitable for cultivation. It is used as native range, and it also provides some food and cover for wildlife. It is one of the soils that make up the best areas in the county for recharging the ground water. Although it generally has a good cover of mid and tall grasses, forbs, and shrubs, careful management is required to control erosion. Reseed bare areas and overgrazed pastures with mixtures of native grasses, and defer grazing for at least one season. Use chemicals to control woody plants. Control or defer grazing to allow native grasses to produce seed. For further discussion, see the description of the Sandy Land range site.

Capability unit VIe-8

This unit consists of very shallow to moderately deep, moderately sloping loamy and clayey soils on uplands. The subsoil is moderately permeable. These soils are—

Weymouth clay loam, 3 to 5 percent slopes.
Weymouth soil in Weymouth-Vernon complex.

These soils take water moderately well but lose a large amount through runoff. They are highly susceptible to water erosion and moderately susceptible to wind erosion. They are not suitable for cultivation and should remain in range. Although they support a fair to good cover of native grasses, careful management is necessary to control erosion. Construct ponds in drainageways to help keep livestock distributed in large pastures. Reseed bare or weedy areas with desirable native or tame grasses. Do not burn pastures to kill woody plants. Allow about half of each year's growth to remain, to increase water intake, decrease runoff, and control erosion. For further discussion, see the description of the Deep Hardland range site.

Capability unit VIw-1

This unit consists of Randall clay, a deep, poorly drained, fine-textured soil in playa lake beds. This soil formed from local clayey sediments washed from the High Plains. It is flooded several months or more each year by runoff from surrounding areas. If the vegetation is drowned out, soil blowing becomes a hazard when the areas dry. Emergency tillage is required to keep material from blowing from these areas onto more valuable soils nearby.

This soil is generally unsuitable for cultivation, but in dry years a number of the smaller and shallower lake bottoms are farmed or grazed. Western wheatgrass and buffalograss temporarily establish themselves on lake bottoms in grazed areas but are drowned out when rain fills up the playas.

In wet seasons water is impounded in the larger playas for long periods. These areas provide food and cover for ducks, geese, and other migratory game birds.

This soil does not have a range site classification. It is usually included in the same range site as the adjoining area.

Capability unit VIIs-1

This unit consists of very shallow, very strongly calcareous, strongly sloping to steep soils on uplands. These soils are—

Potter soils.
Potter soil in Berthoud-Potter sandy loams.
Quinlan soil in Quinlan complex.
Vernon soils in Quinlan complex.

These soils are too shallow and steep for cultivation. They have a low capacity to hold moisture. They are low in fertility and are highly susceptible to water erosion and should be used only as range or as wildlife habitats. The amount of forage is limited. Even if there is a fair to good cover of native grasses, careful management is necessary to control erosion. Prevent burning and overgrazing. Provide supplemental summer pasture for use during extended droughts. Control woody plants by using chemical sprays. Construct ponds in drainageways to help keep livestock distributed in large pastures. For further discussion, see the description of the Shallow range site and the Shallow Redland range site.

Capability unit VIIs-2

This unit consists of stony, gravelly, flaggy, rough, broken areas on or adjacent to the caliche breaks of the High Plains and the red-bed breaks of the Rolling Plains. The land types and the soil are—

Rough broken land.
Rough broken land in Quinlan complex.
Vernon soil in Weymouth-Vernon complex.

There are small patches of soil material on benches in some of the sheltered areas, but in most places there is little or no soil.

This land type is not suitable for cultivation and is of limited use for grazing. It is used as wildlife habitats. Most areas are sparsely covered with vegetation, and the few that have a good cover of grasses, forbs, and shrubs are too steep and stony for easy grazing. Careful management of the native grasses is required to control erosion. The proper range management is given under the Rough Breaks range site, and the Shallow Redlands range site.

Capability unit VIIs-3

This unit consists of Gravelly broken land, a land type made up of very shallow to moderately deep soils on gravel-capped hills that lie between the High Plains escarpment and the red beds of the Rolling Plains.

The soil material occurs in such a pattern as to make the entire land type unsuitable for cultivation. It is used only for range and wildlife habitats. The vegetation consists of grama grasses, little bluestem, yucca, catclaw, and dwarf juniper. Although this land type has a fair to good cover of native grasses and shrubs, careful management is required to control water erosion. Limit or control grazing to allow native grasses to reseed. Do not burn pastures. Provide supplemental summer pasture for use during extended droughts. For further discussion, see the description of the Gravelly range site.

Capability unit VIIs-4

This unit consists of Rough broken land, gypsiferous, a land type made up of gypsum hills and escarpments. Soil has formed mainly in sheltered swales between the hills and on narrow benches above the gypsum ledges and below the gypsum-capped rocks and the colluvial-alluvial foot slopes. Little or no soil has formed in the badland areas.

This land type is of limited use for grazing, but it pro-

vides habitats for wildlife. Careful management of the vegetation is required to control erosion. Its use for range is discussed under the Rough Breaks range site.

General Management Practices

To plan an effective system of soil management, a farmer must know what conservation practices are suited to the soils and to the climate, how much the soils will produce, and what their limitations are.

Climate is the factor that most affects the agriculture of Armstrong County. The chief hazards result from the variable but normally low rainfall, severe droughts, high winds, occasional rains of high intensity, hail, and blowing snows. The purposes of management, then, are to conserve moisture, to protect the soils against wind and water erosion, to improve the physical condition of the soil, and to maintain productivity.

Following are discussions of practices commonly required in this county. For suggested combinations of conservation practices for specific soils, see "Management by Capability Units."

Management of residues.—Proper management of crop residues is the most important conservation practice in Armstrong County. Crop-residue use and stubble mulching are two methods of managing residues.

Crop-residue use consists of keeping residues on the surface as a protective cover through the critical erosion period. Then the residues are plowed under in normal farming operations.

Stubble mulching is the most effective method of managing residues. Under this system, all farming operations, including tillage, planting, cultivating, and harvesting are done in such a way as to leave residues of the previous crop on the soil until the next crop has been seeded (*5*). These residues form a mulch that helps control wind and water erosion; helps to conserve moisture by increasing the infiltration rate and by reducing evaporation of soil moisture; aids seed germination by keeping moisture at or near the surface; catches and holds snow until it melts and enters the soil; and helps to maintain the organic-matter content and to preserve the structure of the soil.

Cropping systems.—Flexible cropping systems are necessary for efficient crop production and safe use of cropland in this county. Rainfall is low. The growing season is ordinarily about 197 days long but varies in length between 172 days and 240 days. Winter wheat and sorghum are the crops best suited to these climatic conditions. Wheat, the major crop in the system, should be planted in years when a good supply of moisture has been stored in the soil and the surface is well protected with residues. In other years, sorghum crops that resist erosion should be substituted for wheat. If wheat is planted but is blown out or fails for some reason other than lack of moisture, a catch crop of barley or oats can be grown. Emergency chiseling or listing may be needed to make the surface rough and cloddy so it will resist blowing.

Other cropping systems that may be substituted when weather conditions are favorable for dryland farming are as follows: (1) wheat, and occasional fallow; (2) wheat, grain sorghum, and occasional fallow; (3) wheat, and fallow or delayed fallow.

The acreage fallowed is least when weather conditions are most favorable for dryland crops. If the amount of stored moisture is small when it is time to seed winter wheat, most farmers leave the soils fallow, so that moisture will accumulate in the subsoil, and then plant sorghum the next summer or winter wheat the next fall.

Terracing and contour farming.—On nearly level soils, terracing and contour farming are needed mainly to conserve moisture; on stronger slopes, they are needed primarily to control water erosion and secondarily to conserve moisture. Contour farming alone may adequately protect nearly level areas that are not visibly eroded. Diversion terraces are used to break up concentrations of water on long, gentle slopes. Graded terraces require suitable outlets for excess water. If natural grassed drainageways are not available as outlets, grassed outlets should be constructed before terraces are built.

The shallow, sloping, calcareous, medium-textured to moderately fine textured soils require more intensive practices. They are good producers of native grasses and are better used as range than as cropland. The only crops for which they are suitable are small grains and close-drilled feed crops planted on the contour.

Tillage practices.—Excessive tillage breaks down the structure of the soils. It produces a powdery surface layer that is highly susceptible to blowing, does not absorb water readily, and tends to crust.

A plowsole, 1 to 3 inches thick, generally forms when loamy soils are continuously tilled to the same depth. The plowsole is dense and hard; it retards the infiltration of moisture and hinders the growth of plant roots. Varying the depth of tillage prevents the formation of a plowsole. The first tillage should be deepest, and for each succeeding tillage the depth should be reduced.

Stubble-mulch tillage helps to control weeds with least damage to the soil structure and least disturbance of residues. Machinery that is commonly used for maintaining residues on the surface are sweeps, chisels, rod weeders, and field cultivators. Drills for planting into the residues are as important as the equipment used in maintaining the residues on the surface. Hoe or shoe drills work best in heavy residues. Deep furrow drills can also be used. Disk drills can be used in moderate amounts of residues. Stubble mulching is one of the best ways to get water into the soil for storage in the subsoil.

Emergency tillage may be necessary during prolonged droughts when the vegetation is inadequate to protect the soils against blowing. The surface is made cloddy or rough by chiseling or listing, so that the impact of the wind is broken and drifting soil is trapped. Emergency tillage has only a temporary effect, and it may have to be repeated during the blowing season.

Fertilization and moisture conservation.—Lack of moisture, not lack of fertility, is the major factor that limits the productivity of the soils in this county. Two-thirds to three-fourths of the total precipitation is lost through evaporation. Only 60 to 80 percent of the rest is available to crops, even if the soils are properly managed. Moisture conservation is a major requirement if crops are grown.

Table 2 shows that the amount of stored moisture at planting time is the most important factor affecting the success of a wheat crop (*2*).

Most of the irrigated soils in the county respond to fertilizer. The amount and kind to be applied are best

determined by soil tests, which can be arranged for by technicians of the Extension Service.

The moderately fine textured soils of the High Plains do not respond to commercial fertilizer every year if they are dry farmed. In years when at least 2 feet of stored moisture remains in the soil early in spring following a good wheat crop, it has been found profitable to apply 20 to 30 pounds of nitrogen per acre to the growing crop of winter wheat.

TABLE 2.—*Yields of wheat in Southern High Plains in relation to soil moisture at seeding time*

Depth, in inches, of wet soil at sowing time	Average yield per acre for stated years when growing season is—	
	Unfavorable (1938 and 1939)	Favorable (1945, 1946, and 1947)
	Bu.	*Bu.*
0 to 12	1.4	9.2
13 to 24	3.1	10.8
25 to 36	8.5	19.7
37 or more	12.6	26.2

Irrigation.—The first irrigation well in Armstrong County was installed at Wayside in 1932. Irrigation has steadily increased since that time. About 160 wells, 6 or 8 inches in diameter, have been drilled, and approximately 30,000 acres is irrigated at least part of the time. Water is applied by both sprinkler and gravity-flow systems. The quality of water is good. Generally, irrigation is a supplemental practice used chiefly in periods of drought.

Most of the cropland in this county consists of deep, moderately fine textured soils that have a high moisture-holding capacity. The rate of infiltration ranges from 0.05 to 2.0 inches per hour, but it is most commonly less than 0.8 inch. Most of the soils being irrigated are nearly level, fertile, and moderately fine textured.

Spot checks made of irrigation wells on the Pullman soils, north of the Prairie Dog Town Fork of the Red River, show a very steady underground water level with drawdown from 12 to 50 feet. Studies of wells in the vicinity of Wayside show a gradual and very slow decline in the water level.

A properly designed irrigation system makes efficient use of the available water, helps to maintain or improve soil structure and fertility, and increases productivity. It does not cause erosion. For some of the soils in this county a surface system is best; for others, a sprinkler system. If there is a reliable source of water, a sprinkler system is suitable for the deep, moderately to moderately rapidly permeable soils, such as Bippus, Ulysses, and Zita soils. Sprinklers are generally unsatisfactory for the deep, slowly and very slowly permeable Pullman, Lofton, and Olton soils. The main types of surface irrigation used in the county are furrow and border. Although a border system requires a little more land preparation and maintenance, it makes more efficient use of water than the furrow system. The design of the border system is based on the depth, the rate of infiltration, and the water-holding capacity of the soil; the water supply; the crops to be irrigated; and the kind of farm equipment to be used. Some bench leveling is necessary on gently sloping soil. This consists of constructing a series of parallel borders, or stairsteps, on the contour.

The furrow system is more popular than the border system because it requires less land preparation and less maintenance (fig. 21). The time and rate of irrigation and the length of runs need to be planned so that water will penetrate to a uniform depth and not below the root zone of the crop to be grown.

Figure 21.—**Irrigating winter wheat on Pullman soils.**

Underground pipes help to conserve irrigation water and to distribute it evenly. Their use is increasing.

Although the same cropping system can be used under irrigation as under dryland farming, a better soil improvement program is possible if irrigation is practiced. More crops can be grown for green manure, more crop residues are left, and better use can be made of crop residues. If enough water is applied, crops respond to nitrogen.

Because of depletion of the underground water supply, irrigation may be fairly short lived in Armstrong County. More efficient use of the remaining underground water and better methods of conserving rainwater are needed. Technicians of the Soil Conservation Service are available to assist in designing suitable irrigation systems and in solving other irrigation problems.

Predictions of Crop Yields

The yields from any soil reflect the management it has received. Consistent high yields indicate that the soil has been well managed. In table 3 are predictions of average acre yields, based on seeded acres, for the principal crops grown on the cultivated soils in Armstrong County. Yields are given under two levels of management for both dry-farmed and irrigated soils. The figures in the "A"

columns are predictions of yields to be expected under ordinary management; those in the "B" columns are predictions of yields to be expected under improved management. For dry-farmed soils, the difference between yields of wheat under ordinary management and yields under improved management is about 1 to 2 bushels per acre. For irrigated soils, however, there is a marked difference in yields.

TABLE 3.—*Predicted average acre yields under two levels of management*

[Yields in columns A are those obtained under ordinary management; those in columns B are yields to be expected under improved management. Absence of figure indicates that crop is not suited to soil specified]

Soil	Wheat								Grain sorghum [1]					
	Dryland						Irrigated		Dryland				Irrigated	
	Continuously cropped		Wheat-fallow		Wheat-sorghum-fallow				Continuously cropped		Wheat-sorghum fallow			
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Abilene clay loam, 0 to 1 percent slopes	8.5	9.0	13.0	15.0	12.5	14.5	35	60	1,050	1,150	1,100	1,250	4,000	6,000
Abilene clay loam, 1 to 3 percent slopes	8.0	8.5	11.5	13.5	10.0	12.5	32	55	975	1,075	1,050	1,200	3,500	5,500
Bippus clay loam, 0 to 1 percent slopes	9.5	11.0	10.5	14.5	11.5	13.5	37	55	1,000	1,100	1,075	1,200	3,800	5,800
Bippus clay loam, 1 to 3 percent slopes	8.5	10.0	12.5	13.5	10.5	12.5	35	50	975	1,075	1,050	1,175	3,700	5,700
Bippus clay loam, 3 to 5 percent slopes	7.5	8.5	8.5	10.5	8.0	10.0	30	40	625	700	675	725	3,000	4,500
Bippus fine sandy loam, 1 to 3 percent slopes	7.5	9.0	11.5	12.5	9.5	11.5	35	45	1,025	1,125	1,100	1,250	3,500	5,500
Lofton silty clay loam	9.5	11.5	14.0	16.0	13.0	14.5	40	55	1,050	1,175	1,150	1,300	4,000	6,000
Mansker fine sandy loam, 1 to 3 percent slopes	5.0	6.0	7.5	9.0	7.0	8.0	25	37	650	775	700	825	3,200	3,900
Mansker loam, 1 to 3 percent slopes	5.5	6.5	8.0	9.0	7.0	8.0	21	35	650	750	725	775	3,000	3,700
Mansker loam, 3 to 5 percent slopes	----	----	----	----	----	----	19	25	----	----	----	----	2,500	3,200
Miles fine sandy loam, 0 to 1 percent slopes	7.5	9.0	13.5	16.0	11.5	14.0	35	50	1,050	1,100	950	1,100	4,000	6,000
Miles fine sandy loam, 1 to 3 percent slopes	7.0	8.0	10.5	13.0	9.0	12.0	27	45	900	1,100	800	1,000	3,500	5,500
Miles fine sandy loam, 3 to 5 percent slopes	6.5	7.5	8.0	10.0	7.5	9.0	22	35	700	800	750	900	3,000	4,200
Olton clay loam, 0 to 1 percent slopes	9.5	11.5	14.0	16.0	13.0	14.5	40	55	1,050	1,150	1,100	1,300	4,000	6,000
Olton clay loam, 1 to 3 percent slopes	8.5	10.0	12.5	13.5	10.5	12.5	35	50	975	1,075	1,050	1,175	3,700	5,700
Olton clay loam, 3 to 5 percent slopes	6.0	7.0	9.0	10.5	8.0	10.0	27	35	700	850	825	875	3,200	4,000
Pullman silty clay loam, 0 to 1 percent slopes	9.0	10.5	13.5	15.5	12.5	14.0	35	50	950	1,075	1,050	1,200	4,000	6,000
Pullman silty clay loam, 1 to 3 percent slopes	8.0	9.0	9.5	14.5	11.5	13.0	30	45	875	1,025	950	1,125	3,700	5,700
Pullman silty clay loam, 1 to 3 percent slopes, eroded	5.5	6.0	8.0	9.0	7.0	8.0	25	35	650	750	725	775	3,200	4,000
Roscoe clay	9.0	9.5	12.5	14.5	11.5	13.0	35	50	875	1,025	950	1,125	3,700	5,700
Ulysses clay loam, 0 to 1 percent slopes	7.5	9.0	12.0	14.0	12.0	13.5	35	50	900	1,000	950	1,150	3,800	5,700
Ulysses clay loam, 1 to 3 percent slopes	7.0	8.5	11.5	13.5	11.0	12.5	32	45	825	925	900	1,075	3,300	5,200
Vona fine sandy loam, 3 to 5 percent slopes	4.5	5.0	6.0	7.5	4.5	6.0	20	30	700	800	750	850	(2)	(2)
Weymouth clay loam, 1 to 3 percent slopes	5.0	5.5	6.5	8.0	5.5	7.5	25	35	600	700	650	750	(2)	(2)
Weymouth clay loam, 3 to 5 percent slopes	4.5	5.0	5.5	7.0	6.0	6.5	20	27	400	500	450	600	(2)	(2)
Wichita loam, 0 to 1 percent slopes	8.5	10.0	13.0	15.0	13.0	14.5	40	55	1,000	1,200	1,150	1,350	4,000	6,000
Wichita loam, 1 to 3 percent slopes	8.0	9.5	12.5	14.5	11.5	13.5	35	50	900	1,150	1,075	1,200	3,700	5,700
Wichita loam, 3 to 5 percent slopes	7.5	8.5	10.5	12.5	10.0	11.5	28	40	750	950	850	1,000	3,200	4,300
Woodward loam, 1 to 3 percent slopes	5.5	6.5	6.5	8.0	7.0	8.0	28	40	650	750	725	775	(2)	(2)
Zita clay loam, 0 to 1 percent slopes	9.5	11.5	14.0	16.0	13.0	14.5	40	55	1,050	1,200	1,150	1,350	4,000	6,000
Zita clay loam, 1 to 3 percent slopes	8.0	9.5	12.5	14.0	11.5	13.5	35	50	900	1,150	1,075	1,200	3,700	5,700

[1] If a hybrid is used, yields may be as much as 30 percent greater under irrigation and as much as 20 percent greater under dryland farming.

[2] Water is not now available.

Improved management of dry-farmed soils is understood to include the following:

1. Effective measures for conservation of soil and moisture.
   a. Terraces and diversions where needed.
   b. Contour farming.
   c. Adequate measures for maintenance of tilth.
      (1) Proper management of crop residues.
      (2) Timely stubble-mulch tillage.
      (3) Minimum tillage, and least possible disturbance of soil structure.
      (4) Variation in depth of tillage.
      (5) Postponement of tillage, harvesting, or grazing if the soils are wet.
2. Effective control of wind erosion.
   a. Delayed fallow in the drier years.
   b. Conservation and proper management of crop residues.
   c. Minimum tillage.
   d. Maintenance of a vegetative cover.
   e. Timely emergency tillage.
3. Consistent and timely measures for control of insects, plant diseases, and weeds.
4. Selection of proven better varieties or strains of crops, and timely planting.

Improved management of irrigated soils is understood to include the following:

1. Efficient management of irrigation water.
   a. Timely application of water in amounts that meet the needs of the crops and the soils.
   b. Uniform distribution and penetration of water.
   c. Precautions to prevent furrow erosion.
2. Maintenance of fertility at a high level.
   a. Timely application of fertilizer, in amounts determined by soil and crop needs.
   b. Efficient use of soil-improving crops.
3. Adequate measures for maintenance of tilth.
   a. Maintenance of organic-matter content by means of crop rotation.
   b. Postponement of tillage, harvesting, or grazing if the soils are wet.
   c. Variation in depth of tillage.
   d. Minimum tillage.
4. Effective control of wind erosion.
   a. Delayed tillage in dry years.
   b. Maintenance of a vegetative cover.
5. Efficient use of rainfall.
6. Consistent and timely measures for control of insects, plant diseases, and weeds.
7. Selection of proven better varieties or strains of crops, and timely planting.

Ordinary management is management that is deficient in one or more of the measures that make up a program of improved management.

The figures given in table 3 are based on information obtained from farmers; on observations and comparisons made by those familiar with the soils; and on results of experiments recorded by the Southwestern Great Plains Field Station and Pan Tech Farms.

Management of the Soils for Range [2]

The current use of the native grassland in Armstrong County, the range sites and range conditions, and the general practices of management appropriate for most of the rangeland are discussed in this section.

Current use of grassland

About 400,000 acres in Armstrong County is used as native range. This acreage, which amounts to 70 percent of the agricultural land of the county, is mostly on the watershed of the Salt Fork of the Red River and in the Palo Duro Canyon. There are scattered smaller areas in playas, along drainageways, and in small nearly level areas on the High Plains. Except for nearly level and gently sloping areas, the rangelands are not suitable for cultivation. The native grass cover, mostly short grasses, is generally good.

Ranches range in size from less than 1,000 acres to more than 100,000 acres. The average size is 6,000 acres. Most of the ranches are either cow-calf enterprises or steer-feeding enterprises. The number of steers bought and carried over for a year depends on the amount of supplemental winter-wheat pasture. If the growing season is favorable, the winter wheat is extensively grazed, but in a dry year, little or no grazing is permitted. Winter stockers may be added if the supply of forage is ample, and some cows and calves may be carried over. Supplemental and "finish" feeding are practiced to some extent.

Most of the range consists of rolling to hilly hardlands. Smaller parts are made up of mixed lands and of steep and rough, broken lands. The hardlands are mostly on the High Plains in the northern and southwestern parts of the county. Minor areas occur in the Palo Duro Canyon, east of the J. A. Ranch headquarters. The vegetation on the hardlands is chiefly blue grama and buffalograss, with which is mixed a little side-oats grama. On the steep and rough broken lands on and bordering the Rolling Plains, side-oats grama and hairy grama are the dominant grasses, but little bluestem and tall bluestem grow on some of the slopes that face north or northeast and consequently have favorable growing conditions. On the sandy bottom lands along the Prairie Dog Town Fork of the Red River and its tributaries, the cover is a mixture of tall and mid grasses, such as switchgrass, sand bluestem, Indiangrass, tall bluestem, and little bluestem.

Generally, the rangeland is in fair or good condition. Areas of hardland that have been overused for a long time are covered mostly by buffalograss and patches of mesquite. Sand sagebrush is invading the overused sandy lands, yucca is invading the mixed lands, and saltcedar the bottom lands.

The climate, which is one of extremes, has a marked influence on the production of forage. Distribution of rainfall is erratic but is generally favorable; most of the rainfall occurs in May, June, September, and October. Many of the rains in these months are of high intensity and result in excessive runoff. Droughts, which are common in midsummer and may last through the summer, retard plant growth or prevent the reproduction of the range vegetation.

Native grasses grow best from April to October, but drought results in dormancy for a time in July and August almost every year. If enough moisture is available, the warm-season grasses, such as blue grama and buffalograss, start growing in mid-April. They stop growing in midsummer if drought occurs, then start growing again about the last of August and continue to grow until early in October, when they again become dormant because of cool weather. Drought also retards or stops the growth of cool-season native grasses, such as Canada wildrye and western wheatgrass, which furnish fresh forage from late in February through April and from October through November.

Range sites and condition classes

Soils differ in their capacity to produce native grasses and other range plants. Soils that can produce about the same kinds and amounts of vegetation make up what is called a range site. Each range site is sufficiently uniform in climate, soils, and topography to produce a particular kind of climax vegetation.

Climax vegetation is the stabilized plant community on a given site; it reproduces itself and does not change so long as the environment remains unchanged. Generally, the climax vegetation is the most productive combination of forage plants that will grow on a range site.

[2] By DOUGLAS E. CUNNINGHAM, range conservationist, Soil Conservation Service.

The plants on each range site can be grouped as decreasers, increasers, and invaders.

Decreasers are species in the climax vegetation that tend to decrease in relative amount under continued heavy grazing. They generally are the most palatable and nutritious plants on the given site. Blue grama and bluestem are decreasers.

Increasers are species in the climax vegetation that increase in relative amount as the most desirable plants are reduced by close grazing. They are commonly shorter and less palatable to livestock than decreasers. Buffalograss is a common increaser.

Invaders are plants that cannot withstand the competition for moisture, nutrients, and light in the climax vegetation. They come in and grow along with the increasers after the climax vegetation has been weakened or reduced by overgrazing or other disturbance. Many are annual weeds, such as cheatgrass and little wild barley, that provide some grazing early in spring. In some places, undesirable perennials, such as mesquite, yucca, cactus, and broom snakeweed, are common. These plants have little value for grazing and take two or three times as much moisture as buffalograss to produce a pound of dry forage. Invaders may be native to nearby sites, or they may be transported from a considerable distance.

Grass, like other plants, manufactures its food in its leaves and stems. If the leaves and stems are destroyed by continuous heavy grazing, the grasses do not have food for growth and maintenance. As the most palatable and nutritious plants are reduced under heavy grazing, the composition of the vegetation of a range site changes, and the condition of the range declines as the decreasers are replaced by increasers and invaders.

Range condition is the present state of the vegetation on a given site in relation to the climax vegetation for that site. Four classes of range condition are used to indicate the degree to which the climax vegetation has been changed by grazing or other use.

A range is in *excellent condition* if more than 75 percent of the vegetation consists of climax plants. It is in *good condition* if 50 to 75 percent of the vegetation is the same kind as that in the original stand, in *fair condition* if the percentage is between 25 and 50, and in *poor condition* if the percentage is less than 25.

Forage production capacity depends on soil, relief, exposure, range condition, and moisture supply.

One of the main objectives of range management is to keep rangeland in excellent or good condition. If this is done water is conserved, the climax vegetation produces moderate to high yields, and the soils are protected. A major problem is recognizing important changes in the vegetation. These changes take place gradually and can be misunderstood or overlooked. Growth following a heavy rainfall may lead to the conclusion that the range is in good condition, when actually the cover is weedy and the range is in poor condition. Some rangeland that has been closely grazed for short periods, but has been carefully managed, may have a rundown appearance that temporarily conceals its quality and its ability to recover.

Good range management requires knowing what kinds of grasses each site can produce, how these grasses respond to different grazing systems, and what measures serve to maintain or improve rangeland.

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Generally, several sites are represented in any given area of range, but one will be preferred for grazing and will be the first site to be overgrazed. This key site can be used as a basis for managing and evaluating the amount of grazing the entire pasture can provide.

Descriptions of range sites

In this subsection the range sites in Armstrong County are described; the soils in each site are listed; and the important characteristics of the soils, the names of the principal grasses, and the total annual yield of herbage, excluding woody plants, are given.

LOAMY BOTTOM LAND SITE

This site consists only of Loamy alluvial land, a miscellaneous land type on nearly level to gently sloping bottom lands in draws and small valleys throughout the county. These bottom lands receive runoff from higher lying soils. Some areas are subject to frequent flooding and to the deposition of fresh materials. Some areas have a high water table, and some areas consist of saline soil material. If not protected, this site is subject to gullying and scouring. A typical area is along the upper part of the Salt Fork of the Red River and the upper part of Mulberry Creek.

Loamy alluvial land consists of stratified deposits of clay loam and sandy loam more than 20 inches deep. Permeability ranges from moderate to moderately rapid in the subsoil.

The climax vegetation is chiefly grasses. A few elm, chinaberry, and hackberry trees grow along waterways. Switchgrass, little bluestem, and blue grama are the principal decreaser grasses. They make up 40 to 70 percent of the cover and are least abundant where the soils are saline or the water table is high. The principal increasers are western wheatgrass, vine mesquite, alkali sacaton, tall dropseed, silver bluestem, and sedges. Alkali sacaton grows on saline soils. Sedges, prairie cordgrass, and tall dropseed are most abundant where the water table is high.

Continuous overgrazing permits invasion by buffalograss, sand dropseed, three-awn, wild sunflower, western ragweed, and mesquite.

Because of the extra moisture it receives as runoff, this site is highly productive if kept in good or excellent condition. It remains in good condition longer under heavy grazing than the Sandy Bottom Land site, but it responds less readily to management once it has deteriorated. Deferment of grazing, mowing to control weeds, and destruction of woody plants by chemical or mechanical means are necessary if the range condition is poor or only fair.

The basal herbage covers from 25 to 40 percent of the surface. In well-managed areas that have a high water table, the total annual herbage yield, excluding woody plants, ranges from 5,000 pounds per acre in dry years to 8,000 pounds per acre in wet years. In saline areas, the yield ranges from 4,000 to 6,000 pounds.

SANDY BOTTOM LAND SITE

This site consists of Sandy alluvial land, a miscellaneous land type on flat to gently sloping bottom lands along and slightly above the stream beds in draws and valleys on the Rolling Plains. This land type receives runoff from higher lying soils, and it is subject to overflow. Saline areas and areas that have a high water table are common.

A typical area is located where farm-to-market road 284 crosses the Prairie Dog Town Fork of the Red River.

Sandy alluvial land is nonarable. It consists mostly of stratified deposits of sand and loamy sandy alluvium. Surface drainage is medium. Internal drainage is rapid in most areas, but it is slow in areas that have a high water table. Because of the extra moisture it receives as runoff, this is one of the best range sites in the county. In dry periods it may provide the only green forage on the range.

The composition of the climax vegetation varies from place to place, depending on the origin of the alluvial deposits and the frequency of new deposits. The vegetation consists mostly of tall and mid grasses, including Indiangrass, switchgrass, bluestem, tall dropseed, Canada wildrye, alkali sacaton, and sedge. Decreasers constitute from 40 to 70 percent of the plant community, and increasers the rest. Indiangrass, switchgrass, and sand bluestem grow in the most favorable areas. Alkali sacaton makes up a high percentage of the vegetation in the saline areas. Alkali sacaton, tall dropseed, blue grama, silver bluestem, and sedge are the main increasers. A few woody plants, chiefly elm and cottonwood trees, occur in the climax vegetation on some of the bottom lands.

If the climax vegetation is not maintained, the site is invaded by noxious annual and perennial plants. These invaders include cocklebur, sunflower, sandbur, and western ragweed. Saltcedar is the main woody invader in the saline areas, and sand sagebrush in areas that have a low water table.

This site is highly productive if it is kept in good or excellent condition. It deteriorates more rapidly than the Loamy Bottom Land site if overgrazed, but it recovers more rapidly under good management. Grazing should be deferred and weeds should be mowed if the range condition is poor or fair.

The basal herbage covers about 20 to 40 percent of the surface. In well-managed areas where the water table is low or the soils are saline, the total annual herbage yield, excluding woody plants, ranges from 3,000 pounds per acre in dry years to 4,200 pounds per acre in wet years. In areas where the water table is high, production ranges from 4,000 to 5,500 pounds per acre.

DEEP HARDLAND SITE

This site consists mostly of smooth, nearly level to moderately sloping upland plains and some of the smoother erosional plains in the Palo Duro Canyon (fig. 22). A typical area is on the J. A. Ranch, 2 miles east of the ranch headquarters. The soils in this site are—

Abilene clay loam, 0 to 1 percent slopes.
Abilene clay loam, 1 to 3 percent slopes.
Bippus clay loam, 0 to 1 percent slopes.
Bippus clay loam, 1 to 3 percent slopes.
Bippus clay loam, 3 to 5 percent slopes.
Lofton silty clay loam.
Olton clay loam, 0 to 1 percent slopes.
Olton clay loam, 1 to 3 percent slopes.
Olton clay loam, 3 to 5 percent slopes.
Pullman silty clay loam, 0 to 1 percent slopes.
Pullman silty clay loam, 1 to 3 percent slopes.
Pullman silty clay loam, 1 to 3 percent slopes, eroded.
Roscoe clay.
Ulysses clay loam, 0 to 1 percent slopes.
Ulysses clay loam, 1 to 3 percent slopes.
Weymouth clay loam, 1 to 3 percent slopes.
Weymouth clay loam, 3 to 5 percent slopes.
Weymouth soil in Weymouth-Vernon complex.
Wichita loam, 0 to 1 percent slopes.
Wichita loam, 1 to 3 percent slopes.
Wichita loam, 3 to 5 percent slopes.
Zita clay loam, 0 to 1 percent slopes.
Zita clay loam, 1 to 3 percent slopes.

Figure 22.—**Deep Hardland range site that has been properly grazed.**

These soils are moderately deep or deep, and they are fertile. Their subsoil is moderately permeable to very slowly permeable. They have a high moisture-holding capacity. In places the intake of moisture is reduced by a surface crust and by a compacted layer, or "hoof pan," caused by trampling. If not protected, these soils are susceptible to slight wind erosion and to moderate or moderately severe water erosion.

The vegetation is mostly short grasses. Mid grasses grow only in the most favorable locations. About 70 percent of the vegetation consists of climax decreasers, such as blue grama, vine-mesquite, western wheatgrass, and side-oats grama. The rest of the climax vegetation is mostly increasers, such as buffalograss and silver bluestem. Some woody plants occur in the climax vegetation.

Overgrazing results in rapid invasion by pricklypear and mesquite trees. Other invaders are three-awn, broom snakeweed, and western ragweed.

This site is capable of high production of short and mid grasses. It deteriorates slowly, will maintain a sod even if heavily grazed, and responds to good management.

The basal herbage covers from 30 to 40 percent of the surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from 1,400 pounds per acre in dry years to 3,000 pounds per acre in wet years.

MIXED LAND SITE

This site occurs on gentle to moderate slopes on the Rolling Plains. The soils in this site are—

Woodward loam, 1 to 3 percent slopes.
Woodward loam, 3 to 5 percent slopes.
Woodward loam, 5 to 8 percent slopes.
Woodward soil in Quinlan complex.

These shallow to moderately deep soils overlie very fine-grained sandstone of the red beds. They take water readily, but their capacity to store moisture and plant nutrients is moderate to moderately low. If not protected, they are highly susceptible to wind and water erosion. Small areas of colluvial-alluvial soils are included in this site. The

nearly level soils of this site are arable, but because they are inaccessible they are not farmed.

The climax vegetation is mostly mid grasses. Blue grama, side-oats grama, and little bluestem are the principal decreasers. Buffalograss, silver bluestem, and sand dropseed are the principal increasers. The more common invaders are three-awn, mesquite, sandbrush, pricklypear, and yucca.

Continuous overgrazing results in buffalograss replacing blue grama, side-oats grama, and little bluestem in the range vegetation. Areas of range in fair or poor condition are bare or are occupied by the common invaders.

The basal herbage covers from 20 to 30 percent of the surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from 2,200 pounds per acre in dry years to 3,000 pounds per acre in wet years.

MIXED LAND SLOPES SITE

This site is in the sloping and rolling areas transitional between the High Plains and the Rolling Plains. The landscape is characterized by rolling hills and ridges formed by the tributaries of the Prarie Dog Town Fork and the Salt Fork of the Red River (fig. 23). A typical area is in the northeastern corner of the county, south of the High Plains escarpment. The soils in this site are—

Berthoud-Mansker fine sandy loams, 3 to 8 percent slopes.
Berthoud soil in Berthoud-Potter sandy loams.
Berthoud soil in Rough broken land.
Mansker fine sandy loam, 1 to 3 percent slopes.

Figure 23.—**Mixed Land Slopes range site in good condition.**

These soils are mostly moderately deep, but in some places they are shallow or very shallow. They are limy throughout, and they absorb water readily. Fertility is low. If not protected, these soils are highly susceptible to wind erosion. Deep U-shaped gullies are common in areas that are in poor condition. The deeper, nearly level soils of this site are arable, but they occur only as small scattered areas.

Mid grasses predominate in the climax vegetation. About 50 percent of the cover consists of decreasers, chiefly side-oats grama and little bluestem, but also including some sand bluestem and Canada wildrye. Increasers, mainly blue grama, hairy grama, and silver bluestem, make up about 30 percent. Yucca, the chief invader makes up 25 to 40 percent of the vegetation in some places.

This site is capable of producing a good cover of mid grasses if it is properly managed. The basal herbage covers from 10 to 20 percent of the ground surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from 2,500 pounds per acre in dry years to 4,000 pounds per acre in wet years.

HARDLAND SLOPES SITE

This site consists mostly of gently sloping and gently rolling areas bordering the High Plains. It includes playa rims and erosional plains in the Palo Duro Canyon. A typical area flanks the draw of Mulberry Creek southeast of Claude. The soils in this site are—

Berthoud-Mansker loams, 3 to 8 percent slopes.
Mansker loam, 1 to 3 percent slopes.
Mansker loam, 3 to 5 percent slopes.
Mansker loam, 3 to 5 percent slopes, eroded.

These soils take water readily. They are limy throughout, and their subsoil is moderately permeable. Generally they are shallow, and their capacity to hold moisture and plant nutrients is low. If not protected, they are highly susceptible to wind and water erosion.

Mid and short grasses make up the climax vegetation on the moderately deep soils. Mid grasses are dominant on the shallow soils. Decreasers, chiefly side-oats grama and little bluestem, make up about 40 percent of the climax vegetation. The rest of the climax vegetation consists of increasers, such as blue grama and buffalograss. Broom snakeweed, western ragweed, and weedy annuals invade areas of range in poor condition. Some spots are bare of vegetation.

If properly managed, this site is a good producer of mid and short grasses. It deteriorates slowly, even if heavily grazed, and recovers rapidly.

The basal herbage covers from about 15 to 25 percent of the surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from 2,100 pounds per acre in dry years to 3,200 pounds per acre in wet years.

SANDY LOAM SITE

This site consists of nearly level to gently rolling uplands on the Rolling Plains. A typical area, mostly of Miles soils, is due east of Goodnight near the Donley County line. The soils in this site are—

Bippus fine sandy loam, 1 to 3 percent slopes.
Miles fine sandy loam, 0 to 1 percent slopes.
Miles fine sandy loam, 1 to 3 percent slopes.
Miles fine sandy loam, 3 to 5 percent slopes.
Vona fine sandy loam, 3 to 5 percent slopes.

These deep soils are moderately to moderately rapidly permeable. Their capacity to hold both water and plant nutrients is moderate, and they release water readily to plants. If protected by a good stand of grasses, they take water readily and lose little or none through runoff. If not protected, they are highly susceptible to wind erosion and moderately susceptible to water erosion.

The climax vegetation is chiefly mid grasses. It is approximately 60 percent decreasers, chiefly side-oats grama, little bluestem, Indiangrass, and switchgrass. About 30

percent consists of increasers, mainly blue grama, silver bluestem, and hairy grama. About 10 percent consists of invaders, mostly broom snakeweed, western ragweed, mesquite, and cactus. Woody plants make up a small percentage of the vegetation in some places. Any deterioration in the site results in a rapid increase of sand sagebrush and yucca.

This site is capable of producing a good stand of mid grasses if it is kept in good or excellent condition. Once it has deteriorated, recovery is slow.

The basal herbage covers from 15 to 22 percent of the surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from 2,000 pounds per acre in dry years to 4,200 pounds per acre in wet years.

SANDY LAND SITE

This site consists entirely of Likes loamy fine sand. It occurs on gently sloping to moderately hummocky uplands, mostly on the watershed of the Salt Fork of the Red River. A typical area is north of Goodnight, where farm-to-market road 294 crosses the Salt Fork of the Red River.

This soil takes water readily and has a deep root zone. Its capacity to hold moisture and plant nutrients is low. Permeability is rapid. If not protected, this soil is highly susceptible to wind erosion. If a good cover of vegetation is maintained, little or no water is lost through runoff. The soil of this site is nonarable.

The climax vegetation consists predominantly of tall grasses. About 55 percent consists of sand bluestem, little bluestem, Indiangrass, switchgrass, Canada wildrye, and needle-and-thread. Increasers, such as blue grama, side-oats grama, and sand dropseed, make up about 40 percent of the climax vegetation. A few woody plants, such as sandplum and sagebrush, occur in the climax vegetation.

Any deterioration in the vegetation results in a rapid invasion by woody plants and weedy annuals, mostly yucca, sand sagebrush, tumble lovegrass, sandbur, and wild sunflower.

This site is capable of high production if it is kept in good or excellent condition. It deteriorates more rapidly when overgrazed than any other range site in the county, but it responds to good management.

The basal herbage covers from about 5 to 15 percent of the surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from 2,000 pounds per acre in dry years to 4,200 pounds per acre in wet years.

SHALLOW REDLAND SITE

This site occurs on the Rolling Plains. It borders areas of rough, broken shale or sandstone below the breaks. The topography ranges from gently sloping to rolling. The soils in this site are—

Quinlan and Vernon soils in Quinlan complex.
Vernon soil in Weymouth-Vernon complex.

These soils are deep clay loams and very fine sandy loams. They generally are shallow or very shallow, and there are barren outcrops of sandstone and shale. About 15 to 20 percent of the acreage is made up of deep soils that occupy gentle slopes and flats. Natural fertility is low, and the water-holding capacity is low.

This site supports only a sparse cover of mid and short grasses. Some areas are bare of vegetation. Climax decreasers make up about 75 percent of the vegetation. They are sand bluestem, little bluestem, Indiangrass, switchgrass, and needle-and-thread. The chief climax increasers are galleta, black grama, hairy grama, buffalograss, three-awn, silver bluestem, and small soapweed (yucca). The short grasses grow on the less favorable areas. Redberry juniper grows on the steeper, rougher areas and readily invades the smoother areas. Mesquite invades all areas, except those where the soils are very gravelly or very shallow. It grows to tree size on the deeper soils and to shrub size on the shallow soils.

This site deteriorates rapidly if it is overgrazed, and it recovers slowly, even under careful management. The basal herbage covers from 6 to 12 percent of the surface, excluding the areas that are bare. Under good management, the total annual herbage yield, excluding woody plants, ranges from 1,000 pounds per acre in dry years to 1,500 pounds per acre in wet years.

GRAVELLY SITE

This site consists of Gravelly broken land, a land type made up of gravel-capped, dome-shaped knolls and hills that generally occupy areas between the High Plains escarpment and the Permian red beds in the Palo Duro Canyon. The hills range from 25 to 150 feet in height but are most commonly between 75 and 100 feet. Small, scattered areas in the watershed of the Salt Fork of the Red River are included in this site. Also included are areas of sandy soils in narrow swales between the hills. Miniature landslides are common on the steeper slopes and in areas bordering streams. The gravelly and cobbly mulch that covers the hills and knobs resists erosion, helps to conserve moisture, and prevents plants from crowding one another.

The climax vegetation consists of a sparse but thrifty stand of bunch grasses. About 80 percent of the vegetation consists of decreasers. Little bluestem and side-oats grama are the dominant species on the gravelly areas. Blue grama and bluestem are dominant on the sandy areas. Silver bluestem and hairy grama are the chief increasers and make up about 15 percent of the climax vegetation. Woody plants, such as redberry juniper, catclaw, and yucca make up about 1 to 7 percent of the vegetation.

If the range is in fair or poor condition, three-awn and hairy tridens invade the gravelly areas and sagebrush rapidly replaces blue grama and bluestem on the sandy areas.

The basal herbage covers about 1 to 10 percent of the surface. The total annual herbage yield, excluding woody plants, ranges from about 600 pounds per acre in dry years to 1,500 pounds per acre in wet years.

SHALLOW SITE

This site consists only of Potter soils. It occurs in rolling to hilly areas that are transitional between the shallow soils and the breaks and is commonly associated with the Rough Breaks site. Small areas of Mansker and Berthoud soils and spots of Rough broken land are included in this site. These inclusions make up 15 to 20 percent of the acreage.

These soils are dominantly loams and gravelly loams. Ordinarily they are 5 to 10 inches deep. They contain a large amount of lime. Their capacity to hold moisture and plant nutrients is low. Unless protected by vegetation

they blow, wash, and gully severely. The soils of this site are nonarable, and some areas are inaccessible to livestock.

This site is sparsely covered with mid, short, and tall grasses. The tall grasses grow on areas that have a northern or northeastern exposure. The most common decreasers are little bluestem, side-oats grama, blue grama, and switchgrass. The increasers are mostly hairy grama, buffalograss, three-awn, and some yucca and catclaw acacia. Hairy tridens, pricklypear cactus, redberry juniper, shinnery oak, and weedy annuals invade range in poor condition.

The basal herbage covers from 8 to 15 percent of the surface, excluding areas that are bare. Under good management, the total annual herbage yield, excluding woody plants, ranges from 1,100 pounds per acre in dry years to 2,000 pounds per acre in wet years (fig. 24).

Figure 24.—**Shallow range site in excellent condition.**

ROUGH BREAKS SITE

This site consists mostly of nearly vertical caliche and gypsum escarpments, gypsum hills, and severely gullied and "scalded" areas. The land types in this site are—

Rough broken land in Quinlan complex.
Rough broken land.
Rough broken land, gypsiferous.

The soil material in this site is variable. Most of it consists of strongly calcareous, partly weathered sediments from the High Plains. Patches of soil, less than 5 inches deep, occur on mesas, or on foot slopes, or as a thin mantle interspersed with exposed parent material. More than 25 percent of the surface area is covered with caliche, sandstone, and gypsum rocks. This site is highly susceptible to water erosion. Some areas are not accessible to livestock.

This site is sparsely covered with mid grasses and smaller amounts of tall and short grasses. Some areas are nearly bare. About 70 percent of the vegetation consists of decreasers, such as sand bluestem, little bluestem, side-oats grama, blue grama, black grama, and scattered forbs. Under prolonged overgrazing, this site is invaded by woody species, such as shinnery oak, flowering saltbush, and broom snakeweed. Because of droughtiness, yucca and redberry juniper are scarce.

The basal herbage covers from 0 to 7 percent of the surface. Under good management, the total annual herbage yield, excluding woody plants, ranges from nothing in dry years to 1,600 pounds per acre in wet years.

Practices for rangeland

Good range management increases the number of the best native forage plants and encourages their growth and also protects the soil against erosion (fig. 25). The main practices needed are the following.

Control of grazing.—This is the most important range practice. Without it, all other practices will fail. In their green leaves, grasses and other plants manufacture the food they need to grow and reproduce. If too much of the green foilage is removed by grazing, the plants are weakened and stunted.

Because livestock seek out and graze the plants that are most palatable and nutritious, the less palatable plants and those that are low growing and matted tend to survive.

Figure 25.—**Effects of grazing on the growth of tops and roots of plants. These plants were obtained from the same range site and in the same vicinity.**

If grazing is controlled so that no more than half of their annual growth is removed, the more desirable grasses survive and become vigorous enough to compete successfully with the less desirable grasses. The growth left on the ground will—

1. Permit the manufacture of plant food for vigorous growth of tops and roots. Long roots reach and take in moisture stored deep in the soils, and more grass is produced. The roots of overgrazed grass cannot do this, because not enough green shoots are left to provide food for good root development.
2. Provide a mulch that encourages the intake and storage of water. The more water stored in the ground, the better the growth of grasses for grazing. As the mulch decomposes, it provides the soil with humus, which is essential for soil maintenance.
3. Protect the soil from erosion, prevent excessive water evaporation, and prevent damage to seedlings by high and low surface temperatures. Grass is the best cover for controlling erosion.
4. Allow the better grasses to crowd out the weeds. When this happens the range improves.
5. Enable the grasses to store in their roots and crowns the food they need for quick, vigorous growth in spring and after droughts.
6. Build up a reserve of feed for dry spells that otherwise might force sale of livestock at a loss.

Deferment of grazing.—Postponing or deferring grazing through the summer and the early part of fall is a good way to hasten the recovery of a range that is in fair or poor condition. It also builds up a reserve of forage for later use. It gives the desirable plants an opportunity to recover, to spread vegetatively, and to produce seed. A schedule of deferred grazing can be worked out by rotating grazing on different parts of the range. Fenced pastures consisting of portions of large or contrasting range sites are necessary. The rest seasons should be adjusted to the growing and seeding habits of the key plants.

Fencing.—Fences are needed to provide for good livestock and range management. Ranges may have to be separated according to seasonal use. In some areas, range sites that are large enough and that differ enough need to be fenced separately.

Brush control.—Forage yields increase and livestock are easier to handle if brush is removed or controlled. A number of areas in the Deep Hardland and Hardland Slopes range sites are infested with mesquite, pricklypear, and broom snakeweed. Some areas of Mixed Land and Mixed Land Slopes sites are infested with yucca and broom snakeweed. Mesquite can be controlled by root plowing, bulldozing, and using chemical sprays.

Range seeding.—Seeding depleted cropland to perennial native grasses has been successful and profitable in this county. The cropland being converted to range consists of fields in which most of the surface soil has been lost through erosion and the soils have lost most of their native fertility. The year before seeding the perennial grasses, an annual crop of sudangrass or forage sorghum should be drilled or broadcast. This crop should not be allowed to mature and produce seed, but should be shredded or mowed. The following year, the perennial grasses should be drilled in the undisturbed dead cover, which, if properly managed, creates a mulch that reduces evaporation, provides protection against high temperatures, and helps to prevent cracking.

Perennial seedlings are very delicate and require special mulches that are nearly free of competing weeds. Mowing may be necessary if weeds do start to grow. The areas seeded should be fenced to prevent grazing until the seedlings become established. After a stand is established, it needs management for maintenance and improvement.

Overseeding range that is in poor condition helps to reestablish desirable grasses, improve production, and prevent loss of soil and water.

Pitting or chiseling.—Many parts of the Deep Hardland and Hardland Slopes range sites that are in poor condition need pitting or chiseling to increase the intake of water and thereby prevent damaging runoff.

Supplemental feeding.—This is necessary in winter, when the supply of forage is low. Supplemental feeding areas should be located away from water facilities and salting areas, in parts of the range not frequently grazed.

Supplying water.—Water facilities should be so located that livestock never have far to go to find water. Generally, water is supplied by means of windmills with tanks, or by stock ponds, springs, or pipelines. There are some areas to which water has to be hauled. The nature of the range sites determines which type of water development is most practical. Proper distribution of water facilities encourages uniform use of the range.

Salting.—Salting at different places periodically makes for even distribution of grazing over the range.

Proper range stocking.—Selecting the right kind and number of livestock for the range results in the highest production and the best use of the vegetation. Cattle do best if the range vegetation is mainly grass. If the vegetation is largely weeds, sheep can make better use of it than cattle can. Most of the range in this county is used to graze cattle.

To be able to stock rangeland property, a rancher must know what range sites his holdings include and the composition and condition of the vegetation on each site, so he can determine whether the range condition is improving or declining and make adjustments accordingly.

It is often desirable to keep part of the livestock, such as stocker steers, readily salable. This allows a rancher to balance the number of livestock on hand with the available forage without sacrificing breeding animals. The number of livestock in this floater herd depends on the amount of winter wheat grown and used as pasture. Winter wheat provides little or no grazing during droughts.

A breeding program should provide for the selection of animals best suited to the range, for culling nonproductive animals, for the seasonal arrival of calves to take advantage of forage when it is most nutritious, and for continued improvement of the animals in the herd.

Determining best season of use.—Each site should be grazed at the season when the vegetation is at its best. For example, the Sandy Land site is best suited to spring and summer grazing because the tall grasses that predominate on that site are less palatable and less nutritious in winter.

Management problems arise if one pasture is partly in the Deep Hardland site or the Hardland Slopes site and partly in the Shallow site or the Rough Breaks site. Cattle concentrate on the Deep Hardland and the Hardland Slopes sites most of the year. They will not graze on the Rough Breaks site in summer, because of the flies. In winter the most palatable grasses are blue grama and buffalograss, which grow on the upland sites. If possible, the Deep Hardland and Hardland Slopes sites should be fenced off from the Rough Breaks site, so that each can be used at its best season.

All the other range sites in the county can be grazed at any season of the year, or the year round. Year-round use is likely to result in deterioration of the range.

Wildlife [3]

There are many kinds of wildlife in Armstrong County. Migratory birds, such as ducks, killdeer, geese, and herons, live in the playas and livestock ponds for several months each year. Upland birds include blackbirds, meadowlarks, bobwhite quail, blue quail, Chinese pheasants, and mourning doves. Wild animals in the county are antelopes, skunks, jackrabbits, ground squirrels, coyotes, prairie dogs, and badgers. Antelopes prefer the open prairies and, like coyotes, inhabit all open range areas of the county. Wild turkeys are common on the bottom lands along the streams. Deer live in breaks and in rough, broken areas in the southern part of the county.

The natural wildlife habitats in the county should be protected, and others can be developed. These areas need to be protected against grazing and fire. Brushy areas and rough, broken areas should be fenced. Many species of wildlife can live on the ranches if food, cover, and water are provided. The number of bobwhite quail and blue quail have increased since the ranchers started leaving grass on the range to conserve soil and water. Food and cover have been provided by fencing many unused odd areas and by planting suitable vegetation. Shrubs, such as Russian-olive, furnish both food and cover. Antelopes graze on the range along with the cattle and are protected from hunters by the landowners. Feedlot windbreaks provide excellent areas for wildlife.

Skunks and other insect- and rodent-eaters, such as hawks, owls, coyotes, and badgers, help to control insects and rodents on the farms or ranches.

Many landowners stock their farm ponds with fish each year. These ponds provide fishing for local residents only. Sunfish, bass, and catfish are suitable species. After ponds are stocked with fish, the dams and spillways should be fenced, the ponds should be fertilized, and undesirable weeds should be controlled.

Areas used as wildlife habitats may provide economic returns from hunting and fishing rights.

Engineering Applications [4]

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

This report does not eliminate the need for on-site sampling and testing of sites for specific engineering works and uses. It should be used primarily in planning more detailed field investigations to determine the in-place condition of the soil at proposed construction sites.

The information in this report can be used to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of soil properties that will help in the planning of agricultural structures, such as drainage systems, farm ponds, irrigation systems, terrace systems, or other structures for soil and water conservation.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway, airport, pipeline, and cable locations and in planning detailed investigations at the selected locations.
4. Locate probable sources of sand, gravel, and other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs to make maps and reports that will be more useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular areas.

Some of the terms used by the soil scientist may be unfamiliar to the engineer, and other terms may have special meanings in soil science. These terms are defined in the Glossary at the back of the report.

Engineering classification systems

Most highway engineers classify soil materials according to the system used by the American Association of State Highway Officials (AASHO) (*1*). In this system, the soils are placed in seven principal groups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, consisting of clay soils that have low strength when wet. Within each group, the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best materials to 20 for the poorest. The group index numbers are not used in this report. The classification of the soils in Armstrong County by the AASHO system is given in table 4.

[3] By DOUGLAS E. CUNNINGHAM, range conservationist, Soil Conservation Service.

[4] Prepared by DAN C. HUCKABEE, area engineer, Soil Conservation Service.

TABLE 4.—*Brief descriptions of soils*

Map symbol	Soil names	Description of soils and site	Depth from surface
			Inches
AbA AbB	Abilene clay loam, 0 to 1 percent slopes. Abilene clay loam, 1 to 3 percent slopes.	Deep, slowly permeable soils on uplands; formed on nearly level to gently sloping, fine textured to moderately fine textured red-bed material and outwash sediments from the High Plains; about 1¼ feet of clay loam, over about 2¼ feet of light clay, underlain by a lime zone of clay loam about 1 foot thick, over about 1 foot of clay loam parent material.	0 to 15 15 to 42 42 to 65+
BfD BmD Bo	Berthoud-Mansker fine sandy loams, 3 to 8 percent slopes. Berthoud-Mansker loams, 3 to 8 percent slopes. Berthoud-Potter sandy loams.	Moderately sloping, well-drained, very friable, calcareous soils on uplands; formed on smooth, moderately coarse textured sediments on foot slopes in areas transitional from the High Plains to the Rolling Plains; about 1 foot of fine sandy loam, over about 2 feet of sandy clay loam, underlain by 3½ feet of fine sandy loam. Properties of Berthoud soils described here. For properties of Mansker soils, see descriptions of Mansker fine sandy loam and Mansker loam; for properties of Potter soils, see description of Potter soils.	0 to 14 14 to 30 30 to 72
BrA BrB BrC	Bippus clay loam, 0 to 1 percent slopes. Bippus clay loam, 1 to 3 percent slopes. Bippus clay loam, 3 to 5 percent slopes.	Gently sloping to moderately sloping, well-drained soils; formed on fine textured to moderately fine textured local deposits washed from the edge of the High Plains; about 1 foot of neutral clay loam, over about 1½ feet of weakly to strongly calcareous heavy clay loam, underlain by about 3 feet of strongly calcareous and mildly alkaline clay loam parent material.	0 to 12 12 to 30 30 to 66+
BpB	Bippus fine sandy loam, 1 to 3 percent slopes.	Gently sloping, moderately permeable soil; formed on moderately coarse textured local alluvium deposited on foot slopes below the High Plains escarpment; about 1 to 2 feet of neutral fine sandy loam, over about 2 feet of calcareous sandy clay loam.	0 to 15 15 to 30 30 to 72+
Gr	Gravelly broken land.	Consists of gravelly hills or lower Ogallala deposits; scattered areas immediately above the red beds and below the High Plains escarpment; in a few places extends several miles into the Palo Duro Canyon; a 6- to 12-inch mantle of coarse sand and gravel, underlain by fine to coarse sand that grades to soft sandstone; small landslides common on slopes of more than 50 percent.	----------
Lk	Likes loamy fine sand.	Deep, very porous, sloping, immature soil on the Rolling Plains; formed on alluvial-colluvial sediments of Ogallala origin; about 2 to 4 feet or more of coarse-grained, well-drained soil material; noncalcareous at the surface to strongly calcareous at a depth of 2½ feet or more; highly susceptible to wind erosion.	0 to 9 9 to 50+
Lm	Loamy alluvial land.	Deep deposits of soil material on lower flood plains on the Rolling Plains; texture is sandy loam; subject to considerable shifting and deposition by floods.	0 to 50
Lo	Lofton silty clay loam.	Deep, slowly permeable, dark-colored soil on uplands; generally in depressions on the High Plains; about ⅔ foot of slightly acid or neutral silty clay loam, over about 2½ feet of neutral clay, underlain by a lime zone of silty clay loam about 1 foot thick, over 2 feet or more of calcareous silty clay parent material.	0 to 7 7 to 38 38 to 84+
MaB	Mansker fine sandy loam, 1 to 3 percent slopes.	Shallow, well-drained, calcareous, gently sloping to moderately sloping soil; formed on strongly calcareous and mildly alkaline, moderately coarse textured deposits from the High Plains; on upper slopes in areas transitional from the High Plains to the Rolling Plains; about 1 foot of strongly calcareous fine sandy loam, over about 2 feet of strongly calcareous light sandy clay loam that contains a lime zone, underlain by more than 2½ feet of strongly calcareous and moderately alkaline sandy clay loam.	0 to 10 10 to 17 17 to 62

and their estimated physical properties

Classification			Percentage passing sieve—			Permeability	Available water	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
						Inches per hour	*Inches per inch of soil*	*pH*	
Clay loam	CL	A-6	100	100	60 to 75	0.20 to 0.80.	0.17	6.8	High.
Light clay	CL or CH	A-7	100	100	80 to 90	0.05 to 0.20.	.20	7.0 to 7.8.	Moderate.
Clay loam	CL	A-6	100	100	60 to 75	0.20 to 0.80.	.17	8.0	Moderate.
Fine sandy loam	SM or ML	A-4	85 to 100	75 to 100	40 to 90	0.50 to 1.0.	.12	7.0 to 7.4.	Low.
Sandy clay loam	SC or CL	A-6	90 to 100	80 to 100	50 to 90	0.50 to 1.0.	.15	7.5 to 7.8.	Low.
Fine sandy loam	SM or ML	A-2 or A-4	85 to 100	75 to 100	30 to 70	0.50 to 1.0.	.12	7.8	Low.
Clay loam	SC or CL	A-6	97 to 100	95 to 100	40 to 70	0.50 to 0.9.	.15	7.0	Low to moderate.
Heavy clay loam	SC or CL	A-6	97 to 100	95 to 100	45 to 75	0.50 to 0.9.	.17	7.3 to 7.8.	Low to moderate.
Clay loam	SC or CL	A-6	97 to 100	95 to 100	35 to 75	0.50 to 0.9.	.15	7.8	Low to moderate.
Fine sandy loam	SM or SC	A-2 or A-4	95 to 100	90 to 100	30 to 40	1.0 to 3.0	.12	7.0	Low.
Sandy clay loam	SM or SC	A-4	95 to 100	90 to 100	40 to 50	1.0 to 3.0	.15	7.8	Low to moderate.
Sandy clay loam	SC or CL	A-6	95 to 100	90 to 100	45 to 55	1.0 to 3.0	.13	7.8	Low to moderate.
	GM or SM	A-1 or A-2	50 to 75	20 to 60	5 to 20	1.0 to 2.0	.06		Low.
Loamy fine sand	SM	A-2 or A-4	99 to 100	95 to 100	12 to 45	1.0 to 2.0	.12 to .17.	7.0	Low.
Loamy fine sand	SM	A-2						7.0 to 7.8	
Fine sandy loam	SM or SC	A-2	100	100	20 to 30	3.0 to 5.0	.05		Low.
Silty clay loam	CL	A-6						6.6 to 6.8	Moderate.
Clay	CH or MH	A-7	99 to 100	99 to 100	85 to 100	0.10 to 0.50.	.12 to .20.	7.0 to 7.5	Moderate to high.
Silty clay	CH or MH	A-7						7.8 to 8.0	Moderate to high.
Fine sandy loam	SM or SC	A-2 or A-4	90 to 100	85 to 95	30 to 50	0.75 to 1.25.	.07 to .20.	7.7	Low.
Sandy clay loam	SC or CL	A-4 or A-6	90 to 100	85 to 95	40 to 65	0.75 to 1.25.	.07 to .20.	7.8	Low to moderate.
Clay loam	SC or CL	A-4 or A-6	90 to 100	85 to 95	45 to 70	0.75 to 1.25.	.07 to .20.	7.8 to 8.0	Low to moderate.

TABLE 4.—*Brief descriptions of soils and*

Map symbol	Soil names	Description of soils and site	Depth from surface
			Inches
MkB MkC MkC2	Mansker loam, 1 to 3 percent slopes. Mansker loam, 3 to 5 percent slopes. Mansker loam, 3 to 5 percent slopes, eroded.	Shallow, well-drained, calcareous, gently sloping to moderately sloping soils formed on strongly calcareous and mildly alkaline, medium-textured outwash deposits of Cenozoic age; on upper slopes in areas transitional from the High Plains to the Rolling Plains; about ⅔ foot of strongly calcareous and mildly akaline loam, over about 2 feet of clay loam that contains a lime zone, underlain by more than 2 feet of strongly calcareous and mildly aklaline clay loam parent material.	0 to 7 7 to 33 33 to 60+
MsA MsB MsC	Miles fine sandy loam, 0 to 1 percent slopes. Miles fine sandy loam, 1 to 3 percent slopes. Miles fine sandy loam, 3 to 5 percent slopes.	Deep, well-drained, mature soils on uplands; formed on loamy outwash sediments from the upper Rolling Plains: about 1 foot of fine sandy loam, over 3 to 5 feet of light sandy clay loam, underlain by 1 foot of limy material, over several feet of sandy clay loam parent material.	0 to 8 8 to 65+
OcA OcB OcC	Olton clay loam, 0 to 1 percent slopes. Olton clay loam, 1 to 3 percent slopes. Olton clay loam, 3 to 5 percent slopes.	Deep, slowly permeable, nearly level to moderately sloping, mature soils on uplands; formed on loessal or eolian deposits from the High Plains; about ⅔ foot of neutral light clay loam, over about 6 feet of material that is neutral in the upper part and strongly calcareous in the lime zone and the parent material.	0 to 8 8 to 72+
Ps	Potter soils.	Very shallow, strongly calcareous soils; mostly along escarpments; about ½ to 1 foot of very strongly calcareous loam, generally underlain by lime-cemented beds of caliche that are 3 to 5 feet or more thick and are hard in places; most rainfall is lost through runoff; geologic erosion is evident on the steeper slopes.	0 to 8 8 to 20+
PuA PuB PuB2	Pullman silty clay loam, 0 to 1 percent slopes. Pullman silty clay loam, 1 to 3 percent slopes. Pullman silty clay loam, 1 to 3 percent slopes, eroded.	Deep, very slowly permeable, nearly level, mature soils; formed in loessal sediments on the High Plains; about 2 to 6 feet or more of fine-grained material underlain by calcareous, moderately fine grained parent material that is many feet thick; neutral at the surface to strongly calcareous in the lime zone.	0 to 7 7 to 50 50 to 85+
Qc	Quinlan complex.	The Quinlan soil is about 2 to 15 inches of very fine sandy loam, over very fine grained packsand or weathered soft sandstone; little or no soil on the steeper slopes, because of geologic erosion; rapid surface runoff. The Woodward soil is somewhat shallower than Woodward loam described in this table. The Vernon soil is 1 to 12 inches of clay or clay loam, over compact, calcareous, weathered, very coarse platy shale and sandstone. For properties of Vernon soil, see description of Weymouth-Vernon complex.	0 to 20+
Ra	Randall clay.	Poorly drained, very slowly permeable, very weakly developed soil formed on clayey sediments washed from surrounding High Plains; on floors of enclosed depressions; about 4 or 5 feet of heavy clay; self-mulching caused by swelling and shrinking of the soil on wetting and drying.	0 to 30 30 to 65+

their estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
						Inches per hour	*Inches per inch of soil*	*pH*	
Loam	SC or CL	A-6	97 to 100	95 to 100	40 to 75	0.5 to 1.0.	.12 to .20.	7.8	Low to moderate.
Clay loam	SC or CL	A-6	97 to 100	95 to 100	45 to 90	0.5 to 1.0.		7.8 to 8.0	Low to moderate.
Light clay loam	SC or CL	A-4 or A-6	97 to 100	95 to 100	40 to 75	0.5 to 1.0.		7.8 to 8+.	Low to moderate.
Fine sandy loam	SM	A-2 or A-4	98 to 100	95 to 100	30 to 40	1.0 to 2.0.	.14	6.5	Low.
Sandy clay loam	SM or SC	A-6	98 to 100	95 to 100	40 to 50	0.75 to 1.75.	.15	7.0 to 7.5	Low to moderate.
Clay loam	CL	A-6	99 to 100	95 to 100	80 to 90	0.2 to 0.5	.12 to .20.	6.8	Moderate.
								7.0 to 8.0	
Fine sandy loam	SM or ML	A-4	95 to 100	85 to 100	45 to 80	0.5 to 1.0	.07 to .12.	8.0	Low.
Caliche								8.2	
Silty clay loam	CL	A-6	100	100	96	0.05 to 0.5.	.12 to .20.	6.7	Moderate to high.
Clay	CL	A-7	100	100	90 to 95	0.05 to 0.5.	.12 to .20.	7.0 to 7.8.	Moderate to high.
Silty clay	CL	A-7	100	100	85 to 95	0.05 to 0.5.	.12 to .20.	7.0 to 8+.	Moderate to high.
Fine sandy loam	SM	A-2 or A-4	100	95 to 100	30 to 45	2.0 to 3.0	.06		Low.
Clay	CH	A-7	100	100	75 to 90	0.05 to 0.3.	.18	6.0	Very high.
Clay	CH	A-7	100	100	75 to 90	0.05 to 0.3.	.20	6.0 to 7.2.	Very high.

TABLE 4.—*Brief descriptions of soils and*

Map symbol	Soil names	Description of soils and site	Depth from surface
			Inches
Rb	Roscoe clay.	Very slowly permeable, very weakly developed soil; formed on clayey sediments washed from surrounding High Plains; on lower benches of the larger playas; about 4 or 5 feet of clay or silty clay, underlain by strongly calcareous clay or clay loam in the shallower playas; self-mulching caused by swelling and shrinking of soil on wetting and drying.	0 to 10 10 to 20 20 to 65+
Ro	Rough broken land.	A miscellaneous land type bordering the caliche escarpment and the Triassic breaks on the High Plains; occurs as a narrow band along the lower rim of the Palo Duro Canyon; large ledges of caliche and sandstone intermixed with some sandy loam; little or no soil; sparse vegetation; rapid surface runoff; geologic erosion is strongly evident in many places.	----------
Rs	Rough broken land, gypsiferous.	A land type that includes the steep, jagged, gypsum escarpments, ledges, and canyons and the severely gullied red-bed plains of the Palo Duro Canyon; bordering the escarpments are smoother areas of gypsum and scattered areas of gypsiferous soils, 2 to 12 inches thick; some large boulders of alabaster gypsum and soft sandstone intermingled with caliche and clay loam.	----------
Sa	Sandy alluvial land.	Deep, sandy soils on lower flood plains; subject to flooding.	0 to 50+
UcA UcB	Ulysses clay loam, 0 to 1 percent slopes. Ulysses clay loam, 1 to 3 percent slopes.	Moderately deep, calcareous soils on uplands; formed on eolian or loessal deposits of the High Plains; mostly on rims of playas and along drainageways between areas of Pullman and Mansker soils; about 2½ feet of calcareous clay loam, underlain by a lime zone of clay loam ½ foot thick, over about 1½ feet of silt loam parent material.	0 to 30 30 to 60+
VoC	Vona fine sandy loam, 3 to 5 percent slopes.	Mature soil on uplands; formed on the Rolling Plains under a cover of native grass, on recent sandy eolian sediments from the High Plains; highly susceptible to wind erosion; 1 to 2 feet of fine sandy loam, over 3 to 3½ feet of heavy fine sandy loam; subsoil has moderately rapid to rapid permeability.	0 to 24 24 to 48 48 to 60+
WcB WcC	Weymouth clay loam, 1 to 3 percent slopes. Weymouth clay loam, 3 to 5 percent slopes.	Shallow to moderately deep, calcareous soils on uplands; formed on a mixture of red-bed material and outwash sediments from the High Plains, underlain by consolidated red-bed material; about 1 to 2 feet of calcareous, granular clay loam, underlain by a lime zone of silty clay loam about ½ foot thick, over about 2 feet of clay loam parent material.	0 to 12 12 to 48+
Wf	Weymouth-Vernon complex.	Moderately permeable; about 65 percent Weymouth clay loam, 20 percent Vernon clay loam, and 15 percent other red-bed soils. Vernon soil weakly formed on exposed red-bed shale and sandstone; less than 11 inches thick. Weymouth soil weakly formed on red-bed material and outwash sediments from the High Plains; about 10 to 20 inches thick. Properties of Vernon soil described here. For properties of Weymouth soil, see description of Weymouth clay loams.	0 to 12 12 to 48+
WhA WhB WhC	Wichita loam, 0 to 1 percent slopes. Wichita loam, 1 to 3 percent slopes. Wichita loam, 3 to 5 percent slopes.	Deep, well-drained, mature, arable soils on uplands; formed on loamy outwash sediments of the upper Rolling Plains; about 1 foot of loam, over 3 to 5 feet of sandy clay loam, over 1 foot of limy material, underlain by several feet of sandy clay loam parent material.	0 to 7 7 to 18 18 to 33 33 to 48+

their estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
						Inches per hour	*Inches per inch of soil*	*pH*	
Clay	CH or CL	A-7	100	100	65 to 90	0.05 to 0.3.	.16	6.7	High.
Clay	CH	A-7	100	100	75 to 90	0.05 to 0.3.	.20	6.7 to 7.0.	Very high.
Clay	CH	A-7	100	100	75 to 90	0.05 to 0.3.	.20	7.5 to 8.0.	Very high.
Loamy fine sand	SM	A-2	100	95 to 100	20 to 25	3.0 to 5.0	.05		Low.
Clay loam	CL	A-6	98 to 100	93 to 100	60 to 80	0.75 to 1.00.	.12	7.6 to 7.8	Low to moderate.
Clay loam	CL	A-6	98 to 100	95 to 100	70 to 90	0.5 to 1.00.	.16	7.8 to 8.0	Low to moderate.
Fine sandy loam	SM	A-4	95 to 100	85 to 95	40 to 50	1.5 to 2.0	.12	7.0	Low.
Sandy clay loam	SC or CL	A-6	95 to 100	85 to 95	45 to 70	1.0 to 1.5	.15	7.0 to 7.5	Low to moderate.
Sandy clay loam	SC or CL	A-6	95 to 100	85 to 95	45 to 70	1.0 to 1.5	.15	7.5 to 7.6	Low to moderate.
Clay loam	CL	A-6	100	99 to 100	80 to 90	1.0 to 2.0	.15	7.5 to 7.8	Moderate.
Clay loam	CL	A-6	100	99 to 100	75 to 85	1.0 to 2.0	.15	7.8 to 8.0	Moderate.
Clay loam	CL	A-6	99 to 100	98 to 100	80 to 90	1.0 to 1.5	.15	7.0 to 7.2	Moderate.
Clay loam	CL	A-6	99 to 100	98 to 100	75 to 90	1.0 to 1.5	.15	7.0 to 7.5	Moderate.
Clay loam	CL	A-6	100	95 to 100	60 to 70	0.50 to 1.50.	.20	6.8	Low to moderate.
Clay loam	CL	A-6							
Heavy clay loam	CL	A-6	100	95 to 100	60 to 65	0.50 to 1.50.	.17	7.0 to 7.5	Low to moderate.
Clay loam	CL	A-6	100	95 to 100	45 to 60	0.50 to 1.50.	.13	7.5 to 7.8	Low to moderate.

TABLE 4.—*Brief descriptions of soils and*

Map symbol	Soil names	Description of soils and site	Depth from surface
			Inches
WoB WoC WoD	Woodward loam, 1 to 3 percent slopes. Woodward loam, 3 to 5 percent slopes. Woodward loam, 5 to 8 percent slopes.	Gently sloping, loamy soils on uplands; formed on the erosional red-bed plains in the Palo Duro Canyon; about 1 to 2 feet of calcareous, granular loam, underlain by a lime zone of light clay loam about ½ foot thick, over about 2 feet of light clay loam parent material.	0 to 18 18 to 50+
ZcA ZcB	Zita clay loam, 0 to 1 percent slopes. Zita clay loam, 1 to 3 percent slopes.	Friable soils on uplands; formed on calcareous eolian or loessal deposits of the High Plains; about ¾ foot of clay loam, over about 2¼ feet of silty clay loam, underlain by a chalky lime zone of clay loam 1 to 1½ feet thick, over several feet of clay loam parent material; moderately permeable subsoil; Zita soils in playas lack a C horizon.	0 to 9 9 to 36 36 to 48+

Some engineers prefer to use the Unified soil classification system established by the Corps of Engineers, U.S. Army (*9*). In this system, the soils are grouped on the basis of their texture and plasticity and their performance as material for engineering structures. Soil materials are classified in eight coarse-grained groups (GW, GP, GM, GC, SW, SP, SM, SC); six fine-grained groups (ML, CL, OL, MH, CH, OH); and one organic group (Pt). Particle-size distribution is the basis for the GW, GP, SW, and SP groups. Particle-size distribution, liquid limit, and plasticity index are used to determine the GM, GC, SM, SC, and fine-grained groups. The estimated classification of the soils in this county by the United system is given in table 4.

Engineering properties of the soils

Table 4 gives brief descriptions of the soils mapped in Armstrong County and estimates of the soil properties that affect engineering work.

No laboratory tests were made of the soils in Armstrong County. However, test data for similar soils in Carson, Deaf Smith, Gray, and Lamb Counties were furnished by the Texas State Highway Department. The Unified and AASHO classifications given in table 4 are based on this data and on experience and knowledge of the area. Soil survey reports from other counties containing the same soils were also used as a basis for the estimates.

Permeability indicates the rate at which water will move through soil material that is not compacted; it is measured in inches per hour. It was estimated for the soil as it occurs in place. The estimates were based on soil structure and porosity and were compared with the results of permeability tests on undisturbed samples of similar soil materials.

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

Reaction is the degree of acidity or alkalinity expressed in pH value. A notation of 7.0 indicates precise neutrality; higher values indicate increasing alkalinity, and lower values indicate increasing acidity.

The shrink-swell potential is an indication of the volume change to be expected with a change in moisture content. Ratings are high, moderate, and low. This potential is based on volume change tests or observance of other physical characteristics of the soil. Randall clay is very sticky when wet and develops large shrinkage cracks when it dries. It has a high shrink-swell potential. Likes loamy fine sand is almost structureless and is nonplastic. It has a low shrink-swell potential.

Engineering interpretations of the soils

Table 5 rates the soils of Armstrong County as sources of material for engineering uses and lists specific characteristics that affect the suitability of each soil as a site for engineering structures. The data in this table are based on the estimates from engineering test data, on field experience, and on the observed performance of the soils.

Topsoil is material that is high in organic-matter content. It is used to topdress roadsides, gardens, and lawns.

The suitability of a soil for road fill depends largely on its texture and its natural water content. Plastic soils with a high natural water content, such as Roscoe clay, Randall clay, and Pullman silty clay loam, are difficult to compact and to dry to the desired moisture content. These soils are poor as a source of road-fill material. Very sandy soils are poor to fair. They are difficult to place and to compact because they do not contain enough binding material. The red beds are a good source of fines that can be mixed with sand to create good road-fill material.

their estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
						Inches per hour	*Inches per inch of soil*	*pH*	
Loam	ML	A-4	100	99 to 100	80 to 90	0.5 to 2.0	.15	7.5 to 7.8	Low.
Loam	CL	A-6 or A-7	100	99 to 100	75 to 90	0.5 to 1.5	.15	7.8 to 8.0	Moderate.
Clay loam	CL	A-7	99 to 100	95 to 100	90 to 95	0.5 to 1.0	.17	7.0	Moderate.
Silty clay loam	CL	A-7	99 to 100	95 to 100	90 to 95	0.5 to 1.0	.17	7.3 to 7.8	Moderate.
Sandy clay loam	CL	A-6	99 to 100	95 to 100	90 to 95	0.5 to 1.0	.17	7.5 to 7.8	Moderate.

Gravelly broken land is a fair source of sand and gravel for use in road construction. The Potter soils and Rough broken land are possible sources of hard caliche. Soft caliche, which is not considered a good construction material, occurs in areas of Mansker soils and in the limy areas of Rough broken land. Most of the other soils on the High Plains are underlain by soft caliche at a depth of 3 to 8 feet.

The soil features affecting highway locations or road subgrades are based on the estimated classification of the soil materials. In flat terrain, the features apply to the soil materials in the A and B horizons, and in steeper terrain (slopes of 5 percent or steeper) they apply primarily to the soil materials in the C horizon. Soils that have a plastic clay layer, such as Randall clay, Roscoe clay, and Pullman silty clay loam, have impeded internal drainage and have low stability when wet. Such soils make poor sites for highways. Loamy fine sands, which are very erodible and have a low percentage of material passing the No. 200 sieve, are poorly graded and generally lack stability unless they are properly confined. These soils are fair to good for highway construction. Coarser textured and better graded soils make better sites for highways and are rated good for this purpose.

Embankments for impounding water can be constructed safely on most soils of the county, if they are properly placed and the soil is compacted. Special treatment is sometimes needed to control seepage.

Most of the irrigated acreage consists of Pullman soils. The moderately permeable soils are suited to either surface irrigation or sprinkler irrigation. The slowly permeable and very slowly permeable soils can be irrigated by surface methods (level or graded border and level or graded furrows). Sprinkler irrigation is the best method for the rapidly permeable soils and the soils on rough topography. The cost of land leveling is a major problem on the steeper slopes.

Waterways and terraces can be constructed satisfactorily on most soils in this county. Because of lack of rain when moisture is needed, it is difficult to establish a cover of grass on the waterways. Waterways are difficult to maintain, and their carrying capacity is limited by accumulations of windblown material if they are constructed on highly erodible soils.

Terraces and diversions constructed from coarse-textured soils are difficult to maintain. Wind and water erosion are serious hazards in maintaining terrace ridges and channels. Diversions or other terraces on Pullman and Olton soils should be constructed with a slight grade, and provisions should be made for outlets. Either level or graded terraces can be constructed on the more permeable soils.

Winter grading and frost action are not considered serious problems, because the soils generally have a low moisture content during the winter, and subfreezing temperatures are of relatively short duration.

In rural areas and in small communities beyond the existing sewage lines, it is necessary to install private sewage disposal systems. The sandy, moderately sandy, and calcareous soils that have moderate to rapid permeability are suitable for sewage filter fields. Filter fields in Pullman, Olton, and Roscoe soils do not function properly, because these soils have a slowly permeable or very slowly permeable subsoil. Wells or seepage pits, about 3 feet in diameter and 40 to 50 feet deep, are commonly used for sewage disposal. The effluent flows into the calcareous loamy substratum. The wells or pits in areas on the Rolling Plains need not be so deep, because the depth to the calcareous substratum is not so great.

TABLE 5.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Abilene (AbA, AbB)	Good to depth of 25 inches; fair at depth of 25 to 48 inches.	Poor	High shrink-swell potential; slowly permeable.	Slowly permeable; will seal.
Berthoud (BfD, BmD, Bo).	Fair	Fair	Strongly calcareous; low shrink-swell potential.	Moderately permeable; will seal.
Bippus (BpB, BrA, BrB, BrC).	Fair to good	Fair	Well drained: low to moderate shrink-swell potential.	Moderately permeable; will seal.
Gravelly broken land (Gr).	Unsuitable	Fair; need to add fines; hard limestone in some places.	Low shrink-swell potential; slopes generally steep; rocks in some places.	Not suited unless red bed is at or near the surface.
Likes (Lk)	Poor	Fair to good; needs topsoil cover to prevent wind and water erosion.	Highly erodible; hummocky.	Not suited unless an impermeable blanket is used.
Loamy alluvial land (Lm).	Good	Fair to good	Low shrink-swell potential; on flood plains.	Very rapidly permeable; probably will not hold water.
Lofton (Lo)	Fair to good	Poor	High shrink-swell potential.	Very slowly permeable; strongly calcareous subsoil; will seal.
Mansker (MaB, MkB, MkC, MkC2).	Fair to good; loams (MkB, MkC, MkC2) good to a depth of 6 to 12 inches.	Fair to good	Well graded; strongly calcareous.	Moderately permeable; strongly calcareous; will seal.
Miles (MsA, MsB, MsC).	Fair to good	Good	Well drained; low shrink-swell potential.	Moderately rapidly permeable.
Olton (OcA, OcB, OcC)	Good	Fair	Fine textured	Slowly permeable; strongly calcareous in lower part of subsoil; will seal.
Potter (Ps)	Poor; shallow soil	Fair; rocky in some places.	Underlain by hard caliche in some places.	Moderately permeable; strongly calcareous; may be stony; may not seal.
Pullman (PuA, PuB, PuB2).	Good	Poor	Fairly high shrink-swell potential; poor surface drainage in level areas.	Very slowly permeable; strongly calcareous in lower part of subsoil; will seal.
Quinlan (Qc)	Fair to good	Good	Low to moderate shrink-swell potential.	Highly permeable
Randall (Ra)	Poor	Poor	High shrink-swell potential.	Very slowly permeable; generally suitable for dug ponds only.
Roscoe (Rb)	Poor to fair	Poor	High shrink-swell potential.	Very slowly permeable; generally suitable for dug ponds only.
Rough broken land (Ro, Rs).	Unsuitable	Fair	Generally rocky and steep; gypsum in some places.	Moderately permeable; strongly calcareous; may not seal; gypsum may cause leaks.
Sandy alluvial land (Sa)	Good	Fair to good	Low shrink-swell potential; on flood plains.	Very rapidly permeable; probably will not hold water.

interpretations of soils

Soil features affecting—Continued	Suitability for—		
Farm ponds—Con.	Irrigation	Terraces and diversions	Waterways
Embankment			
Stable fill; good compaction and erosion control.	Suitable for sprinkler or surface system; slowly permeable.	Suitable; stable fill; no hazard of wind erosion.	Suitable; fertile; susceptible to slight erosion.
Fair stability; well graded.	Poor; used mainly for range	Suitable; diversions may be needed to protect adjacent nearly level areas.	Suitable; will support vegetation.
Good stability; well graded.	Suitable; clay loams (BrA, BrB, BrC) suitable for surface or sprinkler system; sandy loam (BpB) has a high intake rate and is suitable for sprinkler system only.	Suitable; generally needed to control erosion; level or graded terraces satisfactory.	Suitable; will support vegetation; waterways needed as terrace outlets and to control outside runoff.
Poor stability; use only if clay material is added as binder.	Unsuitable; used mainly for range	Unsuitable; used mainly for range	Unsuitable.
Poor stability; use only if binder is added.	Unsuitable; used mainly for range	Not needed	Not needed.
Fair stability	Poor; very high intake rate	Unsuitable; unstable; subject to wind erosion.	Poor; subject to erosion; unstable.
Fair stability; good core or blanket material.	Poor; very slowly permeable; low intake rate.	Limited suitability; these structures needed on slopes of more than 1 percent; subject to cracking; graded terraces preferable.	Suitable; no construction problems; will support adequate vegetation; waterways needed as terrace outlets.
Fair stability; well graded.	Limited suitability; moderately permeable; shallow; suitable for surface or sprinkler system.	Suitable; generally needed on slopes of more than 1 percent; level or graded terraces satisfactory.	Fair; will support vegetation; adequate to control erosion if cuts are shallow; waterways generally needed.
Stable fill; good compaction and erosion control.	Suitable for surface or sprinkler system; moderately rapidly permeable.	Suitable; generally needed on slopes of more than 1 percent; level or graded terraces satisfactory.	Suitable; will support vegetation; erodible; subject to erosion.
Fair stability for low fills; good core or blanket material.	Limited suitability; generally suitable for surface system.	Suitable; needed on slopes of more than 1 percent; slightly graded terraces suggested.	Suitable; no construction problem; will support vegetation adequate to control erosion.
Fair stability; may be rocky.	Unsuitable; very shallow; used mainly for range.	Unsuitable; very shallow and stony	Unsuitable; very shallow and stony.
Fair stability for low fills; good core or blanket material.	Suitable; best suited to surface system; very slowly permeable; high water-holding capacity.	Suitable; needed on slopes of more than 1 percent; slightly graded terraces suggested.	Suitable; no construction problem; will support adequate vegetation.
Fair stability	Poor; high intake rate; subject to wind erosion.	Suitable; fair stability; subject to wind erosion.	Fair; moderate fertility; subject to wind erosion.
Fair stability	Poor; generally not irrigated because of location.	Not needed	Not needed.
Fair stability	Suitable; best suited to surface system; very slowly permeable; high water-holding capacity.	Not needed	Not needed.
Rocks, boulders, and gypsum make it difficult to obtain embankment material.	Unsuitable; generally used for range.	Not needed	Not needed.
Fair stability	Poor; very high intake rate	Unsuitable; unstable; subject to wind erosion.	Poor; subject to erosion; unstable.

TABLE 5.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Ulysses (UcA, UcB)	Good	Poor to fair	Moderately permeable; moderate to high shrink-swell potential.	Moderately permeable; calcareous throughout the profile; will generally seal by siltation.
Vernon (Wf)	Poor to fair	Poor	Slowly to moderately permeable; moderate shrink-swell potential.	Slowly to moderately permeable.
Vona (VoC)	Fair to good	Fair	Moderately rapidly permeable; poor stability; susceptible to wind erosion.	Moderately to rapidly permeable; calcareous subsoil.
Weymouth (WcB, WcC, Wf).	Fair	Poor to fair	Shallow; underlain by lime zone of clay loam; strongly calcareous subsoil.	Moderately to slowly permeable; strongly calcareous subsoil.
Wichita (WhA, WhB, WhC).	Fair to good	Fair	Well drained; moderate shrink-swell potential.	Moderately permeable
Woodward (WoB, WoC, WoD).	Fair	Fair	Shallow; underlain by lime zone of clay loam; strongly calcareous subsoil.	Moderately to slowly permeable; strongly calcareous subsoil.
Zita (ZcA, ZcB)	Good	Fair	Moderately permeable; moderate shrink-swell potential; calcareous subsoil.	Moderately permeable; will seal by siltation; calcareous subsoil.

Geology

The origin of the High Plains is significant in the geologic history of Armstrong County. About 200 million years ago, a shallow sea covered the area that is now the Panhandle of Texas. Marine sediments that were deposited during this period formed the Permian red beds (figs. 26, 27). After these formations rose above the level of the sea, streams that flowed over the exposed Permian rocks eroded fine-textured materials and redeposited them along the flood plains. These materials formed the Triassic red beds.

During the Cretaceous period, a shallow arm of the sea again partly covered the High Plains. Sand, silty clay, and limestone were deposited over much of the area.

While the Rocky Mountains were being formed, swift streams from the mountains cut valleys and canyons through the Cretaceous and Triassic rocks into the Permian rocks. Most all of the Cretaceous deposits and in places all of the Triassic deposits were washed from the High Plains toward or into the Gulf of Mexico. When the mountains approached their maximum height, they began to erode. As the mountains eroded, the streams slowed abruptly at the foot of the steep slopes, and large amounts of gravel, sand, and silt were deposited. These deposits formed a massive fan of coarse gravelly material

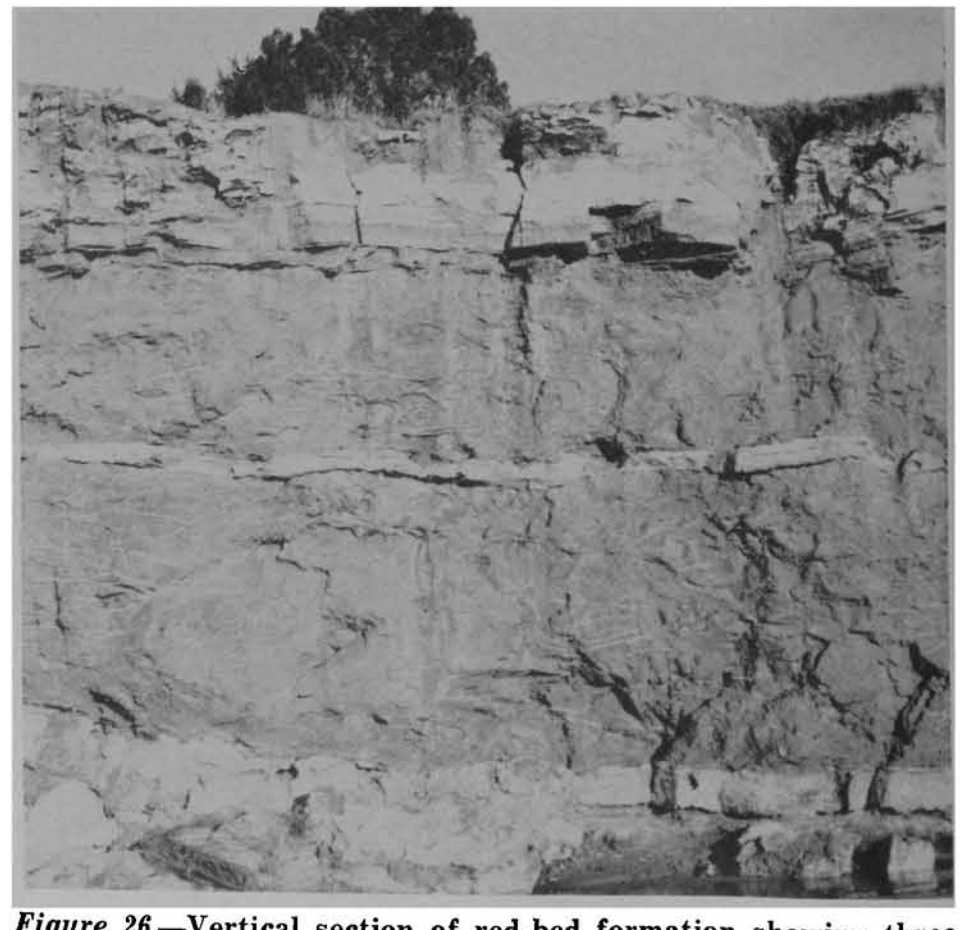

Figure 26.—**Vertical section of red-bed formation showing three beds of alabaster gypsum ranging from 8 to 10 feet apart.**

of soils—Continued

Soil features affecting—Continued	Suitability for—		
Farm ponds—Con.	Irrigation	Terraces and diversions	Waterways
Embankment			
Fair stability; fairly well graded.	Suitable for surface or sprinkler system; moderately permeable; moderate water-holding capacity.	Suitable; fair stability; slightly susceptible to wind erosion.	Suitable; no construction problem; will support adequate vegetation.
Stable fill material; slow to moderate permeability.	Suitable for surface system; low to moderate permeability; good water-holding capacity.	Suitable; stable fill material; moderate shrink-swell potential.	Suitable; moderate fertility; resistant to erosion.
Soil material fairly well graded; poor stability.	Moderate to rapid permeability; subject to wind erosion; low water-holding capacity.	Unsuitable; poor stability; susceptible to wind erosion.	Unsuitable; susceptible to wind and water erosion.
Stable fill material; moderate shrink-swell potential.	Moderate to slow permeability; resistant to erosion.	Suitable; good stability; moderate shrink-swell potential.	Suitable; will support good vegetation; resistant to erosion.
Stable fill; good compaction and erosion control.	Suitable for surface or sprinkler system; moderately permeable.	Suitable; generally needed on slopes of more than 1 percent; level or graded terraces satisfactory.	Suitable; will support vegetation; subject to erosion.
Stable fill material; moderate shrink-swell potential.	Moderate to slow permeability; resistant to erosion.	Suitable; good stability; moderate shrink-swell potential.	Suitable; will support good vegetation; resistant to erosion.
Fair stability; fairly well graded; moderate shrink-swell potential.	Suitable for surface system only on gentle slopes; moderate permeability; fair moisture-holding capacity.	Suitable; fair stability; susceptible to wind erosion when extremely dry.	Suitable; will support good vegetation; subject to wind or water erosion.

along the foot slopes of the mountains. Finer material was transported and spread several hundred miles to the east. The Ogallala formation consists of the deposits of outwash. In Armstrong County, this formation was as much as 700 feet thick and reached nearly to the present level of the High Plains (*4, 6*).

The glaciers did not reach as far south as Armstrong County. They did, however, make the climate there cool and humid. Because of the heavy precipitation, a few large rivers and valleys formed. The rivers are the Canadian, Cimarron, and Arkansas to the north, the Pecos to the west, and the Red to the south. All of these rivers have cut through the Cenozoic and Triassic deposits, and in some places they have cut deeply into the Permian deposits.

The parent material of most of the soils in this county consists of the eolian and loessal deposits that capped the High Plains. These deposits are called "cover sands" (*3*). They range from a few feet to more than 100 feet in thickness. The eolian material was deposited in the Early Wisconsin glacial stage of the Pleistocene epoch.

The water-bearing sands of the Ogallala formation make up the largest and most valuable natural reservoir of water in Armstrong County. Triassic and Permian formations underneath the Ogallala formation are nearly impervious to water, so it is not likely that water could be obtained from any of the lower strata. The beds of sand and gravel in the Ogallala formation became saturated with water from the Rocky Mountains while the formation was developing. Later, the formation was cut off from the Rocky Mountains and its source of water was blocked by the valley of the Canadian River to the north and that of the Pecos River to the west. Rain and snow are now the only sources of water to replenish the underground supply.

The water table slopes gently to the southeast, and the water moves very slowly. The natural flow is estimated at 1 or 2 feet a day.

The amount of water available for irrigation varies from place to place because of variations in the thickness of the water-bearing Ogallala sands and the depth to the red-bed formations.

Genesis, Classification, and Morphology of the Soils

This section explains how soils form and what factors are involved in their formation. It describes briefly the system of soil classification used in the United States, shows how the soils of Armstrong County have been classified, and describes the outstanding morphological characteristics of these soils.

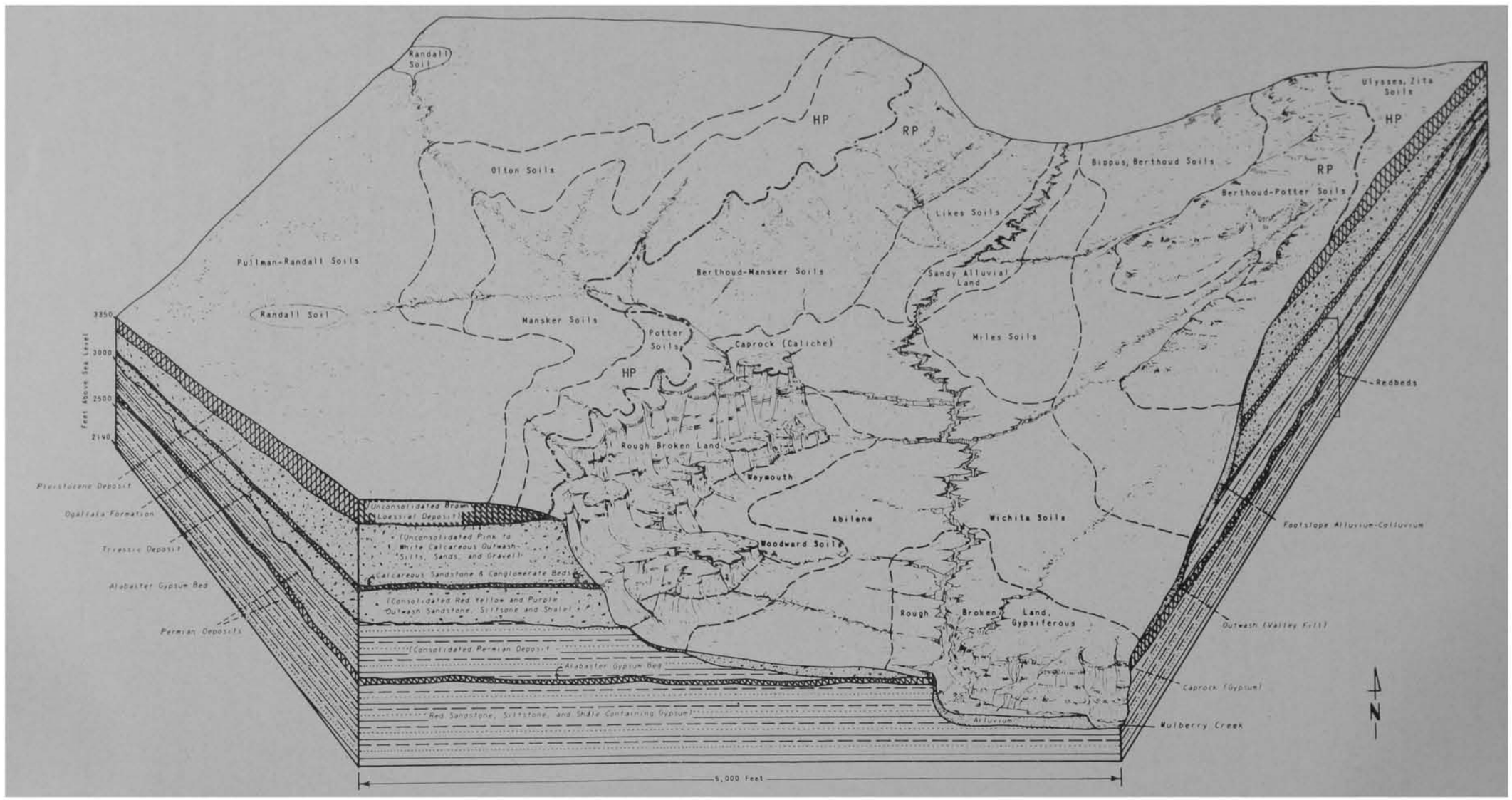

Figure 27.—**The major associated soils, landforms, and geologic formations on the High Plains (HP) and Rolling Plains (RP) in an area where Mulberry Creek enters the Palo Duro Canyon.**

Factors of Soil Formation

Soil is a function of climate, living organisms, parent material, topography, and time. The nature of the soil at any point on the earth depends upon the combination of the five major factors at that point. All five of these factors come into play in the genesis of every soil. The relative importance of each differs from place to place; sometimes one is more important and sometimes another. In extreme cases one factor may dominate in the formation of the soil and fix most of its properties, as is common when the parent material consists of pure quartz sand. Little can happen to quartz sand, and the soils derived from it usually have faint horizons. (Likes loamy fine sand is an example.) Even in quartz sand, however, distinct profiles can form under certain types of vegetation where the topography is low and flat and the water table is high.

The interrelationships among the factors of soil formation are complex, and the effects of any one factor cannot be isolated and identified with certainty. It is convenient, however, to discuss the factors of soil formation separately and to indicate some of their probable effects. The reader should always remember that the factors interact continually in the processes of soil formation and that the interactions are important to the nature of every soil.

Climate

Precipitation, temperature, humidity, and wind have been important in the development of the soils of Armstrong County. The wet climate of past geologic ages influenced the deposition of parent materials. Later, as a result of limited rainfall that seldom wet the soil below the area of living roots, horizons of calcium carbonate formed in most of the zonal and intrazonal soils, such as the Pullman, Olton, Abilene, and Weymouth soils. The limited precipitation has not been enough to leach free lime from the profile of the young soils, such as those of the Mansker and Ulysses series.

Wind has affected soil development in this area from the time it deposited silts and sands over the preexisting land surface in the Pleistocene epoch to the present, when it continues to shift sand, silt, and clay on exposed surfaces.

Living organisms

Vegetation, micro-organisms, earthworms, and other organisms that live on and in the soil contribute to its development. The type and amount of vegetation are important. They are determined partly by the climate and partly by the kind of parent material. Climate limited the vegetation in Armstrong County to grass. The parent material determined whether the grass would be tall, as on the sandy soils of the Likes series, or short, as on the clayey soils of the Pullman series.

The mixed prairie type of native vegetation contributed large amounts of organic matter to the soil. Decaying grass, leaves, and stems distributed the organic matter on the soil surfaces. Decomposition of fine roots distributed it throughout the solum. The network of tubes and pores left by these decaying roots facilitated the passage of air and water, and the roots themselves provided abundant food for bacteria, actinomycetes, and fungi.

Earthworms are the most noticeable form of animal life in the soils of Armstrong County. Despite low rainfall and periods when the entire solum is dry, the importance of earthworms in soil development is easily seen. The AC horizons of the intrazonal soils and the B horizons of some of the zonal soils are largely worm casts. Worm casts facilitate the movement of air, water, and plant roots in the soil.

Soil-dwelling rodents have had a part in the development of some soils. The burrowing of these animals did much to offset the leaching of free lime from the soil, but it also destroyed soil structure. Ulysses soils that occur within large areas of Chestnut soils furnish a good example of the results of this process. In contrast to the undisturbed Chestnut soils around them, the Ulysses soils are calcareous to the surface, have weaker structure in the subsoil, and have weaker Cca horizons in many places.

In the last 50 years, the activities of man have had considerable effect on the soils of this county. At first men fenced the range, allowed it to be overgrazed, and thereby changed the vegetation. They then plowed the land and planted crops. By harvesting crops and allowing runoff and wind erosion, they reduced the amount of organic matter and the proportion of silt and clay particles in the plow layer. By poorly timed tillage and the use of heavy machinery, they compacted the soils and thus reduced aeration and infiltration of water. They have drastically changed the moisture regime in some areas by irrigating. These changes will be reflected in the future direction and rate of development of the soils.

Parent material

Parent material, particularly its texture and lime content, greatly influence soil development. Soils that have developed from fine-textured material generally developed more rapidly and to a greater degree than soils that have developed from coarse-textured material. The parent material of the soils of Armstrong County is dominantly strongly calcareous and mildly alkaline, unconsolidated sandy and silty clay earthen material. It was derived mostly from loessal deposits and from Rocky Mountain outwash, part of which has been reworked by wind. The geology of the parent material is discussed in more detail in the section "Geology."

Relief

Relief influences soil development through its effect on drainage and runoff. The degree of profile development depends mainly on the average amount of moisture in the soil, if other factors of soil formation are equal. The soils on steep slopes, such as those of the Potter series, absorb less moisture and have less well-developed profiles than the smooth, gently sloping soils, such as those of the Olton series. On the steeper slopes continuous erosion retards the soil-forming processes. In depressions, or playas, Randall soils have formed in heavy clay. Since they are very poorly drained and have deep self-mulching characteristics, only slight horizonation is evident.

The prevailing southwesterly winds have deposited soil material on slopes facing northeast but have removed soil material from those facing southwest; consequently, in many areas the soils are deeper and more strongly developed on slopes facing north and northeast.

Relief also affects the kind and amount of vegetation on a soil; however, this is not so important in Armstrong County. Slopes facing north and northwest are sheltered from the drying prevailing southwesterly winds and re-

ceive less direct sunlight than those facing south. The soils on these slopes lose less moisture through evaporation and melting of snow; consequently, they have a denser cover of vegetation than soils on slopes facing south.

Some examples of the influence of topography and drainage upon the development and distribution of soils (illustrated in figures 28 and 29) are discussed in the soil survey report for Carson County, Tex., in the section "Formation, Classification, and Morphology of the Soils," under the heading "Soil Toposequences."

Time

The length of time that climate, living organisms, and relief have had to act on parent material affects the kind of soil that develops, but the effects of time are modified by the other four factors. Soils that do not have clearly expressed horizons are considered immature; those that do are considered mature.

Young soils, such as those of the Likes series, which have formed in recent colluvium-alluvium, are examples of immature soils in this county. The steeply sloping Potter and Mansker soils are immature also, because geologic erosion has removed the products of soil formation.

Mature soils, such as those of the Pullman and Olton series, show marked horizon differences. Most of the mature soils are well drained and gently sloping and have been in place a long time.

Classification of the Soils by Higher Categories

Classification of soils consists of an orderly grouping of defined kinds of soils in a system designed to make it easier to remember soils, including their characteristics and interrelationships, and to organize and apply the results of experience and research to areas ranging in size from a few acres to millions of square miles. The defined kinds of soils are placed in narrow classes for use in detailed soil surveys and for the application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories so that information can be applied to large geographic areas.

Classes of soils defined on a comparable basis and of the same rank in a classification system comprise what is called a category. A comprehensive system of soil classification, one that will be useful in dealing with the soils of a small field as well as with the soils of a continent and areas of intermediate size, must therefore consist of a number of categories. The higher categories consist of fewer and broader classes than the lower categories.

The system of soil classification now being used in the United States has six categories (*8*). Each successively higher category consists of a smaller total number of classes, and each of those classes has a broader range of characteristics. Thus, there are thousands of classes in the lowest category and three in the highest category. The intermediate categories are also intermediate in number of classes and in permissible span, or breadth, of each class. Beginning with the broadest, the six categories in the system of soil classification are the order, the suborder, the great soil group, the family, the series, and the type.

Four of the six categories have been widely used, and two have been used very little. The order and great soil group have been used widely, and so have the two lowest categories, the soil series and soil type. On the other hand, the categories of the suborder and family have never been fully developed and are therefore of little value now. In soil classification and mapping, attention has been given largely to the recognition of soil types and series within counties or comparable areas and to the subsequent grouping of the series into great soil groups and orders. The two lowest categories have been used primarily for the study of soils of small geographic areas, whereas the categories of the order and great soil group have been used for the study of soils of large geographic areas.

Differences in the breadth, or span, of individual classes in each category are indicated by the total number of classes in that category. All soils in the United States are included in three classes in the highest category, that of the soil order. These same soils are placed in some three dozen great soil groups, a category of somewhat lower rank. Going down to the next lower category in general use, approximately 6,000 soil series have been recognized in the United States. More series will be recognized as the study of soils continues, especially in areas where little work has been done in the past. The total number of soil types is not known exactly, because records are not maintained for individual soil types as they are for individual soil series. The total number of soil types recognized in the country as a whole, however, would be at least twice as large as the number of series. From comparisons of the respective numbers of orders, great soil groups, series, and types, it is immediately obvious that the ranges permitted in the properties of soils within one class in a category of high rank are broad, whereas ranges within individual classes in a category of low rank are relatively narrow.

The nature of each of the four categories—order, great soil group, series, and type—will not be described at length in this section. The soil series and the soil type are defined in the section "How Soils Are Named, Mapped, and Classified." The soil order and the great soil group are described briefly in the subsequent paragraphs.

The highest category in the present system of soil classification consists of three classes, known as the zonal, intrazonal, and azonal orders (*7*). The *zonal order* comprises soils with evident, genetically related horizons that reflect the dominant influence of climate and living organisms in their formation. The *intrazonal order* comprises soils with evident, genetically related horizons that reflect the dominant influence of one or more local factors of parent material or topography over the effects of climate and living organisms. The *azonal order* comprises soils that lack distinct, genetically related horizons because of one or more of the following: youth of parent material, resistance of parent material to change, and steep topography.

Soils of all three orders can generally be found within a single county, as is true in Armstrong County. Soils of two or all three orders may occur in a single field.

Primarily, the order indicates something about important factors of soil formation and something about degree of horizonation. The range in properties are wide within any one order; consequently, the total number of statements that are valid for all soils within an order is limited.

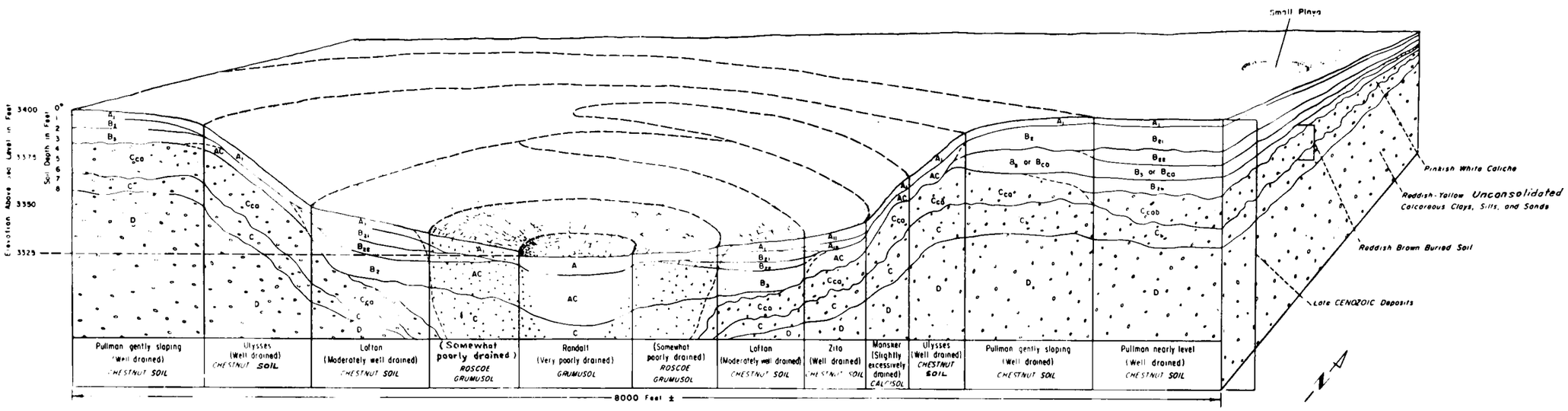

Figure 28.—**Soil toposequence of playas of the High Plains.**

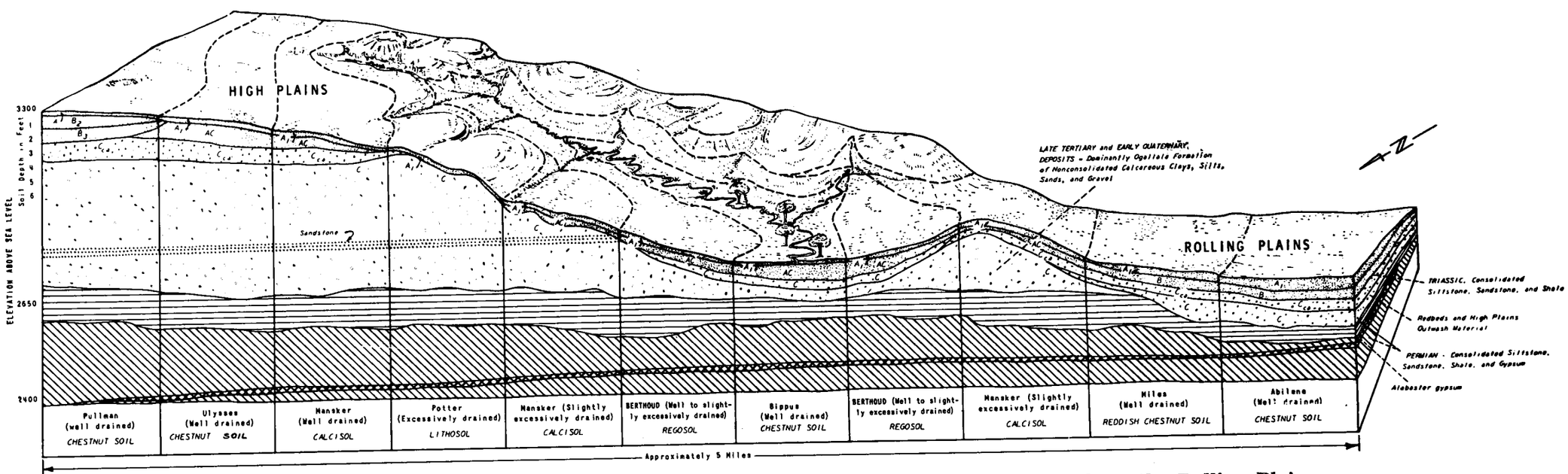

Figure 29.—**Soil toposequence of the subdued escarpment separating the High Plains from the Rolling Plains.**

The great soil group is the next lower category that has been widely used in this country. This category indicates a number of relationships in soil genesis and also something about fertility, suitability for crops, grass, or trees, and the like.

Each great soil group consists of a large number of soil series that have many internal features in common. All members of a single great soil group in either the zonal or intrazonal order have the same number and kind of horizons in their profiles. These horizons need not be expressed to the same degree, nor do they need to be of the same thickness in all soils within one great soil group. Specific horizons must be recognizable, however, in every profile of a soil representing a given great soil group.

Great soil groups in the azonal order are defined in part on the basis of the nature of the profile and in part on the basis of history, or origin, of the soil. All members of one great soil group in the azonal order have a number of internal features in common, but none of the three great soil groups in this order has distinct horizonation. Consequently, all of the soils still strongly resemble the parent material. Definitions of the great soil groups in the azonal order are based on the part of the profile approximately comparable in thickness to the solum of associated great soil groups of the zonal and intrazonal orders.

Most soil series have characteristics that are representative of one or another of the great soil groups, and they are classified accordingly. A few soil series, however, have some characteristics of two great soil groups; such soil series are grouped with the great soil group they resemble most closely but are classified as intergrades to the other great soil group. For example, soil series that are within the Chestnut great soil group but have weakly expressed horizons are classified as Chestnut soils that intergrade to Regosols.

The soil series of Armstrong County are listed by order and great soil groups in table 6. This table also gives some distinguishing characteristics of each series. Each series has been classified on the basis of the current understanding of the soils and their formation.

TABLE 6.—*Classification of soils by order, great soil group, and series, and some distinguishing characteristics*

Order, group, and series	Position	Parent material	Dominant relief	Drainage	Texture of subsoil
Zonal order:					
Chestnut group:					
Abilene series	Uplands	High Plains red-bed outwash.	Nearly level	Good	Moderately fine.
Bippus series	Foot slopes and alluvial fans.	High Plains alluvium	Nearly level	Good	Moderately fine.
Lofton series	Depressions	High Plains loess or eolian deposits.	Nearly level	Fair to good	Fine.
Pullman series	Uplands	High Plains loess or eolian deposits.	Nearly level	Fair to good	Fine.
Ulysses series	Uplands	High Plains loess or eolian deposits.	Gently sloping	Good	Moderately fine.
Zita series	Uplands and depressions.	High Plains loess or eolian deposits.	Nearly level	Good	Moderately fine.
Reddish Chestnut group:					
Miles series	Uplands	High Plains and red-bed outwash.	Nearly level to undulating.	Good	Moderately fine to medium.
Olton series	Uplands	High Plains loess or eolian deposits.	Gently sloping	Good	Moderately fine.
Wichita series	Uplands	High Plains and red-bed outwash.	Gently sloping	Good	Moderately fine.
Brown group:					
Vona series	Uplands	Eolian sand	Moderately sloping and undulating.	Slightly excessive	Moderately coarse.
Intrazonal order:					
Calcisol group:					
Mansker series	Uplands	High Plains loess or eolian deposits.	Moderately sloping	Good to excessive	Moderately fine to medium.
Weymouth series	Uplands	High Plains and red-bed outwash.	Moderately sloping	Good	Moderately fine.
Woodward series	Uplands	Silty red beds	Gently sloping	Good	Medium.
Grumusol group:					
Randall series	Playas	Lacustrine sediments.	Level	Poor	Fine.
Roscoe series	Playas	Deposits similar to lacustrine sediments.	Nearly level	Imperfect	Fine.

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TABLE 6.—*Classification of soils by order, great soil group, and series, and some distinguishing characteristics*—Con.

Order, group, and series	Position	Parent material	Dominant relief	Drainage	Texture of subsoil
Azonal order:					
Lithosol group:					
Potter series	Uplands	High Plains sediments.	Nearly level to steep	Excessive	Moderately fine to medium.
Quinlan series	Uplands	Sandy red-bed sediments.	Gently sloping to steep.	Excessive	Moderately coarse and coarse.
Vernon series	Uplands	Shaly red-bed sediments.	Nearly level to steep.	Excessive	Moderately fine.
Regosol group:					
Berthoud series	Foot slopes	Recent colluvium	Moderately sloping	Good	Moderately fine to medium.
Likes series	Foot slopes	Recent colluvium	Sloping	Good to excessive	Coarse.

Morphology and Classification of the Soils in Armstrong County

The relationship of the outstanding morphological characteristics of the soils of this county to the factors of soil formation is briefly discussed in this section. The soil series are also classified into orders and great soil groups, and a typical profile of each series is described. (The miscellaneous land types—Gravelly broken land, Loamy alluvial land, Rough broken land, Rough broken land, gypsiferous, and Sandy alluvial land—which are not true soils, are not classified.)

Zonal order

The zonal order is represented in Armstrong County by the Chestnut, Reddish Chestnut, and Brown great soil groups.

CHESTNUT SOILS

The soils in this group are dark brown or dark grayish brown. They have a whitish, calcareous horizon at a depth of 2 to 5 feet. Their distinct, genetically related horizons and other characteristics show that the predominant influences in their formation have been those of climate and living organisms.

This is the most extensive group of soils in Armstrong County. The Abilene, Bippus, Lofton, Pullman, Ulysses, and Zita series are in this group.

ABILENE SERIES.—This series consists of deep, dark-colored, nearly level soils on smooth uplands of the Rolling Plains. These soils have developed in Tertiary and Quaternary alluvium deposited over the Permian formation, under a cover of short native grasses.

Abilene soils are finer textured and less permeable than the associated Wichita soils, and they contain more organic matter and are darker colored. They are deeper, darker colored, and less permeable than the associated Weymouth soils, and they are more mature structurally.

These soils are very productive if moisture conditions are favorable. They are not extensive in Armstrong County. All of the acreage is in the Palo Duro Canyon, and most is east of the headquarters of the John Adair Ranch.

Profile of Abilene soil located about 2 miles east of the first cattle guard on county road, or main ranch road, north of John Adair Ranch headquarters:

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure readily breaking to moderate, fine granules; hard when dry, friable when moist, slightly sticky when wet; many fine and very fine fibrous roots; worm casts common in lower part; neutral; gradual boundary.

B1—8 to 15 inches, very dark grayish-brown (10YR 3/2) heavy clay loam; very dark brown (10YR 2/2) when moist; moderate, medium and coarse, prismatic structure breaking to moderate, medium blocks and granules; very hard when dry, firm when moist, sticky when wet; thin patchy clay films coating ped surfaces; fine and very fine fibrous roots common; few coarse mesquite roots; biological activity (worms and roots) decreases with depth; scattering of fine, waterworn quartz gravel; neutral; gradual boundary.

B21—15 to 30 inches, dark grayish-brown (10YR 4/2) light clay; very dark grayish brown (10YR 3/2) when moist; strong, medium, blocky structure; thin clay films continuous on ped surfaces; extremely hard when dry, firm when moist, sticky when wet; few flattened roots, mostly between peds; few false mycelia on ped surfaces near lower part; neutral in upper part, weakly calcareous in lower part; gradual boundary.

B22—30 to 42 inches, dark grayish-brown (10YR 4/2) light clay; very dark grayish brown (10YR 3/2) when moist; moderate, medium, blocky and subangular blocky structure; very hard when dry, firm when moist; few fine roots; fine and very fine old root channels common; false mycelia, thin films, and fine concretions of calcium carbonate, becoming more more common with depth; strongly calcareous; clear boundary.

Cca—42 to 53 inches, light-brown (7.5YR 6/4) clay loam; brown (7.5YR 5/4) when moist; weak, medium, prismatic structure breaking to medium, subangular blocky structure; scattered fine and very fine fibrous roots; about 25 percent of mass is splotches and pockets consisting mainly of soft calcium carbonate concretions, mostly between the vertical ped walls; very strongly calcareous and moderately alkaline; gradual boundary.

C—53 to 65 inches brown (7.5YR 5/4) clay loam; dark brown (7.5YR 4/4) when moist; porous; massive (structureless); fewer calcium carbonate concretions than in Cca horizon.

The A horizon ranges from 6 to 9 inches in thickness and from loam to silty clay in texture. Its color is mostly dark grayish brown (hue 10 YR; dry value 4, moist value 3; chroma 2) but ranges to brown (hue 7.5 YR; dry value 5, moist value 4; chroma 2).

The B horizon ranges from 25 to 50 inches in thickness

but is ordinarily about 35 inches thick. The texture ranges to clay in a few nearly level, less well drained areas. The dry color is generally darker (1 value unit lower) than that of the A horizon, but in some places the value is the same in hue 7.5YR as that of the A horizon. The B21 horizon is more compact and blocky and less permeable than either the B1 or the B22 horizon.

The Cca horizon generally is prominent. It ranges from 10 to 25 inches in thickness and from clay loam to silty clay in texture. Its dry color ranges from light brown to pink (hue 7.5YR; value 3 to 6; chroma 4 to 8). Soft and hard concretions of calcium carbonate make up about 10 to 40 percent, by volume, of this horizon.

The C horizon is clay loam or heavy clay loam in texture. Its color ranges from brown to yellowish red (hue 5YR mostly, but 7.5YR in some places; dry value 5 to 6, wet value 4 to 5; chroma 4 to 6). This horizon contains fewer calcium carbonate concretions than the Cca horizon. It generally contains a little quartz gravel.

These soils generally contain fine segregated lime at a depth of more than 25 inches, but it is calcareous to the surface in areas adjacent to the Weymouth soils and in areas where the soil is very shallow. Surface drainage is slow, and the subsoil is slowly permeable. The slope ranges from 0 to 2.5 percent but generally is less than 0.5 percent.

Bippus Series.—This series consists of deep, well-drained, dark grayish-brown soils on the Rolling Plains. These soils occur on plane or weakly concave low foot slopes, aprons, and fans, some distance below the escarpment bordering the Salt Fork of the Red River and along Mulberry Creek. They have developed under short and mid native grasses, in calcareous, loamy, local alluvium-colluvium washed from High Plains deposits of late Cenozoic age.

Bippus soils are less sloping and less calcareous than the closely associated Berthoud soils and are darker colored. They are darker colored than Likes soils and contain much more clay. They are not stratified like the lower lying alluvial soils.

Although these soils are not extensive in Armstrong County, they are locally of moderate importance to agriculture, mainly as rangeland.

Profile of a Bippus soil 125 feet south and 425 feet east of the northwest corner of sec. 119, block B3, H. and G.N. RR. Survey, or about 5 miles north and nearly 2 miles east of Goodnight:

A1—0 to 12 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; compound structure—weak to moderate, fine and medium, granular and weak, coarse, prismatic; hard when dry, friable when moist, slightly sticky when wet; many fine and very fine fibrous roots; worm casts common to many; many fine biological pores; slight hoofpan formation in uppermost 2 to 3 inches; neutral; gradual boundary.

AC—12 to 30 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; compound structure—moderate, medium, prismatic and subangular blocky that easily breaks to granules (predominantly worm casts); hard to very hard when dry, slightly less friable than A1 horizon when moist; very fine and fine fibrous roots and fine biological pores and channels common; threads and films of calcium carbonate common on ped surfaces; scattering of fine to medium, hard, nodular concretions of calcium carbonate; weakly to strongly calcareous and mildly alkaline; gradual boundary.

C—30 to 66 inches, grayish-brown (10YR 5/2) clay loam; dark grayish brown (10YR 4/2) when moist; compound structure—moderate, medium, subangular blocky and granular; hard when dry, friable when moist; fewer fine fibrous roots than in AC horizon; very fine old grass root channels common; white threads and films of calcium carbonate common on peds; few, fine to medium, nodular concretions of calcium carbonate; strongly calcareous and mildly alkaline; clear boundary.

D—66 to 78 inches +, reddish-brown (5YR 5/3) loam; reddish brown (5YR 4/3) when moist; massive; slightly hard when dry, friable when moist; few very fine grass roots; fewer threads and films of calcium carbonate than in C horizon; fine old root channels common throughout; less calcareous than C horizon.

Two types of Bippus soils, clay loam and fine sandy loam, have been mapped in this county.

In the clay loam type, the A horizon ranges from loam to clay loam in texture. It is 10 to 18 inches thick but most commonly about 13 inches. Its color is very dark grayish brown (hue 10YR; dry value 3 to 4, moist value 2 to 3; chroma 2 to 3). The reaction is neutral.

In the fine sandy loam type, the A horizon ranges from sandy loam to fine sandy loam in texture. It is 12 to 24 inches thick but most commonly about 16 inches. Its color varies from dark brown to brown to grayish brown (hue 10YR and 7.5YR; dry value 4 to 5, moist value 3 to 4; chroma 2 to 3).

The AC horizon is 10 to 40 inches or more thick but generally is about 25 inches. Its color is lighter by 1 value unit than that of the A horizon. This horizon is calcareous. Scattered fine caliche nodules make up as much as 3 percent, by volume, of this horizon.

The C horizon ranges from 4 to 10 feet or more in thickness. Depth to this horizon ranges from 22 to 50 inches or more.

Lofton Series.—This series consists of deep, dark-colored soils on uplands of the High Plains. These soils have developed under short native grass in strongly calcareous alluvial or loessal deposits of late Cenozoic age. They occur on the higher benches in large playas and, to a minor extent, in the smaller depressions within areas of Pullman soils.

Lofton soils are in a lower position and are darker colored than the closely associated Pullman soils. They are deeper and less permeable than the Zita soils, and they have more clearly defined horizons. The lower lying Randall and Roscoe soils are Grumusols that have developed in deposits similar to lacustrine sediments.

These soils are not extensive in Armstrong County, but they are scattered throughout the county. They are of moderate importance for crops and as range.

Profile of a Lofton soil in a pasture 4,200 feet south and 400 feet west of the northeast corner of sec. 143, block B4, H. and G.N. RR. Survey, or about 3 miles south and 1/4 mile east of Washburn:

A1—0 to 7 inches, very dark grayish-brown (10YR 3/1.5) silty clay loam; very dark brown (10YR 2/1.5) when moist; weak, fine, platy structure in uppermost 1 to 2 inches; compound structure—moderate, medium and fine, granular and subangular blocky—in lower part; very hard when dry, slightly friable when moist; many fine and very fine fibrous roots; worm casts and nests few to common; few patchy clay films on ped surfaces; neutral; gradual boundary.

B21—7 to 22 inches, very dark grayish-brown (10YR 3/1.5) clay; nearly black (10YR 2/1.5) when moist; strong, medium, blocky structure with shiny surfaces when dry; nearly massive when wet; extremely hard when dry, very firm when moist, sticky when wet; fine and very fine fibrous roots abundant in upper part and common in lower part, mostly between vertical walls of peds, flattened but holding the peds in vertical columns; neutral; gradual boundary.

B22—22 to 38 inches, dark grayish-brown (10YR 4/1.5) clay; very dark grayish brown (10YR 3/1.5) when moist; strong, medium, blocky structure; nearly massive when wet; continuous clay films on ped surfaces when dry; extremely hard when dry, very firm to firm when moist, sticky when wet; fewer flattened fibrous roots between peds than in B21; few threads and films of calcium carbonate on ped surfaces in lower part; weakly calcareous; gradual boundary.

B23—38 to 50 inches, grayish-brown (10YR 5/1.5) heavy silty clay loam; dark grayish brown (10YR 4/1.5) when moist; compound structure—moderate, medium, subangular blocky and granular; very hard when dry, firm when moist; few fibrous roots; few very fine old root channels; threads, films, and soft segregated concretions of calcium carbonate are few but become more common with depth; strongly calcareous and mildly alkaline; clear boundary.

Cca—50 to 62 inches, very pale brown (10YR 7/3) silty clay loam; pale brown (10YR 6/3) when moist; compound structure—moderate, medium, granular and subangular blocky; hard when dry, moderately friable when moist; fine and very fine old root channels common; pockets of various sizes that contain soft concretions of calcium carbonate make up about 25 percent of soil mass; very strongly calcareous and moderately alkaline; gradual boundary.

C—62 to 84 inches +, reddish-yellow (7.5YR 6/6) silty clay; strong brown (7.5YR 5/6) when moist; nearly massive; calcium carbonate occurs mostly as scattered, small and medium pockets and masses in amounts less than in Cca horizon; few fine and very fine old root channels; some dark weblike films or stains, probably of iron or manganese; very strongly calcareous and moderately alkaline.

The A horizon ranges from very dark grayish brown to very dark gray in color (hue 10YR; dry value 3 to 4.5, moist value 2 to 3; chroma 1 to 2). In thickness, this horizon ranges from 5 to 10 inches. It has a weak, fine, granular structure in areas that have been tilled. In areas of native sod it has a moderate, fine and medium, granular structure that grades to moderate, medium, subangular blocky in the lower part.

The B horizon ranges from clay to silty clay loam in texture. It has a strong to moderate, medium, blocky structure when dry but is nearly massive when wet. This horizon ranges from 35 to 60 inches in thickness but is most commonly about 50 inches thick. Older buried soil horizons generally occur at a depth of more than 40 inches. These buried soils are reddish brown in color, and they contain a few krotovinas.

The Cca horizon is generally present, but it is less prominent than that in the Pullman soils. It is about 10 to 20 inches thick. Depth to this horizon ranges from 40 to 70 inches or more. Krotovinas 1 to 12 inches in diameter are common.

The C horizon contains scattered pockets and films of lime. Krotovinas 1 to 12 inches in diameter are common in the upper part of this horizon.

Surface drainage is slow, and the subsoil is very slowly permeable when wet.

PULLMAN SERIES.—This series consists of deep, dark-colored, nearly level to gently sloping soils on smooth uplands of the High Plains. These soils have developed in calcareous and alkaline eolian or loessal sediments, under a cover of short native grass. The gently sloping soils occur on south and southwest exposures.

Pullman soils are lighter colored than the closely associated Lofton soils, which contain more organic matter and receive more water from surrounding areas. They differ from the Zita and Ulysses soils in having B horizons and in being much less permeable.

Soils of this series are very extensive in Armstrong County. They are important both as cropland and as grassland.

Profile of Pullman soil in an undisturbed area about 2,200 feet west and 550 feet south of the northeast corner of sec. 12, block C, T.W.N.G. RR. Survey, or about 13 miles south and 7 miles east of Claude:

A1—0 to 7 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; weak, fine and very fine, granular structure; hard when dry, friable when moist, slightly sticky when wet; very fine pores common; many grass roots; neutral; clear boundary.

B21—7 to 18 inches, dark grayish-brown (10YR 4/2) clay; very dark grayish brown (10YR 3/2) when moist; strong, medium, blocky structure when dry, nearly massive when wet; very hard when dry, very firm when moist, sticky and plastic when wet; fine and very fine, flattened, fibrous roots common, mostly between peds; distinct, continuous clay films; neutral; gradual boundary.

B22—18 to 35 inches, dark-brown (7.5YR 4/3) clay; dark brown (7.5YR 3/3) when moist; strong, medium, blocky structure when dry, nearly massive when wet; extremely hard when dry, very firm when moist, sticky and plastic when wet; flattened grass roots common, mostly between peds; thin, continuous clay films; weakly calcareous in lower half or two-thirds of horizon; neutral to mildly alkaline and weakly calcareous; gradual boundary.

B23—35 to 50 inches, dark-brown (7.5YR 4/3) clay; dark brown (7.5YR 4/3) when moist; strong, medium, blocky structure when dry, nearly massive when wet; very hard when dry, firm when moist, sticky when wet; continuous clay films; few fine and very fine fibrous roots; many very fine old root channels; weak calcium carbonate horizon in which threads, films, and dispersed and fine segregated calcium carbonate are common; moderately alkaline and calcareous; clear boundary.

B2b—50 to 64 inches, reddish-brown (5YR 4/4) light clay; dark reddish brown (5YR 3/4) when moist; moderate, medium and coarse, blocky and subangular blocky structure; very hard when dry, friable when moist; few grass roots; many fine and very fine old root channels; few false mycelia and some specks of calcium carbonate on ped surfaces; neutral to mildly alkaline; abrupt boundary.

Ccab—64 to 85 inches, pink (7.5YR 7/4) silty clay; light brown (7.5YR 6/4) when moist; nearly massive; very hard when dry, friable when moist; 50 percent or more, by volume, is calcium carbonate, mostly soft but including some semihard, fine to medium concretions; about 50 percent is pinkish-gray earthen material; very strongly calcareous and moderately alkaline; gradual boundary.

Cb—85 to 108 inches +, light-brown (7.5YR 6/4) heavy clay loam; brown (7.5YR 5/4) when moist; massive; very hard when dry, friable when moist; contains much less calcium carbonate than Ccab horizon; scattered pockets containing mostly soft but some hard pinkish-white concretions of calcium carbonate; fine and very fine old root channels common; few dark films of iron or manganese; very strongly calcareous and moderately alkaline.

The color of the solum ranges from dark brown to dark grayish brown (hue 10YR is dominant in the A horizon, but in some places the hue is 7.5YR; hue 7.5YR is dominant in the B horizon, but in some places the hue is 5YR; dry value 4 to 5, moist value 3 or 4; chroma 2 to 5).

The A horizon ranges from about 3 to 8 inches in thickness. The differences in thickness result from water and wind erosion. The texture ranges from clay loam to silty clay, but in most places it is silty clay loam.

The B horizon ranges from about 24 to 70 inches in thickness but is ordinarily about 48 inches thick. The B21 horizon is more compact and less permeable than the B22 and B23 horizons.

Buried soils (the B2b, Ccab, and Cb horizons) are generally present in the nearly level areas. They occur at a depth of 45 to 84 inches or more. Krotovinas, ranging from about ¾ inch to 12 inches in diameter, are common in the Ccab and Cb horizons and are scattered in the B2b horizon.

In areas where slopes range from 1 to 3.5 percent, the B horizon is slightly thinner than that in nearly level areas and the buried soil is absent. A strongly developed Cca horizon is generally present at a depth of 28 to 50 inches. Although these soils are generally well drained, they are very slowly permeable when wet.

Ulysses Series.—The Ulysses series consists of calcareous, friable soils on uplands of the High Plains. These soils have developed in strongly calcareous, loessal sediments, under a cover of short and mid grasses. They occur as scattered areas, mostly on low broad ridges or knolls surrounded by Pullman soils, along the rims of playas, and on the side slopes of drainageways.

Ulysses soils are similar to Mansker soils in color and reaction, but they are deeper and show a slightly stronger horizonation. They are much more friable, more permeable, lighter colored, and less clayey than the associated Pullman, Olton, or Lofton soils, and they show distinctly less horizonation.

These soils are not extensive in Armstrong County, but they are of moderate importance to agriculture. Most of the less sloping acreage is cultivated.

Profile of a Ulysses soil in a native pasture 600 feet south and 25 feet west of the northeast corner of sec. 171, block B3, H. and H.N. RR. Survey:

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; compound structure—weak to moderate, fine, granular and subangular blocky; hard when dry, friable when moist; many fine and very fine fibrous roots; many worm casts and nests in lower two-thirds of horizon; few scattered, fine and very fine, hard concretions of calcium carbonate; strongly calcareous and mildly alkaline; gradual boundary.

AC—8 to 30 inches, grayish-brown (10YR 5/2) clay loam; dark grayish brown (10YR 4/2) when moist; compound structure—weak, coarse, prismatic, easily breaking to moderate, fine, subangular blocky and granular; layer is mostly worm casts and nests; the darker casts indicate movement of worms downward from the A1 horizon and light casts indicate movement of worms upward from the Cca horizon; soil material is hard when dry, friable when moist, slightly sticky when wet; many biological pores and channels; many grass roots and a few moderate-sized herbaceous roots easily penetrate this horizon; segregated and dispersed calcium carbonate common throughout horizon and becomes more concentrated with depth; strongly calcareous and moderately alkaline; clear boundary.

Cca—30 to 36 inches, very pale brown (10YR 7/3) sandy clay loam; pale brown (10YR 6/3) when moist; weak or ill-defined structure; fewer roots than in AC horizon; fine and very fine old root channels common; about 25 percent, by volume, consists of calcium carbonate concretions, mostly soft; very strongly calcareous and moderately alkaline; gradual boundary.

C—36 to 56 inches +, pale-brown (10YR 6/3) silt loam; brown (10YR 5/3) when moist; ill-defined prismatic structure; scattered pockets of soft and hard calcium carbonate concretions make up about 10 to 15 percent of layer, by volume; very strongly calcareous and moderately alkaline.

The A horizon is generally clay loam that has granular structure, but it ranges from loam that has weak granular and prismatic structure to heavy clay loam that has moderate granular and subangular blocky structure. Its color is mostly grayish brown but ranges to dark grayish brown (hue 10YR; dry value 4 to 5, moist value 3 to 4; chroma 2 to 3). The noneroded soils range from 6 to 12 inches in thickness; the eroded soils are about 3 to 5 inches thick.

The AC horizon is similar to the A1 horizon, but it is slightly stronger in structure and is more calcareous. Its dry and moist Munsell values are lighter by one chip. Its thickness ranges from 10 to 24 inches but is ordinarily about 16 inches.

The Cca horizon is generally weak and ill defined. Its color ranges from pale brown to light brown or pinkish white (hue 10YR to 7.5YR; dry value 6 to 7, moist value 5 to 6; chroma 3 to 4). The content of dispersed lime and soft concretions of calcium carbonate generally total about 10 percent of the Cca horizon, but the range is up to 40 percent. This horizon contains some hard concretions of calcium carbonate.

The C horizon ranges from light clay loam to heavy clay loam in texture. It is mostly light brown but it ranges to reddish yellow (hue 10YR to 5YR). It contains a few soft concretions of calcium carbonate.

Except for the concretions, the entire solum has been and is still being reworked by earthworms.

Zita Series.—The Zita series consists of moderately deep, dark-colored, nearly level to gently sloping loamy soils on uplands of the High Plains. These soils have developed under short and mid native grasses, in calcareous, moderately fine textured, eolian or loessal sediments that mantle the High Plains outwash sediments. They occur on slightly concave and level to gently sloping plains, on the nearly level, higher lying benches of large playas, and as scattered areas along drainageways.

Zita soils differ from Ulysses soils in being noncalcareous to the surface and in having a darker colored solum and a stronger, granular and subangular blocky structure in the subsoil. They are shallower, less clayey, and much more permeable than the associated Pullman soils, and they have less horizonation.

Zita soils are not extensive in Armstrong County, but they are among the most productive cultivated soils in the county.

Profile of a Zita soil in a cultivated field 2,150 feet south and 350 feet west of the northeast corner of sec. 210, block B4, H. and G.N. RR. Survey, about 3 miles west and 1¾ miles south of Claude:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; mostly structureless but contains some weak, fine and medium granules from A12 horizon; very friable when

moist, slightly sticky when wet; neutral; abrupt plow-slice boundary.

A12—9 to 24 inches, very dark grayish-brown (10YR 3/2) silty clay loam; very dark brown (10YR 2/2) when moist; moderately strong, fine to medium, granular structure; hard when dry, friable when moist, sticky when wet; many worm casts, nests, and burrows; fine pores and old root channels common; neutral in upper part, weakly calcareous in lower part; gradual boundary.

AC—24 to 37 inches, grayish-brown (10YR 5/2) silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate to moderately strong, medium, granular and subangular blocky structure; hard when dry, friable when moist, sticky when wet; fine and very fine old biological channels common; weakly to strongly calcareous; threads and films of dispersed and finely segregated calcium carbonate throughout the horizon and increasing with depth; mildly alkaline; clear boundary.

Cca—37 to 50 inches, light brownish-gray (10YR 6/2) loam to fine sandy loam; grayish brown (10YR 5/2) when moist; weak, fine, granular structure; hard when dry, slightly sticky when wet; much dispersed lime, chalky masses, and many fine and medium, hard concretions of calcium carbonate make up about 35 percent, by volume, of horizon; very strongly calcareous and moderately alkaline; abrupt boundary.

D–50 to 60 inches +, white (10YR 8/1), fine quartz sand coated with calcium carbonate; single grained; soft, porous; strongly calcareous and mildly alkaline.

The A horizon ranges from loam to silty clay loam in texture but is dominantly clay loam. It ranges from 8 to 25 inches in thickness but ordinarily is 15 inches thick. Its color, largely influenced by organic matter, ranges from dark brown to very dark grayish brown (hue 10YR; dry value 3 to 4, moist value 2 to 3; chroma 2 to 3). This horizon is nearly structureless in areas that are cultivated. It has a moderate, medium, granular structure in areas covered with native grasses.

The AC horizon ranges from brown to grayish brown in color (hue mostly 10YR but 7.5YR in places; dry value 4 to 5, moist value 3 to 4; chroma 2 to 4). Its texture is clay to silty clay loam. It has a moderate to moderately strong, medium, granular and subangular blocky structure. This horizon ranges from 8 to 25 inches in thickness but is ordinarily about 15 inches thick. It is weakly to strongly calcareous.

The Cca horizon is generally very prominent. It is about 25 to 60 percent or more chalky and hard embedded concretions of calcium carbonate. The rest is pale-brown earthen material. This horizon ranges from about 12 to 28 inches or more in thickness. It is at a depth of 22 to 50 inches but is most commonly between 25 and 36 inches.

The C horizon is lacking in playas; apparently all of the material has become part of the soil. In other areas the C horizon is present and ranges from reddish brown to reddish yellow in color (hue 5YR; dry value 5 to 6, moist value 4 to 5; chroma 4 to 6). This horizon is calcareous earthern material of clay loam texture and contains scattered pockets of soft and hard concretions of calcium carbonate.

Krotovinas 1 to 12 inches in diameter are fairly common in the upper part of the C horizon; they are less common in the Cca horizon.

REDDISH CHESTNUT SOILS

This great soil group consists of reddish-brown soils that normally grade to white or pink caliche at a depth of 40 to 60 inches.

The Miles, Olton, and Wichita series represent this great soil group in Armstrong County.

MILES SERIES.—This series consists of deep, well drained, nearly level to moderately sloping soils on smooth uplands of the Rolling Plains. These soils have developed under native grass, in a mixture of calcareous sediments washed from the High Plains and sandy loam red-bed material. Surface relief is weakly undulating to rolling.

Miles soils are less smooth than the closely associated Abilene and Wichita soils, and they have a less clayey and more permeable subsoil. They are deeper, much less calcareous, and structurally more mature than the associated Weymouth soils.

These soils are not extensive in Armstrong County. They are somewhat scattered but are important to agriculture. They are cultivated or used as native range.

Profile of a Miles soil in a cultivated field 1,650 feet south and 150 feet east of the northwest corner of sec. 70, block B3, H. and G.N. R.R. Survey, or about 5 miles east and ¾ mile south of Goodnight:

Alp—0 to 8 inches, dark-brown (7.5YR 4/4) fine sandy loam; dark brown (7.5YR 3/4) when moist; structureless; some fine to very fine, weak granules; slightly hard when dry, very friable when moist; few sorghum roots; porous; neutral; abrupt plow-slice boundary.

B1—8 to 24 inches, reddish-brown (5YR 4/4) light sandy clay loam; dark reddish brown (5YR 3/4) when moist; moderate, coarse or very coarse, prismatic structure that easily breaks to moderate, medium, subangular blocks and fine granules; hard when dry, friable when moist; few thin, patchy clay films; old fine root channels common; worm burrows filled with worm casts are common; neutral; gradual boundary.

B2—24 to 45 inches, reddish-brown (5YR 4/4) sandy clay loam; dark reddish brown (5YR 3/4) when moist; compound structure—moderately strong, very coarse, prismatic and subangular blocky; very hard when dry, firm when moist, slightly sticky when wet; clay films continuous on ped surfaces; old fine root channels common; worm burrows filled with worm casts in upper part, few in lower part; a little scattered, fine and very fine, partly lime-coated quartz gravel, mostly in lower part; neutral; gradual boundary.

B3—45 to 57 inches, yellowish-red (5YR 5/6) light sandy clay loam; yellowish red (5YR 4/6) when moist; moderate, very coarse, prismatic structure which breaks into moderate, medium granules; hard when dry, friable when moist; fewer roots than in B2; worm burrows and nests less common with depth; a little fine to coarse, waterworn, lime-coated quartz gravel, increasing in amount with depth; threads and films of calcium carbonate common on ped surfaces; weakly calcareous; clear boundary.

Cca—57 to 78 inches, pink (5YR 7/4) light sandy clay loam; light reddish brown (5YR 6/4) when moist; massive; porous; dispersed and chalky to semihard calcium carbonate concretions make up about 25 percent of horizon; very strongly calcareous and mildly alkaline; gradual boundary.

C—78 to 96 inches +, reddish-yellow (5YR 7/6) light sandy clay loam; reddish yellow (5YR 6/6) when moist; massive; porous; fewer pockets of chalky and semihard calcium carbonate concretions than in Cca horizon.

The A horizon ranges from about 7 to 14 inches in thickness but is ordinarily about 10 inches thick. Its color ranges from brown to dark brown (hue 7.5YR; dry value 4 to 5, moist value 3 to 4). The texture ranges from loamy fine sand to fine sandy clay loam, but it is generally fine sandy loam. In areas that have been cultivated, the wind has blown away much of the silt and clay particles, and the

texture now is loamy fine sand. The upper part of this horizon has a weak to moderate, granular structure or is structureless. The lower part has a coarse or very coarse, prismatic structure.

The B horizon ranges from light sandy clay loam to sandy clay loam in texture and from about 30 to 60 inches in thickness. Its color ranges from brown to yellowish brown but is most commonly reddish brown (hue mostly 5YR but 7.5YR hue in some places; dry value 4 to 5, moist value 3 to 4; chroma 4 to 6).

The Cca horizon is weakly to strongly developed, but in most places it is weakly developed. It occurs at a depth of 3 to 7 feet.

The C horizon ranges from 3 to 12 feet or more in thickness and is underlain by raw Permian red beds.

Older buried soils are fairly common in areas with gradients of less than 2 percent. They occur at a depth of 2 to 5 feet. Surface drainage is low to medium. Permeability of the subsoil is moderate to moderately rapid.

Olton Series.—This series consists of deep, dark-brown, moderately fine textured soils of the uplands. These soils have a subsoil of reddish-brown, firm clay loam. They appear to have developed in High Plains deposits that were older and lighter colored than those in which the Pullman soils have developed. They occur as scattered areas and bands on side slopes of drainageways that border the High Plains.

The Olton soils are redder and less clayey than the closely associated Pullman soils, and they are less compact in the subsoil. They have more horizons that are well defined, are less permeable, and are deeper than the associated Zita and Ulysses soils.

These soils are not extensive in Armstrong County, but they are of agricultural importance for both crops and range.

Profile of Olton soil on a slope of about 1.5 percent, in a native short grass range, 1,900 feet south and 100 feet west of the northeast corner of sec. 6, block 1, I. RR. Survey, or about 8.5 miles south and 6 miles west of Claude:

A1—0 to 8 inches, dark-brown (7.5YR 4/2) light clay loam; dark brown (7.5YR 3/2) when moist; compound structure—moderate, fine, granular in upper part and moderate, fine, subangular blocky in lower 4 inches; hard when dry, friable when moist; many fine and very fine fibrous roots; worm casts, nests, and burrows common; many fine and some medium-sized biological pores and channels; neutral; clear boundary.

B21—8 to 18 inches, dark reddish-brown (5YR 3/2) clay loam; dark reddish brown (5YR 2/2) when moist; compound structure—moderate, fine to medium, subangular blocky and blocky structure; very hard when dry, firm when moist; thin, continuous clay films on ped surfaces; compressed fibrous roots common between peds; fewer pores and root channels than in A1 horizon; neutral; gradual boundary.

B22—18 to 29 inches, reddish-brown (5YR 4/3) heavy clay loam; dark reddish brown (5YR 3/3) when moist; moderate, fine to medium, blocky structure; very hard when dry, firm when moist; clay films continuous on ped surfaces; fewer roots between ped surfaces than in B21 horizon; fewer earthworm burrows, but largely filled with worm casts; fine and very fine old root channels common; few specks, threads, and films of calcium carbonate in lower part; neutral to weakly calcareous; gradual boundary.

B3—29 to 46 inches, yellowish-red (5YR 5/6) clay loam; yellowish red (5YR 4/6) when moist; moderate to weak, medium, blocky structure; very hard when dry, friable when moist; few thin clay films; few fine, soft and hard calcium carbonate concretions; false mycelia common; some fine and very fine old root channels; weakly calcareous and mildly alkaline; clear boundary.

Cca—46 to 60 inches, pink (5YR 7/3) clay loam; light reddish brown (5YR 6/3) when moist; about 30 percent, by volume, white segregated calcium carbonate, mostly soft but including some hard, fine to medium concretions; very strongly calcareous and mildly to moderately alkaline; gradual boundary.

C—60 to 72 inches +, reddish-yellow (5YR 6/6) clay loam; yellowish red (5YR 5/6) when moist; calcium carbonate less in amount than in Cca and occurs mostly in scattered pockets or lumps, which contain few fine to medium, hard concretions; very strongly calcareous and mildly alkaline.

The A1 horizon ranges from loam to clay loam in texture and from dark brown to very dark brown to reddish brown in color (hue 10YR and 7.5YR; dry value 3 to 4, moist value 2 to 3; chroma 2 to 4). This horizon ranges from 7 to 11 inches in thickness but is ordinarily about 8 inches thick.

The B horizon ranges from clay loam to light clay in texture and from about 20 to 50 inches in thickness. In color, this horizon ranges from dark reddish brown or reddish brown to yellowish red (hue 5YR and 7.5YR; dry value 3 to 5, moist value 2 to 4; chroma 2 to 6).

The Cca horizon is generally well developed. It ranges from 10 to 20 inches in thickness. It is from 20 to 50 percent, by volume, calcium carbonate, mostly chalky. It occurs at a depth of 30 to 65 inches.

In the Cca horizon are a few krotovinas 1 to 10 or 11 inches in diameter, and krotovinas are fairly common in the upper part of the C horizon.

Wichita Series.—This series consists of deep, well-drained soils that have developed under short and mid native grasses, in a mixture of silty and sandy clay red-bed sediments and strongly calcareous sediments washed from the High Plains. The slope range is nearly level to moderately sloping, and the relief is weakly undulating to rolling.

Wichita soils are more clayey and less permeable than the closely associated Miles soils. They are more permeable, lighter colored, and less clayey than the associated Abilene soils.

These soils are not extensive in Armstrong County but are potentially important as cropland and rangeland. They occur in the Palo Duro Canyon.

Profile of a Wichita soil in a native pasture 100 feet east of cattle corral, or about 3,100 feet east and 2,600 feet south of J. A. Ranch airport:

A1—0 to 7 inches, dark-brown (7.5YR 4/2) clay loam; dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure grading to moderate, medium, prismatic in lower part of horizon; hard when dry, friable when moist, slightly sticky when wet; many fine and very fine fibrous roots; worm casts, nests, and burrows common in lower part; fine and very fine biological pores and channels common; a few scattered, small, waterworn quartz pebbles on surface and throughout the solum; neutral; gradual, smooth boundary.

B1—7 to 18 inches, dark-brown (7.5YR 4/4) clay loam; dark brown (7.5YR 3/4) when moist; compound structure—moderate, medium, prismatic and moderate, coarse, subangular blocky; few thin clay films on ped surfaces; very hard when dry, firm when moist; grass roots, worm casts, nests, and burrows common; fine and very fine old root channels common; noncalcareous and mildly alkaline; gradual boundary.

B2—18 to 33 inches, reddish-brown (5YR 4/4) heavy clay loam; dark reddish brown (5YR 3/4) when moist; moderately strong, medium, subangular blocky and blocky structure; very hard when dry, firm when moist, sticky when wet; continuous clay films on ped surfaces; roots fewer than in B1, and most are between peds; weakly calcareous and mildly alkaline; gradual boundary.

B3—33 to 48 inches, reddish-brown (5YR 5/4) clay loam; reddish brown (5YR 4/4) when moist; compound structure—moderate, medium, prismatic and moderate, medium, subangular blocky; fewer roots and worm casts; fine and very fine old root channels common; few fine and medium, soft and hard calcium carbonate concretions, threads, and finely segregated lime, all increasing with depth; strongly calcareous and mildly alkaline; clear boundary.

Cca—48 to 65 inches, light reddish-brown (5YR 6/4) clay loam; reddish brown (5YR 5/4) when moist; massive; segregated lime and masses or pockets of soft and hard calcium carbonate concretions make up about 30 percent of the mass, and rest of mass is earthen material; few roots and many fine and very fine old root channels; few scattered, waterworn quartz pebbles; very strongly calcareous and moderately alkaline; gradual boundary.

C—65 to 74 inches +, light reddish-brown (2.5YR 6/4) loam or light clay loam old alluvial sediments that contain less lime than Cca horizon; somewhat stratified; scattered, thin lenses of waterworn quartzite and caliche pebbles; strongly calcareous and mildly alkaline.

The A horizon ranges from 6 to 11 inches in thickness but is ordinarily about 8 inches thick. Its texture is mostly loam but ranges to sandy clay loam. The color ranges from dark brown to brown to reddish brown (hue 7.5YR to 5YR).

The B horizon generally is about 40 inches thick. The dry color ranges from reddish brown to dark red (hue 5YR and 2.5YR). Its texture ranges from light clay loam to heavy clay loam. It has a weak to moderately strong, subangular blocky and blocky structure.

The Cca horizon ranges from scarcely evident to strongly developed, but it is most commonly weakly developed.

Surface drainage is medium, and the subsoil is moderately permeable.

BROWN SOILS

Vona soils are the only soils of the Brown great soil group in this county. They have a brown, noncalcareous surface layer that grades to a yellowish-brown subsoil. At a depth of 3 or 4 feet is light-colored, calcareous, unconsolidated soil material.

VONA SERIES.—The Vona series consists of well-drained, brown sandy soils on uplands of the Rolling Plains. These soils have developed under mid and tall native grasses in fairly recent sandy eolian deposits blown from the High Plains and reworked by the wind.

Vona soils show more profile development than either the associated Likes soils, which occupy colluvial foot slopes and are generally calcareous throughout, or Tivoli soils, which are noncalcareous, structureless sands that have a dunelike topography. (Tivoli soils are not mapped separately in this county.)

These soils are not extensive in Armstrong County, and they are of minor agricultural value. They are in the northeastern part of the county along draws and on undulating flats between Mulberry Creek and the Salt Fork of the Red River.

Profile of a Vona soil 3,400 feet west and 2,200 feet south of the northeast corner of sec. 76, block B3, H. and G.N. RR. Survey, or about 2 miles north and 3 miles east of Goodnight:

A1—0 to 9 inches, brown (10YR 5/3) fine sandy loam; dark brown (10YR 4/3) when moist; weak, very fine and fine, granular structure or single grained; loose when dry, very friable when moist; porous; roots common; neutral; diffuse boundary.

B1—9 to 21 inches, brown (10YR 5/3) fine sandy loam; dark brown (10YR 4/3) when moist; weak, very coarse, prismatic structure easily breaking to fine and very fine granules; slightly less loose when dry than A1 horizon, very friable when moist; porous; roots, worm casts, and fine to medium channels common; neutral; gradual boundary.

B2—21 to 53 inches, yellowish-brown (10YR 5/4) heavy fine sandy loam; dark yellowish brown (10YR 4/4) when moist; compound structure—moderate, very coarse, prismatic and moderate, fine, granular; less porous than B1 horizon; hard when dry, and very friable when moist; few fine iron concretions; neutral to mildly alkaline and weakly calcareous; gradual boundary.

C—53 to 60 inches, brownish-yellow (10YR 6/6) heavy fine sandy loam similar to B2 horizon in structure and consistence; many fine pores and channels; films and fine, soft concretions of calcium carbonate few to common; moderately calcareous and mildly alkaline; gradual boundary.

D—60 to 68 inches +, strong-brown (7.5YR 5/8) sandy clay loam; strong brown (7.5YR 4/8) when moist; few very fine to medium quartz pebbles; weakly calcareous.

The A1 horizon ranges from dark brown to grayish brown in color but is mostly brown (hue 10YR; dry value 4 to 5, moist value 3 to 4; chroma 2 to 3). Its texture is dominantly fine sandy loam. It ranges from 8 to 16 inches in thickness but generally is about 10 inches thick.

The B horizon ranges from heavy fine sandy loam to light fine sandy clay loam in texture and from about 15 to 45 inches in thickness. Free carbonates may occur at a depth of as little as 18 inches but most commonly occur at depths of 25 to 35 inches.

The C horizon is strongly calcareous throughout. It occurs at a depth of 25 to 55 inches.

The slope range is 3 to 5 percent, but 4 percent slopes are dominant.

Intrazonal order

The intrazonal order is represented in Armstrong County by the Calcisols and Grumusols.

CALCISOLS

The soils of the Mansker, Weymouth, and Woodward series represent this great soil group in Armstrong County.

Mansker, Weymouth, and Woodward soils have a thick accumulation of calcium carbonate in their profiles. Mansker soils are only weakly developed because of their age or because of conditions of parent material or relief.

MANSKER SERIES.—The Mansker series consists of shallow, grayish-brown soils on the uplands. These soils have developed under short and mid native grasses, in strongly calcareous and moderately alkaline outwash and loessal deposits of late Cenozoic age.

Two soils types, Mansker loam and Mansker fine sandy loam, are recognized in this county. Mansker loam is on sloping areas, on exposures on playa rims, and on the stronger side slopes of intermittent drainageways on the

High Plains. Mansker fine sandy loam is mainly in the transitional area between the High Plains and the Rolling Plains.

Mansker soils occur on smoother slopes and are deeper than the closely associated Potter soils. They are less structurally developed than the closely associated Ulysses soils. They are shallower, much lighter colored, and more calcareous than the Zita soils.

These soils are scattered but are fairly extensive in Armstrong County. They are of significant value as native range.

Profile of Mansker soil located on the north rim of a large playa 20 feet north and 1,040 feet east of the southwest corner of sec. 139, block B4, H. and G.N. RR. Survey, or about 3 miles south and 1 mile west of Washburn:

A1—0 to 7 inches, grayish-brown (10YR 5/2) loam to light clay loam; dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic structure easily breaking to moderate, fine granules, which are predominantly worm casts in the lower half of this horizon; slightly hard to hard when dry, very friable when moist; many fine and very fine fibrous roots; many fine biological pores and channels; uppermost ½ inch is weak, fine, platy, silty material washed or blown from adjoining areas; strongly calcareous and mildly alkaline; gradual boundary.

AC—7 to 15 inches, grayish-brown (10YR 5/2) clay loam; dark grayish brown (10YR 4/2) when moist; weak, prismatic structure easily breaking to moderate, fine granules, predominantly worm casts; hard when dry, friable when moist, slightly sticky when wet; few roots; many old fine pores and channels; very fine to medium, soft and hard concretions of caliche are few to common and increase with depth; strongly calcareous and mildly alkaline; gradual to clear boundary.

Cca—15 to 33 inches, very pale brown (10YR 7/3) clay loam; pale brown (10YR 6/3) when moist; clumps and pockets of soft and hard concretions of calcium carbonate make up about 35 percent of horizon; these concretions are imbedded in the pale-brown granular earthen mass, which consists largely of worm casts; fine fibrous roots common; very strongly calcareous and moderately alkaline; gradual boundary.

C—33 to 60 inches +, light-brown (7.5YR 6/4) light clay loam; brown (7.5YR 5/4) when moist; ill-defined structure or massive; hard when dry, friable when moist; fine and very fine old root channels common; scattered pockets of soft and hard calcium carbonate concretions, which diminish in number with depth; very strongly calcareous and moderately alkaline.

The A1 horizon ranges from dark grayish brown to grayish brown in color (hue 10YR; dry value 4 to 5, moist value 3 to 4; chroma 2). This horizon ranges from about 6 to 11 inches in thickness. It is calcareous to strongly calcareous. The loam type is slightly darker colored, slightly thinner, and less porous than the A1 horizon in the sandier type.

The AC horizon is strongly calcareous or very strongly calcareous, mildly alkaline, friable clay loam to sandy clay loam. Its color is about 1 value unit lighter than that of the A1 horizon. This horizon ranges from 7 to 13 inches in thickness but ordinarily is about 9 inches thick. Generally the loam type has a thinner solum than the fine sandy loam type.

The Cca horizon is distinct and occurs at a depth of about 12 to 20 inches. It ranges from about 8 to 24 inches or more in thickness. Its color is mostly pinkish white but ranges from white to very pale brown (hue 10YR mostly, 7.5YR less common). The content of soft and hard concretions ranges from 20 to 60 percent.

The C horizon ranges from light yellowish brown to pinkish gray in color. It contains less calcium carbonate than the Cca horizon. Scattered pockets and streaks of calcium carbonate occur between vertical cleavage planes.

Weymouth Series.—The Weymouth series consists of shallow to moderately deep, reddish-brown soils of the uplands. These soils developed in material weathered from calcareous red beds, under a cover of short native grasses and shrubs. They are within areas of Reddish Chestnut soils. They occur as scattered areas, locally known as "parks" and "flats," on the erosional red-bed plains in the Palo Duro Canyon.

Weymouth soils are shallower and less permeable than Abilene soils, and they show less horizonation. They are deeper, browner or less red, and better developed structurally than the Vernon soils. They are more clayey and less permeable than Woodward soils.

In Armstrong County Weymouth soils are inextensive and somewhat scattered, but they are moderately important as rangeland.

Profile of a Weymouth soil in a native pasture about 750 feet south and 150 feet east of J. A. Ranch road, about 1.75 miles north of J. A. Ranch headquarters:

A—0 to 9 inches, reddish-brown (5YR 4/4) clay loam; dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; hard when dry, friable when moist; many fine and very fine fibrous roots; worm casts few near top of horizon to many in lower part; fine pores common; a little medium water-worn quartz gravel on surface; weakly calcareous; gradual boundary.

AC—9 to 23 inches, reddish-brown (5YR 5/4) heavy clay loam; reddish brown (5YR 4/4) when moist; compound structure—moderate, medium, granular and subangular blocky; hard when dry; friable when moist, sticky when wet; many worm casts; fine and very fine, fibrous roots common; fine pores and channels common; false mycelia of calcium carbonate on ped surfaces common in lower part; strongly calcareous and mildly alkaline; clear boundary.

Cca—23 to 29 inches, light reddish-brown (2.5YR 6/4) silty clay loam; reddish brown (2.5YR 5/4) when moist; weak, medium, granular and angular blocky structure; hard when dry, friable when moist, sticky when wet; films and finely segregated calcium carbonate concretions make up about 15 percent of the volume; very strongly calcareous and moderately alkaline; gradual boundary.

C—29 to 52 inches +, red (2.5YR 4/6) clay loam; dark red (2.5YR 3/6) when moist; mixture of old, weathered, calcareous, red-bed sediments and some strongly calcareous sediments from the High Plains; few roots in upper part; material grades to massive siltstone and shale substratum containing some round spots of bluish-gray, shalelike material.

The A horizon ranges from brown to reddish brown in color and from about 5 to 11 inches in thickness. It is weakly calcareous to strongly calcareous.

The AC horizon is yellowish red to reddish yellow in some places.

The Cca horizon is normally weakly developed. It ranges from about 10 to 20 inches in thickness and occurs at a depth of about 12 to 25 inches.

The substratum is consolidated, partly weathered, stratified, silty, red-bed material interbedded with shale in the more sloping areas. In the less sloping areas the substratum contains lenses to thick beds of alabaster gypsum.

The slope range is from 1 to 5 percent, but 4 percent slopes are dominant.

WOODWARD SERIES.—The Woodward series consists of well-drained, shallow to moderately deep soils on uplands. These soils have developed in calcareous, weakly consolidated red-bed siltstone and very fine-grained sandstone of Permian age, under a cover of mid grasses. They occupy the smoother areas of the erosional red-bed plains in the Palo Duro Canyon.

Woodward soils are smoother, deeper, less sandy, and less eroded than the closely associated Quinlan soils, and their horizonation is more evident. They are more sandy throughout than Weymouth soils and are deeper, smoother, and less clayey than Vernon soils.

Profile of Woodward soil about 1.4 miles south and 0.4 mile west of where farm-to-market road 284 crosses the Prairie Dog Town Fork of the Red River:

A1—0 to 9 inches, reddish-brown (5YR 4/4) loam; dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; fine fibrous roots and worm casts common; many fine pores; weakly calcareous; gradual boundary.

AC—9 to 18 inches, reddish-brown (5YR 5/4) loam; reddish brown (5YR 4/4) when moist; weak to moderate, fine granular structure; hard when dry, friable when moist, slightly sticky when wet; roots less common with depth; worm casts, fine pores, and old root channels common throughout horizon; strongly calcareous and gypsiferous; gradual boundary.

Cca—18 to 25 inches, yellowish-red (5YR 5/6) silt loam; weak, granular structure; many fine pores and old root channels common; many fine, hard and soft, segregated concretions of calcium carbonate; very strongly calcareous; gradual boundary.

C1—25 to 35 inches, red (2.5YR 5/6) very fine sand containing much silt; red (2.5YR 4/6) when moist; soft, weathered, calcareous and gypsiferous red-bed material.

C2—35 to 50 inches +, red (2.5YR 4/6), deep beds of very fine sandy material derived from soft sandstone and containing much silt; compact; calcareous.

The A horizon ranges from brown to dark reddish brown in color (hue 7.5YR to 2.5YR; dry value 4 to 6, moist value 3 to 5; chroma 4). It ranges from loam to very fine sandy loam in texture and from about 7 to 15 inches in thickness.

The AC horizon ranges from light reddish brown to dark reddish brown in color (hue 5YR to 2.5YR; dry value 4 to 6, moist value 3 to 5; chroma 4). It ranges from 4 to 10 inches in thickness.

The Cca horizon is generally present but is ordinarily not prominent and is barely evident in some places.

GRUMUSOLS

The soils in this great soil group have developed in playa beds from clayey material. Because of their low position on the landscape, they developed under wet conditions.

The Randall and Roscoe series represent this great soil group in Armstrong County.

RANDALL SERIES.—This series consists of very poorly drained, dark-gray soils on the High Plains. These soils have developed in clay deposits, similar to lacustrine sediments, washed from the surrounding soils. They occur in depressions or playa bottoms and are from 2 to 50 feet below the level of the surrounding plains. These areas are circular or oval, and they range from less than an acre to several hundred acres in size.

The native vegetation consists mainly of lake sedges, buffalograss, western wheatgrass, and, in places, some smartweed, blueweed, and ragweed. After heavy rains, the areas are ponded for extended periods, and during these periods nearly all the vegetation dies except sedges and smartweed.

When in native vegetation, these soils have a characteristic micromound-and-pit (gilgai) surface relief caused by swelling and shrinking of the soil. When the soil is dry, cracks several feet deep and as much as 4 inches wide form. Part of the air-slacked surface soil sloughs, washes, or falls into these cracks. When the soil is wet, the cracks close; when it dries again, more surface soil falls into the cracks. Thus, there is slow circulation of the entire soil mass.

Randall soils are grayer, more clayey and more poorly drained than the associated higher lying Lofton soils, and they are less well developed structurally. They are more poorly drained, less gray, and less calcareous than the closely related and associated Roscoe soils, and they are less well developed structurally.

These soils are not extensive in Armstrong County, and they are of minor importance to agriculture. They are not suitable for cultivation unless runoff from the surrounding soils is diverted or the playas are drained.

Profile of a Randall soil in a large playa 2,900 feet west and 1,700 feet south of the northeast corner of sec. 165, block B4, H. and G.N. RR. Survey, or one mile northeast of Claude:

A1—0 to 25 inches, dark-gray (10YR 4/1) heavy stiff clay; very dark gray (10YR 3/1) when moist; moderate, medium to coarse, subangular and angular blocky structure when dry; massive when wet; larger peds easily air slack to fine angular peds; slickenside peds few to common; very hard to extremely hard when dry, very firm when moist, very sticky and plastic with characteristic anaerobic odor when wet; shiny surface peds; many underground sedge stems and roots that diminish with depth; few medium to very fine concretions or pellets of iron and manganese in lower part; weakly acid; gradual boundary.

C—25 to 65 inches+, gray (N 5/0) very stiff clay; dark gray (N 4/0) when moist; massive, with some indistinct, coarse, structural lines; very hard when dry, very firm when moist, very sticky and plastic when wet; noticeable anaerobic odor when wet for a long time; less distinct shiny surface peds or clay films than in A1 horizon; slickenside peds common; few fine to very fine concretions of iron and manganese; neutral.

Because of structural immaturity, these soils do not show clearly defined horizons. Clay is the dominant texture except in a few places where an inch or two of grayish-brown silty clay has been washed or blown from the surrounding cultivated soils.

The A horizon ranges from about 8 to 30 inches in thickness but averages 20 inches. Its color is dark gray (hue 10YR to 2.5Y; dry value 4 to 5, moist value 3 to 4; chroma no more than 1).

The C horizon is mostly gray in color (hue N 5/0 to N 5/1).

In some areas these soils have a transitional AC horizon that is lighter colored than the other horizons because it contains some fine calcium carbonate or is lower in organic-matter content. These soils are generally noncalcareous, but in some areas they are calcareous.

ROSCOE SERIES.—This series consists of calcareous, somewhat poorly drained, dark-gray clayey soils. These soils have developed under a cover of native grasses in clayey deposits, similar to lacustrine sediments, washed from the

surrounding soils within the watershed. They are on playa benches 5 to 35 feet or more below the level of the surrounding plains and 4 to 10 feet above the Randall soils. They occur as level, crescent-shaped areas or concentric bands that range from a few hundred feet to a quarter of a mile or more in width.

In undisturbed areas Roscoe soils are easily identified by a dense cover of buffalograss, western wheatgrass, saltgrass, and vine mesquite and by a characteristic micromound (gilgai) relief.

Roscoe soils are grayer and more clayey than the closely associated Lofton soils but are less well drained and have less distinct horizons. They are darker colored and less clayey than the closely related Randall soils, but they are better drained and less subject to prolonged inundation.

These soils are arable, but they are of limited use for cultivated crops. They are not extensive in Armstrong County.

Profile of a Roscoe soil in a large playa 1.25 miles due west of Washburn, or 1,875 feet south and 100 feet west of the northeast corner of sec. 100, block B4, R. and B.N. RR. Survey:

A11—0 to 9 inches, dark-gray (10YR 4/1) silty clay to clay; very dark gray (10YR 3/1) when moist; compound structure—moderate, very fine, granular and blocky; few slickenside peds in lower part when dry; massive when wet; very hard when dry, very sticky when wet; shiny faces on peds in lower part; many fine and very fine fibrous roots; slight hoofpan in uppermost 2 or 3 inches; neutral; gradual boundary.

A12—9 to 19 inches, dark-gray (10YR 4/1) clay; very dark gray (10YR 3/1) when moist; moderate, medium, blocky structure; slickenside peds common when dry; nearly massive when moist or wet; extremely hard when dry, very firm when moist, very sticky when wet; fine flattened fibrous roots common between peds; thin clay films continuous on ped surfaces; some fine and very fine root channels; neutral in upper part, weakly calcareous in lower part; gradual boundary.

AC—19 to 45 inches, grayish-brown (10YR 5/2) clay; dark grayish brown (10YR 4/2) when moist; moderate to weak, medium and coarse, blocky structure when dry; massive when moist or wet; wedge-shaped slickenside peds common; consistence similar to that of A12 horizon; clay films patchy and less common than in A12; fewer fine fibrous roots than in A12; few fine and medium, soft to hard, black pellets, probably of iron or manganese; calcareous and alkaline; gradual boundary.

C—45 to 68 inches +, gray (10YR 6/1) clay; massive; very hard when dry, sticky when wet; few fine to medium, nearly black, hard pellets, probably of iron or manganese; few soft, fine and very fine concretions of calcium carbonate; strongly calcareous and moderately alkaline.

The texture of the profile generally is clay. A few areas have a thin accumulation of silty sediments on the surface. These sediments were washed or blown from the surrounding cultivated areas.

The A horizon ranges from 12 to 25 inches in thickness but is ordinarily about 18 inches thick. Its structure varies from moderate, very fine, granular to moderate or strong, medium or coarse, blocky. The color is dominantly dark gray but varies to very dark gray (hue 10YR; dry value 4 to 5, moist value 3 to 4; chroma 1). The reaction is neutral in some places.

The AC horizon ranges from 12 to 50 inches or more in thickness but is ordinarily about 35 inches thick. Its color ranges from gray to grayish brown (hue 2.5YR to 10YR; dry value 5 to 6, moist valve 4 to 5; chroma 1 to 2).

The C horizon generally contains a few fine and very fine calcium carbonate concretions, but some profiles show a Cca horizon that is 20 percent or more segregated calcium carbonate.

Azonal order

The azonal order is represented in Armstrong County by the Lithosols and the Regosols. Soils of this order generally have only a weak A1 horizon.

LITHOSOLS

The Potter, Quinlan, and Vernon soils are in this great soil group.

The Potter soils lack development because of geologic erosion on the steep slopes.

POTTER SERIES.—This series consists of strongly calcareous, very shallow, light-colored loamy soils on uplands. These soils have developed in place on weakly cemented beds of caliche believed to have been deposited by underground water in the Pleistocene epoch. They border the smoother High Plains escarpment areas and occur on knolls and ridges that extend into the Rolling Plains.

Potter soils are lighter colored and shallower than the closely related Mansker soils, and they have stronger relief and show less horizonation. They are lighter colored and shallower than the associated Berthoud soils, and they have a rougher surface relief.

These soils are nonarable. They are not extensive in Armstrong County and occur mostly as small, scattered areas and bands in the range section. They are of only minor value for agriculture and wildlife, but are important as a source of caliche to be used as road base material and in the manufacture of cement.

Profile of Potter soil in a steep range area 2,100 feet south and 60 feet east of the northwest corner of sec. 246, block B4, H. and G.N. RR. Survey, or about 3.5 miles south of Claude:

A1—0 to 8 inches, grayish-brown (10YR 5/2) fine sandy loam; brown (7.5YR 5/2) when moist; weak, fine and very fine, granular structure; slightly hard when dry, very friable when moist; fine roots few to common in some places; porous; worm casts and nests common to many in lower part; fine to coarse, mostly hard calcium carbonate nodules and fragments common throughout the layer and increasing in amount with depth but representing less than 10 percent of the volume; very strongly calcareous and moderately alkaline; clear boundary.

C—8 to 20 inches +, pinkish-white (10YR 8/2), lime-cemented caliche nodules, coarse platy lumps, and flags, grading to soft, chalky caliche; light gray (10YR 7/2) when moist; few vertical tongues of grayish-brown earthen material consisting mostly of worm casts but including some roots; very strongly calcareous and moderately alkaline.

The A1 horizon ranges from 2 to 10 inches in thickness. The color is mostly grayish brown but ranges from pale brown to dark grayish brown (hue 10YR and 7.5YR, but 10YR is dominant; dry value 4 to 5, moist value 3 to 4; chroma 2). The darker colored soil is mostly loam or gravelly loam that has a moderate to strong, medium, granular structure. The lighter colored soil is porous sandy loam or fine sandy loam that has a weak, fine granular structure. Angular or platy fragments and concretions of hard caliche make up about 2 to 15 percent of this horizon. Caliche concretions and fragments are common

on the surface in areas where erosion has removed the fine soil particles.

The C horizon ranges from one to several feet in thickness. As much as 80 percent of this horizon is made up of beds of soft and hard calcium carbonate.

Slopes are complex and short. The gradient is as much as 50 percent but generally is less than 30 percent. The soil material is only a mantle less than 10 inches thick. Runoff is rapid on stronger slopes, erosion is active, and the parent material is at or near the surface. Vegetation is fairly sparse and dwarfed. On the less sloping and less exposed areas, these soils are better developed and have a fair cover of vegetation.

QUINLAN SERIES.—This series consists of reddish-brown very fine sandy loam or silty soils on uplands of the Rolling Plains. These soils have developed on soft sandstone and packsand of Permian origin, under a cover of mid and tall native grasses. In this county, they occur mostly on rolling and strongly rolling or broken erosional red-bed plains. They also occupy flats and gentle slopes in the Palo Duro Canyon, in areas where the sandy parent material is near the surface.

Quinlan soils differ from the closely associated Woodward soils in having no recognized calcium carbonate horizon and in being more shallow and less coherent. They are much sandier than the associated Vernon soils, which have developed in residual silty clay, shale, and siltstone.

In Armstrong County Quinlan soils are mapped only in a complex with Woodward and Vernon soils and Rough broken land. They are nonarable soils, but they are extensive in this county and are important as rangeland.

Profile of Quinlan soil in a native range about 1.5 miles south and 0.5 mile west of where farm-to-market road 284 crosses the Prairie Dog Town Fork of the Red River:

A1—0 to 14 inches, reddish-brown (5YR 5/4) very fine sandy loam; reddish brown (5YR 4/4) when moist; weak, fine, granular structure; slightly hard to soft when dry, very friable when moist; porous; few fine fibrous roots; gypsiferous and calcareous; diffuse boundary.

C—14 to 26 inches+, red (2.5YR 5/6), fine-grained packsand and soft sandstone; some dispersed gypsum and calcium carbonate; calcareous.

The A1 horizon ranges from light reddish brown to reddish brown to light red in color (hue 5YR and 2.5YR; dry value 4 to 6, moist value 3 to 5; chroma 4 to 6). It ranges from fine sandy loam to very fine sandy loam in texture and from 6 to 18 inches in thickness. Generally, the lower part of this horizon is slightly redder than the upper part.

VERNON SERIES.—This series consists of undulating to sloping, reddish clayey soils on uplands. These soils have developed on shaly clay and siltstone of the red beds, under a thin cover of short native grasses and dwarfed shrubs.

Vernon soils are similar to Potter soils in depth, but they are much less calcareous and are reddish in color. They are similar to the associated Woodward soils in color, but they are shallower and more clayey.

Vernon soils are inextensive in Armstrong County and are mapped only in complexes with Quinlan and Weymouth soils in the Palo Duro Canyon. They are not suited to cultivation.

Profile of a Vernon soil in native range about 3.0 miles west and 5.5 miles south of Goodnight, or about a quarter of a mile north of where the county road crosses Mulberry Creek:

A1—0 to 7 inches, yellowish-red (5YR 5/6) clay loam; yellowish red (5YR 4/6) when moist; weak, fine, granular structure; hard and compact when dry, friable when moist; a little fine to coarse, waterworn quartzitic gravel on the surface in places; worm casts and roots few to common; weakly calcareous; clear boundary.

C1—7 to 15 inches, red (2.5YR 5/6) clay; red (2.5YR 4/6) when moist; very coarse, platy structure; partly weathered thin lenses of siltstone, very fine sandstone, and shaly clay; hard to very hard when dry, very firm when moist; a few roots in cracks and crevices; at higher elevations, strongly calcareous and mildly alkaline.

C2—15 to 30 inches +, similar to C1 horizon, but less wethered; hard, massive, consolidated siltstone and shaly bedrock material; very few roots.

The A1 horizon ranges from 1 to 12 inches in thickness but is most commonly about 6 inches thick. It ranges from clay to clay loam in texture and from reddish brown to yellowish red in color. This horizon is calcareous.

The C horizon ranges from 6 to 15 inches in thickness. This horizon is red, very compact, slightly weathered, calcareous shaly clay and siltstone that contains a few white streaks, spots, and fine concretions of calcium carbonate.

The substratum is mostly red in color but is bluish gray in some places. This horizon is hard, platy to massive, consolidated shaly clay and siltstone from the Permian red beds.

Lenses of alabaster gypsum, a few inches to 10 feet or more thick, occur in the less sloping areas.

REGOSOLS

Soils of this great soil group lack appreciable development of genetic horizons except for some weak expression of an A1 horizon at the surface.

The Berthoud and Likes series represent this great soil group in Armstrong County.

BERTHOUD SERIES.—This series consists of calcareous, moderately sloping, grayish-brown loamy soils on uplands of the Rolling Plains. These soils have developed on uncompacted and strongly calcareous local alluvial-colluvial foot-slope sediments of the Ogallala formation and various other formations of late Cenozoic age. They typically occur between the lower lying Bippus soils and areas of Potter and Mansker soils and Rough broken land. They have strong, concave surface relief and a few small, receding scarps. The scarps range from less than 1 foot to as much as 4 feet in thickness but are most commonly about 2 feet thick.

Berthoud soils are less sandy and less permeable than the associated Likes soils, and they are darker colored. They are lighter colored and less clayey than the closely associated Bippus soils, but they are more calcareous and more permeable.

Three types of Berthoud soils—loam, sandy loam, and fine sandy loam—have been mapped in this county. All were mapped in complexes with the Mansker and Potter soils.

These soils are fairly extensive in Armstrong County. They are used mostly as native range.

Profile of Berthoud soil 1,160 feet west and 530 feet south of the northeast corner of sec. 78, block B3, H. and G.N. RR. Survey, or about 6 miles northeast of Goodnight:

A1—0 to 14 inches, grayish-brown (10YR 5/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, fine to very fine granules grading to weak, coarse, prismatic structure; soft to slightly hard when dry, very friable when moist; porous; many fine and very fine fibrous roots; many worm casts, nests, and burrows of different ages, forming most of the lower part of this horizon and most of the AC horizon; neutral to mildly alkaline and weakly calcareous; gradual boundary.

AC—14 to 30 inches, light brownish-gray (10YR 6/2) light sandy clay loam; grayish brown (10YR 5/2) when moist; compound structure—weak, coarse, prismatic easily breaking to fine and very fine granules, which are largely worm casts; slightly hard when dry, friable when moist; fine and very fine root channels and roots common; few scattered threads and films of calcium carbonate on ped surfaces; weakly calcareous in upper part to strongly calcareous and mildly alkaline in lower part; gradual boundary.

C—30 to 72 inches +, light yellowish-brown (10YR 6/4) fine sandy loam; yellowish brown (10YR 5/4) when moist; weak, very fine, granular structure or structureless; porous and soft when dry, very friable when moist; few fibrous roots; few fine to medium sandstone and calcium carbonate concretions scattered throughout horizon; strongly calcareous and mildly alkaline or moderately alkaline.

LIKES SERIES.—This series consists of deep, well-drained, calcareous, brown soils on uplands of the Rolling Plains. These soils have developed under a cover of mid and tall native grasses in unconsolidated sands of the Ogallala formation and other formations of late Cenozoic age. They occur on alluvial-colluvial foot slopes and alluvial fans below the High Plains escarpment or remnants of that escarpment.

Likes soils are more sandy than the closely related Berthoud soils. They are less mature structurally and are more calcareous than the Vona soils.

These soils are not extensive in Armstrong County. They are nonarable and are of minor importance to agriculture.

Profile of a Likes soil 3,100 feet south and 450 feet west of the northeast corner of sec. 153, block B3, H. and G.N. RR. Survey, or about 6.5 miles north of Goodnight:

A1—0 to 9 inches, brown (10YR 5/3) loamy fine sand; dark brown (10YR 4/3) when moist; very weak, fine, granular structure to nearly structureless; very porous; soft when dry, very friable when moist; fine fibrous roots common; a little fine waterworn quartz gravel; neutral; diffuse boundary.

AC—9 to 35 inches, light yellowish-brown (10YR 6/4) loamy fine sand; brown (10YR 4.5/3) when moist; structureless; very porous; soft when dry, very friable when moist; fibrous roots less common than in A1; few false mycelia of calcium carbonate; weakly to strongly calcareous; diffuse boundary.

C—35 to 50 inches +, pale-brown (10YR 6/3) loamy fine sand; brown (10YR 5/3) when moist; structureless; very porous; soft when dry, very friable when moist; few fibrous roots; some fine and very fine, hard, nodular concretions of calcium carbonate; a little fine round quartz gravel; strongly calcareous.

The A1 horizon ranges from brown to grayish brown to pale brown in color (hue 10YR; dry value 5 to 6, moist value 4 to 5; chroma 3). It ranges from 8 to 15 inches or more in thickness but is commonly about 10 inches thick.

The AC horizon ranges from 18 to 35 inches or more in thickness but is ordinarily about 25 inches thick. Its color is lighter by 1 value unit than that of the A1 horizon.

The C horizon ranges from 2 to 15 feet or more in thickness and from loamy fine sand to fine sand in texture. It contains some waterworn gravelly quartzitic material and caliche.

Surface runoff is slow to medium, but internal drainage is medium to rapid. Free lime occurs throughout the profile in most areas, but in a few areas it is not evident above a depth of 10 to 20 inches.

The A1 horizon ranges from 7 to 15 inches in thickness but ordinarily is 9 inches thick. Its texture is dominantly fine sandy loam, but in places it is loam or sandy loam. Its color ranges from brown to grayish brown (hue 10YR; dry value 5, moist value 4; chroma 2 to 5).

The AC horizon ranges from 12 to 25 inches in thickness, but it is most commonly 20 inches thick. It ranges from loam to sandy loam in texture and from brown to light brownish gray in color (hue 10YR and 7.5YR; dry value 5 to 6, wet value 4 to 5; chroma 2 to 4). The content of dispersed and segregated calcium carbonate concretions varies from slight to moderate.

The C horizon ranges from 2 to 5 feet or more in thickness and from clay loam to fine sandy loam in texture. It ranges from light brown to light yellowish brown in color (hue 10YR and 7.5YR; dry value 5 to 6, moist value 3 to 5; chroma 4).

As the slope increases, coarse, hard nodules of calcium carbonate generally are common throughout the profile. These nodules are at the surface in places where erosion has thinned the A horizon.

Additional Facts About the County

In 1541, Coronado led the first expedition of white men across the plains now known as the Texas Panhandle. Other expeditions followed but left little evidence of their routes. As late as 1874, large herds of buffalo roamed the area. Various tribes of Plains Indians hunted and camped in the area. Buffalo hunters arrived in the 1860's and 1870's. The early ranchers came soon afterward. In 1876, Col. Charles Goodnight arrived with a herd of cattle driven from Colorado. He set up headquarters about 23 miles south of the present site of the town of Washburn. Here he established a ranch, which eventually occupied 650,000 acres, and started the first cattle-raising enterprise in the Panhandle.

The scarcity of water limited the number of ranches. The first successful water well was drilled in 1885. After windmills and barbed wire were introduced, many small ranches were established on the High Plains.

Armstrong County was organized in 1890. In 1960, the population of the county was 1,966, and that of Claude, the county seat, was 895. Other centers of population include Goodnight (population 75), Washburn (population 25), and Wayside (population 19).

Climate

The Panhandle region is subject to rapid and wide changes in temperature, especially in winter, when masses of cold air from the Northern Plains States and the prairie provinces of Canada surge southward over the nearly level, unsheltered High Plains. These cold fronts move at speeds as high as 40 or more miles an hour. Temperature drops of 50° to 60° F. within a 12-hour period are common during winter.

According to records kept at Amarillo, Potter County, January is the coldest month, though the record low temperature of −16° F. occurred in February 1899. The average temperature in January is 35.3° F., the mean maximum is about 50° F., and the mean minimum about 24° F. In an average year there are 2 days when the temperature is below zero. Although very cold temperatures may occur, cold spells are likely to be shorter in Armstrong County than farther north. The weather that follows passage of a cold front is often clear, sunny, and rather pleasant. Because of the low relative humidity, low temperatures during winter are not extremely uncomfortable.

The average annual relative humidity is about 74 percent at 6:00 a.m., 46 percent at noon, and 44 percent at 6:00 p.m.

Temperatures are highest in July. The highest temperature recorded in the county was 108° F. It occurred on June 24, 1953. The mean July maximum is about 94° F., and the mean minimum about 65° F. A nearly constant breeze, low humidity, and a high evaporation rate keep the high temperatures in the daytime from becoming uncomfortable. The high elevation and clear skies allow rapid cooling at night, so summer nights are always pleasant. The sun shines about 72 percent of the time. Hot, drying winds occasionally damage dryland crops. Free surface evaporation during the 6-month growing season (April through September) is approximately 65 inches, and the total for the entire year is approximately 95 inches.

The frost-free season is ordinarily about 197 days but varies from about 172 to 240 days. The approximate date of the last occurrence of 32° F. in spring is April 10, and there is one chance in 20 that a freeze will occur after May 4. The approximate date of the first occurrence of 32° F. in fall is October 25. Because of differences in elevation and in terrain between the High Plains and the Rolling Plains, these dates vary within the county, and the growing season may be as much as 10 days shorter in the extreme northwestern portion of the county than in the extreme southeastern part.

The caprock escarpment affects temperatures in the county. Easterly and southeasterly winds are cooled as they are lifted up the escarpment onto the High Plains, and consequently the northwestern part of the county has slightly cooler temperatures. Late in the winter and in spring, these winds cause cloudiness and early morning drizzle along the escarpment. Westerly and northwesterly winds have the opposite effect; they produce a rise in temperature below the caprock.

The average annual precipitation in Armstrong County is slightly more than 23 inches, but the annual total has ranged from a low of 13.19 inches in 1956 to a high of about 46 inches in 1923. From 1892 through 1960, there were 4 years in which precipitation was less than 15 inches and 9 years in which it was more than 30 inches (fig. 30).

About three-fourths of the total annual precipitation falls between April and September. Ordinarily, a single shower affects only part of the county, but occasionally one may affect the whole county. Short heavy showers, many accompanied by thunder, hail, and strong gusty winds, are common, particularly in May, June, and July. Nevertheless, the distribution of rainfall is generally favorable (fig. 31).

The hard summer showers damage growing crops and interfere with the harvesting of wheat late in June. Much of the rain that falls during such showers is lost through runoff.

The average annual snowfall in Armstrong County is about 12 inches. The annual total varies from less than 1 inch to more than 30 inches. High winds cause snow to collect in drifts on bare cropland and heavily grazed grassland. On stubble and on properly used grassland, snow drifts less, and consequently the moisture it adds to the soil is more evenly distributed.

Table 7 shows the precipitation at Claude for a 10-year period, through 1960.

Good crop years do not always coincide with years of adequate rainfall. Rainfall may be normal or above but come too late in the season to benefit the current crops. In such years, the success or failure of crops depends on the amount of water stored in the soils from the previous year.

The prevailing winds are from the south and southwest all the year, though "northers" are frequent in winter. March and April are the two windiest months, but in all

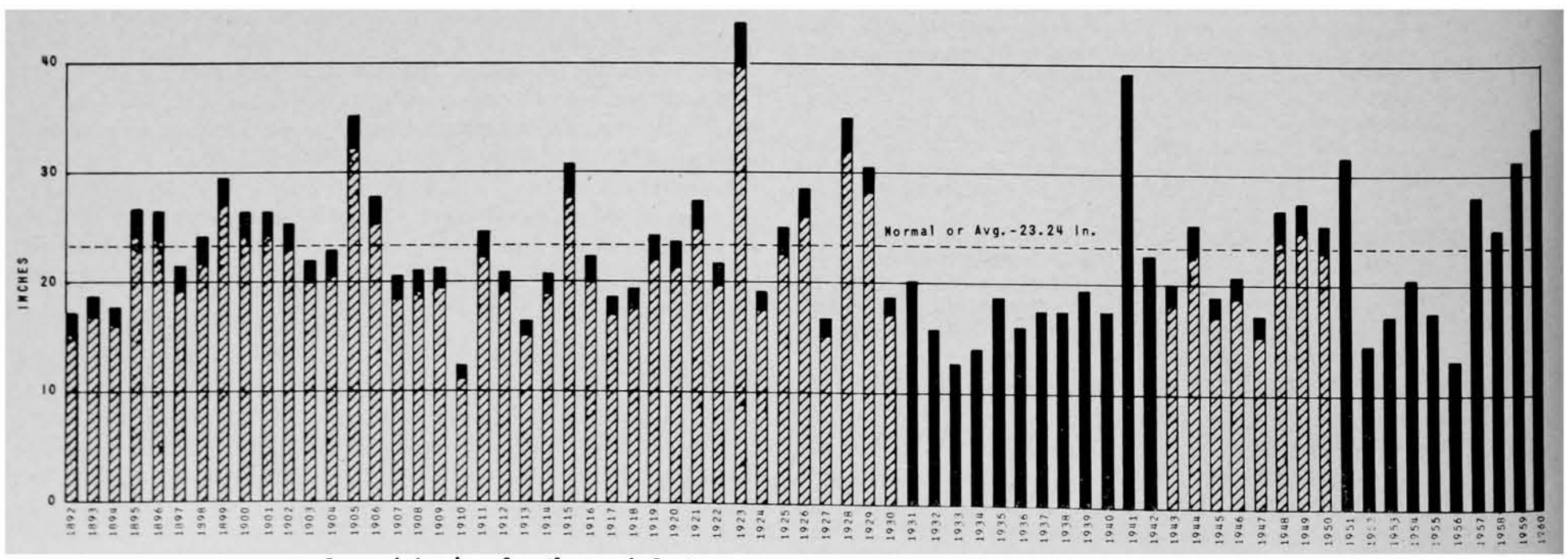

Figure 30.—**Average annual precipitation for the period 1892–1960. Bars that are solid black are based on data from records kept at Claude; bars that are partly solid and partly striped are from records kept at two stations, the solid black from Claude, and the striped from Amarillo, Potter County.**

TABLE 7.—*Precipitation at Claude for the years 1951–60*

[Data furnished by U.S. Weather Bureau at Austin, Tex.]

Month	Mean precipitation	Greatest daily precipitation		Precipitation in—		1 year in 10 will have—		Number of days having—		
		Amount	Year	Driest year (1956)	Wettest year (1960)	Less than—	More than—	0.10 inch or more	0.50 inch or more	1.0 inch or more
	Inches	*Inches*		*Inches*	*Inches*	*Inches*	*Inches*	*Days*	*Days*	*Days*
January	0.55	0.68	1958	0.10	1.31	0.2	1.4	(1)	(1)	(1)
February	.60	.57	1957	1.13	1.86	.1	1.8	(1)	(1)	(1)
March	.83	.93	1960	.00	1.17	.1	2.6	(1)	1	0
April	1.95	2.45	1957	.11	.51	.5	4.8	3	1	1
May	4.97	6.42	1951	5.17	2.60	1.4	11.7	7	3	2
June	4.16	5.92	1951	1.93	7.54	1.3	8.6	5	2	1
July	3.07	1.82	1958	1.77	4.52	1.4	6.7	5	2	1
August	2.68	2.43	1957	1.27	3.82	.8	6.4	4	2	1
September	1.17	.86	1956	1.00	2.84	.4	2.8	2	1	0
October	2.05	1.68	1959	.67	6.80	.1	6.8	3	2	1
November	.39	.66	1953	.00	.00	.1	1.5	1	(2)	0
December	.82	1.94	1959	.04	.98	.1	4.8	(2)	(2)	(2)
Year	[3] 23.24	[4] 6.42	1951	[5] 13.19	[5] 33.95	[6] 14.5	[7] 33.9			

[1] No record.
[2] Less than half a day.
[3] Annual average for the 10-year period.
[4] Greatest daily precipitation during the 10-year period.
[5] Total for year.
[6] Lowest probable for 1 year in 10.
[7] Highest probable for 1 year in 10.

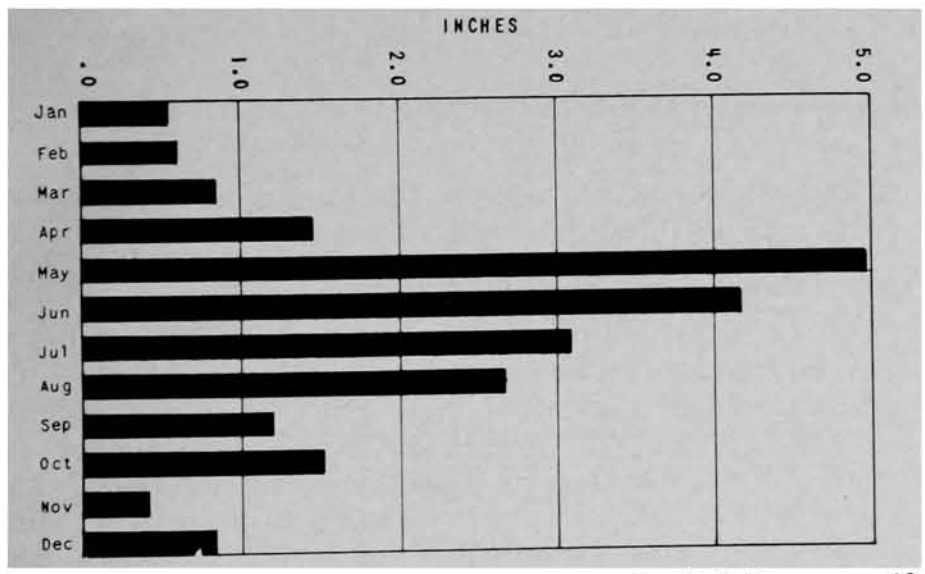

***Figure 31.*—Average monthly distribution of rainfall over a 10-year period. Data obtained from records kept at Claude for the years 1951–60.**

months the average wind velocity is more than 10 miles an hour. There are no mountain ranges to temper the strong winds. Three to five tornadoes occur annually, and occasionally one strikes the ground.

Strong winds, scarcity of vegetative cover, and light winter precipitation are the causes of duststorms. The drought of the 1950's was more intense than that of the 1930's, but duststorms were both less numerous and less intense in the 1950's because of the extension and improvement of soil conservation practices. Figure 32 shows the frequency of duststorms limiting visibility to less than 1 mile and the precipitation pattern for the county.

Agriculture

Agriculture is the major occupation in Armstrong County. It includes dryland and irrigation farming and cattle ranching. Cattle ranching was the first agricultural pursuit in the county. Later the settlers that came from the Middle West planted small grain.

This subsection gives some statistics on the farms in the county, as reported by the U.S. Census of Agriculture.

Crops

Wheat, sorghum, and cotton are the most important crops grown in the county. Wheat, the major crop, is grown primarily for grain, but much of the wheat acreage is also pastured. Because of the acreage controls, sorghum is now grown on much of the acreage once used for wheat. Barley and oats are grown on a small acreage. Cotton is a minor crop on the High Plains, but cotton grown on the Rolling Plains brings a higher return per acre than any other crop grown in the county.

Irrigation farming, which began in 1932, has increased gradually. It developed rapidly during the long drought in the 1950's. About 200 irrigation wells are presently furnishing water for supplemental irrigation of 30,000 acres of cropland.

Table 8 gives the acreage of the principal crops grown in the county for stated years.

TABLE 8.—*Acreage of principal crops in stated years*

Crops	1939	1949	1959
	Acres	*Acres*	*Acres*
Wheat threshed or combined	64,285	128,449	53,663
Sorghum:			
Harvested for grain	3,894	9,397	22,054
Cut for silage or dry forage	23,207	97	1,102
Barley threshed or combined	2,532	1,115	3,410
Oats threshed or combined	1,901	1,676	73
Cotton	1,664	1,032	1,458

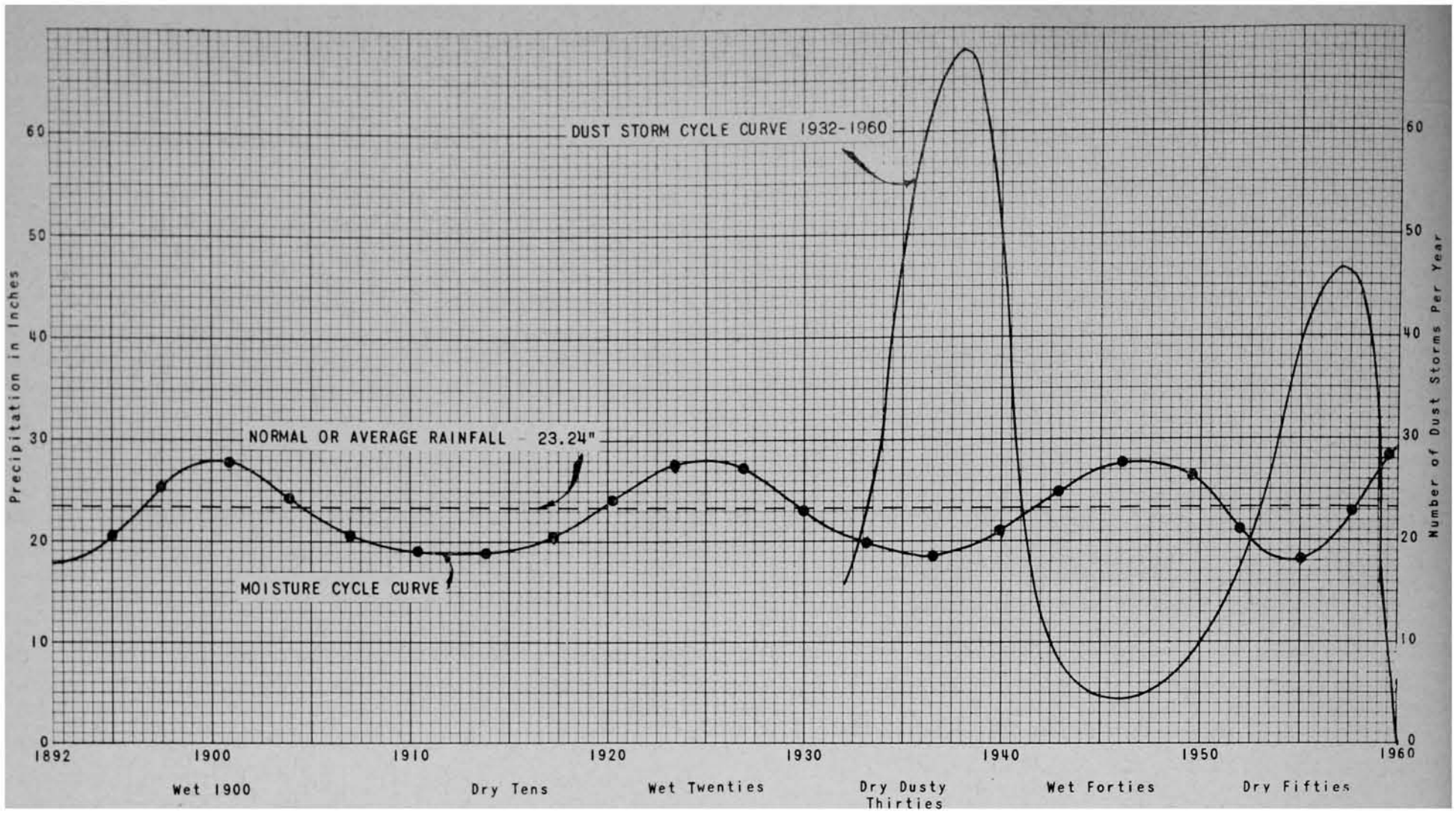

***Figure 32.*—Precipitation pattern for Armstrong County and frequency of duststorms limiting visibility to less than one 1 mile.**

Livestock

Beef cattle are the chief livestock. A few dairy cattle are raised to supply local needs.

Since the development of irrigation, a large number of cattle are fed with locally grown grain. There has been a noticeable increase in the number of herds of purebred cattle and other livestock.

Table 9 shows the number of livestock in Armstrong County in stated years.

TABLE 9.—*Number of livestock*

Livestock	1940	1950	1959
	Number	*Number*	*Number*
Cattle and calves	[1] 39,443	34,969	31,541
Hogs and pigs	[2] 1,446	1,353	1,421
Sheep and lambs	[3] 4,610	1,665	775
Horses and mules	[1] 1,870	908	652
Chickens	[2] 32,092	[2] 25,425	[2] 15,466

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.

Farm power and mechanical equipment

Farming in Armstrong County is becoming highly mechanized. Heavy tillage implements, such as chisels, sweeps, one-way plows, and rotary rod weeders, are mostly drawn by large rubber-tired tractors that are powered by diesel, propane, or gasoline engines. Self-propelled combine harvesters have practically replaced tractor-drawn combines. Special implements, such as fertilizer applicators, hay and silage harvesters, fuel tanks, weed sprayers, and ditchers, are used in irrigated areas.

Farm tenure and size of farms

In 1959, about 80 percent of the farms in the county were operated by full or part owners. Most of the owner-operators rented additional land from absentee owners.

The U.S. Census of Agriculture shows that the proportion of farms operated by tenants decreased from 35.5 percent in 1940 to 26.9 percent in 1950 and that by 1959 it had declined to 22.2 percent.

The census reports for 1940 showed that there were 408 farms in the county and that the average size was 1,986 acres. The number of farms had decreased to 353 in 1950, but the average size had increased to 2,231 acres. In 1959, there were 297 farms, and they averaged 2,151 acres in size.

The numbers of farms by size in 1959 were as follows: Up to 69 acres, 20; 70 to 139 acres, 3; 140 to 259 acres, 20; 260 to 999 acres, 161; and 1,000 acres or more, 93.

The ranches in the range areas are much larger than the farms. One ranch, for example, is more than 108,000 acres in size.

Public Facilities

Public facilities in Armstrong County include schools, churches, and highway and railroad transportation. One grade school is located at Wayside. All other grade and high schools are in Claude. Several churches of various denominations are located throughout the county.

Most all parts of the county have electricity, natural gas, and telephones.

The farm and ranch roads are usually surfaced with oil. A few rural roads, however, are still difficult to travel in wet weather. State Highway 15 extends southward to Claude and connects with U.S. Highway 287 and farm and ranch roads 1151 and 284. Farm and ranch roads 1151, 1258, 2272, and 285 extend east and west, and roads 2250, 284, and 294 extend north and south. All farm-to-market roads are hard surfaced.

The Fort Worth and Denver Railroad passes through Claude and connects the county with grain and livestock markets in Amarillo and Forth Worth, Tex., and Denver, Colo.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alkaline soil. Generally, a soil that is alkaline throughout most or all of the part occupied by plant roots. Precisely, any soil having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

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

Available moisture capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Badlands. Areas of rough, irregular land where most of the surface is occupied by ridges, gullies, and deep channels.

Bench terrace. A shelflike embankment of earth that has a level or nearly level top and a steep or vertical downhill face, constructed along the contour of sloping land or across the slope to control runoff and erosion. The downhill face of the bench may be made of rocks or masonry, or it may be planted to vegetation.

Buried soil. A developed soil, once exposed but now overlain by a more recently formed soil.

Calcareous soil. A soil containing calcium carbonate, or a soil that is alkaline in reaction because of the presence of calcium carbonate.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. It may consist of soft, thin layers in the soil; or it may consist of hard, thick beds just beneath the solum; or it may be exposed at the surface by erosion.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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

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

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

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

Firm.—When moist, can be crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure, but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

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

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

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

Dispersion, soil. Deflocculation of the soil and its suspension in water. The breaking down of soil aggregates, resulting in single-grain structure.

Eolian soil material. Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.

Hardlands. A term used in the southern Great Plains that includes mostly moderately fine textured soils.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

A horizon. The mineral horizon at the surface. It has an accumulation of organic matter, has been leached of soluble minerals and clay, or shows the effects of both.

B horizon. A horizon in which clay minerals or other material has accumulated, or that has developed a characteristic blocky or prismatic structure, or that shows the effects of both processes.

C horizon. The unconsolidated material immediately under the true soil. In chemical, physical, and mineral composition, it is presumed to be similar to the material from which at least part of the overlying solum has developed.

D horizon. Any layer, or stratum, underlying the C horizon, or the B horizon if no C horizon is present. If this stratum is rock that presumably was the source of material in the C horizon, it is designated Dr.

Outwash. In this report, outwash refers to soil material washed from the High Plains and Rocky Mountains by melt water, carried by streams and deposited on the Permian red beds during the Pleistocene epoch.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Poorly graded soil (engineering). A soil material consisting mainly of particles nearly the same size. Because there is little difference in size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

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

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

Saline soil. A soil that contains soluble salts in amounts detrimental to plants but does not contain excess exchangeable sodium.

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

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

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 millimeters to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 millimeters to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer beneath the solum, or true soil; the C or D horizon.

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

Talus. Fragments of rock and other soil material accumulated by force of gravity at the base of cliffs or steep slopes.

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

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

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

Toposequence. A group or sequence of geographically associated soils, developed from essentially similar parent materials, in which the soil characteristics differ primarily because of the influence of variations in topography and drainage.

Well-graded soil (engineering). A soil or soil material consisting of particles that are well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded.

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