Series 1948, No. 7

Issued June 1960

SOIL SURVEY

Logan County Oklahoma

OUR SOIL ★ OUR STRENGTH

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

HOW TO USE THE SURVEY REPORT

THIS SOIL SURVEY of Logan County will serve various groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields, and it will add to the knowledge of soil scientists.

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

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

Locating the soils

Use the index to map sheets to locate areas on the large map. The index is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map is found, it will be seen that boundaries of the soils are outlined, and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map. Suppose, for example, an area located on the map has the symbol Rb. The legend for the detailed map shows that this symbol identifies Renfrow silt loam, 1 to 3 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. The introductory part, which mentions climate and physiography, relief, and drainage, and gives some statistics on agriculture, will be of interest mainly to those not familiar with the county.

Farmers and those who work with farmers can learn about the soils in the section Descriptions of the Soils, and then turn to the section Use and Management of Soils. In this way they first identify the soils on their farm or ranch and then learn how these soils can be managed and what yields can be expected. The soils are grouped by capability units; that is, groups of soils that need similar management and respond in about the same way. For instance, in the section Descriptions of the Soils, Renfrow silt loam, 1 to 3 percent slopes, is shown to be in capability unit IIIe-2. The management this soil needs will be stated under the heading Capability Unit IIIe-2 in the section Use and Management of Soils.

Soil scientists will find information about how the soils were formed and how they were classified in the section Genesis, Morphology, and Classification of Soils.

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

Farmers in Logan County have organized the Logan County Soil Conservation District. The district, through its board of supervisors, arranges for farmers to receive technical help from the Soil Conservation Service in planning good use and conservation of the soils on their farms. The survey furnishes some of the facts needed for this technical help. The soil survey map and report also are useful to land appraisers, credit agencies, road engineers, and to others who are concerned with the use and management of land.

The fieldwork for this survey was completed in 1948. Unless noted otherwise, all statements refer to conditions at the time of the survey.

U.S. GOVERNMENT PRINTING OFFICE: 1960

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Contents

Series 1948, No. 7

Issued June 1960

SOIL SURVEY OF LOGAN COUNTY, OKLAHOMA

REPORT BY HARRY M. GALLOWAY, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE AND THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION

SOIL SURVEY BY HENRY P. MICKLES, L. H. MARSHALL, A. G. FIELDER, FLOYD W. CLARKE, AND MARCO L. MARKLEY SOIL CONSERVATION SERVICE

CORRELATION BY HARVEY OAKES AND E. H. TEMPLIN, SOIL CONSERVATION SERVICE

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

LOGAN COUNTY is in the central part of Oklahoma. Guthrie, the county seat, is north of Oklahoma City and southeast of Enid. Distances by air from Guthrie to principal cities in the State are shown in figure 1.

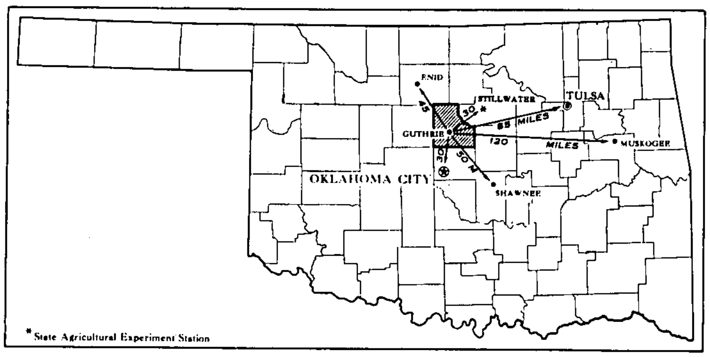


***Figure 1.*—Location of Logan County in Oklahoma.**

The land area of the county is 478,080 acres, or 747 square miles. The county is at the eastern edge of the main wheat-producing area of the State. It is in the southern part of the tall-grass prairie in the Central Lowland Province of the United States.

Logan County is in the part of the State known as Old Oklahoma; it was settled by a land run in 1889. Guthrie was the seat of government for the western part of the State, then called Oklahoma Territory. When this part of the State was united with the eastern part, then called Indian Territory, to form the State of Oklahoma, the State Capital was established at Oklahoma City.

General Description of the County

This section is provided mainly for those not familiar with Logan County. It tells about the relief, drainage, climate, vegetation, water supply, and agricultural trends.

Relief and Drainage

Logan County is a plain consisting of weakly consolidated reddish clays and sandstones of Permian time. Most of the upland is gently rolling. The southeastern part of the county is a rolling to hilly, thinly wooded area, known as Cross Timbers, that is underlain by sandstone. In the western part of the county around Marshall, Crescent, and Navina, there are broad areas of nearly level upland.

Most of the surface drainage enters the Cimarron River, which flows eastward through the central part of the county. Drainage in the hilly southeastern part of the county is toward Deep Fork, in Oklahoma County, a tributary of the North Canadian River. Deep deposits of old alluvium and loess occur on former flood plains of the Cimarron River and Cottonwood and Skeleton Creeks. Much of the alluvium has been reworked by wind, and as a result there are many dunes and sandy ridges. Most of this area is cultivated, and wind erosion is severe.

The flood plains are important agriculturally because the soils are deep and fertile. One-eighth of the county acreage is in flood plains. However, only two-thirds of the flood-plain acreage is suitable for cropland. Relief, drainage, silting, sanding, or other factors limit use of the rest of the land.

Climate

Temperature and precipitation data compiled from United States Weather Bureau records are given in table 1. The rainfall at Guthrie averages about 32 inches a year. This is enough for good yields of crops when the rainfall is well distributed through the year. In about 2 or 3 years in 10, one-third of the rain falls during spring, and nearly as much during summer. Long dry spells occur in midsummer in most years. Because of uncertain rainfall, the production of crops is hazardous in some years. In the driest year (1954), about 13 inches of rain fell during the growing season—too little for maximum plant growth, even if all other factors had been favorable. By contrast, about 39 inches fell during the same period in the wettest year (1915).

The effectiveness of precipitation depends on amount and on other factors. Intensity of rainfall affects the amount absorbed by soils. Only the most permeable soils can absorb the rainfall of severe storms (2 to 4 inches in a short period). At the Red Plains Soil Conservation Experiment Station near Guthrie, the storms of April, May, June, August, and September are the most intense. On an average, more than one-third of the rains caused runoff from bare plots. The runoff amounted to nearly 28 percent of the yearly rainfall. All sloping soils in the county lose moisture through runoff. Nearly 10 inches of potentially valuable moisture is lost each year through runoff.

TABLE 1.—*Temperature and precipitation at Guthrie, Logan County, Okla.*

[Elevation, 910 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1954)	Wettest year (1915)	Average snowfall
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December	40. 1	80	−9	1. 54	2. 26	0. 40	2. 0
January	38. 1	82	−24	1. 17	. 17	1. 60	2. 8
February	40. 9	93	−18	1. 27	. 67	4. 80	2. 4
Winter	39. 7	93	−24	3. 98	3. 10	6. 80	7. 2
March	51. 2	100	−8	2. 13	. 44	1. 95	1. 1
April	61. 3	98	16	3. 54	2. 24	8. 40	(3)
May	68. 9	99	33	4. 75	5. 02	3. 60	(3)
Spring	60. 5	100	−8	10. 42	7. 70	13. 95	1. 1
June	77. 8	110	44	3. 68	. 92	8. 45	(3)
July	82. 6	113	49	2. 46	. 04	2. 25	0
August	82. 3	116	46	3. 08	3. 59	6. 23	0
Summer	80. 9	116	44	9. 22	4. 55	16. 93	(3)
September	74. 6	109	31	3. 45	. 24	6. 95	0
October	63. 1	99	10	3. 03	1. 15	3. 98	(3)
November	50. 3	92	7	2. 16	. 32	1. 49	. 2
Fall	62. 7	109	7	8. 64	1. 71	12. 42	. 2
Year	60. 9	116	−24	32. 26	17. 06	50. 10	8. 5

[1] Average temperature based on a 62-year record, through 1955; highest temperature on a 58-year record, and lowest temperature on a 57-year record, through 1952.
[2] Average precipitation based on a 62-year record, through 1955; wettest and driest years based on a 52-year record, in the period 1894–1955; snowfall based on a 57-year record, through 1952.
[3] Trace.

Temperatures are very important in determining the amount of water used by crops. The annual average temperature in Logan County is about 61 degrees; the summer average is 80.9 degrees, and the winter average is 39.7 degrees. Temperatures have gone as high as 116 degrees, and they are often more than 100 degrees in July and August. High temperature, combined with low relative humidity, causes evaporation and transpiration of moisture from plants far in excess of the rain that normally falls in July and August. Alfalfa may need 12 inches of moisture for optimum growth in these months, but it gets only about 5½ inches of this from rainfall. The rest must be obtained from the subsoil. Drought and dry subsoil may cause the death of deep-rooted crops.

Winters are generally dry. Extremes of cold as low as 10 degrees below zero may damage drought-weakened crops of all kinds.

Continuous high winds are common in March, April, May, and June. Hot, dry summer winds sometimes damage corn and other crops requiring large amounts of moisture. These winds rapidly dry the soil through evaporation and plant transpiration. When accompanied by high temperatures, strong winds dry out and stunt the growth of crops within a few days. Winds can be nearly as damaging to immature summer crops as hailstorms can be to nearly mature small grain.

The length of the average growing season is 214 days—March 31 to October 31. The latest frost recorded in spring occurred on May 13; the earliest recorded in fall occurred on September 26.

Climatic conditions make yields uncertain on even the most productive soils and limit somewhat the choice of crops that can be grown. The farmers getting better yields are equipped to stand the highs and lows in crop production. They are willing to adopt new methods of farming and to try experimental ones to help reduce their operating risks. Strict adherence to well-worked-out rotations for improvement of soil and for maximum crop yields is less often possible in the southern plains than in the north-central States. Instead, each farmer tries to fit his cropping system to the climate and soil. The relationship of land use and soil is now fairly well understood, and this knowledge is the basis for the capability classification of soils discussed in the section Use and Management of Soils.

Vegetation

A large part of Logan County was originally tall grass prairie, mainly bluestem grasses together with switchgrass, Indiangrass, side-oats grama, blue grama, and buffalograss. Post and blackjack oaks and hickory occupied the sandy areas. Elm, oak, hackberry, sycamore, walnut, pecan, and other hardwoods were common on bottom lands.

According to long-time residents, oak has been spreading steadily from the uplands to adjacent grassy areas or to old fields. Oak spreads to the permeable sandy soils and to the shallow soils on sandstone. It is not a valuable tree in this county, because of its poor form and slow growth.

On loams underlain by medium to clayey subsoils, the natural tendency is for some kind of grass to persist, even after heavy grazing. Sumac and persimmon invade old fields and overgrazed pastures on these heavier soils, but they cause less trouble than the invasion of oak on sandier soils.

The bluestem and other native tall grasses decrease in vigor when intensively grazed. These grasses are replaced by those of less value for grazing. Native pasture becomes drier and less able to absorb moisture if it is excessively trampled and surface litter is removed. On the steep, clayey, and severely eroded soils particular care is needed to maintain enough vegetation to cover the soil.

Most of the native grasses of the prairies are now in meadows and unused areas along roads. These places are a good source of seed for the revegetation of rundown pastures and eroded old fields.

Water

The principal source of water for livestock in Logan County is dams that impound surface water. Nearly every farm has at least one pond for livestock; some pond water is used in homes. Well water for domestic use is generally available. In the sandy mantled areas, water generally occurs at the base of the mantle, where it rests on bedrock.

Water for irrigation is available locally in channels of the larger streams. In the Cimarron River flood plain, water can be obtained from shallow wells in the river alluvium. Water from the Cimarron River or from the valley alluvium is extremely variable because of salts. Its quality should always be tested before using it for irrigation.

Agricultural Trends

Agriculture in Logan County during the first 50 years was generally exploitative. Fertilizers, crop rotations, and legumes were not used extensively, and little effort was made to improve the soil or prevent erosion. When pastures were short, livestock was grazed on crop residues. Pastures were nearly always overgrazed. This usage hastened soil and grassland depletion.

Land use has been changed in the last 20 years, partly because of necessity and partly by choice. Small grains have been grown much more extensively since 1929. Before then most of the cultivated acreage was used for corn, cotton, and sorghum. In contrast, most of the acreage in 1954 was used for small grains and less than 10 percent for row crops. The acreage of the principal crops, as reported by the United States census, is given for stated years in table 2.

The change from row-crop to small-grain farming has helped to conserve the soil because small grains, like grasses, protect the soil. The change has also allowed more organic matter to be returned to the soil. The part of small grains harvested is only a small percentage of total plant tissue grown, so most of the plant is returned to the soil.

TABLE 2.—*Acreage of the principal crops in stated years*

Crop	1939	1949	1954
	Acres	*Acres*	*Acres*
Corn, for all purposes	13, 176	9, 019	1, 379
Cotton	12, 973	6, 082	3, 445
Sorghum, for all purposes except sirup	8, 116	8, 834	7, 657
Oats (threshed)	24, 840	12, 646	20, 268
Barley (threshed)	12, 121	559	8, 119
Rye (threshed)	1, 292	210	(1)
Wheat (threshed)	64, 808	78, 400	68, 456
Hay crops, excluding soybean, cowpea, peanut, and sorghum hay	19, 462	20, 412	23, 427
Alfalfa and alfalfa mixtures	3, 767	6, 799	10, 388
Small grains cut for hay	593	918	3, 356
Wild hay	7, 291	9, 081	6, 392
Other hay cut	7, 811	3, 614	3, 291

[1] Not reported.

During the first 40 years of agriculture in the county, cotton and corn were grown on all farms and soil erosion was very extensive. The most serious erosion occurred in areas where continuous row-crop farming was practiced. Much of the eroded land has now been taken out of cultivation. Erosion is a spectacular result of misuse, but the steady loss of fertility, though not so apparent, may be equally damaging to the soil. Crops have exhausted phosphorus to the point that nearly all the commonly grown crops on upland soil respond to additions of this element. The supply of nitrogen, available chiefly from soil organic matter, has been reduced, and nitrogen fertilizers are needed for vigorous plant growth. The removal of calcium, magnesium, and other basic elements through leaching and cropping has made the soils more acid. Limestone has been used widely to counteract soil acidity on areas prepared for sweetclover and alfalfa.

Some fertilizers were used as early as 1929, but until 1948 the quantity used in the county per year did not exceed 100 tons. At the time of the survey, the amount of fertilizer used in Logan County (about 3,000 tons per year) was among the highest in the State. The total applied to the nearly 150,000 acres of cropland amounts to only an average of 40 pounds of fertilizer per acre per year. This is less than one-third the quantity suggested for small grains in Logan County.

A large percentage of the sloping cropland has been terraced during the past 25 years. Many early terrace systems were built on croplands that were later abandoned. Many systems have not been properly utilized or maintained, and they do not provide the beneficial effects for which they were built.

The 1954 census reported an estimated 1,659 farms in the county. Farms by type were as follows:

	Number
Cash grain	535
Cotton	25
Dairy	81
Poultry	20
Livestock other than dairy and poultry	267
General farms	161
Miscellaneous and unclassified	570

Livestock and livestock products provide a large part of the farm income in Logan County. Most of this income is derived from grazing animals, principally beef cattle. The number of cattle in the county has fluctuated with demand, but the general trend has been upward.

Livestock in the county, as reported by the Federal census, is shown in table 3.

TABLE 3.—*Number of livestock on farms in stated years*

Livestock	1930	1940	1950	1954
	Number	*Number*	*Number*	*Number*
Cattle and calves	19, 137	[1] 26, 416	31, 656	42, 465
Horses and mules	8, 850	[1] 5, 421	2, 384	1, 215
Hogs and pigs	8, 309	[2] 8, 640	12, 020	6, 417
Sheep and lambs	4, 089	[3] 5, 835	2, 074	2, 510
Chickens	[1] 181, 093	[2] 145, 199	[2] 116, 083	[2] 106, 064

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.

Geology and General Soil Areas

In studying the soils of a county, their general relation to topography, parent material, and vegetation under which they developed should be considered. If one kind of rock or other geologic material is exposed to soil-forming processes, soils develop that show differences caused by topography and slope. A knowledge of the geologic formations is useful in understanding the occurrence and distribution of the soils in Logan County.

Geologic Formations and Soils

The principal rocks of the county are sedimentary clay and sandstone. They were laid down in the seas in Permian time and are commonly referred to as Permian "Red Beds."

The geology and general terrain of Logan County are shown in figure 2. The western third of the county is generally smooth, the central part is rolling, and the southeastern part is rolling to hilly. The underlying rock formations dip toward the west at a gradient of about 40 feet per mile. Rock strata that are exposed in the eastern part of the county are covered in the western part by formations higher in the geologic column. Hennessey shale, Garber sandstone, and the Wellington formation are exposed successively in going from west to east across the county.

The Hennessey formation exposed in western Logan County is in an area of gentle slopes and broad divides, although locally there are steep areas along the sides of drainageways. The formation consists of red, calcareous, generally nonshaly joint clays. Large bodies of clayey, very slowly permeable soils develop from the weathered Hennessey formation. The main soils are those of the Kirkland, Renfrow, and Vernon series.

The Garber formation outcrops at lower elevations than the Hennessey formation and east of it. It consists of interbedded red sandstone and clay. It underlies an area of gently rolling open plains in which the divides are generally narrow. Some of the sandy caps on the divides are wooded.

The upper part of the Garber formation, called the Hayward sandstone member, is a massive, slightly soft sandstone. It underlies an area consisting mostly of permeable loamy soils of the Chickasha, Zaneis, and Lucien series. The lower Garber, called the Lucien shale member, is interbedded clay and sandstone. The soils that have developed on it are in small bodies and are members of the Renfrow-Vernon-Kirkland and the Zaneis-Lucien-Chickasha soil associations.

The Wellington formation is mixed clay and sandstone, and it occupies the rolling to hilly eastern part of the county. North of the Cimarron River the eastern part of the county is open and rolling. The soils are mainly clayey and are members of the Renfrow-Vernon-Kirkland soil association. East of Guthrie, in mixed clay and sandstone, the Zaneis-Lucien-Chickasha soil association is dominant, but there are also many medium-size areas of the Renfrow and Vernon soils.

Sandstone is somewhat coarser grained toward the east and southeast. The area is generally wooded, and the main soils are of the Darnell and Stephenville series.

Quaternary deposits

In a large area around Crescent and in narrow areas along the Cimarron River and Skeleton and Cottonwood Creeks, the Permian rocks are mantled by loose loamy and sandy Quaternary deposits laid down mainly in Pleistocene time. The loamy deposits are smooth to rolling and consist of old alluvium with or without a mantle of loess. The sandy deposits are gently undulating or wavy and have scattered dunes on the surface. These deposits are mainly of old alluvium that has been greatly modified and shifted by wind.

The loamy Quaternary deposits generally support grasses that influence the development of the Teller, Vanoss, Minco, Norge, and Bethany soils; whereas, the sandy sediments support woodlands of varying densities that influence the development of the Dougherty and Derby soils.

Recent alluvium

Recent stream alluvium is an important soil-forming material in the valleys of the Cimarron River and of other streams throughout the county. The composition of this material varies greatly from place to place. It depends on the source of the material and the sedimentation pattern of streams that carried it. In general there are three kinds of alluvium in Logan County that affect soil development.

Cimarron River alluvium is clayey to sandy at the surface, but it usually has substrata of sandy loam within 2 feet. Low swales are filled with clayey sediments. Large areas of alluvium have ridges and intervening swales, and some areas have been modified by low dunes. The soils that have developed from Cimarron River alluvium are mainly of the Yahola and Reinach series and Mixed alluvial land.

The valley floors of tributary streams draining mixed beds of clay and sandstone consist of loam to clay loam alluvium. Channels are deeply cut and can hold most floodwaters. The main soil is of the Port series.

Valleys within hilly sandstone areas contain more of the sandy alluvium and have received many new deposits of sediment in recent years because of clearing and rapid erosion of the uplands. Stream channels are choked with sand and cannot carry extra water. Floods are more prevalent now than in early years. The main soils in these valleys belong to the Pulaski and Noble series.

General Soil Areas

In mapping a county or other large tract, it is fairly easy to see many differences as one travels from place to place. Some of the differences are in shape, steepness, and length of slopes; in the course, depth, and speed of the streams; in the width of the bordering valleys; in kinds of wild plants; and in the kinds of agriculture. With these more obvious differences there are others less easily noticed in the pattern of soils. The soils differ along with the other parts of the environment.

By drawing lines around the different patterns of soils on a small map, one may obtain a map of the general soil areas, or, as they are sometimes called, soil associations. Such a map is useful to those who want a general idea of the soils, who want to compare different parts of a county, or who want to locate large areas suitable for some particular kind of agriculture or other broad land use.

Considerably less land is in cultivation now than when the field survey was underway. The greatest decreases have taken place in the Darnell-Stephenville-Noble, the Zaneis-Lucien-Chickasha, and the Renfrow-Vernon-Kirkland soil associations. The colored soil association map in the back of the report shows the six soil associations in Logan County.

Zaneis-Lucien-Chickasha association

This association covers about 32 percent of the county and contains about 151,000 acres. It is the most extensive association in the county. The major soils have

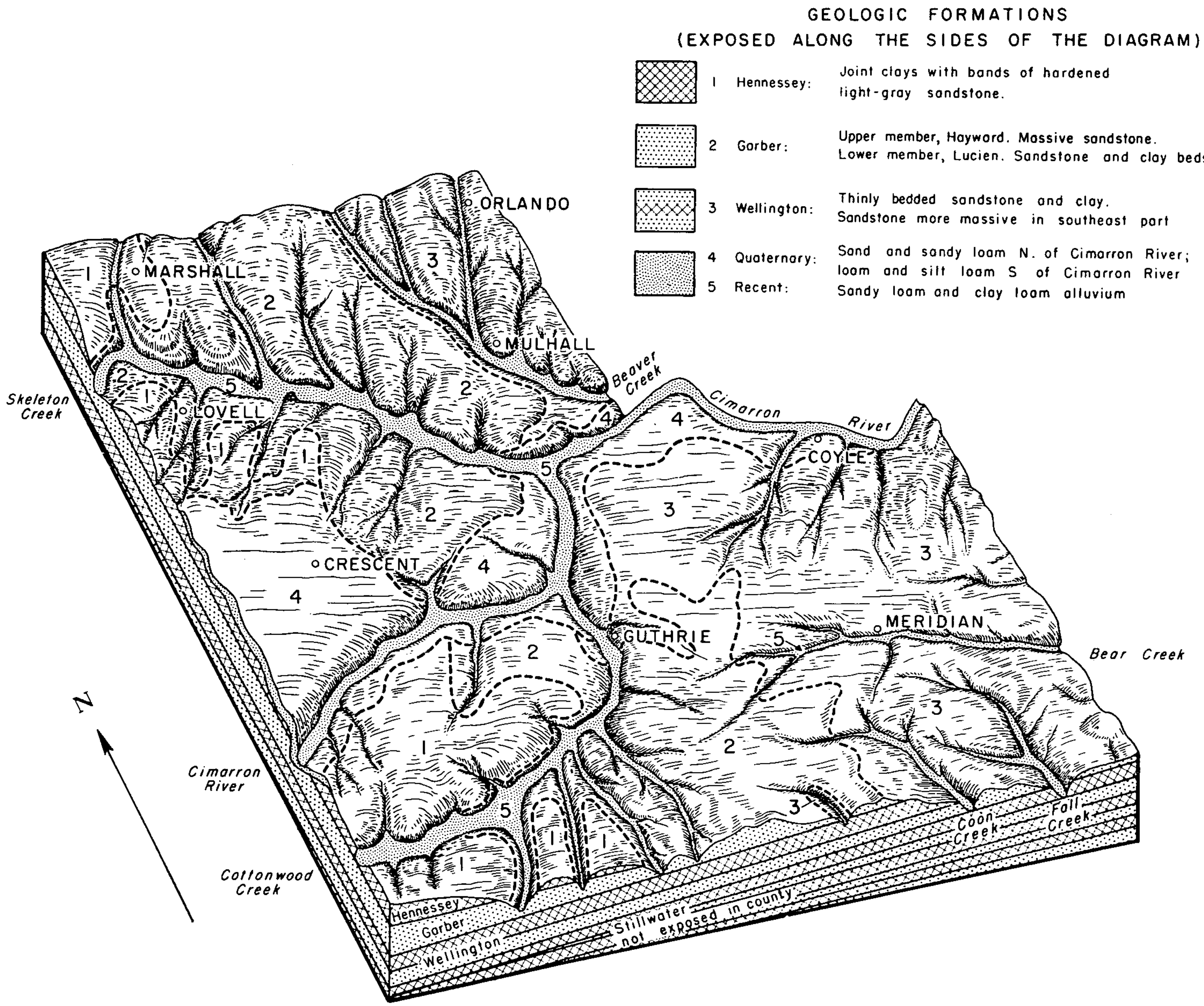


Figure 2.—**Main features of terrain in Logan County, Oklahoma.**

developed on gently rolling prairies under tall grasses and on sandstone and silty shale. The reddish-brown Zaneis soils are permeable loams and sandy loams with granular clay and clay loam subsoils. They occupy moderate slopes. The shallow Lucien soils are underlain by sandy rock and are on steep slopes and narrow sloping ridgetops. The Chickasha are the darkest soils of the association. They are browner than the Zaneis and have slightly mottled subsoils. They developed on smooth divides.

Vernon soils occur with the soils of this association. Small areas of Port soils occur in all the valleys; they are important crop soils.

This association is used mainly for improved pasture and native range. The cultivated areas are used mainly for wheat, grain sorghum, and cotton. Figure 3 shows how the soils are related to rocks and slopes.

Renfrow-Vernon-Kirkland association

This association covers about 29 percent of the county and contains about 135,500 acres. The soils have developed on red clay beds and under tall grasses of the gently rolling prairies. They occur on more clayey rocks than those of the Zaneis-Lucien-Chickasha association.

The Renfrow, Vernon, and Kirkland series have developed on different gradients. The Kirkland, darkest of the three, has developed on nearly level areas. The more reddish Renfrow soils developed on gentle slopes, and the Vernon soils, on steep slopes and broken areas. Considerable acreage in the county is made up largely of these series, and their occurrence can be predicted in this climate by red clayey materials on the surface.

Renfrow and Kirkland soils are known as hard-land prairie soils. The subsoils are compact, blocky, and very slowly permeable. The Vernon subsoils are only slightly developed and are underlain by clay beds. How these soils are related to slopes and rocks is shown in figure 3.

Port soils commonly occur with the soils of this association.

A large part of the soils of this association is used for native range and improved pasture. Small grain is

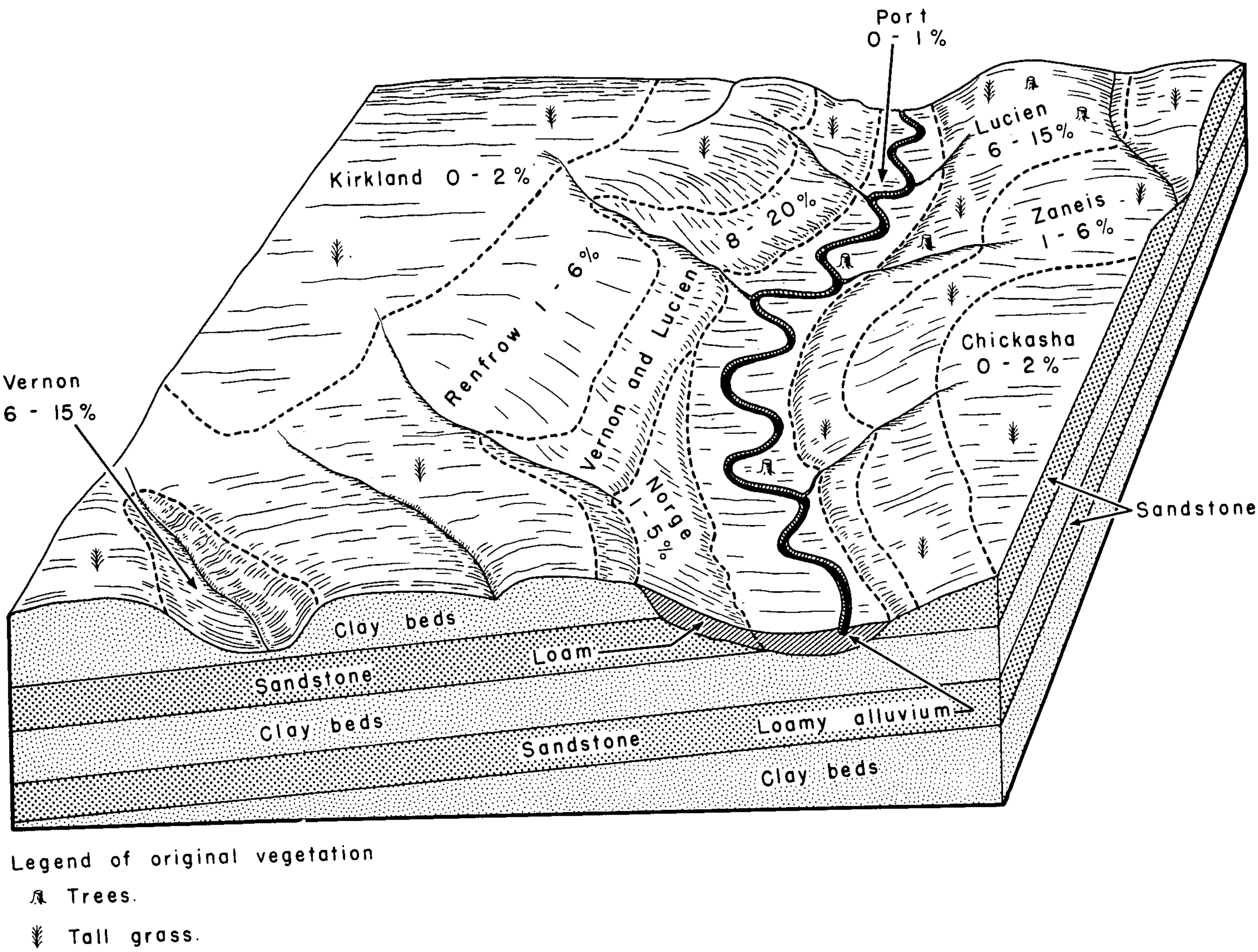


Figure 3.—**Soils of the Zaneis-Lucien-Chickasha and the Renfrow-Vernon-Kirkland associations on red clays, sandstone, siltstone, and alluvium. They have developed largely on the Wellington, Garber, and Hennessey formations that dip successively toward the west.**

grown on much of the cultivated area; other crops are cotton and grain sorghum. The Renfrow and Kirkland soils are not so well suited to summer crops as the Zaneis and Chickasha soils.

Darnell-Stephenville-Noble association

This soil association consists of about 73,000 acres—about 15 percent of the county. Most of it is in the southeastern part, but small tracts are scattered over the central part. The soils are sandy loams of good permeability. They have developed in soft, reddish sandstone in rolling to hilly wooded areas. The landscape consists of narrow ridgetops, sharply breaking slopes, and colluvial-alluvial valleys.

The Darnell soils are shallow over sandstone and do not have clayey subsoils to hold moisture. The Stephenville soils have depths ranging from 24 to 48 inches. The subsoil is a reddish-brown sandy clay loam and is underlain by sandstone bedrock. The Noble soils are deep and occur in narrow areas below the Darnell and Stephenville.

The clayey Vernon and Renfrow and the loamy Zaneis and Chickasha soils occupy small prairie openings in the wooded areas of this association. The narrow drainageways are occupied by the Pulaski soils. Along the larger streams, Pulaski soils are in dikelike positions next to the channels and the Port soils are on the more nearly level areas.

The relation of the soils in this association to the rocks and slopes is shown in figure 4.

Most of these soils are used for grazing. Cotton, sorghum, and small grains are grown to some extent on the smoother ridgetops of Stephenville soils and on the foot slopes of Noble soils. Grass production on the upland is poor because trees compete with the grass for moisture. Most good grazing is obtained from the small grassed openings among the trees. Some owners control brush by spraying it with herbicides from the air or by clearing with a bulldozer. Grasses grow well when the trees are removed, but careful grazing is needed to keep the grass growing vigorously. The reestablishment of oak through sprouting from unkilled roots is a constant problem.

Port-Yahola-Pulaski association

This association covers about 12 percent of the county and contains about 58,600 acres. The soils occupy the flood plains of the Cimarron River and its tributaries

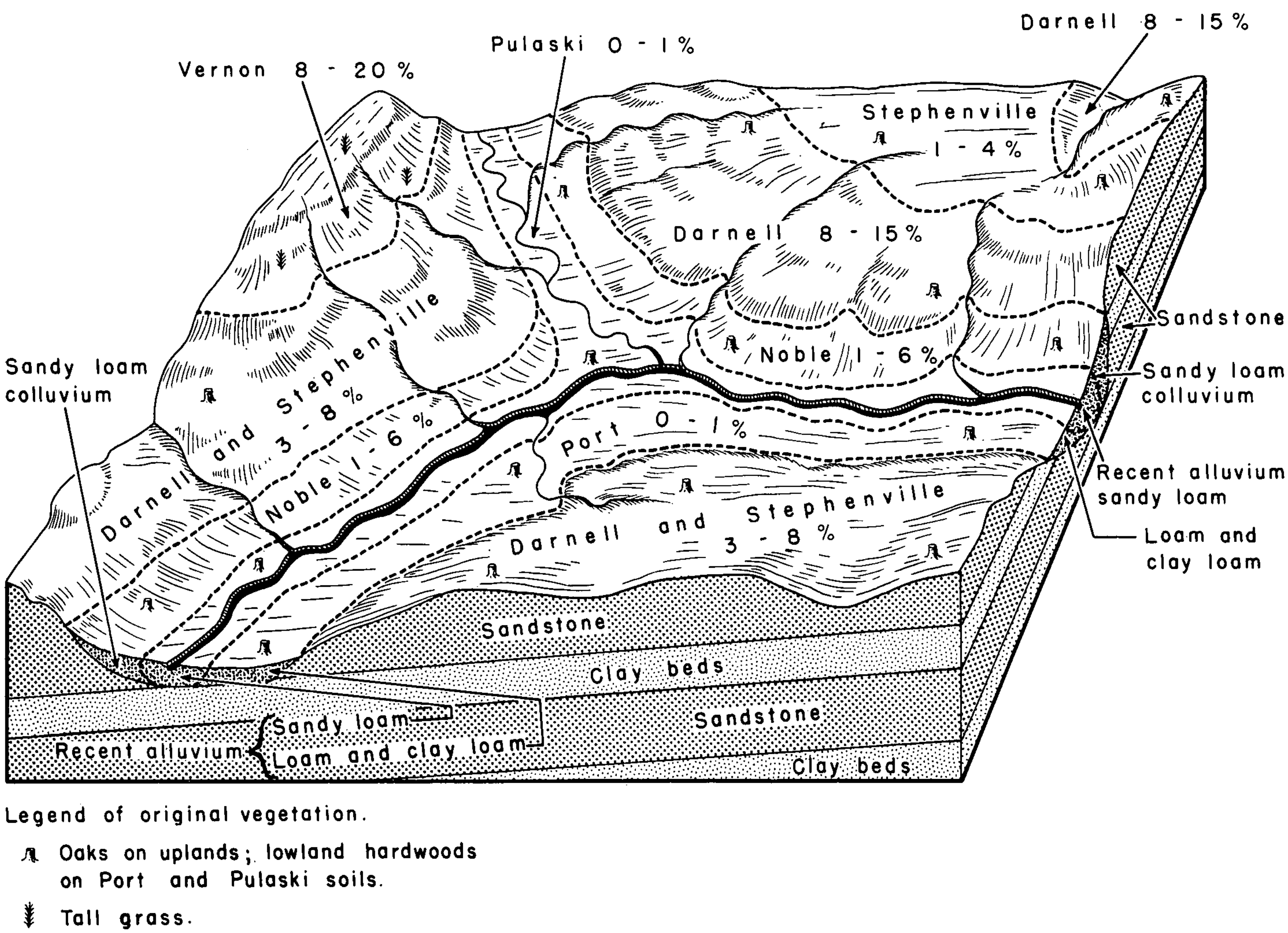


Figure 4.—**Soils of southeastern Logan County on reddish sandstone, colluvium, and alluvium.**

491776—59——2

and the bottom lands in the southeastern part of the county that are drained by Deep Fork. The relationship of these soils to rocks and slopes is shown in figures 3, 4, and 5.

The Port soils are clay loams and silt loams. They are the main soils in the bottom lands along Beaver, Skeleton, Cottonwood, Bear, and Fitzgerald Creeks, and they produce good yields of the commonly grown crops.

The Yahola soils are clay loams and sandy loams underlain by substrata of sandy loams. They are the principal soils in cultivation on the flooded bottom lands of the Cimarron River. Sand dunes, Lincoln material, and Mixed alluvial land are adjacent to the Yahola soils, but their soil materials are too mixed to be valuable for crops. Reinach soils occupy the high bottom lands along the Cimarron River and are above ordinary overflow. They are some of the best soils for crops in the county.

The Pulaski soils consist of strongly stratified loams and sandy loams. They occur mainly in the valleys within the Darnell-Stephenville-Noble soil association in the upper reaches of Bear, Fall, and Coon Creeks, and in the many short drainageways that flow into the Cimarron River. Channels are choked with sand, and silt and sand have recently been deposited on the surface of these soils.

Soils of this association are used mainly for small grains, cotton, alfalfa, corn, and grain sorghum. The cultivated acreage of these soils has decreased because of the high water table and recent sanding and silting.

Derby-Dougherty-Vanoss association

This soil association covers about 7 percent of the county and contains about 35,100 acres. It consists of undulating to billowy, light-colored soils that are sandy and partly wooded. A few areas of nearly level prairies are included. This association makes up an important agricultural area around Crescent, and a large part is in cultivation. The steep slopes and low dunes are wooded.

The Derby soil is a loamy sand. It does not contain appreciable amounts of clay in the subsoil to hold moisture. The Dougherty soil is similar to the Derby, but it has a sandy clay loam subsoil that can hold moisture. The Vanoss soil consists of fine sandy loam over a clay loam subsoil. Bethany soils occur near the Vanoss and differ in having a more clayey subsoil. The relation of these soils to slopes and rocks is shown in figure 5.

These soils are moderately productive, but they are subject to severe wind erosion. They are used mainly for cotton, melons, and grain sorghum. Considerable rye for winter pasture is also grown. Other small grains are grown for the grain, particularly on the Vanoss and Bethany soils.

Teller-Minco-Vanoss association

This association covers about 5 percent of the county and contains about 24,700 acres. It occurs mostly along the south side of the Cimarron River. Important areas, however, are west and north of Lawrie. There are a few small areas along Cottonwood Creek and its tributaries south and west of Guthrie. The landscape is mostly nearly level to rolling prairie upland, but there are some flats that are remnants of an earlier terrace.

The Teller soils are on slopes. They are deep-brown very fine sandy loams with a slightly developed clay loam subsoil. The Minco soils are similar to the Teller, but they lack the horizon development of the Teller. In addition, the subsoil contains no more clay than the surface layer. The Vanoss soils occupy smooth flats. They are dark-brown, nearly level loamy soils with a clay loam subsoil. Bethany soils resemble the Vanoss but are slightly grayer and have a grayish-brown clayey subsoil below depths of 18 to 24 inches. Typical locations of the soils of this association are shown in figure 5.

Soils of Logan County

This section contains a discussion of methods and definitions used in making this soil survey, as well as detailed descriptions of all soils mapped in the county.

Soil Survey Methods and Definitions

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

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

Color is usually related to the amount of organic matter. The darker the surface soils, as a rule, the more organic matter they contain. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

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

Structure, which is the way the individual soil particles are arranged in larger grains and the amount of pore space between grains, gives us clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture.

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.

Parent material is the unconsolidated mass of rock material from which the soil profile develops. It affects the quantities and kinds of plant nutrients the soil may have naturally. Soils from clays, shales, and limestone are usually richer than those from sandy materials, and they tend to retain their natural fertility longer under cultivation.

Other characteristics observed in the course of the field study and considered in classifying the soil include the following: 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 under-

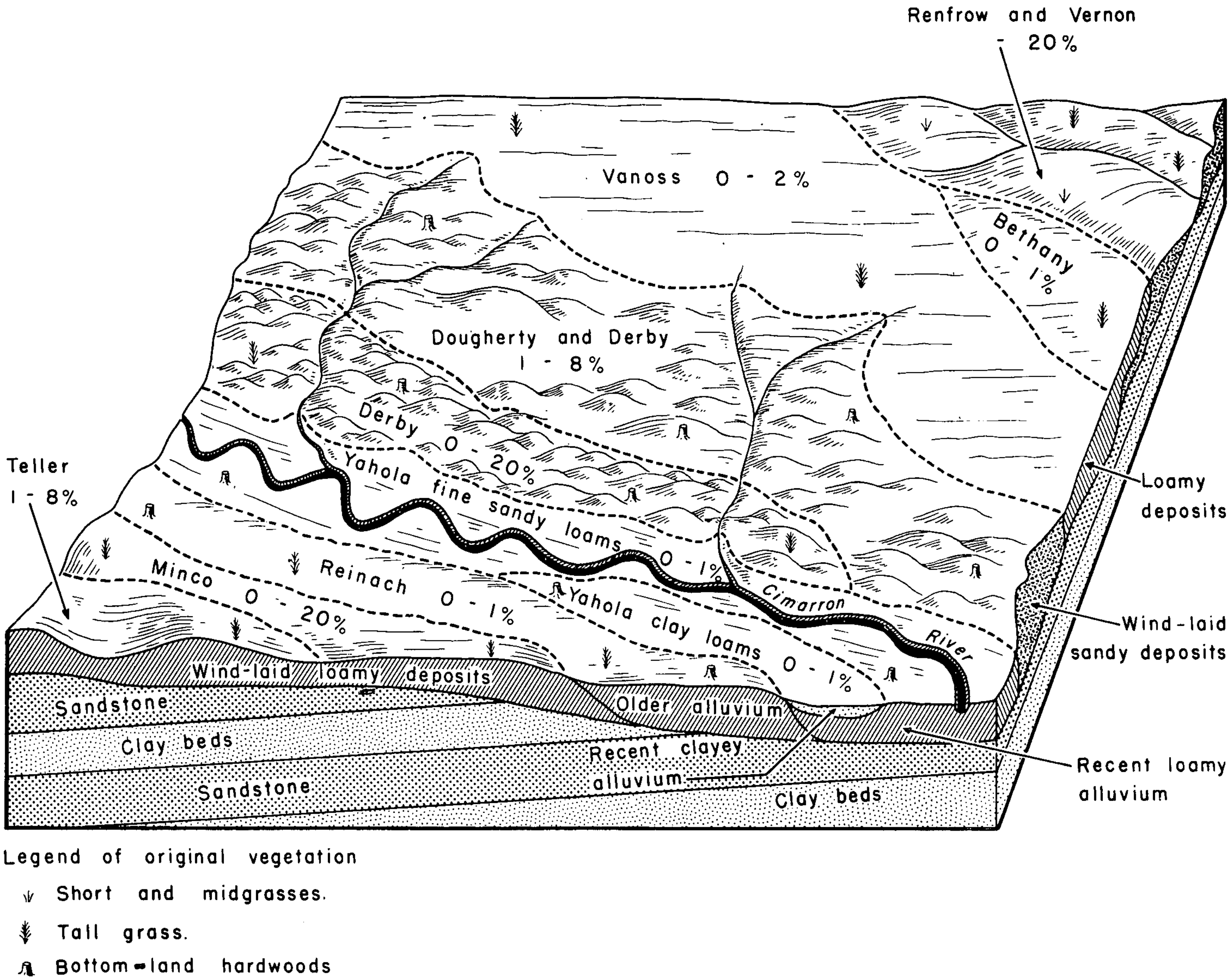


***Figure 5.*—Soils of central and western Logan County on recent alluvium and on loams and sands of Quaternary age. Red beds are exposed in the upper right corner.**

lying parent material from which the soil has developed; surface and internal drainage; and acidity or alkalinity of the soil as measured by chemical tests.

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

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

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

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

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

Miscellaneous land types.—Fresh stream deposits and rough, stony, and severely gullied areas that have little true soil are not classified into types and series; they are identified by descriptive names, such as Sand dunes, Lincoln material.

Undifferentiated soil groups.—Two or more soils that do not occur in regular geographic association may be mapped as an undifferentiated group—a single unit—if the differences between them are too slight to justify a separation. An example is Vernon and Lucien soils, 6 to 20 percent slopes.

Descriptions of the Soils

In this section the soil series, types, phases, land types, and undifferentiated soil groups are described, and their relation to agriculture is set forth to the extent that present knowledge permits. This information will help a farmer, rancher, and agricultural advisor to use the soil map and to learn about the soils of individual farms. Suggestions for soil management and the capability of each soil for several uses are discussed in the section Use and Management of Soils.

Soil scientists, students, or others may wish more specific details about the individual soils, their classification, and their relationship to great soil groups of the world. This information is in a section of this report entitled Genesis, Morphology, and Classification of Soils.

Highway engineers, conservationists, and others who use soil for construction will find helpful information in the section Engineering Properties of the Soils of Logan County.

The acreage and proportionate extent of the soils in the county are shown in table 4.

BETHANY SERIES

The Bethany series consists of friable soils with clay subsoils. They occur as small areas on a mantled upland that is from 30 to 80 feet above the Cimarron River and generally within a few miles of it. Bethany soils resemble the Kirkland but have a deeper layer of friable and permeable material above the clay subsoil. They developed in alkaline silty and clayey earths of alluvial and eolian origin under a cover of tall bunchgrasses. Silt loam is the only type mapped in Logan County.

The surface soil of Bethany silt loam is a dark grayish-brown, granular, friable, silt loam about 10 to 12 inches thick. Below this is a gradational layer of grayish-brown, friable, crumbly clay loam about 6 to 12 inches thick. At depths ranging from 16 to 24 inches is a grayish-brown, moderately compact subsoil.

The soil is slightly acid to medium acid in the upper 2 feet and calcareous below a depth of 3 feet.

Bethany silt loam, 0 to 1 percent slopes (Ba).—This soil occupies nearly level, slowly drained areas in association with the adjoining Vanoss soils. It is generally above the more sloping Teller and Norge soils.

Nearly all this soil is in cultivation. It is used mainly for wheat, but some cotton, grain sorghum, and alfalfa are grown. It is one of the better upland soils, and it is especially good for wheat. Native pasture and meadow on this soil are usually productive.

The soil has good tilth and crusts only moderately. Lime and phosphate are needed for the best growth of alfalfa and sweetclover; phosphate is also beneficial for other crops. On areas with enough phosphorus, nitrogen is beneficial when applied as sidedressing to cotton and as a topdressing to grain.

This soil is in capability unit I–2 and in the claypan prairie range site.

TABLE 4.—*Approximate acreage and proportionate extent of soils*

Soil	Area	Extent
	Acres	*Percent*
Bethany silt loam, 0 to 1 percent slopes	900	0. 2
Chickasha loam, 0 to 2 percent slopes	5, 300	1. 1
Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes	23, 700	4. 9
Darnell and Stephenville fine sandy loams, 8 to 15 percent slopes	30, 300	6. 3
Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded	9, 200	1. 9
Derby loamy fine sand, 0 to 3 percent slopes	6, 600	1. 4
Derby loamy fine sand, 3 to 8 percent slopes	7, 100	1. 5
Derby loamy fine sand, 8 to 20 percent slopes	3, 700	. 8
Dougherty loamy fine sand, 0 to 3 percent slopes	8, 200	1. 7
Dougherty loamy fine sand, 3 to 8 percent slopes	1, 800	. 4
Kirkland silt loam, 0 to 1 percent slopes	9, 400	2. 0
Kirkland silt loam, 1 to 3 percent slopes	11, 200	2. 3
Minco loam, 0 to 3 percent slopes	1, 700	. 4
Minco loam, 3 to 8 percent slopes	2, 900	. 6
Minco loam, 8 to 20 percent slopes	800	. 2
Mixed alluvial land	1, 600	. 4
Noble very fine sandy loam, 1 to 6 percent slopes	8, 300	1. 7
Norge loam, 0 to 3 percent slopes	900	. 2
Norge loam, 3 to 7 percent slopes	1, 300	. 3
Port soils	41, 900	8. 7
Pulaski fine sandy loam	3, 800	. 8
Reinach very fine sandy loam	2, 600	. 5
Renfrow silt loam, 1 to 3 percent slopes	29, 500	6. 1
Renfrow silt loam, 3 to 6 percent slopes	37, 400	7. 8
Sand dunes, Lincoln material	2, 500	. 5
Stephenville fine sandy loam, 0 to 3 percent slopes	1, 500	. 3
Teller very fine sandy loam, 0 to 3 percent slopes	7, 000	1. 5
Teller very fine sandy loam, 3 to 8 percent slopes	6, 300	1. 3
Teller soils, severely gullied	300	(1)
Vanoss loam, 0 to 1 percent slopes	1, 500	. 3
Vanoss loam, 1 to 3 percent slopes	1, 100	. 2
Vanoss fine sandy loam, 0 to 1 percent slopes	5, 400	1. 1
Vanoss fine sandy loam, 1 to 3 percent slopes	2, 300	. 5
Vernon and Lucien soils, 6 to 20 percent slopes	79, 100	16. 4
Yahola clay loam	2, 200	. 5
Yahola very fine sandy loam	4, 000	. 8
Zaneis loam, 0 to 3 percent slopes	17, 600	3. 6
Zaneis loam, 3 to 6 percent slopes	86, 200	18. 0
Zaneis soils, 3 to 8 percent slopes, severely eroded	10, 900	2. 2
Lakes and rivers	3, 300	. 6

[1] Less than 0.1 percent.

CHICKASHA SERIES

Soils of the Chickasha series are moderately dark colored. They occur on ridges and very gentle foot slopes that are underlain by sandy and silty rocks of the Garber formation. They are in the central one-third of the county in a few small prairie openings among trees and in association with the Zaneis soils. Several areas of Chickasha soils occur southeast of Guthrie. Chickasha soils have developed in reddish or brownish sandy shale and sandstone of neutral to alkaline reaction. The native vegetation was tall bunchgrasses. Only one Chickasha soil is mapped in the county.

The surface layer of Chickasha loam is a dark-brown to grayish-brown loam from 8 to 12 inches thick. This is underlain by a dark-brown granular clay loam that extends to depths ranging from 14 to 18 inches. The subsoil is brown heavy clay loam or sandy clay, considerably mottled in the lower part with yellow and red. There are also a few black, shotlike concretions in the subsoil. These concretions are reddish in the lower part of the subsoil.

Chickasha loam, 0 to 2 percent slopes (Ca).—This dark-brown soil occupies very gently sloping, moderately well drained areas on broader ridgetops. It lies above the more reddish, sloping Zaneis soils that extend toward the drainageways. On flat ridgetops, Chickasha soils grade toward the Kirkland, where the underlying rock changes from sandstone to clay.

This soil has good structure and favorable physical properties, is moderately fertile, and responds to management. It is one of the more drought-resistant upland soils. It contains a medium amount of organic matter. Erosion is generally slight and easily controlled.

About three-fourths of the acreage of Chickasha loam is used for wheat, oats, cotton, sorghum, and corn. A small acreage is in native pasture that is usually productive if carefully managed.

Grains and cotton usually require lime and phosphate. If the soil contains enough phosphorus, nitrogen is beneficial if applied as a topdressing to small grains and cotton.

This soil is in capability unit IIe–2 and in the loamy prairie range site.

DARNELL AND STEPHENVILLE SOILS

Darnell and Stephenville fine sandy loams are extensive soils so closely associated that it is difficult to map them separately. They occupy wooded, rolling sandstone uplands that extend from central Oklahoma south into north-central Texas. Early settlers called these areas Cross Timbers, a name that has persisted to the present time. The largest areas of these soils in Logan County occur in the eastern and southeastern parts.

These soils were originally wooded, but they are not good forest soils. The growth rate of the predominant trees—blackjack and post oaks and hickory—is slow. It is doubtful if other species of trees would grow more rapidly on these shallow soils. Many small grassed openings among the trees furnish grazing and enhance the value of these wooded soils.

The high percentage of steep shallow Darnell soils and the cover of scrubby oak trees make this undifferentiated unit poor for crops. Because of steep slopes and shallowness, the soils are difficult to manage. Management problems are some of the most troublesome in the county.

Stephenville fine sandy loam, in areas of sufficient size and importance to be mapped separately, is described elsewhere in this section. It differs slightly from that mapped with the Darnell soils. Fine sandy loam is the only type of Darnell and Stephenville soils mapped in the county.

An undisturbed area of Darnell fine sandy loam has a surface layer of brown friable fine sandy loam that is 3 to 5 inches thick. The subsurface layer, a light-brown to light reddish-brown fine sandy loam, is underlain by reddish sandstone at depths ranging from 8 to 20 inches.

The soil is permeable, but because of shallowness, it does not have a large capacity to hold moisture that plants can use. Outcrops of ledge rock are common, and slabs of loose sandstone are on the surface in places.

In virgin areas, Stephenville fine sandy loam has a dark grayish-brown fine sandy loam surface layer 3 to 5 inches thick. The subsurface layer is a light-brown fine sandy loam. Beneath this layer, at depths of 8 to 12 inches, is subsoil consisting of reddish-brown to red friable and moderately permeable sandy clay loam. The upper two layers are mixed when plowed and are considerably lighter in color. Reddish sandstone underlies the soil at depths ranging from 20 to 40 inches.

Stephenville fine sandy loam is fairly permeable, and the subsoil has good capacity to hold moisture that plants can use. It is moderately drought resistant and is productive if supplied with ample quantities of plant nutrients.

Many areas of Darnell and Stephenville soils once used for row crops are now severely eroded. Many severely eroded areas contain a higher percentage of the deep Stephenville soils than commonly occurs in this undifferentiated group. Severely eroded fields usually are lower on the slopes and are damaged by runoff from adjoining shallow, rocky hillsides. The Darnell and Stephenville soils should be kept friable and porous to help absorb moisture.

Bluestem grasses under the oaks will spread if trees are thinned and grazing is controlled. The overstory of brush and trees can be killed through the use of chemicals. However, these shallow soils will not produce as much forage year after year as the deeper, more productive soils.

Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes (Da).—This mapping unit consists of the smoother parts of the wooded, mixed shallow and deep sandstone soils occupying the broader ridgetops. About 65 percent is Darnell soil, 25 percent is Stephenville, and 5 percent is Lucien and Vernon. Narrow areas of Pulaski and Noble soils near the drainageways, as well as small prairies of Zaneis soils on the uplands, occur in association with this mapping unit and make up 5 percent of the mapping unit.

Most areas of this undifferentiated group are grazed, but at a low rate of stocking. Open grassy areas generally furnish fair pasturage. About one-third of the deeper soil areas have been cleared, and some of them have been cultivated. Bulldozers and chemicals are used to clear brush. The brush, however, sprouts from the roots and is a constant problem. Most areas suitable for cultivation have been cleared.

This mapping unit is in capability unit VIs–2 and in the sandy savanna range site.

Darnell and Stephenville fine sandy loams, 8 to 15 percent slopes (Db).—This mapping unit consists of the rolling to hilly parts of the wooded, mixed shallow and deep sandstone soils on slopes and in narrow valleys. Most areas are in southeastern Logan County. This unit has more rock outcrop and shallow soil than Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes.

Darnell soils make up about 80 percent, Stephenville about 10 percent, and Vernon, Lucien, Zaneis, and Noble soils about 10 percent of this unit. Most of the deep Stephenville, Noble, and Zaneis soils are on lower slopes where gradients are less than the 8- to 15-percent range that is common for most of the mapping unit.

Some of the steeper acreage has been cleared for pasture, but little of it has been in cultivation. A few fields were cultivated on the deeper soils, but most of them have been abandoned to grass and brush because of their small size, erosion, and lack of fertility.

This undifferentiated group is widely used for grazing, but it can support only a low rate of stocking. Grassy openings among the trees furnish fair grazing. Forage is generally best in May and June and becomes poorer in summer because trees use the soil moisture. Many farmers save the grass in these areas for winter use. Oak mast is sometimes plentiful enough to support a few hogs. Little or none of this soil is suitable for crops.

This mapping unit is in capability unit VIs–2 and in the sandy savanna range site.

Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded (Dc).—This mapping unit consists of mixed shallow and deep sandstone soils that have been severely gullied and eroded and are no longer suitable for cultivation. Most of the acreage is on lower slopes within other areas of Stephenville and Darnell soils. Some, however, is on the smoother ridgetops, where it occurs as rims around Stephenville fine sandy loam, 0 to 3 percent slopes.

This mapping unit is dissected at intervals of 50 to 150 feet by narrow V-shaped gullies 1 to 5 feet deep. Areas between the gullies are similar to other cultivated areas of Stephenville soil. Galled spots are common where sandstone is close to the surface. Layers of fine sandy loam range from a thin film to 10 or 12 inches in thickness; they vary considerably from place to place.

The material eroded from this mapping unit has accumulated along the base of the slopes extending from sandstone uplands and also in the narrow bottom lands occupied by Pulaski soils. Many narrow areas of Noble soils are included with the larger areas of severely eroded Darnell and Stephenville soils. There is but little difference in these soils and the severely eroded Zaneis soils.

Tall grasses invade these soils readily and heal all but the steep walls of gullies and the most clayey galled areas (fig. 6). These areas generally need additional treatment. The first invading grasses are often coarse and of low palatability. The improvement of pastures on these soils generally requires a high investment in seed, tillage, and fertilizers. Bermudagrass grows well if fertilized, but careful management is required to make it grow and produce forage on the gullied and galled areas. The first step in improvement of these soils is to prevent further gully erosion by diverting runoff to safe waterways.

This mapping unit is in capability unit VIIe–1 and in the eroded sandy savanna range site.

Figure 6.—**Grass reseeding naturally on old fields occupied by Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded. Soil is still eroding between clumps of grass.**

DERBY SERIES

The Derby series consists of loose sandy upland soils that do not have clayey subsoils. They occur as sandy strips bordering the major streams in central Oklahoma. These strips are gently undulating to dune covered. The least sloping areas are on smooth ridges and in broad swales between the dunes; the steepest areas have the most dunes.

In Logan County Derby soils are closely associated with Dougherty loamy fine sand and Vanoss fine sandy loam. Most of the Derby soils lie north of the Cimarron River in the vicinity of Crescent, but some areas are as far east as the Payne County line. Tall grasses and scattered oaks were the original vegetation. Many areas are now brushy. Loamy fine sand is the only type of Derby soil mapped in the county.

The surface layer of Derby loamy fine sand is brown or grayish-brown loamy fine sand from 5 to 8 inches thick. This layer grades to a light-brown to reddish-yellow, loose loamy fine sand that is several feet deep. The sands have been deposited by wind.

The thickness of the surface layer ranges from 4 to 12 inches. It is thickest in the gently sloping interdune area where the upper soil layer is darkened in small spots to depths of as much as 20 inches. Derby soils with darkened surface layers 10 inches or more in thickness resemble the Pratt soils, which are not mapped separately in this county but are very important in counties west of Logan. The surface layer is darkened to greater depths than in the more strongly sloping phases of Derby loamy fine sand. Tillage or the accumulation of sands from other areas has made the color of the surface layer lighter than that of the layer below.

Water erosion has not been active on the very porous soils of this series, but many areas have been damaged by wind erosion. Organic material in the surface layer helps these soils hold moisture and provides available plant nutrients. When the organic material is lost, the soil is less fertile and becomes more droughty. Sand accumulates near the place from which it was blown. Blowing sand damages growing crops. Derby soils are hard to manage, and their use varies considerably from place to place.

Derby soils in large areas should not be tilled as single fields unless protected by a natural windbreak or by the use of strict measures to control wind erosion.

Derby loamy fine sand, 0 to 3 percent slopes (Dd).—This soil occupies undulating to billowy topography containing few if any dunes. It occurs on fairly broad flats in the vicinity of Crescent and adjacent to a more sloping belt of Derby soils along the Cimarron River. Small areas of this soil occur between the sloping and the dune-covered parts of the Derby soils.

Droughts damage crops on this soil nearly every year. Deep-rooted crops are damaged least. The subsoil is porous and has a low capacity to hold available moisture; consequently, crops depend on summer rains for moisture.

Most of the acreage is in cultivation and is used for sorghum, alfalfa, cotton, and truck crops. Yields are moderate to low, depending on the amount of moisture received during the growing season, the fertility of the soil, and the wind damage. Small grains are not widely grown, except as winter cover and green manure.

Wind erosion damages crops and drifts the soil into roads, ditches, and fences. Wind velocities are highest late in winter and early in spring. A mulch or a cover of growing small grain is needed to protect the soil from blowing. Rye and vetch are an effective winter cover and are good green-manure crops if summer crops are to follow. Their vigorous early growth protects them from wind damage. Row crops should be grown in strips alternating with sorghum and at right angles to the prevailing winds.

Most crops respond to phosphate if it is applied before planting. Alfalfa needs topdressings of phosphate; it sometimes can be grown without additional lime. Row crops benefit from phosphate and nitrogen in moist seasons.

Derby loamy fine sand, 0 to 3 percent slopes, is in capability unit IVs–1 and in the deep sandy savanna range site.

Derby loamy fine sand, 3 to 8 percent slopes (Dg).—This soil occupies undulating to gently rolling terrain containing some low dunes. The loose sands and low dunes make tillage and the use of power equipment difficult.

More than 50 percent of this soil was once in cultivation. Much of it is now idle or in weeds or tall grass. The rest is mainly covered by an open to heavy growth of scrub oak. Tall grasses that once grew vigorously have generally thinned out because of the heavy grazing. According to reports, the area in trees has increased greatly since settlement.

Water erosion seldom damages this soil. Wind erosion is a serious problem, but little of the soil is so badly blown that it would require special management if used for crops. However, the soil is not suitable for cultivated crops. Yields are poor except in seasons of well-distributed rainfall. Little residue is provided by crops to protect the soil in winter. The soil has little capacity to hold water that crops can use. The darkened surface layers are only about 5 to 7 inches thick.

The best use for this soil is for forage crops or permanent pasture. The native grasses are hard to maintain under heavy grazing. Bermudagrass can be used in pastures that are heavily grazed, but its general use is not advisable, because of the droughtiness of the soil. Brush is always hard to control, but the use of chemicals may be feasible in some places.

Small grains and vetch need phosphate; bermudagrass needs phosphate and nitrogen for best growth.

This soil is in capability unit VIs–1 and in the deep sandy savanna range site.

Derby loamy fine sand, 8 to 20 percent slopes (Dh).—This soil is on strong slopes. It consists of dune-covered areas not suitable for cultivation. Many areas are near the Cimarron River flood plain or within a mile of it. Included with this soil are many small areas of lesser slope and some areas of steep Dougherty loamy fine sand.

Wind erosion occurs where the vegetation is thin or absent. Most of the soil moved is blown from the sides and tops of dunes. Grass or oak should cover this soil to prevent erosion. Heavy grazing is not practical, even in years of well-distributed rainfall.

Only a very small percentage of this soil has ever been cultivated, and most of this is now idle. This soil is mainly in native tall grasses and is used for grazing. About one-half the grassland is seriously invaded by oaks and brush. Chemical control may be practical in some areas.

This soil is in capability unit VIs–1 and in the deep sandy savanna range site.

DOUGHERTY SERIES

Soils of the Dougherty series are moderately extensive, forested soils occurring in belts of sandy uplands. Most of the Dougherty soils are in the vicinities of Crescent and Lawrie. The parent materials are old alluvium and wind-modified sands from the Cimarron River.

The native vegetation was a savanna type of scrubby post and blackjack oak and a ground cover of tall grasses. Cutting of trees often resulted in a dense growth of sprouts without undergrowth. Trees grow slowly and are of poor quality. The soils and climate, however, are suitable for fruit trees and for woodland plantings that will produce fence posts. Loamy fine sand is the only type mapped in the county.

In virgin areas, Dougherty loamy fine sand has a dark grayish-brown to brown loamy fine sand surface layer 4 to 7 inches thick. This layer is underlain by a light-brown, structureless loamy fine sand that grades to a reddish-brown sandy clay loam at depths ranging from 18 to 22 inches. This material is yellowish red and more sandy below depths of about 36 inches, and it grades to a fine sandy loam parent material at a depth of about 48 inches.

In some areas the surface layer is a light fine sandy loam. Cultivation and loss of organic material have changed the surface layer from dark grayish-brown to brown or light brown. The thickness of sandy material over the sandy clay loam subsoil ranges from 15 to 30 inches. The widest range in thickness of the loamy sand occurs in areas nearest the Cimarron River that are surrounded by Derby soils. The variation in this layer probably has been caused by shifting of the sands by wind and by continuous additions of materials from the channel of the Cimarron River.

Water moves readily through the soil and penetrates deeply during moist seasons. Since Dougherty soils absorb the small amounts of rain that fall during summer, they produce summer crops successfully.

Wind erosion and gullying are two serious hazards on Dougherty soils. Wind erosion occurs late in winter and early in spring unless the soil is protected by a growing crop or a mulch. Gully erosion must be prevented because the soil has no hard layer or substratum to resist cutting. Large areas of the steeper Dougherty soils are badly eroded and no longer used for crops. Erosion in these areas must be controlled by the use of close-growing crops or grass, as contour cultivation is not practical.

Bluestem grasses spread over the ground if the competing overstory of scrubby oaks is removed and grazing is limited for 1 or 2 years. As a result of overgrazing, the soil is seriously depleted and even newly cleared areas are eroded.

Dougherty loamy fine sand, 0 to 3 percent slopes (Dk).—This soil occurs on undulating ridges above the steeper Dougherty soils. In many places it is adjacent to Vanoss fine sandy loam. Areas of Derby loamy fine sand occur nearby in some places. They differ from Dougherty loamy fine sand mainly in having more dunes and in lacking a well-developed sandy clay loam layer.

Wind causes more erosion on this soil than water. In winter and spring, wind readily erodes this soil unless it is covered by crop residue or a growing crop of small grain. Rye and vetch are effective in preventing erosion in most years, and they can be plowed under for green manure before sowing a summer crop. Materials blown from this soil may seriously damage crops on adjacent fields or accumulate as drifts in county roads and highways.

Crusting and poor tilth are also problems on this soil. Moisture is readily absorbed, and the soil has a good capacity to hold moisture that plants can use. This soil is suitable for alfalfa, grasses, and other deep-rooted crops.

A large acreage of this soil is used for growing feed, small grains, melons, and fruits; some is used for cotton and alfalfa. Yields are generally moderate. The lack of organic matter is probably the chief cause of low production in most years.

A good practice on this soil is to grow row crops and grain sorghum in alternating strips that run at right angles to the prevailing winds. Small grains respond to phosphate; row crops benefit from additions of phosphate and nitrogen.

This soil is in capability unit IIIs–1 and in the deep sandy savanna range site.

Dougherty loamy fine sand, 3 to 8 percent slopes (Dm).—This soil occupies wavy to billowy terrain, mainly in association with Dougherty loamy fine sand, 0 to 3 percent slopes, and the Teller and Derby soils. This soil is lighter colored and more sandy in the upper part than the Teller soils. It differs from the Derby soils in having a sandy clay loam subsoil and fewer dunes. Other areas occur along the slopes that border drainageways some distance from the flood plain.

Some areas have been cultivated, but they have been abandoned to grass because of erosion and depletion of plant nutrients. Native grasses usually grow fairly readily after cultivation is discontinued. Wind and water erosion damage this soil. Gully erosion is a hazard because the soil is very friable and offers very little resistance to scouring.

Inadequate organic matter is often the cause of poor tilth and surface crusting. The soil has a good capacity to hold moisture that plants can use.

This soil is used for sorghum, small grains, melons, and orchards. A few areas are used for row crops and alfalfa. Yields are moderate to low. They are limited mainly by the low content of organic matter and the lack of moisture. The soil responds to management, and all cropping systems should include moisture-conservation practices. Contour cultivation is not always possible because of the irregular slopes.

The use of small grains and legumes as green manure benefits the soil. They can be plowed under most years before planting summer crops. The soil is well suited to deep-rooted crops.

Permanent pastures of tame grasses and legumes are of much more value than the usual native grasses. Winter pastures consisting of small grains and vetch are well suited to this soil.

Phosphate improves the growth of small grains and vetch, and nitrogen and phosphate are needed for the best growth of row crops.

This soil is in capability unit IVs–1 and in the deep sandy savanna range site.

KIRKLAND SERIES

Soils of the Kirkland series occur on the smooth ridges and nearly level foot slopes underlain by red clay beds in the western one-third of Logan County near Marshall and Navina.

The native vegetation consisted of tall grasses mixed with mid grasses and short grasses. This mixture of grasses now occur only in meadows. The tall grasses have disappeared from the over-grazed pastures, and only the mid grasses, short grasses, and weeds remain. Silt loam is the only type of Kirkland soil mapped in this county.

Unplowed areas of Kirkland silt loam have a surface layer of dark grayish-brown or dark-brown granular silt loam about 10 to 14 inches thick. This rests on or grades to a dark grayish-brown or dark-brown, blocky, firm clay or claypan. The upper part of the clay layer is high in organic matter. Below 24 inches the color in many places is browner and the clays more blocky. Below depths of 30 to 40 inches the color of the profile grades to brown and reddish brown and resembles the color of the parent clays. The subsoil merges with parent red clays so gradually that it is difficult to determine the depth to which the soil has developed.

The upper 2 feet of the profile is acid, and the deeper subsoil is neutral to alkaline. Concretions of fine lime generally occur below a depth of 3 feet.

On some nearly level areas the permeable layers over the claypan are thicker than those in the profile described, and the soil grades toward the Bethany series or, as mapped, includes small areas of Bethany soils. When the underlying rock is sandy, the Kirkland soils grade toward the Chickasha soils.

Cultivation has not greatly changed the color of Kirkland soils except in eroded areas where the brown subsoil has been brought to the surface by plowing. Fields containing light brownish-gray slick spots have a lighter color than other fields.

Erosion is a serious hazard on the more sloping Kirkland soils. The chief losses of soil occur through sheet erosion and the formation of galled spots. Deep gullies seldom form. The steeper Kirkland soils and those grading toward the Renfrow soils have been seriously damaged by erosion.

Water moves through the Kirkland subsoil very slowly. When the Kirkland soils are in good tilth, the first ½ to 1 inch of rain will penetrate the soil readily and fill the layers above the claypan. Water then soaks in very slowly. Heavy storms cause much runoff, and the water trapped above terraces may remain on the surface for days and make cultivation difficult.

Kirkland soils are not well suited to summer crops. If there is no moisture in the surface soil, plants may not be able to draw enough water from the subsoil, even though it is fairly moist.

Kirkland silt loam, 0 to 1 percent slopes (Ka).—This soil occurs on nearly level uplands. Slopes are nearly level to slightly convex, and there is adequate drainage for all crops suited to these soils. A few spots may be wet for a long time following rains. Some shallow circular depressions on the surface may hold water until it evaporates. In plowed fields these depressions are the slowly drained spots, and under continuous cultivation they tend to develop into slick spots on this soil. However, the amount of available moisture is often insufficient for summer crops.

Erosion is not a serious problem. All practical methods are needed to increase the intake of water in order to utilize the large storage capacity of this soil. Contour cultivation and plowing in of crop residues should be practiced to keep the soil porous and to prevent crusting and sealing of the surface. Double cropping is seldom if ever a good practice on this soil.

Most of this soil is used for small grains; some is used for cotton. Alfalfa is grown where the soil is deepest over the claypan. Small grains respond to phosphate; row crops benefit from phosphate and nitrogen. Lime is needed for sweetclover and alfalfa.

This soil is in capability unit IIs–1 and in the claypan prairie range site.

Kirkland silt loam, 1 to 3 percent slopes (Kb).—This soil occurs on gentle slopes around the edges of broad ridges and along nearly level foot slopes. It often occurs as a rim around the heads of drainageways. On stronger slopes it grades toward the Renfrow.

Because of erosion, surface colors are slightly less dark and the permeable surface layers are slightly less thick than in Kirkland silt loam, 0 to 1 percent slopes. Erosion is usually a serious hazard because the subsoil is slowly permeable and the surface soil tends to puddle and to wash.

After continuous cultivation and the loss of organic matter, slick spots are common. These may form around the contour of an area like beads on a necklace and reveal a particular band or layer of rock.

Most of this soil is used for wheat, but sorghum is grown for forage and feed. When the supply of moisture is favorable, some of the acreage is used for cotton. Summer crops are good in seasons of above-average rainfall, but some drought occurs every year to lower the yields. Double cropping is a poor practice, and it will not pay over a long period. Alfalfa is grown on a few areas. Eroded areas at the heads of drainageways are in grass that was planted or that seeded from natural sources.

Contour cultivation and stubble mulch tillage should be used to keep the soil porous and improve the infiltration of moisture. Terraces are useful in controlling runoff from land in row crops.

Small grains will generally respond to phosphate; row crops usually need nitrogen and phosphate. Sweetclover or alfalfa can be grown successfully only after additions of lime and phosphate.

This soil is in capability unit IIIe–2 and in the claypan prairie range site.

MINCO SERIES

Soils of the Minco series occupy uplands adjoining the flood plains of the Cimarron River. The largest areas are on the south side of the river west and northwest of Guthrie. Minco soils occur in association with Teller soils but have less clayey, more permeable subsoil. The two soils are much alike on the surface. Minco soils grade to Teller soils, which have clay loam subsoils. In places they grade to the darker Vanoss soils, which have a brown to yellowish-brown clay loam subsoil. Sloping Minco soils in places join the level Reinach soils that occupy low terraces bordering the flood plains of the Cimarron River. The Minco and Reinach soils are similar in profile, except that the Reinach is redder and is calcareous in the upper 30 inches. Reinach soils have little runoff and are usually better supplied with moisture than the Minco. Minco soils have developed under tall grasses in recent silts and fine sands that were blown from the flood plains of the Cimarron River. Loam is the only type mapped in Logan County.

Minco loam has a dark-brown permeable loam surface layer 14 to 18 inches thick. This overlies a reddish-brown or brown porous loam to silt loam that in most places is light brown below a depth of about 40 inches. There are many pores and pinholes, and the entire soil is well drained.

Minco soils on slopes of less than 8 percent are largely in cultivation, and, where organic matter has been depleted, the surface soils are light brown.

Erosion in a few areas has exposed the reddish subsoil. Gullies have formed on some of the steeper slopes. Prevention of gullies is necessary, as they erode deeply.

Minco soils are valuable for summer crops because moisture is readily absorbed, and the deep subsoil has a good capacity to hold moisture that plants can use. Some of the stronger slopes are in tall-grass pasture and meadow.

Minco loam, 0 to 3 percent slopes (Ma).—This soil usually occurs between Minco loam, 3 to 8 percent slopes, and the Vanoss or Teller soils. Slopes are convex and allow ample surface drainage.

Erosion is not a serious hazard on this soil. All cultivation should be along the contour to conserve soil and moisture. A few fields are level enough to be farmed without contouring. Wind erosion in the winter and spring months can be controlled by cover crops of small grain and vetch.

This soil has a large capacity to hold water that plants can use. Deep-rooted crops that are able to reach deeply for moisture can endure long droughts.

Most of this soil is used for wheat, other small grains, corn, sorghums, and alfalfa. Yields are generally moderate to good; those of small grain are most dependable. Yields of corn depend mostly on moisture, and they vary considerably from year to year. Those of sorghum and alfalfa are generally more dependable. Some cotton is grown, but the acreage is small.

This soil responds well to management. Small grains and alfalfa will generally respond to phosphate; row crops respond both to phosphate and to nitrogen.

This soil is in capability unit IIe–1 and in the loamy prairie range site.

Minco loam, 3 to 8 percent slopes (Mb).—This soil occurs along the outer slopes covered by silt and fine sand and along drainageways sloping toward the Cimarron River flood plain. Slopes are strongly convex; they average from 5 to 6 percent. Drainage is excessive. Sheet and gully erosion occur unless the soil is protected.

Much of the rain is lost as runoff, but the soil has a high capacity to hold moisture that plants can use. Management should include stubble mulching or other practices that keep the soil porous, prevent runoff, and improve the infiltration of moisture.

Much of this soil is used for small grains, livestock feed, and alfalfa. A small acreage is used for corn and cotton. Yields depend upon the availability of moisture and the condition of the soil; they range from moderate to low. Reduced yields are noticeable on areas that have lost surface soil and are low in organic matter.

This soil responds to management. Mixtures of small grains and legumes used as green manure are beneficial in years of ample moisture. Because of good moisture relations, this soil is more suitable for summer crops than the more clayey sloping soils. It is well suited to alfalfa and other deep-rooted crops. The late summer growth of alfalfa should be left as a cover to protect the soil in winter.

Areas of this soil no longer in cultivation generally reseed rather quickly to native grasses. Bermudagrass is well adapted, and it grows well if properly fertilized.

Small grains respond to phosphate; row crops generally need both phosphate and nitrogen. Some lime will be needed for alfalfa.

This soil is in capability unit IIIe–1 and in the loamy prairie range site.

Minco loam, 8 to 20 percent slopes (Mc).—This soil is on narrow dissected areas and low escarpments. It occurs among other Minco soils or between the gently sloping Minco soils and adjoining flood plains. The profile differs from that described for the Minco series in having a thinner brown loamy surface soil. The surface layer is only 6 inches thick in places and is lacking in some eroded areas.

This soil is too steep for cultivation, and most of the acreage is in grass. Oak trees are scattered over some areas. Runoff is rapid and likely to cause erosion. Natural drainageways have formed V-shaped courses in this soil.

A good stand of close-growing plants is needed to furnish mulch and to protect the soil. Water that accumulates above terraces will form gullies if released on ungrassed areas. If the surface is kept porous, this soil has a high capacity to absorb moisture and to hold it for plant use.

The vigor and density of native grasses usually can be improved by grazing control. Areas that are to be heavily grazed should be planted to bermudagrass to form a close sod. Fertilizers are needed to produce successful growth. In some seasons it is profitable to seed legumes or bermudagrass over the grazed areas.

The soil is in capability unit VIs–1 and in the loamy prairie range site.

MIXED ALLUVIAL LAND

This land type is on the flood plain of the Cimarron River. It is 5 to 10 feet above the normal water level, and it occurs where soil materials are subject to movement during channel changes of the river. Most areas have probably been altered appreciably within the past 50 years. They have been scoured or filled somewhat by each flood since that time. These soil materials have not developed well-defined characteristics in the short time they have been in place. Surfaces are irregular, and usually have ridges from 2 to 4 feet higher than the intervening swales. All materials are stratified, and the texture ranges from loamy sand to silty clay. Most areas are flooded too often for cultivation.

This land type is an irregular pattern of low, loamy sand dunes and intervening smoother areas consisting of sandy loams and silt loams. In addition, slight depressions or swales occur that are filled with stratified clay loams, loams, and clays. The dunes and swales were parallel to the river at the time they were formed, but they may not bear any relation to the present direction of flow.

This land type includes some bare riverwash, but most areas are fairly well covered by coarse tall grasses and johnsongrass. Clumps of sandplum and other brush are on the low sandy ridges. Swales are often covered with smartweed, and the very sandy flats may be covered by tamarisk. The least disturbed inner edges sometimes contain a scattered stand of cottonwood trees and, in the low moist places, a brushy growth of willow.

Mixed alluvial land (Md).—This land type is moderately extensive along the channels of the Cimarron River, and it occurs a few feet lower in elevation than the tillable Yahola soils. An area of this land type is at the mouth of Skeleton Creek, east of United States Highway 77 and north of Guthrie.

This mapping unit may be wet for considerable periods after heavy rains or floods, and its use as cropland is very limited. It is best suited to grazing and as a refuge for the wildlife that gets food and water in the river area. Extensive cultivation should not be attempted, but some of the smooth, well-drained areas are cropped during favorable seasons along with the higher areas of Yahola very fine sandy loam.

Areas that are not overflowed too often can be used for growing locust and catalpa trees for fence posts. Sites on which excessive sanding or silting occurs should not be selected for trees.

This land type is in capability unit Vw–1 and in the sandy bottom-land range site.

NOBLE SERIES

The Noble series consists of young soils formed on deep reddish sandy deposits that have weathered from sandstone or washed from soils on the slopes above. They occur on the foot slopes of shallow valleys in the sandstone uplands, generally in long narrow tracts. Most areas are in the southeastern part of the county.

These soils in most places have a thin stand of scrubby oak and a moderately good cover of tall grasses. Noble soils below the Zaneis are often treeless. Very fine sandy loam is the only type mapped in Logan County.

Noble very fine sandy loam has a dark-brown to dark reddish-brown, granular very fine sandy loam or loam surface layer 8 to 10 inches thick. This layer grades with depth to dark reddish-brown very fine sandy loam. This material is red at a depth of about 18 inches, and it extends to depths of several feet.

Noble soils usually merge with the Pulaski soils and are used for the same kinds of crops. Most of the cultivated Noble soils have been damaged by erosion, but moderate losses have not impaired their use for crops. Gully erosion is a serious hazard, because the soil is deep and friable and has no firm subsoil to resist cutting.

Noble very fine sandy loam, 1 to 6 percent slopes (Na).—This soil occupies gentle to moderate foot slopes below the Darnell and Stephenville fine sandy loams, and above the Pulaski soils of the bottom lands. The Noble profile is porous and permeable.

This soil readily absorbs water if kept in good tilth. However, much rain is lost as runoff from the steeper slopes. Crops respond well to light rainfall. The soil has a good capacity to hold moisture that plants can use.

Most of this soil has been in cultivation, but some of it has been abandoned and is now covered by tall grasses or weeds. Small grains are the most commonly grown crops, but small acreages of cotton, alfalfa, and grain sorghum are also grown. Many areas are planted to small grain and vetch and used as winter pasture.

The supply of plant nutrients is low, but the soil responds to management. Phosphate and potash are needed for small grains, forage crops, and legumes. Summer crops usually benefit from additions of nitrogen. When there is plenty of moisture, the yields of small grain can be improved by adding nitrogen.

Rye and vetch can be used as green manure and, if properly handled, will leave a trashy residue that helps prevent runoff and erosion.

This soil is in capability unit IIIe-1 and in the sandy savanna range site.

NORGE SERIES

Soils of the Norge series developed under native grass from alluvial or eolian deposits that cover the country rock. They have well-developed clayey subsoils. Norge soils resemble the Zaneis. They have about the same permeability and are suitable for similar crops. The Norge soils, however, have less variation from place to place than the Zaneis. The main areas of Norge soils are in the southwestern part of the county along Cottonwood Creek between Navina and Guthrie. Loam is the only type mapped in this county.

The surface layer of Norge loam is about 8 inches thick and consists of a dark-brown loam that grades to a reddish-brown, permeable, granular clay loam. At depths of 15 to 18 inches, this layer grades to a coarse granular to slightly blocky reddish-brown silty clay that is firm and slowly to moderately permeable. At a depth of about 24 inches, this material is red, and at depths of 30 to 36 inches it grades to a red clay loam. Where the deposits overlie clay beds or sandstone, coarse grains of sand and a few pebbles are in the lower part of the profile.

The thickness of the surface loam ranges from 6 to 12 inches, whereas that of the subsurface clay loam ranges from 3 to 10 inches.

Gully erosion is a hazard on the stronger slopes, as the subsoil does not resist cutting. A few areas of this soil are eroded, but little of the acreage has been taken from cultivation.

The Norge soils are mostly in cultivation and in native meadow. They have a good capacity to hold moisture that plants can use and are suitable for summer crops in seasons of average rainfall.

Norge loam, 0 to 3 percent slopes (Nb).—This soil occurs on gently sloping ridge crests where the alluvial mantle is thickest. Generally it grades toward the Renfrow or Zaneis soils in the direction away from the stream. On the stronger slopes surrounding ridge crests are areas of Norge loam, 3 to 7 percent slopes, or areas of the sloping Zaneis or Renfrow soils.

Most of this soil is used for small grain and sorghum. A few acres of alfalfa and cotton are grown. Yields are generally moderate to good, but the yields of small grain are most dependable. If rainfall is well distributed, the yields of summer crops are good. Alfalfa and other deep-rooted crops grow well on Norge soils because they are able to utilize subsoil moisture.

Contour cultivation and tillage that leaves ample surface residues are good practices for conserving soil and water. Small grains and legumes usually produce good winter pastures. In seasons of ample moisture, a mixture of a small grain and a legume can also be plowed under as green manure before planting summer crops.

Norge soils respond to management. Small grains and alfalfa need phosphate for highest yields; row crops generally respond to phosphate and nitrogen. Alfalfa needs lime.

This soil is in capability unit IIe-2 and in the loamy prairie range site.

Norge loam, 3 to 7 percent slopes (Nc).—This soil occurs on slopes that border Cottonwood Creek and other large streams. It usually occurs adjacent to the ridge crests occupied by Norge loam, 0 to 3 percent slopes. It may also grade into the sloping Renfrow and Zaneis soils that have developed on the country rocks where the stream alluvium has been stripped away.

The loam surface layer is from about 4 to about 8 inches thick, and the clay loam subsurface layer is usually not more than 3 to 6 inches thick. Reddish-brown silty clay subsoil merges into rocks of the redbeds at depths below 24 inches, but this layer is generally uniform to depths of 48 inches or more.

Much water is lost by runoff from this soil. The use of stubble-mulch tillage, contour cultivation, and terraces will increase infiltration.

Much of this soil is still in native meadow and pasture. The cultivated part is used for small grains and livestock feed. Alfalfa can be grown successfully in a few areas. Yields of crops are moderate, but they vary somewhat according to degree of slope and thickness of the remaining surface soil.

If near a source of seed, abandoned fields quickly reseed with native grasses. Bermudagrass will grow well if properly fertilized. Alfalfa makes a good cover if the late growth is left to protect the soil in winter.

This soil responds to good management that includes use of fertilizers and practices that conserve soil and moisture. Yields of small grains and alfalfa are improved by phosphate fertilizer; row crops need phosphate and nitrogen. Alfalfa needs lime.

This soil is in capability unit IIIe-1 and in the loamy prairie range site.

PORT SERIES

Soils of the Port series have formed in loam and clay loam sediments that washed from the prairie uplands. These sediments have been deposited over a long period. The Port series occurs on the flood plains of Beaver, Skeleton, Cottonwood, Bear, and Fitzgerald Creeks and other creeks tributary to the Cimarron River. It is associated with the sandier Pulaski soils that occupy dikes and narrow areas that receive additional sandy sediments from adjoining uplands. The Port series has developed under a mixed hardwood forest having an understory of tall grasses.

The texture of the surface soil ranges from silt loam to clay loam. One mapping unit, Port soils, has been recognized.

The dominant soil in the Port soils mapping unit is a noncalcareous to slightly acid, dark-brown or dark reddish-brown, heavy silt loam or light clay loam 2 to 3 feet thick. Below depths of 24 to 36 inches, the soil color is reddish brown.

In places the Port soils are more highly stratified with materials of many textures. Dark-brown layers representing old surface soils occur at various depths.

The level and most clayey Port soils occur on flood plains that receive sediment from the clayey uplands. Here, Port soils are commonly granular silty clay loam somewhat stratified with loam. In a few places these soils have slowly permeable bands of silty clay deep in the profile. Water accumulates on the surface of these level areas and soaks in to moisten the soil to considerable depths. These areas of silty clay loam contain enough moisture for plants in dry seasons. Stands of alfalfa (fig. 7) are thick on them, but during droughts they thin out on adjacent slightly higher areas of Port loam. Seedbeds, however, are more difficult to prepare on these clay loams. They are too wet to cultivate long after areas of Port loam have dried out. In addition, they are less permeable than the areas of Port loam.

Figure 7.—**Cattle grazing alfalfa on Port soils that occur on bottom lands within areas of Renfrow and Zaneis soils.**

Along the tributaries of some creeks, Port soils include some of the sandy Pulaski soils.

Port soils are moderately fertile. They have good tilth and structure. They are permeable, absorb moisture well, and have a good capacity to supply moisture that plants can use.

Port soils (Pa).—Most areas of Port soils are used for small grains, alfalfa, livestock feed, corn, and cotton. If management is good, yields of most crops are good to excellent. The acreage of cotton varies greatly with the season and expected rainfall. In dry cycles small grains are more widely grown than row crops.

Port soils are suitable for a wide range of crops, including some pasture and forage plants not currently grown. They are well suited to irrigation, but most of the acreage needs levelling if the flood-irrigation system is to be used. Irrigation by the sprinkler system can be done without special preparation of the land. If water is applied, these soils will tolerate much higher rates of fertilization than those used for areas not irrigated.

Moderate applications of phosphate are needed for best yields of alfalfa, and small quantities of lime are beneficial in some areas. Small grains usually respond to phosphate and nitrogen.

Port soils are in capability unit I–1 and in the loamy bottom-land range site.

PULASKI SERIES

The Pulaski series consists of moderately sandy soils that occupy bottom lands in narrow valleys. They occur mainly in the southeastern part of the county in association with the Noble soils that occupy adjoining colluvial slopes. Both of these soils are in the narrow valleys flanked by wooded, hilly Darnell and Stephenville soils. The sediment from which the Pulaski soils developed was washed from the Darnell and Stephenville soils and from the included Zaneis soils in the prairie openings. Pulaski fine sandy loam is the only type mapped in the county.

Pulaski fine sandy loam has a weak granular, reddish-brown fine sandy loam surface layer 12 to 16 inches thick. Below this layer, the material grades to a reddish-brown or red fine sandy loam stratified with thin layers of loam and loamy fine sand. All soil layers are weakly acid.

The colors and the kinds of layers differ from place to place. Color ranges from reddish brown to red, and texture ranges from sandy loam to loam. Recent deposits may be very light colored. Below hillside gullies, a foot or more of red sandy loam has been washed over the surface in many places.

Layers of buried, dark soil are common below a depth of 3 feet. They were darkened by organic matter at an earlier period when the bottom lands were stable. After the uplands were settled, the deposits increased as a result of erosion. Many harmful deposits of sand have raised stream channels and caused frequent local overflows. In addition, the water table has been raised until some areas along the channels now are poorly drained. Evidence of this is the thick groves of willow trees growing in many places along the narrow drainageways.

Pulaski fine sandy loam (Pb).—This soil is used mainly for producing alfalfa, livestock feed, and small grain. A small acreage is used for corn and cotton. Among associated soils, Pulaski is often the only soil in cultivation, and it is used for growing winter feed for livestock. Pulaski soil occurs in protected spots and is suitable for winter pastures of small grains. Many acres are covered with johnsongrass, some of which is mowed for hay. Bermudagrass grows well (fig. 8).

This soil is responsive to good management. Most areas need phosphate to produce the best yields of small grain and both lime and phosphate to grow alfalfa. Growing crops and grasses require nitrogen in addition to phosphate.

Pulaski fine sandy loam is in capability unit I–1 and in the loamy bottom-land range site.

Figure 8.—**Newly cleared Pulaski fine sandy loam prepared for planting of bermudagrass.**

REINACH SERIES

Soils of the Reinach series occur mainly on the rarely flooded high bottom lands. They are generally neutral, reddish silt loams or very fine sandy loams that are calcareous below 30 inches. In Logan County they occur on the low bench along the Cimarron River. They have developed under a lowland hardwood forest having a ground cover of vigorously growing tall grasses. They are darkened to greater depths than the Yahola soils. Yahola soils are nearer the river and at a lower elevation than the Reinach. The hazard of overflow on the Reinach soils is not great. Slopes above the Reinach soils are mostly occupied by Teller and Minco soils. Material washed from the higher lying soils has been deposited along the boundary of the Reinach soils. Very fine sandy loam is the only type mapped in Logan County.

Reinach very fine sandy loam has a weakly granular, neutral, reddish-brown very fine sandy loam surface layer that is 16 to 20 inches thick. This layer grades to a yellowish-red, calcareous very fine sandy loam that extends to depths ranging from 36 to 60 inches.

The depth to calcareous material ranges from 16 to 36 inches. The soil is porous and permeable, and the textures are generally very uniform throughout the profile. However, the textures range from fine sandy loam to silt loam. The profile is not stratified, though those of the adjoining overflowed bottom lands are stratified.

Reinach soils are level, easy to work, and highly desirable for farming. In addition, they readily absorb moisture and respond to management.

Reinach very fine sandy loam (Ra).—This soil occurs mainly along the Cimarron River at Coyle and north of Pleasant Valley and Guthrie. Surfaces are very smooth, and there is little evidence of the low sandy ridges and shallow slightly wet swales that mark the normally overflowed bottom land occupied by the Yahola soils. As a result, tillage is the same over all areas of Reinach very fine sandy loam, and crops have uniform growth.

Most of Reinach very fine sandy loam is used for alfalfa, corn, cotton, small grains, and livestock feed. A few groves of native pecan trees remain from the original forest, but there are few or no areas of native grass. A few small areas are in bermudagrass pasture. The soil is suitable for blue panic, bromegrass, and other tame grasses.

Phosphate usually benefits alfalfa, corn, and cotton, and it will help increase the yield of small grain. When the supply of phosphate is high, row crops and tame grasses respond to additions of nitrogen.

This soil is in capability unit I–1 and in the loamy bottom-land range site.

RENFROW SERIES

Soils of the Renfrow series occur mainly in the northern and southwestern parts of the county. They are on gentle to moderate slopes. Many small areas occur in association with the Zaneis, Vernon, Lucien, and other soils in the central part of the county (fig. 9). Renfrow soils have developed in red clay beds and under a tall grass vegetation. Silt loam is the only type mapped in Logan County.

Figure 9.—**Renfrow silt loam in foreground; Vernon and Lucien soils in background.**

A representative area of Renfrow silt loam under a cover of native tall grass meadow, on 3 percent slopes, has a brown to dark-brown granular silt loam surface layer 8 to 10 inches thick. This layer grades to a dark reddish-brown, coarse granular silty clay loam that is 2 to 4 inches thick. Below this material is a compact, blocky, reddish-brown clay that becomes more reddish below depths of 24 to 30 inches and merges indistinctly with the clay beds below. Small, white concretions of lime are present below 30 inches.

The reaction is medium acid in the upper 2 feet of the profile but is mildly alkaline and calcareous at a depth of 3 feet.

In most places the underlying redbeds are calcareous. They break into cubelike clods and swell and shrink considerably on wetting and drying. Narrow bands of light-gray, finely grained sandstone are locally bedded with clays. In the Hennessey formation, the clays are compacted in places to form weak layers of shale.

Under grass the surface soil colors range from dark brown to dark reddish brown. Most cultivated areas are reddish brown. The thickness of coarse granular silty clay loam beneath the silt loam surface-layer ranges from 1 to 6 inches. This variation causes the permeability to differ from place to place. In the northwestern part of the county there is generally only a thin granular layer between the silt loam surface soil and the blocky clay subsoil. Areas of Renfrow soils that have the thickest granular layer generally adjoin the Zaneis soils.

Where tillage has mixed clay in the subsoil with the silt loam and clay loam, small spots of clay loam are at the surface. Severely eroded and very sloping Renfrow soils have been included with the Vernon and Lucien soils, since they are much like the Vernon and are used the same way.

The movement of water through the subsoil is very slow, and much rain is lost as runoff during all except the most gentle rains. The 10 to 16 inches of granular soil and upper subsoil readily absorb water if surface tilth is good; but, when field capacity has been reached, the infiltration rate is very slow. On slopes greater than 3 percent, erosion has thinned the moisture storage zone and very little water is absorbed from heavy rains.

Runoff and erosion are serious hazards on Renfrow soils and increase with steepness of slope. Slopes of more than 6 percent are generally not suitable for cultivation. On slopes of more than about 4 percent, gully erosion often accompanies severe sheet erosion. Terracing and contour tillage on eroded slopes are not fully satisfactory, for the low places are in the terrace intervals. Water stands in low spots for long periods after rains and makes uniform cultivation or harvesting of fields difficult. The stronger slopes should be in permanent, mulch-producing grasses rather than in row crops.

Renfrow soils are not well suited to summer crops. Unless the subsoil moisture is replenished deeply by snows and by gentle fall and winter rains, summer crops may dry up in midseason when the supply of surface moisture is exhausted.

The native tall grasses thrive best in hay meadows that are not used for grazing. There were many mid grasses and short grasses in the original vegetation. The heavily grazed pastures now consist mostly of gramas and buffalograss mixed with occasional clumps of tall grasses. Trampling and grazing of grass mulch reduce the absorption of water in surface soils, and as a result much of the yearly rainfall runs off. Trampled areas become very much drier, and only the drought-resistant grasses can survive.

Renfrow silt loam, 1 to 3 percent slopes (Rb).—This soil occurs on gentle slopes around the edges of broad ridgetops where Kirkland soils are dominant. It also occurs on narrower ridges surrounded by more strongly sloping Renfrow soils and on some long gentle foot slopes below them. The darker spots within areas of this soil are inclusions of Kirkland soils.

Damage from erosion has been moderate, and subsoil clay is not in reach of tillage implements. Erosion can be readily controlled. Measures should be taken to keep the surface porous enough to absorb rainfall. Slick spots sometimes develop as the supply of organic matter gets low and soil structure deteriorates. Contour cultivation and stubble-mulch tillage prevent runoff and keep the soil surface porous. Terraces control runoff and provide a safe means for it to flow into drainageways.

Most of this soil is used for wheat. Some sorghum and alfalfa are grown for feed; cotton is grown during years of favorable moisture. Many farmers have used rotations of sweetclover and wheat to advantage. The sweetclover protects the soil, encourages absorption of water, and provides a residue of nitrogen that benefits the wheat. A few areas are still in native pasture and meadow. Pastures are usually overgrazed and now consist only of the mid grasses and short grasses.

Small grains generally respond to phosphate; row crops usually benefit from additions of nitrogen if there is enough phosphorus in the soil. Sweetclover and alfalfa need lime.

This soil is in capability unit IIIe-2 and in the claypan prairie range site.

Renfrow silt loam, 3 to 6 percent slopes (Rc).—This soil is on the steeper, convex slopes below areas of Renfrow and Kirkland soils. It also occurs below the Vernon and Lucien soils on long foot slopes.

Where thick beds of sandstone are banded with clay beds, Zaneis soils may be banded with Renfrow soils. Severely eroded areas of Renfrow soils were included with the Vernon and Lucien soils.

About half of this soil was once in cultivation, but much of it is now in grass. Much of the cropland has been eroded. The reversion to grass has been caused as much by the change from row crops to cattle as by the depletion of soil. Areas of this soil that are part of larger holdings are used more for pasture than for cash crops. The degree of regrassing on old fields depends on soil condition, seed source, and grazing practice. If they are grazed very heavily, revegetated old fields usually do not contain tall grasses but they develop a low-quality cover of grama and buffalograss.

Native pastures have also been badly depleted by overgrazing, and tall grasses now make up only a small part. Many pastures now contain mostly buffalograss and weeds. Good management is needed to maintain reasonably good growth of forage from year to year.

Sloping Renfrow soils in cultivation are used almost entirely for wheat or other small grains. Some of the acreage is used for sorghum feed in years when prospects of moisture are favorable.

The soil should be kept in good tilth to absorb winter rains and to prevent further soil loss. Terraces are commonly used. They serve as a guide for contour tillage and provide safe disposal of runoff. Stubble mulching leaves crop residue on the surface and helps to keep the soil porous for the infiltration of water. Rotations of wheat and sweetclover have proved successful for many farmers because clover residues make a good mulch and the nitrogen supplied by clover benefits the wheat.

Small grains generally respond to phosphate; sweetclover, to lime and phosphate. Sorghum benefits from nitrogen in years of adequate rainfall if there is enough phosphorus in the soil. In some seasons small grains also respond to additional nitrogen.

This soil is in capability unit IVe-1 and in the claypan prairie range site.

SAND DUNES, LINCOLN MATERIAL

This land type consists of wavy and dune-covered areas on the flood plain of the Cimarron River. These areas are the result of wind action on the sandy alluvium of the flood plain and the channel of the river. They are generally stabilized by plum thickets and coarse grasses. Dunes are as much as 10 feet high but average about 5 feet. The associated soils are Yahola very fine sandy loam, which is at a slightly lower elevation and farther from the stream, and Mixed alluvial land, which is nearer the stream and below the elevation of Sand dunes, Lincoln material.

Sand dunes, Lincoln material, has a brown loamy fine sand surface layer 6 to 8 inches thick. This is underlain by pink fine sand or loamy fine sand that extends to a depth of 4 feet or more. On interdune areas, the brown layer may be thicker and the substrata slightly stratified with sandy loams. The reaction throughout this soil ranges from neutral to slightly calcareous.

Sand dunes, Lincoln material (Sa).—This land type is not suitable for cultivation. It is used as pasture and furnishes fair grazing. Plum thickets and other brush detract somewhat from its grazing value. Johnsongrass grows fairly well in the moist spots, but it thins out if grazed. Bermudagrass also grows fairly well, and it furnishes more forage than the coarse grasses. The small areas of included Yahola soil and the adjoining Mixed alluvial land should be revegetated with grass along with this land type and used for pasture.

The supply of nitrogen is low. Other than nitrogen, this land type needs no fertilizer for use as improved pasture.

This mapping unit is in capability unit VIs-1 and in the sandy bottom-land range site.

STEPHENVILLE SERIES

Soils of the Stephenville series occupy oak woodlands in the sandstone uplands. They occur on the broader ridgetops and foot slopes in the larger valleys. In Logan County most of these soils are in the southeastern part, where they are associated with the shallower Darnell soils. They differ from the Darnell soils in being deeper and in having a sandy clay loam subsoil.

Stephenville soils have developed in noncalcareous reddish to brownish sandstone that is low in phosphorous and potassium. The native vegetation was post and blackjack oaks and a thin ground cover of coarse grasses. Fine sandy loam is the only type mapped in Logan County.

In an undisturbed area Stephenville fine sandy loam has a brown fine sandy loam surface layer that grades to a reddish-brown fine sandy loam. At a depth of about 12 inches is a well-structured, fairly permeable, sandy clay loam subsoil. Sandstone is at depths ranging from 20 to 40 inches.

Most of the organic matter is in the first 2 to 4 inches. The upper layers are mixed in tillage, and the resulting soil is less dark than the prairie soils of the county. The surface soil soon becomes light brown after plowing. Older fields usually have a slightly splotched surface where the reddish subsoil has been exposed. Nearly all cultivated areas have been somewhat eroded, but the soil has not been thinned appreciably.

These soils readily absorb water. Moisture relations are favorable. However, the moderate depth of soil to bedrock allows only a limited amount of moisture to be stored for plant use, and in dry seasons the Stephenville soils are droughty.

Most of these soils have been in cultivation, but many fields are now abandoned to grass and weeds. The commonly grown crops are small grains for winter pasture and sorghum for feed. Some cotton is also grown, but acreages are usually small.

Stephenville fine sandy loam, 0 to 3 percent slopes (Sb).—This soil occupies gentle slopes on broad ridges. It is usually adjacent to the undifferentiated Darnell and Stephenville fine sandy loams and Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded. Some areas grade toward the Zaneis and Chickasha soils, which are the darker soils in prairie openings of the woodlands. Stephenville fine sandy loam, 0 to 3 percent slopes, ranges in depth from about 20 to 48 or more inches, but it is not so deep as the Zaneis and Chickasha soils.

This soil is low in natural fertility and becomes unproductive when the available organic matter is depleted. However, it responds to management and can be improved by fertilizing and by using small grains and legumes as green manure for additional organic matter.

A crop residue should cover the surface during winter to prevent wind erosion. Rye and vetch are excellent for protecting the soil and can be used as a green-manure crop without depleting the moisture needed by the following summer crop.

The soil is low in phosphorus and potassium. Both elements will be needed for best growth of small grains, grasses, and legumes. Sweetclover and legumes require additional lime. The supply of nitrogen is usually low. Complete fertilizers are needed for row crops.

This soil is in capability unit IIe-1 and in the sandy savanna range site.

TELLER SERIES

Soils of the Teller series occur on uplands mantled by windblown materials or on high terraces that border the flood plains of streams. In Logan County, the Teller soils occur mainly south of the Cimarron River and within a few miles of it. A few isolated areas occur above Cottonwood Creek in the southwestern part of the county. Representative areas of Teller soils occur south of Coyle, near Pleasant Valley, and south of the Cimarron River between Guthrie and the western boundary of the county. Teller soils are redder and more sloping than the similar Vanoss soils. They have a redder and more clayey subsoil than the Minco soils and a less clayey and less firm subsoil than the Norge. The Teller, Minco, Vanoss, and Norge are associated soils. Very fine sandy loam is the only type mapped in the county. Steep, severely gullied areas are mapped as Teller soils, severely gullied.

Teller very fine sandy loam in a cultivated area on convex slopes of 3 percent has a granular, brown very fine sandy loam surface layer 8 to 12 inches thick. This layer grades to a granular, reddish-brown light clay loam that continues to depths of 16 to 20 inches. Below this is a granular, porous subsoil of yellowish-red clay loam that, in most places, grades to reddish loam at depths of 36 to 40 inches. The reddish loam extends to depths of as much as 20 feet before the country rock is reached.

Teller soils along the streams and those grading toward the Dougherty soils generally have a fine sandy loam surface soil and a more sandy feel throughout.

Some of the stronger slopes have been damaged by erosion, but not much of the soil has been taken from cultivation. Runoff is rapid from the strong slopes. Gully erosion is a hazard because the subsoil does not resist cutting.

A large percentage of the Teller soils is in cultivation; most of the rest is in native grass. A few areas are covered by oak brush. Teller soils absorb water readily, and they have a good capacity to hold water that plants can use. They are good soils for summer crops when rainfall is plentiful.

Teller very fine sandy loam, 0 to 3 percent slopes (Ta).—This soil occurs on the gently sloping ridges above sloping Teller soils. Some areas grade toward Vanoss loam. Large tracts of this soil occur north of Guthrie and west of the Cimarron River on terraces mantled by windblown material. The relief is gently undulating, but not all areas are regular enough for contour cultivation. In many places near the flood plain, the Teller soil grades to the Minco soils, which have developed on more recent silts blown over the Teller parent materials.

Teller very fine sandy loam, 0 to 3 percent slopes, is used mainly for corn, cotton, small grain, alfalfa, and other field crops. Yields from this soil and from the Vanoss are usually among the best in the county for the upland soils. Alfalfa and other deep-rooted crops grow well because the roots can penetrate the friable subsoil to obtain moisture.

Contour cultivation and stubble-mulch tillage help to improve infiltration of water, reduce runoff, and prevent erosion. Cover crops of vetch and winter grain generally grow well and in most years can be plowed under as green manure before summer crops are planted.

This soil responds to good management. Moderate amounts of phosphate improve the yields of small grains and alfalfa. Row crops need phosphate and nitrogen. In some areas alfalfa needs small amounts of lime.

This soil is in capability unit IIe–1 and in the loamy prairie range site.

Teller very fine sandy loam, 3 to 8 percent slopes (Tb).—This soil is on the sloping mantled uplands around areas of the gently sloping Teller soil and often near Minco and Vanoss soils. It also occurs on the slopes between adjacent old terraces. Examples are in Pleasant Valley and westward, south of the Cimarron River.

The brown surface layer ranges from about 5 to 8 inches in thickness; it averages less in thickness than the gently sloping Teller soil. Cropland commonly has a reddish-brown color because the light clay loam is exposed at the surface. This occurs particularly in fields where shallow gullies have been filled and sizable areas of subsoil were exposed in constructing terraces.

Much rain is lost as runoff. Contour cultivation and stubble mulching should be practiced to keep the soil porous and improve infiltration. Sheet erosion has not harmed this soil permanently, as it can be restored to good tilth through proper management. Terraces are commonly used to help drain runoff to safe channels and to prevent erosion. Contour tillage alone will control runoff if cover crops and crop residues are properly utilized.

Some of this soil is still in native tall grass used as pasture and meadow. Grass production is usually good. Old fields tend to regrass readily if there is a good natural source of seed.

The cultivated soil is used for small grains, feed crops, cotton, and alfalfa. Yields are often lower and more variable than from the gently sloping Teller soil because the supply of moisture is less and the organic-matter enriched surface soils are thinner.

Some areas with slopes greater than 6 percent should be in permanent meadow or pasture. Bermudagrass is well suited to this soil and, if fertilized, will spread, produce good forage, and protect the soil. Legumes seeded over grass should grow well in most years. Permanent meadows of alfalfa and grass are suitable for the stronger slopes.

This soil responds to proper tillage and fertilization. Small grains and alfalfa generally need phosphate; row crops respond to nitrogen, in addition to phosphate, if moisture is adequate. Alfalfa in many places needs lime.

This soil is in capability unit IIIe–1 and in the loamy prairie range site.

Teller soils, severely gullied (Tc).—This soil consists of steep, severely gullied areas of the Teller and similar soils. The Teller soil is dominant, but some small areas of Norge and Minco soils are included. Most of the mapping unit has been severely gullied, but a few steep uneroded areas of Teller and Minco soils with a cover of native tall grasses have also been included. Runoff is greater than from uneroded Teller soils, partly because of the slope increase along the gullies.

Because of their steep slopes and gullies, these soils are no longer cultivated. Most of the intergully areas have not been eroded severely, and many revegetate with grass after cultivation is discontinued. If runoff is diverted, the deeply eroded gullies will gradually stabilize under a cover of trees or grass. A diversion terrace around the heads of the gullies will cut off the overhead water. Black locust and bermudagrass have been used effectively as a cover and soil binder in the bottoms and heads of gullies.

Since the subsoil of these eroded areas is fair to good for plant growth and has a fair amount of plant nutrients, Teller soils, severely gullied, are not difficult to reclaim by use of grass or trees. A new topsoil will develop with added organic matter, and eventually the yield of forage from eroded areas will be as high as from the sloping uneroded Teller soils.

This soil is in capability unit VIIe–1 and in the loamy prairie range site.

VANOSS SERIES

Soils of the Vanoss series occur on the nearly level parts of the terraces and mantled uplands within a few miles of the streams. Vanoss soils are darker but much like the Teller soils described previously. In Logan County, Vanoss soils are associated with Teller and Minco soils on the south side of the Cimarron River and with the Derby and Dougherty soils north of the river. Most of the Vanoss acreage is in the vicinity of Crescent. Vanoss soils developed under tall grasses.

The Vanoss surface soil resembles that of the Bethany, Teller, and Minco, and it grades toward them in places. Vanoss soils are permeable, have a good capacity to hold moisture that plants can use, and do not tend to erode. Most of the acreage is used for crops. Two types of Vanoss soils were mapped in the county—loam and fine sandy loam.

Vanoss loam has a 10- to 14-inch surface layer of granular brown to dark grayish-brown loam. This material overlies light clay loam of similar color. At depths of 18 to 22 inches is a granular, brown silty clay loam that becomes lighter in color below a depth of 30 inches and grades to brown or reddish-brown light clay loam or loam at about 40 inches.

Vanoss fine sandy loam has a 12- to 16-inch, brown, granular and friable fine sandy loam surface soil that grades to a brown sandy clay loam. This material is yellowish brown below a depth of about 24 inches; the lower part is slightly mottled with brown and yellowish red. Deep materials are sandy loams and light clay loams. This soil is generally weakly acid in the upper part and about neutral below 30 inches.

The plowed layer is lighter in color than the soil below it. In places light-brown loamy sands have blown over and mixed with the surface soil. Silt and clay have been removed from the plow layer by wind. As a result, this layer feels coarser than the layer below it. In places the subsoil is yellowish brown as near as 16 inches to the surface.

Vanoss loam, 0 to 1 percent slopes (Vc).—This soil occurs mostly on the level benches in the vicinity of Pleasant Valley and Crescent. It absorbs most of the rainfall, and there is little danger of erosion. In addition, it has a high capacity to hold and supply water that plants can use.

This is the best upland soil for general crops. It is fertile, and most of the acreage is in cultivation. It responds to good management, including fertilization, green manuring, and use of legumes for soil improvement. The main crops are small grain, cotton, alfalfa, corn, and feed for livestock. Yields are moderate to good. Over a period of years, the yields of small grain and alfalfa are dependable. In years of well-distributed rainfall, the yield of summer annuals is also good.

Phosphate is needed for the best growth of small grain and alfalfa. Lime may be needed for alfalfa and sweetclover. Row crops generally respond to phosphate and nitrogen if they follow another row crop.

Vanoss loam, 0 to 1 percent slopes, is in capability unit I–2 and in the loamy prairie range site.

Vanoss loam, 1 to 3 percent slopes (Vd).—This soil occurs around the edges of the nearly level Vanoss loam. It also borders drainageways and is on the nearly level ridge crests above the Teller soils. In some places it lies next to gently sloping Minco soils, which resemble it at the surface. It is much like the Teller soils on similar slopes, but it is not so red.

Erosion is a greater hazard on this soil than on Vanoss loam, 0 to 1 percent slopes. The shallower surface layer and the few runoff rills are evidences of erosion.

Runoff and erosion can be controlled by farming on the contour and by leaving plenty of crop residue on the surface. Partly covered residue will keep the surface soil porous enough to absorb most of the normal rainfall. In winter the soil should be protected by a cover of small grain and vetch that can be turned under as green manure.

Most of this soil is used to grow corn, cotton, small grain, alfalfa, and livestock feed. Yields of most crops are generally good, but those of small grain are more dependable over a long period. Alfalfa and other deep-rooted crops can easily penetrate these soils to get subsoil moisture.

This soil responds to good management that includes the use of phosphate for small grain and alfalfa and the use of lime for legumes. Summer crops should be given moderate quantities of nitrogen unless they follow legumes or green-manure crops.

Vanoss loam, 1 to 3 percent slopes, is in capability unit IIe–2 and in the loamy prairie range site.

Vanoss fine sandy loam, 0 to 1 percent slopes (Va).—This soil occurs on level areas in the vicinity of Crescent. It is a drought-resistant soil, and most of it is used for cotton, corn, small grain, alfalfa, and feed and truck crops. Yields are moderate to good; the yield depends on the distribution of rainfall. Windblown soil material occasionally damages small grain and young alfalfa and reduces yields.

To protect the soil from erosion, a cover of crop residues should be left on the surface in winter and preparation of the seedbed should be delayed until near planting time. A winter cover of small grains and legumes will accomplish the same result most years, and it can be plowed under as green manure a few weeks before planting time. Another method of preventing erosion is to grow sorghum in alternate strips with row crops at right angles to the prevailing wind. Row crops are rotated on these strips from year to year.

This soil responds to fertilizers, and fair yields can be expected of most crops. Small grains and alfalfa benefit if phosphate is applied nearly every year. Corn, cotton, and feed and truck crops respond to phosphate and nitrogen. The response, however, depends largely on the timeliness of summer rain. Some lime probably will be needed for alfalfa, sweetclover, and other legumes.

This soil is in capability unit IIe–1 and in the loamy prairie range site.

Vanoss fine sandy loam, 1 to 3 percent slopes (Vb).—This soil occurs on the edges of drainageways in broader areas of Vanoss fine sandy loam, 0 to 1 percent slopes. A large area is east of State Highway No. 74, 1 to 2 miles north of Crescent.

This soil is mostly in cultivation and is used for the same crops as Vanoss fine sandy loam, 0 to 1 percent slopes. However, because of stronger slopes, it is subject to greater runoff and erosion. Contour tillage should, therefore, be practiced on slopes that border drainageways.

Wind erosion is the main hazard, and in some years yields are greatly reduced by wind damage. Wind erosion can be prevented by keeping a protective cover of small grain on the soil in winter. Another method of preventing wind erosion is to plant alternating strips of row crops and sorghum at right angles to the prevailing wind.

Fair increases in yields can be expected from good management. This is a drought-resistant soil. In years of well-distributed rainfall, green manuring is a good practice. The winter cover of small grains and legumes should be plowed under a short time before seeding summer crops. Small grain responds if phosphate is applied nearly every year. Alfalfa and sweetclover need lime and phosphate for best growth. Corn, cotton, and feed and truck crops respond to additions of nitrogen and phosphate when rain is well distributed throughout the growing season.

This soil is in capability unit IIe–1 and in the loamy prairie range site.

VERNON AND LUCIEN SOILS

The Vernon and Lucien soils are so closely associated in many places that they cannot be mapped separately. They occur on the sloping to steep ridges and along the breaks in the prairie areas. The Vernon soils occur on clay beds; the Lucien, on interbedded sandstone. Where sandstone is exposed on the top of a ridge, the Lucien soils are dominant. Near the heads of narrow drainageways in the clayey plains, the Vernon are the dominant soils. Both soils usually occur in mapped areas, but the percentage of each differs widely.

Vernon and Lucien soils occur in the western two-thirds of the county and in prairie openings in the eastern part. Many long and narrow areas are on steep sides of streams or on escarpments capped by resistant sandstone.

The surface layer of the Vernon soil in this undifferentiated soil group is a reddish-brown calcareous clay or clay loam that grades into substrata of raw, compact red clay.

The compact red clay is slowly permeable, calcareous, and in many places contains numerous concretions of lime. This clay swells and shrinks greatly, and, when dry, cracks into cubelike blocks. Plant roots penetrate the soil along these cracks.

Much runoff occurs on the Vernon soil because of slow permeability and steep slopes. When the soil is covered by a thick growth of grass and surface mulch, a larger percentage of the water is absorbed and held available for summer growth of grass. Clays have a high capacity for holding moisture, and they do not dry out quickly after rains. Better use of available rainfall is a problem on this soil.

The surface layer of the Lucien soil consists of 10 to 18 inches of loam or fine sandy loam. It is underlain by red sandstone.

A few fragments of sandstone are on the surface and throughout the soil. Some areas are more shallow than described. Rock outcrops occur around the rims of some ridges. The shallowest Lucien soil is often covered by oaks. This type of vegetation has spread and increased in density since the first settlement of the county.

The Lucien soil is permeable throughout, and it can absorb moisture readily if the surface is porous. The subsoil does not swell and shrink as much as that of the Vernon. Lucien soils do not have a large capacity for holding moisture.

Grass roots can penetrate all parts of the soil. Tall grasses on this soil withstand grazing better than those on the Vernon soil. Oaks have spread to grasslands as a result of heavy grazing. Grasses respond to summer rainfall but dry up during droughts.

Vernon and Lucien soils, 6 to 20 percent slopes (Vg).—Vernon and Lucien soils usually occur in rough bands around slopes. The Lucien commonly occurs at the tops of slopes on sandstone; the Vernon, along the sides on claybeds. In many places the surface soil above the clay beds is loam that weathered from the sandstone of the higher areas. Many clayey areas are severely eroded and have little useful cover. Clumps of oak grow on some sandy ridges.

Areas of this undifferentiated soil group that occur with the Zaneis soil on beds of Garber sandstone consist mostly of Lucien soils. Areas in western Logan County on beds of Hennessey shale consist mainly of the Vernon soils. Little sandstone occurs in the shale beds. Where Vernon soils predominate, the short and mid grasses are dominant because tall grasses cannot withstand intense grazing. Many pastures are heavily infested by weeds.

All severely eroded areas of Renfrow soils were included with Vernon and Lucien soils. Many of these areas are sheet eroded and gullied and have little or no useful vegetation. Regrassing is one of the most necessary but difficult conservation practices on these severely eroded areas. Only limited amounts of forage can be expected, even if regrassing is completed.

Both soils support tall and short native grasses and are used only for native pasture. The management of the native grasslands is described in another part of this report.

This soil is in capability unit VIIs-1 and in the red clay prairie range site.

YAHOLA SERIES

Soils of the Yahola series occur on the flood plains of the Cimarron River. They are occasionally flooded but drain well afterwards. Clay loam and very fine sandy loam are the two types mapped in Logan County.

Yahola clay loam has a dark reddish-brown coarse granular clay loam surface layer about 15 inches thick. It contains a few thin bands of fine sandy loam. Below the clay loam is a reddish-brown fine sandy loam stratified with thin bands of silt loam and loam.

The soil is weakly calcareous throughout. Stratification differs from place to place. Some localized areas are covered by an overwash of very fine sandy loam a few inches thick. The thickness of the clay loam surface layer ranges from 10 to 30 inches or more.

Yahola very fine sandy loam has a reddish-brown, friable, calcareous very fine sandy loam surface layer 15 to 20 inches thick. It grades to yellowish sandy loam variously stratified with loamy fine sand and silt loam. Occasional bands of clay loam are in the deep substrata.

The surface layer ranges from brown to light reddish-brown in color and from silt loam to fine sandy loam in texture. The subsoil color ranges from light brown to yellowish red. The soil is neutral to weakly calcareous. The reaction depends on the frequency of overflow and the source and thickness of new sediments.

Yahola clay loam (Ya).—This soil occupies flat areas on the flood plains of the Cimarron River. It is in areas that adjoin the uplands. Some of it occurs as long fingerlike swales within the broader areas of Yahola very fine sandy loam. Floodwaters usually stand long enough to permit the clays and silts to settle out and the subsoil to become moistened to considerable depths. The fine-textured materials have the capacity to hold moisture that plants can use, and they prevent excessive downward drainage.

Yahola clay loam is used in about the same way as Yahola very fine sandy loam. It is a little more productive because the better supply of moisture makes it more resistant to drought. Its productivity is somewhat reduced by floods that occur about every 5 years. Crops are damaged more by floods, and tillage is delayed longer on this soil than on Yahola very fine sandy loam. Alfalfa and corn grow particularly well on this soil, and small grain is well suited. Rotations of alfalfa and other crops are well suited.

Alfalfa generally can be started without lime and phosphate, but a topdressing of phosphate is sometimes needed to prolong the life of the stand. Small grains can be grown without fertilizers. Row crops that do not follow legumes need nitrogen and phosphate. Corn responds to nitrogen.

This soil is in capability unit I-1 and in the loamy bottom-land range site.

Yahola very fine sandy loam (Yb).—This soil is on nearly level to slightly wavy flood plains of the Cimarron River. Surface drainage varies from good to slow, but internal drainage is always adequate.

Many areas of Yahola very fine sandy loam contain long narrow swales of Yahola clay loam. These are only a few feet wide and have little effect on the use and value of the soil. They may stay moist longer after rains and delay tillage somewhat.

Yahola very fine sandy loam is used mostly for alfalfa, corn, cotton, small grains, and truck crops. Yields are generally good but can be improved.

This soil is well suited to irrigation. Some favorable sites may be levelled for irrigation, but the irregularity of most areas makes the costs of levelling prohibitive. Irrigation on this soil is mainly of the sprinkler type.

Many areas of this soil have enough phosphorus for small grains. However, alfalfa requires phosphate fertilizer for best yields. Row crops that do not follow a legume usually benefit from additional nitrogen, and they may also need phosphate. All crops, if irrigated, will need larger quantities of fertilizers.

Yahola very fine sandy loam is in capability unit I–1 and in the loamy bottom-land range site.

ZANEIS SERIES

Soils of the Zaneis series occupy moderate slopes in the southeastern part of the county. They have developed under tall grasses and on red sandy and silty clays containing an occasional layer of soft sandstone. They are underlain by Garber sandstone. Loam is the only type mapped in Logan County.

The surface layer of Zaneis loam is a reddish-brown, granular, friable loam about 10 inches thick. This material grades to a reddish-brown, granular, light clay loam that continues to depths of 15 to 18 inches. Below 15 to 18 inches is moderately permeable, friable, reddish-brown clay loam. This material is more reddish below a depth of 30 inches, and it grades to red clay loam. In most places there are seams of weathered, fine-grained sandstone in the red clay loam below depths of 40 to 50 inches. The reaction is moderately acid in the upper layers and slightly acid below about 20 inches.

The texture of the surface soil ranges from loam to fine sandy loam, and the thickness, from 8 to 12 inches. In some sloping areas the surface layer has been thinned by erosion and spots of reddish-brown clay loam are on the surface. In places the subsoil is sandy clay loam. These areas are much like the Teller and Noble soils. The depth of soil over weathered sandstone ranges from 20 inches, where this soil adjoins the Lucien, to 60 or more inches on lower slopes, where it has developed in colluvial material.

Zaneis soils are permeable, and the subsoil has a good capacity to hold water that plants can use. There is much runoff and erosion on the sloping surfaces. Zaneis soils are easily gullied because the subsoil does not resist cutting. A large area of Zaneis soils that has been eroded and gullied is no longer useful for crops. However, many eroded fields have been terraced and are now farmed on the contour. Low spots above terraces often hold water and delay cultivation. Continued tillage gradually fills these spots so that fields improve with use.

Pastures of native tall grass are often only fair and contain many grasses and weeds of low palatability. Meadows are usually in better condition. Tall grasses grow fairly well on the Zaneis soils if grazing is reasonably well managed. The absorption of water is reduced by trampling and close grazing. As these soils become drier, the tall grasses thin out and are replaced by the short, less productive grasses.

Zaneis loam, 0 to 3 percent slopes (Za).—Most of this soil is cultivated. The main crop is wheat, but some alfalfa and sorghum are grown for feed. In years of favorable moisture, some cotton is grown. This soil is considered better for summer crops than the Renfrow soils because summer rains are more effective in adding moisture plants can use. A few areas are in native pasture and meadow. Pastures are commonly overgrazed and do not produce as much forage as they could under improved management.

Erosion has not severely damaged this soil, but it is always a hazard. Contour cultivation and stubble-mulch tillage will generally control erosion. Terraces are used successfully by many farmers.

Small grains generally respond to phosphate; row crops need nitrogen as well as phosphate for best yields. Lime and phosphate are needed for satisfactory growth of sweetclover and alfalfa.

This soil is in capability unit IIe–2 and in the loamy prairie range site.

Zaneis loam, 3 to 6 percent slopes (Zb).—This is an important soil in the central, northern, and southern parts of Logan County.

In some areas, where thick clays are exposed on the surface between beds of sandstone, this soil contains bands of Renfrow soils that occur roughly on the contour. Many slick spots develop on these bands.

The cultivated areas of this soil have been eroded, and, in many places, the surface layer is much thinner than it was originally. Where rills and shallow gullies have been plowed over and smoothed, the only evidence of erosion is the color of the surface soil. Because of the poor fertility of this soil and changes in the use of land, many areas of Zaneis loam, 3 to 6 percent slopes, are no longer cropped. However, if properly managed, all of this soil is suitable for tillage. The severely eroded and gullied areas of this soil are mapped separately and are described elsewhere in this section.

This soil is used more for wheat and sorghum feed than for row crops. Management should include the conservation of soil and moisture. Terraces are often used as a guide for contour tillage and as channels to divert runoff to safe drainageways. A stubble or a mulch keeps the soil surface porous and allows more rain to soak in. Rotations of wheat and sweetclover very effectively provide this kind of cover and mulch.

The quality of cover on old fields returning to grass depends on the source of seed, the kind of grazing practiced, and the condition of the soil. Heavy grazing hinders the establishment of the more desirable tall grasses.

The condition of native pastures depends on how they have been grazed. Tall grasses are a substantial part of the stand if grazing has been managed properly. Generally the native pastures on this soil have more tall grasses than the Renfrow soils. Trampling and close grazing, however, have reduced the capacity of many pasture areas to absorb water. As the soil dries, tall grasses lose their vigor and are replaced by short-season grasses.

Yields of small grain are increased by use of phosphate fertilizers and, in favorable seasons, by use of nitrogen. Sweetclover needs lime and phosphate. Sorghums may benefit from nitrogen in years of adequate rainfall if the amount of phosphate is ample.

This soil is in capability unit IIIe-1 and in the loamy prairie range site.

Zaneis soils, 3 to 8 percent slopes, severely eroded (Zc).—This mapping unit consists of Zaneis soils that are so eroded and gullied that they are no longer usable as cropland. Some areas are below steep slopes that contribute much of the harmful runoff. Others occur as rims around smooth areas of the Zaneis and Chickasha soils on ridges and divides.

These soils developed in less clayey redbeds, but they contain some layers of heavy clay. In many places, these clays are exposed in many deep gullies and galled spots. The loam surface soil ranges from a thin film to 12 inches in thickness. It is absent in places. Included with these soils are narrow areas of Noble soils.

In general the severely eroded areas of Zaneis soils are dissected at intervals from 50 to 150 feet by narrow, V-shaped gullies that range from 1 to several feet in depth. Soils between gullies may be like the Zaneis loam, 3 to 6 percent slopes, and only slightly altered by erosion. Many areas of these severely eroded Zaneis soils have been terraced, but water that accumulated above the terraces broke through and intensified the gully erosion.

Severely eroded Zaneis soils, 3 to 8 percent slopes, are much like the severely eroded Darnell and Stephenville soils. The Zaneis soils generally have more galled spots and exposed clay beds that do not regrass readily, and the natural spread of tall grasses is not complete.

The use of severely eroded areas of the Zaneis, Darnell, and Stephenville soils is nearly the same. The progress of revegetation on each depends on the length of time they have been out of cultivation. Bermudagrass will grow if fertilized, but it must be managed carefully if it is to produce large amounts of forage and heal gullies and galled areas. Gullies heal more rapidly if runoff is diverted from them.

The fertility of these Zaneis soils is generally higher than that of Darnell and Stephenville soils. Consequently, fertilization costs prior to reseeding with grasses and legumes may be less than those of the Darnell soils.

This soil is in capability unit VIIe-1 and in the severely eroded prairie range site.

Use and Management of Soils

In this section the soils of Logan County are grouped into capability classes and units. The use and management of each capability unit are discussed. In addition, the average yields of the principal crops obtained under ordinary management and those expected under improved management are given.

Capability Groups of Soils

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

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

The next broader grouping, the subclass, is used to indicate the dominant kind of limitation. The letter symbol "e" indicates that the main limiting factor is risk of erosion if the plant cover is not maintained; "w" means that uneven surface and the frequency of overflow make the soil unsuited to cultivation; "s" means that sandiness, shallowness, or a very slowly permeable subsoil make the soil too droughty for any but the native plants adapted to the condition. In some parts of the country there is another subclass, "c," for soils that are limited chiefly by a climate that is too dry or too cold.

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

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

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

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

Class III soils can be cropped regularly but have a narrower range of use. These need even more careful management.

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

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

Class V soils are nearly level and gently sloping but are droughty, wet, low in fertility, or otherwise unsuitable for cultivation.

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

Class VII soils provide only poor to fair yields of forage or forest products and have characteristics that limit them severely for these uses.

In class VIII are soils that have practically no agricultural use. Some of them have value for watersheds, wildlife habitats, or scenery.

The soils of Logan County have been grouped in the following capability classes and units.

Class I.—Deep, nearly level, generally well drained soils that are easily worked, suitable to many kinds of plants, and generally fairly well supplied with plant nutrients. They are not easily eroded.
- Unit I–1.—Deep, fertile soils on bottom lands and low terraces.
- Unit I–2.—Deep, fertile soils on high benches.

Class II.—Soils that have some limitations which reduce the choice of plants or require some conservation practices.
- Unit IIe–1.—Deep, permeable soils on gentle slopes.
- Unit IIe–2.—Moderately permeable soils on gentle slopes.
- Unit IIs–1.—Nearly level soils with claypan subsoil.

Class III.—Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.
- Unit IIIe–1.—Deep, permeable, moderately to strongly sloping soils subject to severe water erosion.
- Unit IIIe–2.—Deep, gently sloping, very slowly permeable soils with claypan subsoils.
- Unit IIIs–1.—Smooth to slightly hummocky, readily absorbent sandy soils with moderately permeable subsoil.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Unit IVe–1.—Sloping, very slowly permeable soils with claypan subsoil.
- Unit IVs–1.—Light-colored, rapidly permeable sandy soils with a low capacity to hold moisture for plant use.

Class V.—Soils that have little or no erosion hazard but have other limitations that are impractical to remove that limit their use largely to pasture, range, or woodland or to providing food and cover for wildlife.
- Unit Vw–1.—Mixed sandy and clayey areas adjacent to stream channels and frequently flooded.

Class VI.—Soils having severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Unit VIs–1.—Undulating to dune-covered, deep, rapidly permeable, sandy soils.
- Unit VIs–2.—Moderately to strongly sloping, light-colored, shallow and moderately deep sandy soils over reddish sandstone.

Class VII.—Soils that have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, or woodland, to providing wildlife cover, or some combination of these.
- Unit VIIe–1.—Sloping, severely eroded and gullied soils formerly used for tilled crops.
- Unit VIIs–1.—Sloping and strongly sloping, shallow prairie soils over clay beds and reddish sandstone.

Description of capability units

In this section each capability unit is discussed, and the soils in it are listed. Suggestions are given on how to use and manage the soils in each unit.

CAPABILITY UNIT I-1

Deep, fertile soils on bottom lands and low terraces

Port soils.
Pulaski fine sandy loam.
Reinach very fine sandy loam.
Yahola clay loam.
Yahola very fine sandy loam.

These soils are permeable. Rainfall penetrates them readily, and they are very productive if there is enough rain in the growing season. In some years crops are lost through floods or runoff from the adjacent slopes. Crops in wet spots may be damaged by excessive moisture.

Small grain, alfalfa, corn, cotton, and grain sorghum are widely grown; other legumes are also suited to these soils. A rotation that utilizes one-fourth of the land each year in residue-producing crops should be used. Alfalfa may be used in the cropping system followed by oats or grain sorghum. Cotton or corn may be grown 3 or 4 years in a 6-year rotation between seedings of alfalfa. Stubble-mulch tillage is needed to protect the soils from erosion.

Winter legumes should be grown as green manure in most years and plowed under before row crops are planted. The yields of row crops are improved through the addition of nitrogen fertilizer. Legumes require small quantities of phosphate fertilizer. These soils are not generally acid, and only small amounts of lime are needed. Irrigation improves the yields of crops if proper amounts of fertilizers are applied and management is good.

Runoff from adjacent slopes should be diverted to safe channels to prevent damage to these soils. Streambanks should be stabilized and dikes constructed where additional height is needed to prevent flooding.

CAPABILITY UNIT I-2

Deep, fertile soils on high benches

Bethany silt loam, 0 to 1 percent slopes.
Vanoss loam, 0 to 1 percent slopes.

These are productive soils. They are permeable to moderately permeable, and rainfall is readily absorbed. However, less moisture is available for plants than in soils of capability unit I–1.

Small grains, alfalfa, cotton, and grain sorghum are suitable crops. Summer and winter legumes grow well on these soils and are useful in the rotations. Orchards are successfully grown in some areas. Residue-producing crops should be used on one-fourth of the acreage each year. A suitable 4-year rotation consists of a small grain and sweetclover the first year, sweetclover the second year, grain sorghum the third year, and cotton the fourth year. Corn may be substituted for sorghum in years when soil moisture is adequate. Wheat can be grown for 3 years following sweetclover. Another suitable rotation is alfalfa followed by row crops for 2 years. In years when moisture is plentiful, legumes grown for green manure should be plowed under before row crops are seeded.

A rotation that will produce the maximum forage for cattle consists of sweetclover and fall-sown oats the first year, sweetclover and fall-sown rye the second year, sudangrass the third year, and forage sorghum the fourth year. The plants in this rotation protect the soil from erosion. They may also yield three times as much forage as average pastures in native grass.

Yields of small grains and row crops are improved by additions of phosphate. Nitrogen also improves yields if the supply of phosphorus in the soil is high. These soils are slightly acid, and legumes benefit from both lime and phosphate. Irrigation improves yields if proper amounts of fertilizers are used and other management is good.

Stubble-mulch tillage and contour cultivation should be used to conserve moisture and to prevent erosion.

CAPABILITY UNIT IIe-1

Deep, permeable soils on gentle slopes

Minco loam, 0 to 3 percent slopes.
Stephenville fine sandy loam, 0 to 3 percent slopes.
Teller very fine sandy loam, 0 to 3 percent slopes.
Vanoss fine sandy loam, 0 to 1 percent slopes.
Vanoss fine sandy loam, 1 to 3 percent slopes.

These soils lose considerable moisture through runoff; consequently, they are slightly eroded. The coarser textured soils are subject to wind erosion. Summer moisture is usually adequate for plants.

The soils are productive and, if adequately fertilized, are suitable for small grains, cotton, grain sorghum, alfalfa, and orchards. Summer and winter legumes are suitable and are useful in rotations. Supplies of moisture for growing plants are usually adequate. Residue-producing crops should be grown on one-half the tilled acreage each year to protect the soil from erosion.

A suitable 4-year rotation on these soils consists of a small grain and sweetclover the first year, sweetclover the second year, grain sorghum the third year, and cotton the fourth year. Except on Stephenville fine sandy loam, corn can be substituted for the grain sorghum when soil moisture is adequate. Another suitable rotation is alfalfa followed by row crops for 1 or 2 years. The yields of small grain are more dependable than those of row crops, because of the summer drought. Winter cover should follow row crops of the Vanoss and the Stephenville soils. Green-manure crops should be grown on all soils and plowed under before row crops are planted.

A rotation that will yield the maximum forage for cattle on these soils is the same as that suggested in capability unit I-2.

These soils are slightly acid. Legumes need lime in addition to phosphate; small grains need only phosphate. Yields of row crops will be improved through addition of nitrogen if the supply of phosphorus is adequate. The Stephenville soil often needs phosphate, nitrogen, and potash for best yields of all crops.

On slopes over 1 percent, terraces and contour tillage are needed to control runoff and erosion. Excessive runoff should be diverted to safe channels through well-grassed waterways. The row direction should be perpendicular to the path of the dominant wind, and winter cover crops should follow row crops on the Vanoss and the Stephenville fine sandy loams. Stubble-mulch tillage is necessary on all fields.

CAPABILITY UNIT IIe-2

Moderately permeable soils on gentle slopes

Chickasha loam, 0 to 2 percent slopes.
Norge loam, 0 to 3 percent slopes.
Vanoss loam, 1 to 3 percent slopes.
Zaneis loam, 0 to 3 percent slopes.

These soils are more slowly permeable than those of capability unit IIe-1. They lose more moisture through runoff; consequently, they are not so well suited to summer crops.

Small grains, cotton, grain sorghum, and alfalfa are the most commonly grown crops. Winter legumes are well suited and are beneficial in rotations. The soils are fairly well suited to orchards. Residue-producing crops should be grown on one-third of the tilled acreage each year. Crop rotations and management suitable for these soils are the same as those suggested for capability unit IIe-1.

A rotation that will yield the maximum forage for cattle on these soils is the same as that suggested in capability unit I-2.

The soils are slightly acid. Alfalfa and sweetclover need lime, and most other crops need phosphate.

CAPABILITY UNIT IIs-1

Nearly level soils with claypan subsoil

Kirkland silt loam, 0 to 1 percent slopes.

This soil is very slowly permeable because of the claypan subsoil. Even on slight slopes, this soil does not absorb all the rainfall, and much runoff occurs. The soil is therefore droughty. Because of the clay subsoil, water is released slowly to plants.

Small grains and cotton are the main crops. The yields of small grains are more dependable because they mature before the arrival of dry weather in summer. Only deep-rooted crops grow well in summer.

A good rotation for this soil, when moisture is adequate, is a small grain and sweetclover the first year, sweetclover the second year, and cotton the third year. However, in dry weather this is not a good rotation because the sweetclover does not leave enough moisture for the grain. Another good rotation consists of a legume followed by 1 year of wheat and 1 year of cotton, or by 2 years of wheat.

Residue-producing crops should be grown on one-half the tilled acreage each year. In seasons of adequate moisture, green-manure crops are beneficial, but in dry seasons they depress the yields of some crops that follow. Contour cultivation and stubble-mulch tillage ought to be practiced on these soils.

The supply of plant nutrients is low to moderate, and the yield of small grains can be improved by additions of phosphate. Most legumes need lime.

CAPABILITY UNIT IIIe-1

Deep, permeable, moderately to strongly sloping soils subject to severe water erosion

Minco loam, 3 to 8 percent slopes.
Noble very fine sandy loam, 1 to 6 percent slopes.
Norge loam, 3 to 7 percent slopes.
Teller very fine sandy loam, 3 to 8 percent slopes.
Zaneis loam, 3 to 6 percent slopes.

These soils absorb water moderately well, but they lose large amounts of it through runoff.

These soils are moderately productive if soil and water are conserved and fertilizers are applied. They are used mostly for small grain, alfalfa, grain sorghum, and some cotton. Alfalfa and other deep-rooted crops grow well if enough plant nutrients are supplied. These crops are not always successfully used in rotations; they deplete moisture in the subsoil and may prevent satisfactory growth of the crop that follows.

Half the tilled acreage ought to be in residue-producing crops each year. If the land is terraced, a suitable rotation consists of a small grain and sweetclover the first year, sweetclover the second year, and cotton or sorghum the third year. Winter legumes can be used as green manure when ample moisture is available. Unterraced soils should be used only for close-growing crops, grass, and biennial or perennial legumes.

A rotation that will yield the maximum forage for cattle on these soils is the same as that described in capability unit I–2.

The soils should be tilled on the contour and terraced unless they are in close-growing crops at all times. Runoff from slopes should be diverted to grassed waterways, and all drainageways ought to be kept in permanent vegetation.

Legumes commonly need lime and phosphate. Small grains benefit from applications of phosphate. Row crops generally need nitrogen as well as phosphate.

CAPABILITY UNIT IIIe–2

Deep, gently sloping, very slowly permeable soils with claypan subsoils

Kirkland silt loam, 1 to 3 percent slopes.
Renfrow silt loam, 1 to 3 percent slopes.

These soils absorb water very slowly and lose much of it through runoff. They are droughty and subject to erosion. Slick spots are common.

Small grains and cotton are the main crops. High yields of wheat are obtained only if soil and moisture are conserved and fertilizers are added. Small grains mature before moisture becomes short; consequently, yields are more dependable than those of summer crops. A good rotation consists of a small grain and sweetclover the first year, sweetclover the second year, and cotton the third year. If ample moisture is available, the sweetclover can be used in a rotation with wheat. However, sweetclover is not suitable in dry years, because not enough moisture is left in the soil for the crop that follows. Two-thirds of the tilled acreage should be in residue-producing crops each year. Vetch and other winter legumes can be used in the wheat rotations with some success. Stubble-mulch tillage should be practiced.

The soil and moisture conservation practices suggested for this capability unit are the same as those described in capability unit IIIe–1.

Small grains need phosphate and some nitrogen. Legumes need phosphate and lime.

CAPABILITY UNIT IIIs–1

Smooth to slightly hummocky, readily absorbent sandy soils with moderately permeable subsoil

Dougherty loamy fine sand, 0 to 3 percent slopes.

This soil has a good capacity to hold moisture that plants can use. It is low in fertility and subject to wind erosion. The soil is not droughty, responds well to summer rains, and is moderately productive if well supplied with plant nutrients.

Cotton, grain sorghum, melons, sweetpotatoes, and small grains are the main crops. A good cropping system consists of growing row crops with grain sorghum in strips. The strips are alternated each year and are run at right angles to the prevailing wind. The row crops should be followed by rye and vetch grown for winter cover and green manure. Grain sorghum should be planted on the green-manured strip and row crops on the sorghum strips after late tillage. Melons and sweetpotatoes can be grown in strips with sorghum.

A feed-crop rotation for cattle is recommended on these soils. It is the same as that described for capability unit I–2.

Terraces and contour cultivation are not practical. Wind erosion can be controlled by careful management of crop residues and the use of winter cover. Tillage of these soils should be delayed until seeding time. A trashy cover ought to be maintained as long as possible to help prevent wind erosion.

Small grains need phosphate. Summer crops respond to nitrogen if the supply of phosphorus is ample. Lime is needed for sweetclover.

CAPABILITY UNIT IVe–1

Sloping, very slowly permeable soils with claypan subsoil

Renfrow silt loam, 3 to 6 percent slopes.

Runoff and erosion are serious problems and must be controlled if this soil is to remain in cultivation. Many small- and medium-size areas are eroded and contain slick spots.

Small grains are the most successful crops because they mature before the summer droughts occur. Use of winter legumes in the rotation is of doubtful value because supplies of moisture are too limited. They can be used successfully only in seasons of adequate moisture. All the tilled acreage should be in close-growing crops. A suitable rotation consists of a small grain and sweetclover the first year and sweetclover the second year. Not more than half the acreage in small grain should be harvested each year. The clover furnishes grazing in spring and fall.

This soil ought to be terraced and farmed on the contour, unless it is in close-growing crops or is covered with residues at all times. Runoff from adjacent slopes should be diverted to grassed waterways. Natural drainageways and terrace outlets should be in permanent vegetation.

Small grains need phosphate and will respond to additional nitrogen if the supply of phosphorus is favorable.

CAPABILITY UNIT IVs–1

Light-colored, rapidly permeable sandy soils with a low capacity to hold moisture for plant use

Derby loamy fine sand, 0 to 3 percent slopes.
Dougherty loamy fine sand, 3 to 8 percent slopes.

In places there is no clay in the subsoil to hold moisture, and the soils dry out rapidly in summer. They are low in fertility and subject to wind erosion. They are moderately productive when moisture is adequate. Crops growing on them respond to summer rains.

The main crops are sorghum, orchards, and rye. A good rotation consists of rye and vetch grown for seed and grain followed by forage sorghum and sudangrass. The crops should be planted on different strips each year. A high stubble and all possible residue should be left when harvesting forage crops. The rye and vetch for winter cover should be grazed only late in winter and early in spring when growing vigorously. Erosion in orchards can be controlled by underseeding with rye and vetch. Harvest these grains for seed or graze them off late in winter or early in spring.

A feed-crop rotation that will yield high forage is suggested on these soils. It is the same as that described for capability unit I–2.

Because of topography, terraces and contour tillage are not practical. Water erosion may occur on the steeper slopes unless they are kept in permanent vegetation. Gullies and washes should be vegetated to prevent further damage. Tillage of these soils should be delayed until seeding time, and a trashy cover ought to be maintained as long as possible to control wind erosion.

Rye responds to additional phosphate. Orchards need both phosphate and nitrogen.

CAPABILITY UNIT Vw-1

Mixed sandy and clayey areas adjacent to stream channels and frequently flooded

Mixed alluvial land.

This land type consists of sandy ridges and low clayey swales. The material shifts with each major flood, and cultivation is not practical. However, moisture is generally adequate for the growth of grass. The sandy ridges are subject to wind erosion if excessively grazed.

This unit is used mostly for pasture. Hay is cut from some of the more level areas.

The management of this capability unit is described in the sections Tame Pasture Management, Woodland Management, and Native Meadow Management.

CAPABILITY UNIT VIs-1

Undulating to dune-covered, deep, rapidly permeable, sandy soils

Derby loamy fine sand, 3 to 8 percent slopes.
Derby loamy fine sand, 8 to 20 percent slopes.
Minco loam, 8 to 20 percent slopes.
Sand dunes, Lincoln material.

These soils are subject to severe wind erosion when cultivated. They readily absorb water, but there is no retentive subsoil to hold it in the upper part. Consequently, these soils are droughty in midsummer. Runoff is rapid from the steep Minco soils. These soils are not suitable for permanent cultivation.

These soils are invaded by post and blackjack oaks. Their best use is for grazing. Native and introduced grasses will grow well if grazing is properly regulated.

The management of this capability unit is described in the sections Tame Pasture Management, Woodland Management, and Native Meadow Management.

CAPABILITY UNIT VIs-2

Moderately to strongly sloping, light-colored, shallow and moderately deep sandy soils over reddish sandstone

Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes.
Darnell and Stephenville fine sandy loams, 8 to 15 percent slopes.

The soils in this capability unit are, for the most part, unsuitable for cultivation because the areas of deeper soils are interspersed among areas of shallow soils and are too small to use separately.

Rock is exposed on the steeper slopes, and even on the gently sloping areas it is within 6 to 10 inches of the surface in places. The soils are droughty in summer. The understory of grass dries out in summer if overtopped by oaks. Most of this unit is covered by light to dense stands of post and blackjack oaks. Fairly good native grass pastures can be developed if the oak trees are destroyed. Some areas are suitable for tame pasture.

The management of this capability unit is described in the sections Tame Pasture Management, Woodland Management, and Native Meadow Management.

CAPABILITY UNIT VIIe-1

Sloping, severely eroded and gullied soils formerly used for tilled crops

Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded.
Teller soils, severely gullied.
Zaneis soils, 3 to 8 percent slopes, severely eroded.

These soils are shallow to deep and permeable, and they have moderately retentive subsoils that can hold moisture for plant growth. The diversion of runoff from surrounding slopes is needed to prevent further gullying and to help establish vegetation. Soils that have developed on reddish sandstone have rock outcrops in places.

The soils require careful management. Some areas are suited to tame pasture if plant nutrients are applied. Bermudagrass is a good pasture base because it spreads readily. After tame or native grass pastures are established, the grazing must be carefully controlled.

The management of this capability unit is described in the sections Tame Pasture Management, Woodland Management, and Native Meadow Management.

CAPABILITY UNIT VIIs-1

Sloping and strongly sloping, shallow prairie soils over clay beds and reddish sandstone

Vernon and Lucien soils, 6 to 20 percent slopes.

These soils are generally in native grasses and are used as range. Some of the sandiest areas are invaded by a sparse cover of post and blackjack oaks. Runoff is rapid because of the steep slopes and clayey subsoils. Consequently, a plant cover is needed to assure maximum infiltration of rain. Rainfall penetrates the sandier Lucien soils to some extent.

Grazing should be carefully controlled to permit the growth of thick stands of grass and to control runoff and erosion. The sandier soils on level ridgetops are suitable for tame pasture.

The management of this capability unit is described in the sections Tame Pasture Management, Woodland Management, and Native Meadow Management.

Estimated Yields

The estimated average acre yields that can be expected from the principal crops grown on soils of Logan County under two levels of management are shown in table 5.

Where possible, estimates are for a 10-year or longer period and include some years of high and low yields that resulted from favorable or very low rainfall or from other climatic factors. The estimates are based mainly on information gathered through interviews with farmers, county agricultural workers, and others who have observed yields.

Adjustments of some of the estimated yields were based on knowledge of the behavior of particular soils or crops at nearby experimental stations. The yields are as accurate as can be given without detailed and lengthy

TABLE 5.—*Estimated average acre yields of principal crops*

[Yields in columns A are those obtained over a period of years under common management practices; those in columns B, under improved management. Absence of yield indicates crop is seldom grown or that the soil is not suited to its production]

Soil	Wheat		Oats		Barley		Corn		Sorghum grain		Sorghum fodder		Alfalfa		Lint cotton		Native hay
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Lb.*	*Lb.*	*Tons*
Bethany silt loam, 0 to 1 percent slopes	16	24	26	40	22	36	16	26	22	28	2.2	2.6	1.5	2.5	250	320	1.3
Chickasha loam, 0 to 2 percent slopes	12	22	22	45	18	33	16	26	20	22	2.0	2.6	1.4	2.2	230	300	1.2
Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes [1]	6	10	12	16	9	15	-----	-----	10	18	1.2	1.7	-----	-----	100	140	.8
Darnell and Stephenville fine sandy loams, 8 to 15 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Derby loamy fine sand, 0 to 3 percent slopes	7	12	-----	-----	11	18	8	14	8	12	1.2	1.7	-----	-----	90	120	.9
Derby loamy fine sand, 3 to 8 percent slopes	5	10	-----	-----	-----	-----	-----	-----	6	10	1.0	1.4	-----	-----	-----	-----	.8
Derby loamy fine sand, 8 to 20 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Dougherty loamy fine sand, 0 to 3 percent slopes	9	15	15	22	14	22	14	22	16	26	1.6	2.3	1.4	2.1	140	220	1.0
Dougherty loamy fine sand, 3 to 8 percent slopes	6	10	13	20	9	15	10	20	10	18	-----	-----	1.0	1.5	120	180	-----
Kirkland silt loam, 0 to 1 percent slopes	14	20	22	40	18	30	16	20	16	22	2.0	2.4	1.2	1.6	200	260	1.2
Kirkland silt loam, 1 to 3 percent slopes	14	20	20	35	21	30	-----	-----	15	22	1.8	2.2	1.0	1.5	180	250	1.0
Minco loam, 0 to 3 percent slopes	12	18	22	34	18	27	20	30	18	26	2.0	2.5	2.0	2.5	200	260	1.2
Minco loam, 3 to 8 percent slopes	10	15	16	24	15	22	18	28	16	24	1.8	2.2	1.8	2.4	180	240	1.1
Minco loam, 8 to 20 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mixed alluvial land	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Noble very fine sandy loam, 1 to 6 percent slopes	7	12	14	20	11	18	14	22	14	20	1.3	1.7	1.2	1.8	130	200	.9
Norge loam, 0 to 3 percent slopes	12	22	28	45	18	33	25	40	22	32	1.2	2.7	1.6	2.5	250	350	1.1
Norge loam, 3 to 7 percent slopes	10	18	-----	-----	15	27	20	34	18	26	-----	-----	1.2	2.0	180	240	1.0
Port soils	18	30	30	50	27	45	35	60	30	44	3.0	4.0	2.5	3.5	320	420	-----
Pulaski fine sandy loam	12	24	25	45	18	36	20	45	22	35	2.4	3.2	1.8	3.2	220	310	-----
Reinach very fine sandy loam	20	30	35	55	30	45	40	65	32	44	3.0	4.0	2.6	3.5	340	430	-----
Renfrow silt loam, 1 to 3 percent slopes	14	20	20	35	21	30	-----	-----	14	20	1.4	2.0	1.0	1.5	175	230	1.0
Renfrow silt loam, 3 to 6 percent slopes	11	16	16	28	16	24	-----	-----	10	15	1.0	1.5	-----	-----	-----	-----	.8
Sand dunes, Lincoln material	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stephenville fine sandy loam, 0 to 3 percent slopes	7	15	14	25	10	22	-----	-----	10	18	1.2	1.7	-----	-----	120	170	.8
Teller very fine sandy loam, 0 to 3 percent slopes	14	22	26	38	21	33	22	32	20	32	2.1	2.7	2.3	2.8	250	350	1.3
Teller very fine sandy loam, 3 to 8 percent slopes	12	18	20	32	18	27	15	25	16	24	1.8	2.2	2.0	2.6	180	240	1.1
Teller soils, severely gullied	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vanoss loam, 0 to 1 percent slopes	16	24	28	44	24	36	25	40	22	32	2.1	2.7	2.4	3.0	270	360	1.3
Vanoss loam, 1 to 3 percent slopes	14	22	24	38	21	33	22	35	20	30	1.8	2.4	2.2	2.8	250	320	1.2
Vanoss fine sandy loam, 0 to 1 percent slopes	12	20	22	40	18	30	20	35	20	30	2.0	2.6	1.8	2.5	200	280	1.1
Vanoss fine sandy loam, 1 to 3 percent slopes	10	16	20	35	15	24	18	30	16	26	1.8	2.4	1.6	2.2	200	250	1.0
Vernon and Lucien soils, 6 to 20 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Yahola clay loam	20	30	35	60	-----	-----	40	65	32	50	3.2	4.3	2.6	3.8	340	420	-----
Yahola very fine sandy loam	18	30	32	50	27	45	35	65	30	46	3.1	4.1	2.5	3.8	320	420	-----
Zaneis loam, 0 to 3 percent slopes	12	20	24	40	18	30	-----	-----	18	26	1.9	2.5	1.3	2.0	220	280	1.1
Zaneis loam, 3 to 6 percent slopes	10	16	20	34	15	24	-----	-----	16	24	1.7	2.3	1.1	1.8	150	200	1.0
Zaneis soils, 3 to 8 percent slopes, severely eroded	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[1] Estimates are for the Stephenville soil.

491776—60——3

search of production records. They indicate the relative productivity of soils shown on the soil map.

The yields in columns A were obtained under the management that now prevails on farms that do not use improved management. Those in columns B were obtained under improved management.

Common management

Under common management, crops are selected to suit the soils, suitable varieties are grown, and proper rates of seeding are practiced. The crops are efficiently harvested, and insect control is practiced. However, cropping systems are not consistently followed, tillage practices do not always give protection from erosion and promote good tilth, and fertilizers are not applied in proper amounts.

SELECTING CROPS TO SUIT THE SOIL

The more finely textured upland soils of the Renfrow, Bethany, and Kirkland series are used for small grains. The sandier and more permeable upland soils of the Zaneis, Chickasha, and Stephenville series are used for small grains and row crops. The Reinach, Yahola, and Port soils of bottom lands are used for alfalfa and for all of the commonly grown crops. The deep, permeable soils of the Teller, Vanoss, Minco, Derby, and Dougherty series are used more for summer crops than the other upland soils of the county.

CROPPING SYSTEMS

On the upland soils the sequence of crops is generally one of the following: (1) Wheat following wheat; (2) cotton following small grain, sorghum, or cotton; (3) sorghums following small grain or sorghum; (4) corn following another row crop; (5) small grain cover crops following row crops on sandy areas.

On soils of the bottom lands the general sequence is one of the following: (1) Corn or grain sorghum following alfalfa; (2) small grain following corn or cotton; (3) cotton normally following small grain or corn; (4) cover crops following row crops on only the most sandy areas; (5) small grain sometimes planted after harvesting corn or cotton.

Many farmers grow small grain year after year. Grain sorghum for feed is the only row crop grown by many. Some farmers grow sorghum on the shallower, less productive soils year after year. Stalks are often grazed in fall and winter, and little of the residue is left to turn back into the soil.

Cropping systems using grass and legumes in regular sequence with row crops are not rigidly followed because of the uncertainty of rainfall and the difficulty in establishing and growing sod crops and legumes. Legumes are grown by many farmers, but they are generally used as much for pasture and hay as they are for soil building.

Alfalfa is the most widely used legume, and it is grown mainly for hay. It is suited to bottom-land and permeable upland soils when adequate moisture is available during the growing season. Alfalfa usually follows a small grain on land plowed right after harvest and fallowed free of weeds all summer. It is planted in fall on a well-firmed seedbed. Crops following alfalfa on upland soils may suffer because of dry subsoils.

Sweetclover is not so widely used as feasible, partly because it is hard to establish. It is seeded in spring with a small grain, and during the second year it is the only crop. Sweetclover is usually followed by a small grain, but on some farms it is followed for at least 1 year by a row crop.

Vetch has been sown to some extent with small grain, but it is widely used in mixtures with rye and winter pasture. It is also grown as green manure preceding cotton and sorghum.

TILLAGE

Land intended for fall-sown small grain is usually plowed 3 to 6 inches deep in spring and is tilled during summer to control weeds. It is suitable for planting after the first fall rains. In some years, however, small grain is planted when fall moisture is lacking.

Areas intended for spring oats are generally plowed in the fall and harrowed late in winter just before planting time. Those used for corn and cotton are generally plowed late in winter and planted when conditions are suitable. Row crops are sometimes plowed early with a lister so that the soil will catch moisture during months of high rainfall.

Vetch, or a mixture of rye and vetch, is often drilled in cotton middles or planted after the corn or sorghum stubble has been double disked. Winter cover crops are drilled in the middles, mainly on the sandier soils that need protection from wind erosion. On other soils most plant residue remaining after harvest is left on the land during winter, unless the fields are to be used for spring grains.

All crops are cultivated only enough to control weeds. Hoeing is done to kill weeds not reached in plowing or to thin stands of cotton and other row crops. There is a tendency to overtill soils intended for fall-sown crops. They ought to be kept cloddy and porous as long as possible.

Most tillage of sloping fields is on the contour, and many of the sloping fields have been terraced.

FERTILIZATION

Commercial fertilizers are commonly used in Logan County, but not in large enough quantities to produce highest yields. Most farmers do not use fertilizers regularly.

Before using fertilizers, farmers estimate the chances of a favorable season and of returns large enough to warrant the additional expense. Not enough attention is yet given to improving soil fertility so that the soils will produce high yields in the years when climate is favorable.

On many farms producing row crops, low-analysis fertilizers are used chiefly to start the crops. Some farmers, however, apply additional nitrogen as a side dressing later in the growing season and substantially increase the yields of their crops.

Limestone is applied at the rate of about 2 tons per acre and probably is in line with actual needs of the soil.

Improved management

Improved management includes all the good practices farmers are now using and the improved cropping systems, methods of tillage, fertilization, and conservation of soil and water suggested in the section Description of Capability Units.

Native Grassland Management

The acreage of native grazing land in Logan County is estimated to be 246,000 acres. Much of the acreage produces considerably less forage than it could. Particularly poor forage occurs on the red clay soils in western Logan County, where tall grasses have been largely replaced by the short grasses and mid grasses. About 65,000 acres has been cultivated and is now in various stages of natural revegetation. This acreage is usually far less productive than virgin grasslands and requires careful grazing management. An additional 65,000 acres is covered with blackjack and post oak brush and produces less than 25 percent of the forage possible under proper management.

Bermudagrass and johnsongrass, the principal introduced grasses, occur mostly along the valleys and drainageways. They are used for hay and pasture to supplement the forage obtained from native grasslands.

An estimated 80,000 acres of native grassland is in farm pastures, the average size of which is less than 100 acres. Farmers often plan their livestock numbers on the anticipated production of feed and temporary pasture in addition to the native pasture. These small farm pastures are a special problem in management because they are used as year-long holding areas and are grazed too heavily. Forage production is frequently less than 40 percent of its potential.

An appraisal of native grassland conditions in the county indicates that productivity of forage can be more than doubled if operators use the best practices in range management. An increase in productivity would not result in a major increase in livestock numbers. However, it would mean an increase in beef and milk produced per animal. More important still, it should yield a much higher return to the operator because of lower production costs.

Proper grazing is the most important practice in the management of native grassland. All other management fails if grass is grazed improperly. Grazing must be regulated so that enough leaf area remains for plants to carry on the vital processes necessary for growth.

Grazing tends to retard the growth of the most palatable plants by removing the foliage. Plants that are grazed the least continue to grow because their greater leaf area can assimilate more light, water, and plant nutrients for the life processes. Consequently, the less palatable plants and those that escape grazing for various reasons are the ones that tend to survive on overgrazed areas. For example, a claypan prairie range site in excellent condition supports a productive growth of little bluestem, Indiangrass, big bluestem, and side-oats grama. If these grasses are heavily grazed continuously, the composition of plants is changed to a sod type of cover consisting of buffalograss and blue grama, and, in the drainageways, mainly ironweed and coralberry (buckbrush). Three-awn grass, western ragweed, annual broomweed, and other low-grade plants almost completely hide the shorter buffalograss and blue grama in years of favorable rainfall. This type of cover decreases the production of forage.

The decline of native grasslands in Logan County can be reversed in most cases by good grazing management alone. In a few areas, particularly on claypan soils, overseeding may be required if only a few of the more desirable plants are present after light or deferred grazing.

Specific guides for safe stocking are not included in this report, because many pastures are a mixture of range sites that have different range conditions. The technical personnel of local agricultural agencies will gladly help an operator classify range sites and condition classes in each pasture. They can also suggest proper rates of stocking and other necessary practices for grassland improvement.

The operator who becomes familiar with his range sites and understands the signs of improvement or decline can vary the management to obtain the desired results.

The development of high-yielding, vigorous grassland requires flexibility in management and in rates of stocking. A general rule for good management is to leave ungrazed at least half of the growth of desirable forage. An operator may prefer to maintain a fairly small breeding herd to utilize properly the forage in dry seasons, and obtain stocker cattle to graze the more abundant forage in seasons when moisture and plant growth are more favorable.

Range sites in Logan County

Increased production of forage from native grassland is obtained primarily through practices that will improve the vigor and abundance of desirable vegetation. Among these are proper use, deferred grazing (fig. 10), proper grazing distribution, brush control, range seeding, pasture planting, and stock water development.

Figure 10.—**Grazing has been deferred on this pasture during the growing season. Following summer rest, cattle were turned in for winter grazing.**

To improve grassland, the operator should know the important range grasses and the combination in which they grow. He should be able to recognize the signs of range improvement or deterioration. Changes in the kinds of range plants often take place gradually, and they are overlooked or misunderstood if the operator is not acquainted with his vegetation and soils. Sometimes the range is thought to be improving when plant growth is stimulated by favorable rainfall, whereas actually the long-time trend is toward poorer grasses and lower production. On the other hand, a range may appear to be worn out because of occasional close grazing but may have had only a temporary setback that can be remedied by proper management.

To help operators understand their grasslands, the Soil Conservation Service classifies all native grassland into range sites on the basis of climate and soils. Range sites are then divided into range condition classes, which indicate trends in vegetation.

Range condition classes

The operator should study grasslands that have not been damaged by grazing, fire, or other disturbance and compare them with similar sites grazed under several types of management. Thus, by comparison, he is able to classify the degree of change that has taken place on each site of his own pasture. Range sites are divided into excellent, good, fair, and poor condition classes. A range in excellent condition has 75 to 100 percent of the best kinds of vegetation the site is capable of producing. On the other hand, one in poor condition has only from 0 to 25 percent of the best kind of vegetation the site is capable of producing.

The range condition class may be lowered a grade for reasons other than vegetation. For example, a site formerly in poor condition may have recovered to the extent that from 50 to 75 percent of the range cover consists of the better kinds of plants. The condition of this range would normally be classed as good. However, if very little litter is on the ground, soil condition is poor, and erosion is active, the range condition class might be lowered to fair. This indicates the range should be grazed less heavily than if it were in good condition.

Description of range sites

Because of differences in the kind or amount of native grass, native legumes, or other natural vegetation, the soils of Logan County are divided into nine range sites. Range site differences are important enough to affect the rate of stocking or other range management.

CLAYPAN PRAIRIE RANGE SITE

The soils have a loamy surface soil but are underlain by heavy clay. Buffalo wallows or slick spots are common. Water is absorbed very slowly, and there is much runoff unless a good mulch is kept on the surface.

Soils in this range site are the Renfrow, Kirkland, and Bethany silt loams.

Grass production is fairly good when the range is in its best condition (fig. 11). The better grasses are big bluestem, little bluestem, and side-oats grama. Blue grama and buffalograss are usually present and increase rapidly under continuous heavy grazing. Three-awn grass is a pest on poor ranges. After the taller grasses disappear, this range site recovers more slowly from overuse than sites on more open, permeable soils.

LOAMY PRAIRIE RANGE SITE

This is the most extensive range site in Logan County. It is also the most productive upland site. The soils have a good depth for the growth of plant roots. The subsoils are porous enough to allow good infiltration of moisture.

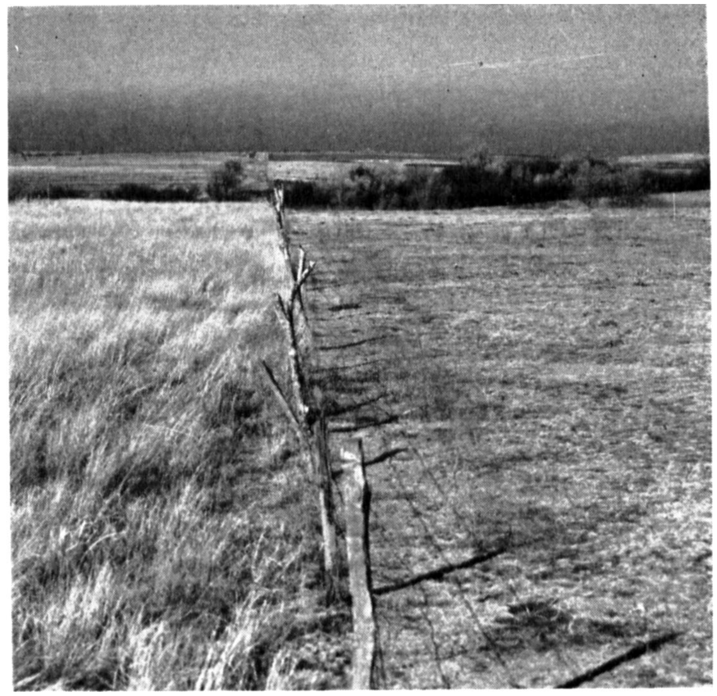


Figure 11.—**Claypan prairie range site. Left, unused grass in excellent condition; right, heavily grazed grass in poor condition.**

Soils in this range site are the Chickasha, Minco, Norge, Vanoss, and Zaneis loams; Teller very fine sandy loams; Teller soils, severely gullied; and Vanoss fine sandy loams.

The main grasses are big bluestem, little bluestem, Indiangrass, and switchgrass (fig. 12). The main native legume is the leadplant. If this range site is heavily grazed, blue grama and side-oats grama greatly increase. If overgrazed, it is invaded by silver bluestem and sand dropseed.

RED CLAY PRAIRIE RANGE SITE

This range site is made up of Vernon and Lucien soils. The Vernon are sloping red clay soils. The Lucien are more sandy soils on the sandstone of the ridgetops and side slopes. Many severely eroded areas of clayey soil without much vegetation are included.

These soils absorb water fairly well if the surface is protected by a mulch and has not been trampled heavily. The main problem is to reestablish vegetation, reduce runoff and erosion, and improve the rate of moisture infiltration. The growth of grass is poor, and revegetation on the severely eroded areas is difficult because of low fertility and droughtiness of the soils. The production of forage on most areas of this site is poor.

Side-oats grama and little bluestem are the most common grasses. Hairy grama, a poor producer of forage, increases if the site is overgrazed. Continuous overgrazing results in bare eroding red lands that recover slowly under even the best management.

SEVERELY ERODED PRAIRIE RANGE SITE

This range site consists of severely eroded fields that were once cultivated. It consists of Zaneis soils, 3 to 8 percent slopes, severely eroded.

Figure 12.—**Loamy prairie range site. Proper grazing has left this site in excellent condition at the end of a favorable growing season. Half the forage was utilized and half was left in reserve.**

In many places this range site has a cover of silver bluestem, fall switchgrass, annual three-awn, western ragweed, and other low-grade vegetation. The principal better grasses are little bluestem, Indiangrass, switchgrass, and side-oats grama.

This range site is hard to revegetate. The composition of grasses can be improved by deferring grazing during the growing season to allow natural seeding of the better grasses.

SANDY SAVANNA RANGE SITE

The soils of this range site developed from sandstone. Sandstone bedrock is at depths of 6 to 30 inches or more and in many places is at the surface.

In this site are the Darnell and Stephenville fine sandy loams, Stephenville fine sandy loam, and Noble very fine sandy loam. The shallowness of the Darnell soils somewhat limits the growth of plants, but cracks and joints in the rock allow some roots to penetrate deeply. The production of grass is moderately good.

This range site originally was covered by grass and an overstory of scattered post and blackjack oaks. In most places fire and overgrazing have reduced the stand of grass and helped to increase the density of scrubby oak brush (figs. 13, 14, and 15).

The main grasses are big and little bluestem, Indiangrass, switchgrass, and side-oats grama. Perennial lespedeza, tickclover, leadplant, and other native legumes are abundant on this site.

Figure 13.—**Sandy savanna range site. Productivity of site has been restored by killing the brush and deferring the grazing for two summers. Careful management is needed to prevent reinvasion of brush.**

Figure 14.—**Sandy savanna range site. Left, brushy grassland in poor condition; right, treated and well-managed grassland in excellent condition.**

Figure 15.—**Sandy savanna range site. Old field 7 years after seeding contains an excellent stand of little and big bluestem, Indiangrass, and switchgrass. It has been protected from grazing for 3 years after seeding and then grazed lightly. The surface mulch does not yet adequately prevent erosion.**

ERODED SANDY SAVANNA RANGE SITE

The soils in this range site are medium textured and severely eroded. They were formerly in cultivation. Many deep uncrossable gullies have formed. The soil is deep in most places between the gullies, although fertility is somewhat low.

In this site are the Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded, and some severely eroded areas of Noble fine sandy loam.

Seeding equipment is difficult to operate on this site. The erosiveness of the soil makes it hazardous to prepare a clean seedbed prior to the seeding of grasses. Consequently, the reestablishment of native grasses depends on natural seeding. Once the native bluestem grasses are reestablished, production of forage is good. Grazing will be spotty, however, on account of the deep gullies.

Management should consist of preventing runoff and erosion, encouraging the natural seeding, and improving the bluestem grasses. If the site is in poor condition, it should not be grazed during the growing season. Otherwise, grazing should be light or restricted in August, September, and October, when seed is formed (figs. 16 and 17).

DEEP SANDY SAVANNA RANGE SITE

The soils of this range site are deep coarse sands. They are subject to severe wind erosion if the vegetation is removed.

In this site are the Dougherty and Derby loamy fine sands. These soils absorb water readily, and they are potentially good producers of forage. Under good conditions, they supported tall prairie grasses and some post and blackjack oaks.

This site is used for small pastures that have been severely overgrazed. The production of forage is very low, and the overstory is in many places a dense growth of post and blackjack oaks. The main grasses are now sand bluestem, switchgrass, Indiangrass, and little bluestem. The good native legumes are perennial lespedeza, sand pea, and tickclover.

LOAMY BOTTOM-LAND RANGE SITE

The soils in this range site are deep and highly productive. They absorb moisture readily, and some of them are subject to overflow. In this site are the Port soils, Yahola clay loam, Yahola very fine sandy loam, Reinach very fine sandy loam, and Pulaski fine sandy loam.

A large percentage of these soils is in cultivation. The acreage still in native grass generally is along the banks of creeks. The main grasses are big bluestem, switchgrass, eastern gamagrass, and Florida paspalum. Canada wild-rye, Texas bluegrass, and other winter grasses are prevalent. Johnsongrass, a common invader, produces considerable forage. The overstory consists of an open stand of elm, ash, cottonwood, hackberry, and other lowland hardwoods.

Management consists of proper stocking and the control of brush.

SANDY BOTTOM-LAND RANGE SITE

The soils in this range site are deep and sandy. They occur along the Cimarron River and occupy areas that range from low wet swales to low dunes. Some areas are frequently flooded. In this site are Mixed alluvial land and Sand dunes, Lincoln material.

Figure 16.—**Eroded sandy savanna range site in poor condition. Heavy grazing has interfered with natural reseeding.**

Figure 17.—**Eroded sandy savanna range site. Naturally reseeded and lightly grazed old field out of cultivation for 25 years at Red Plains Soil Conservation Experiment Station, Guthrie, Okla. The stand still has a considerable amount of the less desirable grasses, such as splitbeard bluestem and silver bluestem, but it controls runoff and erosion.**

The site is generally productive, but it changes with changes in the river channel. The main grasses are sand bluestem, switchgrass, little bluestem, Indiangrass, and sand reedgrass. Johnsongrass has spread to this site. The main woody plants are tamarisk, sandplum, and cottonwood.

Overgrazing of this site will cause the land to blow.

Native Meadow Management

Approximately 6,400 acres of native grassland is mowed for hay. Most hay is cut from the gently sloping, stone-free prairie soils. The range site and range condition class are determined for native meadows in the same way as for native grassland management. The native meadows, however, are managed mainly so that sustained good yields of high quality hay can be obtained. It is most important to determine the proper dates and frequency of mowing, to prevent damage by fire, and to regulate winter grazing.

As a general rule, one cutting a year in June or early in July allows better grass recovery and a healthier meadow than if mowing is continued late in the growing season. Early cut hay contains more protein and carotene than that cut later. Higher yields are obtained by mowing late in July and in August, but continuous late cutting may eventually cause a decrease in the yield of hay.

Meadows that are mowed early should be grazed after frost because grazing during the period of seed formation is detrimental. Winter grazing of meadows should be moderate, since heavy use and trampling tend to remove mulch and open the stand to invasion of annual three-awn grass and other weeds.

In mowing native grass, the cutter bar should be set, if possible, to cut the grass at least 3 inches from the ground. This height allows enough leaf surface to remain on the plants to protect the soil and to allow the grass to continue growing, even if mowing is followed by drought.

Tame Pasture Management

The production of forage in Logan County can be increased through the establishment of tame pastures. Many native pastures have been so depleted that returns from summer grazing are low and undependable.

Bermudagrass will grow well on some soils, and many acres of it have been established in the past few years. Mechanical planting has speeded up this operation. Vetch can be seeded in the bermudagrass in moist seasons when early fall growth is expected. The legume furnishes nitrogen and improves the growth of bermudagrass in summer.

If management is good, bermudagrass will produce three or four times the forage produced by native grasses. It should be separated from native pastures by a fence. Fertilization, control of weeds, and occasional rest assure good growth of bermudagrass. Grass carried over from the growing season is very valuable and is readily eaten by livestock in winter.

Caddo switchgrass is another useful introduced grass that grows well in summer and may considerably exceed the productivity of native grasses. Although not greatly restricted as to soil, it grows best on the sandier soils. Like bermudagrass it is best planted by itself and managed separately from the native grasses.

Sudangrass is a reliable producer of summer forage. It grows best on bottom lands and on deep, permeable, gently sloping upland soils. It may be grazed or cut for hay.

Weeping lovegrass was more extensively planted in past years. Some good stands remain, and many could be managed more efficiently. The grass becomes tough and unpalatable if not utilized closely in spring. Lovegrass will grow faster and furnish more palatable feed for a longer time if it is fertilized in winter and grazed early in spring. Managed in this way, it will furnish supplemental forage before the later grasses can be grazed. Grazing should be discontinued in May to allow lovegrass to seed, to improve its vigor, and to build root reserves. The aftermath produces fair hay, or it may be grazed in winter. High levels of phosphorus and nitrogen in the soil are needed to produce seed. Therefore production of seed and early grazing can be combined if fertilizer is applied in winter.

Blue panic may have some value on level, fertile, bottom-land soils. It is planted in rows and is a good producer of forage, but it needs ample supplies of plant nutrients. Winterkilling is a hazard in Logan County.

The climate of Logan County allows winter grass, small grains, and legumes to grow well if moisture is adequate.

Bromegrass is suited to fertile bottom lands and to nearly level permeable uplands. It can be grown alone or in a mixture with alfalfa, but the soil must be fertile.

In favorable years hay can be cut early, the grass rested in summer, and the aftermath and late growth grazed throughout the winter.

The fine-textured soils with a clay subsoil are not well suited to bermudagrass in summer because they are droughty. In addition they do not have the fertility or physical properties needed for growing bromegrass in winter and keeping it alive in summer. However, in most years these soils will produce good yields of small grains for grazing or for spring hay. It is possible that forage can be produced more economically on these fine-textured soils in winter and spring than in summer, but high fertility is needed for maximum growth. A mixture of small grains that contains considerable rye for early vigor and growth is suggested. A good stubble or volunteer weeds should cover sloping areas in summer to protect them from erosion. The smoother and more nearly level areas may be plowed following harvest. Generally, grain should be seeded early to get early pasture.

Fescue is another cool-season perennial grass that is suited to most soils except those that are very sandy, are shallow, or have very clayey subsoil. It is not so palatable as bromegrass and should not be used where bromegrass can be grown.

Suggestions for improving tame pastures on Logan County soils are given in table 6.

Woodland Management

About 14 percent of Logan County is in trees that have little or no value for timber. Some good timber grew on the soils of the bottom lands, but most of it has been harvested. That remaining is in very small tracts that are cut over as the trees mature. Cottonwood is the main species, and it is used mostly for rough framing lumber.

The shallow soils of sandstone uplands are covered by an open stand of post and blackjack oaks. The area is grazed to utilize the thin growth of native grasses in the openings and under the trees. Chemicals have been used in recent years to destroy the trees and permit the grass to grow better. Trees cleared by cutting are sometimes used as fuel or fenceposts. Blackjack oak sprouts prolifically if the trees are cut or are cleared by a bulldozer.

The deep sandy soils north of the Cimarron River are also partly wooded. The Dougherty soils have developed under oak, and the Derby, under grass that has been invaded by oak in recent years. The growth rate of oak on deep sandy soils is somewhat faster than that on the sandstone uplands. These soils are suitable for growing trees for windbreaks and fenceposts.

Many small areas of bottom-land soils are suitable for post lots. A good post lot is a valuable asset on any farm.

Farmsteads on the prairies are generally more pleasant and are more comfortable in winter if protected by windbreaks. Many soils of the county are suitable for windbreaks if the trees are cultivated during the first several years of their growth. Tree growth in this area is affected by moisture in the soil, and some plantings fail to survive long droughts.

Suggestions for using present woodland and for the establishment of post lots and windbreaks on various soils are given in table 7. The soils were grouped according to the amount of moisture available for tree growth.

Engineering Properties of the Soils of Logan County[1]

Soils in Highway Construction

Highway engineers who work with foundations and embankments constantly need information on soil materials. Soil information about large areas is particularly valuable. The value of many agricultural soil surveys in the past has been restricted by the lack of a method that translates soil information into language of the engineer. Data suitable for use by engineers are obtained from laboratory tests of soil samples. They include analysis of the percentage distribution of soil-grain sizes and the determination of the effects of water on soil consistency.

A hydrometer is used to determine the particle sizes of the smaller grains in a suspension with water, and a sieve analysis is used to measure the particle sizes of the larger grains. The proportion of gravel, sand, silt, and clay is determined.

The effect of water on the consistency of a soil is determined by the liquid limit and the plastic limit tests. The liquid limit is the moisture content at which a mixture of soil and water is no longer liquid and has changed to a plastic material. The plastic limit is the moisture content at which the soil becomes semisolid and is no longer plastic. The loss of moisture from a liquid soil causes it to become plastic and to decrease in volume. The loss of volume is proportional to the volume of water removed. The loss of moisture from a semisolid soil will also cause it to lose volume. The plastic limit, subtracted from the liquid limit, gives the plasticity index of a soil. This figure indicates the range in content of moisture through which the soil is plastic.

The American Association of State Highway Officials has approved a system of classifying soils according to laboratory tests. This system has been used extensively by the United States Bureau of Public Roads. Soils are classified into seven primary groups, some of which have been divided into subgroups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, consisting of clay soils having low strength when wet. Within each group, the relative engineering value of the material is indicated by a group index number (shown in parentheses following the soil group symbol in table 9). Group indexes range from 0 for the best material to 20 for the poorest. The suitability of a soil for engineering purposes can be estimated from the soil group. The lower the group index number within the same soil group, the better the rating of the soil. Each soil must be tested in the laboratory to determine its engineering values under this system of classification. The essentials of the system of soil classification used by the American Association of State Highway Officials is shown in table 8.

This system of classification is of great value to engineers because it integrates the physical soil tests. When these classification results are shown for the soils on the map, the engineering qualities of these soils are permanently recorded. Additional sampling and testing of soil materials is simplified, as previous tests can be used to predict the qualities of similar soils in other localities.

[1] This section of the soil survey report was prepared with the help of Richard Helmer, highway research engineer, Oklahoma Department of Highways.

TABLE 6.—*Suggestions for tame pasture management on soils of Logan County, Okla.*

Soils [1]	Plant mixtures for pasture and hay and fertilization needs
1. Bottom lands and deep level uplands: Port soils; Pulaski fine sandy loam; Yahola clay loam; Yahola very fine sandy loam; Reinach very fine sandy loam; Vanoss loam, 0 to 1 percent slopes; Vanoss fine sandy loam, 0 to 1 percent slopes; Mixed alluvial land	Bromegrass and alfalfa: Apply lime and phosphate as needed. Blue panic: Plant in rows. Keep supply of nitrogen high. Bermudagrass and vetch: Overseed bermudagrass with vetch in fall, or, if moisture is adequate, use Korean lespedeza instead of vetch. Apply phosphate in large amounts; extra nitrogen may be needed for high yields. Keep a thin stand of trees on mixed alluvial land and plant it by hand with sprigs of bermudagrass.
2. Uplands; permeable and responsive to moisture: Teller very fine sandy loam, 0 to 3 percent slopes; Vanoss loam, 1 to 3 percent slopes; Vanoss fine sandy loam, 1 to 3 percent slopes; Bethany silt loam, 0 to 1 percent slopes; Chickasha loam, 0 to 2 percent slopes; Norge loam, 0 to 3 percent slopes; Zaneis loam, 0 to 3 percent slopes; Minco loam, 0 to 3 percent slopes	Small grain and vetch: Use for winter pasture and for hay crop the following spring. Rotate part with sudangrass for summer pasture when moisture is adequate. Large amounts of phosphate are needed. Bromegrass and alfalfa: Use this on the best areas and apply lime and phosphate liberally. Bermudagrass and vetch: Overseed bermudagrass with vetch in the fall, or, if moisture is adequate, use Korean lespedeza instead of vetch. Bermudagrass may need more nitrogen than vetch can supply. Weeping lovegrass and Caddo switchgrass: Good for forage and hay; needs much phosphate. For best production of hay and seed, needs nitrogen.
3. Uplands; permeable and responsive to moisture, but have less in summer than preceding group of soils: Noble very fine sandy loam, 1 to 6 percent slopes; Norge loam, 3 to 7 percent slopes; Teller very fine sandy loam, 3 to 8 percent slopes; Zaneis loam, 3 to 6 percent slopes; Minco loam, 3 to 8 percent slopes; Minco loam, 8 to 20 percent slopes	Same plants as suggested for soils of group 2, but the response to large quantities of fertilizer may not be as good. Brome and alfalfa should be planted on smoothest, least eroded areas.
4. Uplands; rapidly permeable, droughty: Dougherty loamy fine sand, 0 to 3 percent slopes; Dougherty loamy fine sand, 3 to 8 percent slopes; Stephenville fine sandy loam, 0 to 3 percent slopes; Derby loamy fine sand, 0 to 3 percent slopes	Same plants as suggested for soils in group 2, except that brome and alfalfa are not often suited, because the soils are too droughty and low in fertility. Plants respond to fertilizers, but the quantity applied should be adjusted to the available moisture.
5. Uplands; clayey soils, droughty in summer: Kirkland silt loam, 0 to 1 percent slopes; Kirkland silt loam, 1 to 3 percent slopes; Renfrow silt loam, 1 to 3 percent slopes; Renfrow silt loam, 3 to 6 percent slopes	Small grain and vetch: Use for winter pasture and spring hay crop. Liberal quantities of phosphate are needed. Bermudagrass and lovegrass: Use on heavily grazed areas; forage production is poor because of summer drought. Nitrogen and phosphate are needed, but drought limits effectiveness of fertilization. Gramagrass mixtures: Best for permanent revegetation.
6. Uplands; very sandy and droughty: Derby loamy fine sand, 3 to 8 percent slopes; Derby loamy fine sand, 8 to 20 percent slopes; Sand dunes, Lincoln material	Tame grasses: Not suited because soils are too droughty. Native grasses: Graze lightly; remove competing clumps of oak to encourage grass to spread and increase in density.
7. Uplands; mixed shallow and deep sandy sites: Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes. Darnell and Stephenville fine sandy loams, 8 to 15 percent slopes.	Native grasses: Graze lightly; destroy oaks to allow grass to spread and increase in density. Bermudagrass: Sprig bermudagrass on deeper soils; overseed with vetch and apply phosphate. Switchgrass or lovegrass: May be used instead of bermudagrass.
8. Uplands; severely eroded mixed sites: Teller soils, severely gullied; Zaneis soils, 3 to 8 percent slopes, severely eroded. Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded.	Bermudagrass: Sprig bermudagrass in gullies; overseed vetch and apply phosphate and potash. Divert water from gullies. Native grass and lovegrass: Use for revegetation. Apply phosphate and nitrogen in fairly large quantities.
9. Uplands; steep, clayey, and droughty soils: Vernon and Lucien soils, 6 to 20 percent slopes.	Tame grasses: Not suited, as soils are too droughty. Lovegrass or bermudagrass: Use in old washes and gullies. Native grasses: Drill in sorghum stubble to revegetate large eroded areas. Sorghum needs nitrogen.

[1] Suggestions for groups 1, 2, 3, 4, and 5 apply to present or former cropland, and they apply to soils in natural condition. Only small areas of groups 6, 7, 8, and 9 have been cultivated, so statements apply to areas in their natural state. Soils in each group are listed according to decreasing production of forage.

491776—59——4

TABLE 7.—*Suggestions for utilization of woodland and for tree planting*

Soils [1]	Woodland	Post lots, windbreaks, Christmas trees, and other uses
1. Bottom-land soils (moisture relations very good). Port soils. Pulaski fine sandy loam. Reinach very fine sandy loam. Yahola very fine sandy loam. Yahola clay loam. Mixed alluvial land.	Thin present stand of trees by favoring desirable species. Clear out decadent stands and replant to post-producing species.	Plant catalpa and black locust in odd corners and on overflowed land and creek banks for posts. Plant redcedar on areas not frequently flooded. Control weeds until trees are well established.
2. Upland soils (moisture relations good). Dougherty loamy fine sand, 0 to 3 percent slopes. Teller very fine sandy loam, 0 to 3 percent slopes. Vanoss fine sandy loam, 0 to 1 percent slopes. Vanoss loam, 0 to 1 percent slopes. Vanoss loam, 1 to 3 percent slopes. Vanoss fine sandy loam, 1 to 3 percent slopes. Minco loam, 0 to 3 percent slopes.	(2)	Suitable for post lots, windbreaks, and redcedar for Christmas trees. Plant on contour. Control weeds until trees are well established. Trees grow more slowly than on soils of group 1. Long droughts may cause some failures.
3. Upland soils (moisture relations fair). Chickasha loam, 0 to 2 percent slopes. Norge loam, 0 to 3 percent slopes. Bethany silt loam, 0 to 1 percent slopes. Stephenville fine sandy loam, 0 to 3 percent slopes. Zaneis loam, 0 to 3 percent slopes. Minco loam, 3 to 8 percent slopes. Minco loam, 8 to 20 percent slopes. Dougherty loamy fine sand, 3 to 8 percent slopes. Noble very fine sandy loam, 1 to 6 percent slopes. Teller very fine sandy loam, 3 to 8 percent slopes. Derby loamy fine sand, 0 to 3 percent slopes. Norge loam, 3 to 7 percent slopes. Teller soils, severely gullied.	Some oaks on Stephenville, Dougherty, and Derby soils of no present value.	Suggestions same as for soils of group 2. The soils of group 3, however, are drier because of slower water penetration and greater runoff. Growth rate is slower, and failures of plantings can be expected during long droughts. Divert water from areas of Teller soils, severely gullied. Plant locust in gully bottoms to help stabilize soils.
4. Upland soils (moisture relations poor). Zaneis loam, 3 to 6 percent slopes. Kirkland silt loam, 0 to 1 percent slopes. Kirkland silt loam, 1 to 3 percent slopes. Renfrow silt loam, 1 to 3 percent slopes.	No woodland present	Planting not suggested for post lots. Plant only the most drought-resistant species for windbreaks.
5. Upland soils (clayey and severely eroded, moisture relations very poor). Renfrow silt loam, 3 to 6 percent slopes. Darnell and Stephenville soils, 3 to 8 percent slopes, severely eroded. Zaneis soils, 3 to 8 percent slopes, severely eroded. Vernon and Lucien soils, 6 to 20 percent slopes.	No woodland present	Suggestions same as for group 4. Chances of success for tree plantings are very limited.

See footnotes at end of table.

TABLE 7.—*Suggestions for utilization of woodland and for tree planting*—Continued

Soils [1]	Woodland	Post lots, windbreaks, Christmas trees, and other uses
6. Upland soils (sandy, deep and shallow soils, very poor moisture relations). Derby loamy fine sand, 3 to 8 percent slopes. Derby loamy fine sand, 8 to 20 percent slopes. Sand dunes, Lincoln material. Darnell and Stephenville fine sandy loams, 3 to 8 percent slopes. Darnell and Stephenville fine sandy loams, 8 to 15 percent slopes.	Some oaks of no present value	Very few areas suitable for tree planting because soils are droughty and shallow. Use Stephenville soils as suggested for those of group 2. Rate of growth very slow.

[1] Groups arranged in decreasing order of productiveness for trees. Within groups, soils are in decreasing order of value for trees.
[2] There is little inducement for the management and perpetuation of the remaining upland oak stands. Posts from more desirable tree species are readily obtainable throughout the county. With the disappearance of the oak stands, the sites are generally converted to grassland or to occasional plantations of the more valuable post or Christmas tree species.

Some of the things a highway engineer wants to know about a soil are its load-supporting ability, its volumetric shrinkage, and its suitability as a binder for a base course. Other information needed about the soil is (1) its value for construction of shoulders along the highway; (2) whether it will stabilize with asphalt or cement; (3) its resistance to erosion; and (4) its suitability for seeding and sodding of backslopes and ditches.

The test data for materials of the A, B, and C horizons of some of the principal soils in Logan County are shown in table 9. The data were obtained in the Materials Laboratory, Oklahoma Department of Highways. The information in this table is general and should be supplemented by additional sampling and testing of materials for specific uses.

A rough estimate of the suitability of the A, B, and C horizons for earth construction and their relative volumetric shrinkage are given in table 10 for important soils of Logan County. For the A horizons, suitability for seeding and sodding was judged by the expected performance of each soil as a medium for plant growth. Organic-matter content, soil granulation, and capacity of the soil to absorb and store moisture were considered. Consequently, the rating for suitability for seeding and sodding may be different for materials having similar soil engineering test values in the C horizons.

Table 11 shows the test values used in making the estimates in table 10 of the suitability of the soil materials for various kinds of earth construction and for volumetric shrinkage.

Variations in engineering properties

Some soils should be carefully observed for variations in engineering properties. The undifferentiated soil groups—the Darnell and Stephenville fine sandy loams and the Vernon and Lucien soils—are on rolling to rough terrain. The soils in each group differ because of rock banding and because differences in slope affect the depth of profile development. Within any of these soil areas, the soils may differ considerably in engineering properties and should be checked carefully. When moved in road construction, these soils will usually consist of a composite of the soils in the undifferentiated group.

The Darnell and Stephenville soils are about 80 percent Darnell; so mixtures of this undifferentiated group will behave about like the Darnell. Thin beds of clay occupied by Vernon soils occur within areas of Darnell and Stephenville soils.

The Vernon and Lucien soils consist of about 60 percent of clayey Vernon soil and 40 percent of the sandier Lucien soil. In the western and northern parts of Logan County, the Lucien soil is mainly on ridgetops. In the central and southern parts, most of the Lucien soil occurs on ridgetops and on slopes that are banded with Vernon soil developed on clay beds.

Soils of the Zaneis series are more variable than those of other soil series because of the erratic banding of sandstone, siltstone, and beds of clay. Zaneis subsoils range from sandy clay loams to light granular clays. Narrow bands of Renfrow soils, not mapped separately, are included with Zaneis soils. The engineering data on Zaneis loam in table 9 shows properties of the average Zaneis soil, but actually a range in characteristics should be expected in both directions. Properties of the Renfrow soils are probably less variable, but some gradations toward Zaneis may be expected in most areas of Renfrow.

The bottom-land soils—Pulaski fine sandy loam, Yahola very fine sandy loam, Yahola clay loam, Mixed alluvial land, and Port soils—are erratic in properties because of stratification of the alluvium in which they are forming. Pulaski soils are covered by recent sediments that washed from the sandier hillsides and contain layers ranging from sandy loams to clay loams. The slowly drained Pulaski areas contain thick lenses of clay loam.

Yahola soils range from sandy loams to clay loams in texture and from 12 to 30 inches in thickness. They have developed over substrata of sandy loam. The upper and lower parts of the Yahola profiles differ much and may furnish materials that are desirable for different purposes. The underlying sandy material of Yahola soils has been used commercially.

Mixed alluvial land includes materials similar to those under the Yahola soils. These materials, however, are considerably more stratified.

The Port soils are probably the most uniform of the bottom-land soils. However, in the upper 12 to 24

TABLE 8.—*Essentials of the classification used by*

Group classification	Granular materials (35 percent or less passing No. 200 sieve [2])				
	A–1		A–3	A–2	
	A–1–a	A–1–b		A–2–4	A–2–5
Sieve analysis:					
Percent passing—					
No. 10	50 maximum				
No. 40	30 maximum	50 maximum	51 minimum		
No. 200	15 maximum	25 maximum	10 maximum	35 maximum	35 maximum
Characteristics of fraction passing No. 40:					
Liquid limit				40 maximum	41 minimum
Plasticity index	6 maximum	6 maximum	NP [3]	10 maximum	10 maximum
Group index [5]	0	0	0	0	0
Usual types of significant constituent materials.	Stone fragments, gravel, and sand.	Stone fragments, gravel, and sand.	Fine sand	Silty gravel and sand.	Silty gravel and sand.
Stability properties	Highly stable at all times.	Highly stable at all times.	Highly stable when confined.	Stable when dry; easily worn away by traffic (ravels).	Stable when dry; easily worn away by traffic (ravels).

[1] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. I): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, A. A. S. H. O. Designation: M 145–49.

[2] The 200-mesh sieve (0.074 mm. openings) separates soil fractions at about the middle of the very fine sand range based on the classification in use by the Soil Survey, United States Soil Conservation Service.

TABLE 9.—*Engineering test data for materials of the A, B,*

[Test data are for one

Soil	A Horizon (surface soil layer containing the most organic matter)					
	Depth	A. A. S. H. O.[1]	California bearing ratio [2]	Liquid limit [3]	Plasticity index [4]	Percent passing 200 sieve
	Inches					
Bethany silt loam	0–12	A–4(8)	2	32	10	82
Chickasha loam	0–10	A–4(4)	10	22	3	57
Darnell fine sandy loam	0–5	A–2–3(0)	14	[5] NP	NP	28
Derby loamy fine sand	0–5	A–2(0)	10	20	2	31
Dougherty fine sandy loam [6]	0–7	[7] A–2–4(0)		NP	NP	33
Kirkland silt loam	0–12	A–4(8)	4	28	6	94
Lucien fine sandy loam	0–7	A–4(3)	9	26	3	50
Noble very fine sandy loam	0–10	A–4(1)	14	23	4	38
Port soils [8]	0–36	A–4(8)	4	26	7	74
Pulaski fine sandy loam [8]	0–36	A–4(4)	23	22	2	54
Renfrow silt loam	0–10	A–4(7)	3	26	4	70
Stephenville fine sandy loam	0–9	A–2(0)	16	21	4	26
Teller very fine sandy loam	0–10	A–4(8)	7	28	4	91
Vanoss loam	0–12	A–4(8)	16	24	3	76
Vernon clay loam	0–6	A–6(8)	6	34	11	73
Yahola silty clay loam [9]	0–22	A–4(6)	8	22	6	63
Zaneis loam	0–9	A–4(2)	6	27	7	45

[1] Based on combined physical soil tests developed by American Association of State Highway Officials. The Oklahoma Department of Highways has modified the A.A.S.H.O. subgroup A–2–4 by using three subgroups as follows: A–2–3 when soil material is nonplastic (NP); A–2 when plasticity index is 1 to 5; and A–2–4 when plasticity index is 6 to 10.

[2] A punching shear test on confined samples compacted at optimum moisture percent that expresses the load-supporting value of soil materials. The C.B.R. is equal to: (Force to push piston into compacted soil divided by force to push piston into well-graded, compacted crushed stone) × 100.

the American Association of State Highway Officials [1]

Granular materials (35 percent or less passing No. 200 sieve [2])		Silt-clay materials (more than 35 percent passing No. 200 sieve [2])				
A–2		A–4	A–5	A–6	A–7	
A–2–6	A–2–7				A–7–5	A–7–6
35 maximum	35 maximum	36 minimum	36 minimum	36 minimum	36 minimum	36 minimum.
40 maximum 11 minimum	41 minimum 11 minimum	40 maximum 10 maximum	41 minimum 10 maximum	40 maximum 11 minimum	41 minimum 11 minimum [4]	41 minimum. 11 minimum. [4]
4 maximum	4 maximum	8 maximum	12 maximum	16 maximum	20 maximum	20 maximum.
Clayey gravel and sand.	Clayey gravel and sand.	Nonplastic to moderately plastic silty soils.	Highly elastic silts.	Medium plastic clays.	Highly plastic clays.	Highly plastic clays.
Good stability	Good stability	Fair stability when dry, poor when wet.	Doubtful stability; hard to compact.	Good stability when properly compacted.	Fair stability when well drained.	Fair stability when well drained.

[3] NP=nonplastic.
[4] Plasticity index of A–7–5 subgroup is equal to, or less than, liquid limit minus 30. Plasticity index of A–7–6 subgroup is greater than liquid limit minus 30.
[5] In parentheses after group classification in table 9. Values are based on particle size gradation, liquid limit, and plasticity index.

and C horizons of some of the principal soils in Logan County, Okla.

sample at each stated depth]

B Horizon (most clayey part of subsoil)						C Horizon (parent material)					
Depth	A.A.S.H.O.[1]	California bearing ratio [2]	Liquid limit [3]	Plasticity index [4]	Percent passing 200 sieve	Depth	A.A.S.H.O.[1]	California bearing ratio [2]	Liquid limit [3]	Plasticity index [4]	Percent passing 200 sieve
Inches						*Inches*					
22–36	A–7–6(11)	7	42	18	82	42–54+	A–6(10)	7	36	15	78
16–30	A–6(9)	4	38	17	64	38–48+	A–6(8)	9	34	14	57
No B horizon						5–18	A–2–3(0)	17	NP	NP	27
No B horizon						5–36+	A–2–3(0)	28	NP	NP	14
18–36	A–4(1)		23	8	39	58–94+	A–4(7)		21	3	71
12–24	A–7–6(19)	9	53	30	95	36–50+	A–7–6(15)	4	49	23	98
No B horizon						10–22	A–4(2)	17	22	2	46
No B horizon						16–50	A–4(1)	29	21	3	40
10–26	A–7–6(12)	10	43	19	84	32–50+	A–7–6(19)	10	53	29	87
10–20	A–6(3)	11	36	14	44	24–30	A–6(2)	13	35	14	40
15–32	A–4(8)	30	28	7	88	40–60+	A–4(8)	15	25	4	86
20–32	A–4(8)	8	25	3	79	38–54+	A–6(10)	8	37	16	83
No B horizon						6–20+	A–7–6(12)	6	44	18	87
Contrasting layer—shown as C horizon						22–36+	A–2–3(0)	13	NP	NP	30
12–24	A–6(6)	9	38	14	55	30–44+	A–4(1)	14	31	10	40

[3] Moisture content, in percent, at which a mixture of soil and water is no longer liquid and changes to a plastic material.
[4] Difference between the percentage moisture at liquid limit and the percentage moisture at plastic limit.
[5] Nonplastic.
[6] Modal profile (552–OK–59–3), tested by Bureau of Public Roads.
[7] If Oklahoma modification is used, the classification becomes A–2–3(0).
[8] A composite sample was tested that consisted of all soil layers to a depth of 36 inches.
[9] In order to show the variability of test properties for layers of a stratified bottom-land soil, the layers were sampled separately.

TABLE 10.—*The suitability of the important soils of Logan County, Okla., for earth construction and the volumetric shrinkage*

Soil type	Horizon	Depth	Load-supporting ability as subgrade	Shoulder construction	Resistance to erosion on slopes and in ditches	Seeding and sodding	Soil binder	Soil stabilization	Volumetric shrinkage
		Inches							
Bethany silt loam	A	0–12	Poor	Poor	Poor	Poor	No	No	Low.
	B	22–36	Fair	Poor	Fair	Fair	No	No	Medium.
	C	42–54+	Fair	Poor	Fair	Fair	No	No	Medium.
Chickasha loam	A	0–10	Good	Fair	Poor	Good	No	Yes	Low.
	B	16–30	Poor	Fair	Fair	Fair	Yes	No	Medium.
	C	38–48+	Fair	Fair	Fair	Fair	Yes	No	Medium.
Darnell fine sandy loam	A	0–5	Good	Poor	Poor	Fair	No	Yes	Low.
	C	5–18	Good	Poor	Poor	Poor	No	Yes	Low.
Derby loamy fine sand	A	0–5	Good	Poor	Poor	Fair	No	Yes	Low.
	C	5–36+	Good	Poor	Poor	Good	No	Yes	Low.
Dougherty loamy fine sand [1]	A	0–14	Good	Poor	Poor	Fair	No	Yes	Low.
	B	14–28	Good	Fair	Poor	Poor	No	Yes	Low.
	C	36–48+	Fair	Poor	Poor	Fair	No	Yes	Medium.
Kirkland silt loam	A	0–12	Poor	Poor	Poor	Fair	No	No	Low.
	B	12–24	Fair	Poor	Good	Poor	No	No	High.
	C	36–50	Poor	Poor	Good	Poor	No	No	High.
Minco loam [1]	A	0–16	Good	Poor	Poor	Fair	No	Yes	Low.
	C	16–48+	Good	Fair	Fair	Good	Yes	No	Low.
Noble very fine sandy loam	A	0–10	Good	Fair	Poor	Good	No	Yes	Low.
	C	16–50+	Good	Fair	Poor	Fair	No	Yes	Low.
Norge loam [1]	A	0–12	Fair	Fair	Poor	Good	No	Yes	High.
	B	18–30	Fair	Poor	Good	Fair	No	No	Low.
	C	36–48+	Good	Fair	Fair	Fair	Yes	No	Low.
Port soils	Composite to 36		Good	Fair	Poor	Fair	No	No	Low.
Pulaski fine sandy loam	Composite to 36		Good	Poor	Poor	Fair	No	Yes	Low.
Renfrow silt loam	A	0–10	Poor	Poor	Poor	Fair	No	No	Low.
	B	10–26	Good	Poor	Good	Poor	No	No	High.
	C	36–48+	Good	Poor	Good	Poor	No	No	High.
Reinach very fine sandy loam [1]	A	0–18	Good	Poor	Poor	Good	No	No	Low.
	C	18–36+	Good			Fair			
Stephenville fine sandy loam	A	0–9	Good	Fair	Poor	Good	No	Yes	Low.
	B	10–20	Good	Fair	Fair	Fair	Yes	No	Medium.
	C	24–30	Good	Good	Fair	Good	Yes	No	Medium.
Teller very fine sandy loam	A	0–10	Fair	Poor	Poor	Fair	No	No	Low.
	B	15–32	Good	Poor	Poor	Fair	No	No	Low.
	C	40–60+	Good	Poor	Poor	Fair	No	No	Low.
Vanoss loam	A	0–12	Good	Poor	Poor	Fair	No	No	Low.
	A	20–32	Fair	Poor	Poor	Fair	No	No	Low.
	C	38–54+	Fair	Poor	Fair	Fair	No	No	Medium.
Vernon clay loam	A	0–6	Fair	Poor	Fair	Fair	No	No	Medium.
	C	6–20+	Fair	Poor	Fair	Fair	No	No	Medium.
Yahola clay loam	A	0–22	Fair	Fair	Poor	Good	No	No	Low.
	C	22–36+	Good	Poor	Poor	Poor	No	Yes	Low.
Zaneis loam	A	0–9	Fair	Fair	Poor	Good	No	Yes	Low.
	B	12–24	Fair	Fair	Fair	Fair	Yes	No	Medium.
	C	30–44+	Good	Good	Poor	Good	No	Yes	Low.

[1] Soil sampled by Oklahoma Highway Department from counties other than Logan.

TABLE 11.—*Test values used in estimating the suitability of soil materials for various kinds of earth construction and for gradations in volumetric shrinkage*

Suitability of soil material for earth construction	California bearing ratio	Liquid limit	Plasticity index	Percent passing 200 sieve
Load-supporting ability as subgrade:				
Good	More than 10	Less than 35	2 to 12	0 to 15.
Fair	5 to 10	35 to 45	12 to 20	15 to 35.
Poor	Less than 5	More than 45	Less than 2 or more than 20.	More than 35.
Shoulder construction:				
Good			6 to 15	15 to 35.
Fair			3 to 6 or 15 to 20	35 to 50.
Poor			Less than 3 or more than 20.	Less than 15 or more than 50.
Resistance to erosion on slopes and in ditches:				
Good			More than 20	More than 50.
Fair			15 to 20	35 to 50.
Poor			Less than 15	Less than 35.
Seeding and sodding:				
Good			6 to 15	10 to 50.
Fair			1 to 6 or 15 to 25	50 to 90.
Poor			Nonplastic, or more than 25.	Less than 5 or more than 90.
Soil binder:				
Yes			10 to 25	Less than 50.
No			Less than 10 or more than 25.	More than 50.
Soil stabilization:				
Yes			Less than 10	15 to 50.
No			More than 10	Less than 15 or more than 50.
Volumetric shrinkage:				
Low		Less than 35	Less than 12	
Medium		35 to 40	12 to 20	
High		More than 40	More than 20	

inches they range from fine sandy loam to silty clay loam. The substrata usually consist of loams to clay loams that are high in fine-textured materials.

All soils mapped in Logan County are described in the section Descriptions of the Soils. The variations of the different soils should be noted when using the soil maps.

Soils in Conservation Engineering

Conservationists who use soil materials want to know the degree of suitability each soil has for use in various types of conservation structures. The suitability of Logan County soils for stated types of construction is shown in table 12.

Farm ponds.—Engineers need to know if the sides and bottom of farm ponds will hold water. A soil of good binding properties and containing enough sand for internal friction is suited best for the construction of embankments. Clay has to be used as a sealer if the bottom of a pond is of porous material. Corings are usually studied in doubtful areas to determine subsurface conditions. A general knowledge of the suitability of soil materials for ponds is useful, as sites can sometimes be judged from this knowledge alone.

Terraces.—The surface layers of some soils are better suited to the construction of terraces than are others. A suitable terrace soil must contain enough binder to hold soil on the terrace ridge and to prevent it from washing or blowing away. The very sandy soils are not suitable for terracing.

Waterways.—After waterways have been constructed, they must be stabilized and planted to permanent grasses. If the exposed soil in a waterway is very clayey, a good cover of grasses is hard to establish.

Gully control.—The reclamation of heavily gullied areas usually requires mechanical treatment. Some of the deep gullies must be filled by use of heavy machinery and the runoff diverted to safe drainageways. Gullies differ in shape and depth according to the texture and structure of the soil, subsoil, and parent material. The gullying characteristics of some Logan County soils and suggestions for treatment are as follows:

1. Kirkland, Renfrow, and Vernon soils are seldom deeply gullied, but areas on both sides of the gullies are severely sheet eroded and have many galled and slick spots. Seedbeds are hard to prepare, and only vigorous plants can survive on these soils. Consequently, large quantities of fertilizer and a vegetative mulch are needed to help young plants grow. Grazing should not be permitted for two growing seasons so as to allow the formation of mulch that will improve the absorption of water.
2. Norge, Stephenville, and Zaneis soils may have deep gullies with flat bottoms that have eroded to rock. The side slopes should be bladed to as flat a gradient as possible, and the bottoms should be widened.
3. Noble, Teller, and Vanoss soils are deeply gullied in many places. The nearly vertical sides allow the soil to slough and fall into gullies. These soils contain no tough layers that prevent the deepening of gullies. Side slopes should be flattened as much as possible, and the

TABLE 12.—*The suitability of soils of Logan County for conservation engineering on farms and ranches*

Soil	Suitability for—		
	Farm ponds [1]	Terraces	Waterways [2]
Bethany	Fair	Good	Good.
Chickasha	Good	Good	Good.
Darnell	Fair	Not used	Fair.
Derby	Poor	Poor	Fair.
Dougherty	Poor	Fair	Fair.
Kirkland	Fair	Good	Fair.
Lucien	Fair	Good	Fair.
Minco	Fair	Fair	Good.
Mixed alluvial land	Not used	Not used	Not used.
Noble	Fair	Fair	Good.
Norge	Good	Good	Good.
Port	Good	Not used	Good.
Pulaski	Poor	Not used	Good.
Reinach	Fair	Not used	Good.
Renfrow	Fair	Good	Poor.
Sand dunes, Lincoln material.	Not used	Not used	Not used.
Stephenville	Good	Good	Good.
Teller	Good	Good	Good.
Vanoss loam	Good	Good	Good.
Vanoss fine sandy loam	Fair	Fair	Good.
Vernon	Fair	Not used	Poor.
Yahola clay loam	(3)	Not used	Good.
Yahola very fine sandy loam.	(3)	Not used	Good.
Zaneis	Good	Good	Good.

[1] Material considered as a mixture of the several soil horizons and the usual associated geologic material.
[2] Assuming that B horizons may be exposed in construction and become the medium for plant growth.
[3] Stock water reservoirs are often built on those soils where sheet water can be reached at depths of 8 to 10 feet.

bottoms should be widened. All layers of soil should be mixed and fertilized to allow vegetation to get started.

4. Dougherty and Minco soils are very deeply gullied. The sides of gullies are vertical, and there is much sloughing and undercutting. Overfalls are often deep. These soils produce a good growth of vegetation to control erosion.

5. Port, Pulaski, Reinach, and Yahola soils may gully if runoff is allowed to concentrate along roads or fences. Gullies usually can be filled easily and good sites developed for plant growth.

6. The Derby soils usually are not badly gullied, for they readily absorb runoff. Bethany soils are so level that only a few deep gullies have formed.

Vegetation has a good chance to become established on all soils except the Kirkland, Renfrow, and Vernon. One way to establish vegetation is to seed bermudagrass between gullies, and fertilize it well and at regular intervals to obtain a vigorous sod. Bermudagrass will spread when the sides are sloped or the gullies filled in. During the first several years when the bermudagrass has not fully covered the area, vetch, or a mixture of rye and vetch, should be seeded to stabilize the soil.

Genesis, Morphology, and Classification of Soils

The purpose of this section is to present the outstanding morphologic characteristics of the soils of Logan County and to relate them to the factors of soil formation:

Factors Influencing the Development of Logan County Soils

Soils develop from rock through the interaction of rainfall, temperature, winds, and humidity; and living plants and animals. The degree of development of a soil in any area depends upon the slope and length of time the soil has been developing.

The climate in all parts of Logan County is broadly similar. Local variations occur on north and south slopes, in narrow valleys, and in flood plains, but they influence the general soil pattern only slightly.

The vegetation on uplands ranges from oak forest to tall prairie grasses. On the alluvial bottom lands, it is a dense stand of mixed hardwoods. Differences in vegetation and in other living soil organisms have caused some of the more obvious differences in Logan County soils.

The soils have developed from mixtures of disintegrated and partly weathered rocks or from loose windblown or alluvial materials. These differing materials strongly influence the physical properties of the soils. On uplands, the highly variable parent materials are the result of the weathering of medium hard sandstone, siltstone, and slightly compacted red clay. On flood plains, terraces, and mantled uplands, they are loose sands, friable sandy loams, clay loams, and silty clays deposited in the past by stream action or carried there by wind.

Slopes strongly influence the amount of rainfall absorbed by the soil. They range from nearly flat alluvial bottom lands and wide ridge crests to strongly sloping, steep, or rolling uplands. Many combinations of slopes and relief are between these extremes.

Effect of climate and soil material on vegetation

The climate of this county is classed as subhumid because the percentage of rainfall effective for plant growth is much less than that in the cooler, more humid parts of the United States. During the growing season, winds are hot and dry, humidity is low, and the rainfall, though fairly well distributed, is seldom plentiful enough for water to soak into the subsoil, except in the most sandy permeable soils. The average temperature during summer is about 81 degrees, and the rainfall is only about 9 inches. Much of this moisture is lost through evaporation and transpiration. The thick, fibrous roots of native tall grasses in the top 2 or 3 feet of soil fully utilize the limited summer rainfall. These grasses become dormant in very dry weather and resume growing if moisture becomes available later on. Grasses are thus adapted to regions of low and medium rainfall. In this county, tall grasses originally were dominant over about 70 percent of the area. They were generally on soils that had loam, sandy loam, or clay loam surface soils.

Trees transpire large quantities of water during the growing season and consequently need large supplies of moisture. On the uplands, trees occur naturally only on permeable sandy soils and on shallow sandstone soils. Post and blackjack oaks have many fibrous roots near the surface and fairly long tap roots. The tap roots draw moisture from the subsoil and from rock material. The fibrous roots obtain many of the mineral nutrients from the upper soil layers. Trees are better able to survive than grasses on leached sandy soils relatively low in plant nutrients. Water is readily absorbed by such soils and is held in layers beyond the reach of grass roots but within reach of the longest tree roots. Trees west of the main hardwood forest regions of the United States commonly occupy the sandy soils. Grassland often completely surrounds these sandy areas and may extend far to the east into humid areas of fine-textured soils high in lime.

Bluestem grasses require larger quantities of the basic elements than oak trees, and they logically should be the dominant vegetation on alluvial soils rich in minerals. However, several kinds of lowland hardwood trees also have high requirements for base minerals and for moisture and are well suited to the alluvial bottom-land soils. If this tall, vigorous forest is removed or heavily thinned, a thick cover of grass soon covers these soils.

Effect of grasses on soil formation

Grasses and trees have different effects on the soil on which they grow. The fibrous roots of tall grasses add large quantities of organic matter to the upper 18 to 24 inches of soil and visibly color it. Grasses can use nearly all of the rain that falls during the growing season, and therefore they also largely prevent the leaching of the basic elements in the soil solution. Organic matter, accumulated deeply, helps produce the granular structure common to prairie soils, and it improves their capacity to hold water that plants can use. Living micro-organisms and burrowing animals help mix the upper layers of these soils. Various bacteria that live in a slightly acid medium decompose organic matter and release the nutrients for the use of plants. The decomposition products are not highly acid and do not cause rapid soil leaching. Soils in the southern part of the tall grass prairie region are called Reddish Prairie soils.

Effect of forest on soil formation

Forest trees characteristically have deep roots and limited fibrous ones. They do not contribute the large supplies of organic matter to the soil that grasses do. A great amount of litter falls each year as leaves and twigs, but this is not incorporated deeply into the soil. The litter under the thin forest normal in this climate is largely lost through oxidation, and organic residues color the soil to depths of only 2 to 4 inches. The surface litter consists of a thin layer of dry oak leaves from the leaf fall of the last 1 or 2 years. Under the surface is a thin mat of partly decomposed leaves laced by fungal mycelia. Fungi decompose the oak leaves and release acids that are active in leaching the soil. Below the dark surface layer is a light-colored layer from which fine particles of soil and basic elements have been leached. This leached layer usually is more sandy than the soil parent material. The fine soil materials and some of the leached bases are deposited in a lower layer that has more clay and a more definite structure.

The leached, light-colored forested soils are members of the Red-Yellow Podzolic great soil group. These are inherently less fertile than the dark, granular Reddish Prairie soils. The effects of leaching are plainly visible in the bleached A_2 horizons of these soils, but the leaching is not complete. Forested soils in Logan County are not nearly so leached as those of eastern Oklahoma. Long droughts in central Oklahoma kill the older oak trees, grass occupies the openings, and the process of leaching stops for a time. The permeable soils have a fine balance between trees and grass, and they are thus altered from time to time by the kind of vegetation.

Bottom-land soils developing under hardwood forests are not like upland soils formed under oak. Here, new soil material, accumulated as alluvium, largely prevents leaching. Organic materials become incorporated to considerable depths in the soil by being gradually mixed with new alluvium. Soils developed in this environment are known as Alluvial soils. They are generally deep and fertile, and nearly all have surface layers visibly darkened by organic matter.

The characteristics of the soil series in Logan County, and factors that have influenced their formation, are shown in table 13.

Classification of Soils by Higher Categories

Soils are classified into categories that progressively become more inclusive. The lowest category commonly used in the field—series, type, and phase—are discussed in the section Soil Survey Methods and Definitions. The higher categories of classification, called great soil groups and orders, are discussed in this section. The great soil groups consist of soil series that show the same general sort of profile but that differ greatly in kinds of parent material, relief, and degree of development. Soils are classified in three orders—zonal, intrazonal, and azonal.

Zonal soils have well-defined characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms. They have developed from parent materials that have been in place a long time and that have not been subject to extreme conditions of relief or of parent materials.

Intrazonal soils have definite characteristics that result from extremely mild relief or from parent materials that are high in salts or clay. These factors have had a greater influence on the development of these soils than climate and vegetation alone. In Logan County, intrazonal soils occur as small areas within large areas of zonal soils, and they were not mapped separately.

Azonal soils have little or no soil profile development because of their youth, their steep slopes, or the hardness of parent material.

The soil series of Logan County are classified according to great soil groups and soil orders in table 14. Following the table, the great soil groups, the soil series in each group, and some relationships of the series are discussed.

Zonal soils

In this county, the zonal order is represented by the Reddish Prairie and the Red-Yellow Podzolic great soil groups.

REDDISH PRAIRIE SOILS

Reddish Prairie soils are in the southern part of the tall-grass prairie region of the United States. Many but not all areas of these soils are reddish, a color derived more from the usual parent materials than from processes of soil development. These soils normally have slightly acid, grayish-brown to brown, granular loamy surface soils and grayish-brown to reddish-brown, granular to blocky subsoils of clay loam to clay. The parent materials range from siltstone and fine-grained sandstone to weakly consolidated beds of clay. They also include reconsolidated alluvium and loess.

TABLE 13.—*Some factors influencing soil formation and*

UPLANDS

Soil series [1]	Factors influencing soil development		
	Natural vegetation	Parent material	Slope
Kirkland	Tall grass	Calcareous red clay	Weakly convex, 0 to 3 percent
Renfrow	Tall grass	Calcareous red clay	Convex, 1 to 6 percent
Vernon	Tall grass	Calcareous red clay	Convex steep, 6 to 20 percent
Chickasha	Tall grass	Reddish and brownish silty and sandy shale and sandstone.	Weakly convex, 0 to 2 percent
Zaneis	Tall grass	Reddish and brownish silty and sandy shale and sandstone.	Convex, 6 to 20 percent
Lucien	Tall grass	Reddish sandstone	Convex-rolling, 3 to 15 percent
Stephenville	Oak woodland	Reddish sandstone	Convex, 0 to 3 percent
Darnell	Oak woodland	Reddish sandstone	Convex-rolling, 3 to 15 percent
Noble	Oak woodland	Red colluvium from sandstone	Concave, 1 to 6 percent
HIGH TERRACES			
Bethany	Tall grass	Moderately clayey alluvium and loess	Level, 0 to 1 percent
Norge	Tall grass	Moderately clayey alluvium and loess	Convex, 0 to 7 percent
Vanoss	Tall grass	Loamy alluvium and loess	Nearly level, 0 to 3 percent
Teller	Tall grass	Loamy alluvium and loess	Convex, 0 to 8 percent
Minco	Tall grass	Loamy loess	Convex-rolling, 0 to 20 percent
Derby	Oak woodland	Sandy alluvium reworked by wind	Dunes, 0 to 20 percent
Dougherty	Oak woodland	Sandy alluvium reworked by wind	Dunes to undulating, 0 to 8 percent
LOW TERRACES			
Reinach	Oak woodland	Silty alluvium	Level, 0 to 1 percent
Yahola	Oak woodland	Sandy alluvium	Nearly level, 0 to 2 percent
Port	Oak woodland	Loamy local alluvium	Nearly level, 0 to 2 percent
Pulaski	Oak woodland	Sandy local alluvium	Smooth, 0 to 2 percent

[1] Soil series arranged to form catenas down to and including the Minco series.

important characteristics of the soil series of Logan County, Okla.

UPLANDS—Continued

Degree of development	Surface soil characteristics	Subsoil characteristics	Usual depth of developed soil
			Inches
Strong	Dark grayish-brown silt loam, 10 to 14 inches thick.	Dark grayish-brown or dark-brown blocky clay becoming reddish below 3 feet.	40–60
Strong	Dark-brown to reddish-brown silt loam, 8 to 10 inches thick.	Reddish-brown blocky clay to depths of 24 or 30 inches; more reddish below this depth.	40–60
Weak	Dark reddish-brown clay loam, 5 to 10 inches thick.	Red clay	10–20
Strong	Dark grayish-brown to brown loam, 8 to 12 inches thick.	Dark-brown granular clay loam to 14 or 18 inches; brown sandy clay mottled with yellow and red in lower part.	40–60
Strong	Reddish-brown loam, 8 to 10 inches thick	Reddish-brown light clay loam to 15 or 18 inches; reddish-brown granular clay loam below.	40–60
Weak	Reddish-brown to brown fine sandy loam or loam, 6 to 18 inches thick.		6–18
Strong	Brown to reddish-brown fine sandy loam, 3 to 5 inches thick, underlain by light-brown fine sandy loam.	Reddish-brown, somewhat blocky sandy clay loam, usually more reddish and less clayey below 24 inches.	20–40
Weak	Brown fine sandy loam, 3 to 5 inches thick, underlain by light-brown fine sandy loam at depths of 8 to 20 inches.		6–18
Slight	Brown or reddish-brown very fine sandy loam, 8 to 10 inches thick.	Reddish-brown to red fine sandy loam	8–16

HIGH TERRACES—Continued

Degree of development	Surface soil characteristics	Subsoil characteristics	Usual depth of developed soil
Strong	Dark grayish-brown silt loam, 10 to 12 inches thick.	Grayish-brown granular clay loam to 16 or 24 inches thick; grayish-brown firm clay sometimes slightly mottled in lower part.	40–60
Strong	Dark-brown to reddish-brown loam, 6 to 12 inches thick.	Reddish-brown granular silty clay to depths of 18 or 22 inches, slightly more red clay loam below.	40–60
Medium	Brown to dark grayish-brown loam to fine sandy loam, 10 to 14 inches thick, over brown silty clay loam at 18 to 22 inches.	Brown or yellowish-brown clay loam	40–50
Medium	Brown, granular very fine sandy loam, 8 to 12 inches thick.	Reddish-brown friable clay loam becoming yellowish-red below depths of 16 to 20 inches.	38–48
Slight	Brown, porous and friable loam, 14 to 18 inches thick.	Brown to reddish-brown porous silt loam	20–30
Slight	Brown to grayish-brown very friable loamy fine sand, 10 to 30 inches thick.	Light brown to reddish-yellow loamy fine sand	10–30
Strong	Dark grayish-brown to brown loamy fine sand, 4 to 7 inches thick, over light-brown loamy fine sand to depths of 18 to 22 inches.	Yellowish-red sandy clay loam below depths of about 36 inches.	48

LOW TERRACES—Continued

Degree of development	Surface soil characteristics	Subsoil characteristics	Usual depth of developed soil
Slight	Reddish-brown very fine sandy loam, 16 to 20 inches thick; noncalcareous.	Reddish-yellow to red, friable, porous very fine sandy loam; calcareous below depths of 16 to 36 inches.	36
Slight	Reddish-brown, clay loam, about 15 inches thick, or reddish-brown very fine sandy loam, 15 to 26 inches thick; calcareous.	Yellowish-red fine sandy loams erratically stratified with brown loamy fine sands and darker clay loams.	Little development.
Slight	Dark-brown or reddish-brown silt loam or light clay loam, 24 to 36 inches thick; noncalcareous.	Reddish-brown silt loam to clay loam, noncalcareous	Little development.
Slight	Reddish-brown fine sandy loam, 12 to 16 inches thick; weakly acid.	Reddish brown to red fine sandy loam; weakly acid	

TABLE 14. —*Soil series classified according to order and great soil groups*

Soil order	Great soil group	Soil series
Zonal soils	Reddish Prairie	Kirkland. Renfrow. Chickasha. Zaneis. Bethany. Norge. Vanoss. Teller.
	Red-Yellow Podzolic	Stephenville. Dougherty.
Azonal soils	Alluvial soils	Yahola. Pulaski. Reinach. Port. Noble. Lincoln.
	Regosols	Vernon.[1] Minco. Derby.
	Lithosols	Lucien. Darnell.

[1] The more shaly parts of Vernon can be considered Lithosols.

The Reddish Prairie soils of Logan County are those of the Kirkland, Renfrow, Chickasha, Zaneis, Bethany, Norge, Vanoss, and Teller series.

Kirkland Series

Kirkland silt loam is on broad ridgetops and at the head of gently sloping stream divides. It has formed over clay beds. The native vegetation was tall grass, but most of the soil is now in cultivation. The soil is slowly permeable; surface drainage is slow to moderate. A representative profile of Kirkland silt loam in a grass pasture of uniform 1 percent slope (900 feet north of the quarter-section corner on the south boundary of section 36, T. 16 N., R. 4 W.) is as follows:

A_1 0 to 10 inches, dark-brown (7.5YR 4/2; 3/2, moist [2]) silt loam; moderate, medium, granular structure; friable; hard when dry; permeable; contains many pinholes; pH 6.2; grades to the layer below.

B_1 10 to 12 inches, dark-brown (7.5YR 4/2; 3/3, moist) silty clay loam; strong, medium to coarse, granular structure; friable; permeable; hard when dry; pH 6.2; boundary abrupt.

B_{21} 12 to 24 inches, dark-brown (7.5YR 4/2; 3/3, moist) clay; moderate, medium, blocky structure; very compact and very hard when dry; very slowly permeable; pH 6.5; grades to the layer below.

B_{22} 24 to 33 inches, clay similar to B_{21} layer but slightly less dark and less distinctly blocky; nearly massive structure; few, faint, strong-brown mottles; noncalcareous; pH 6.9; grades to the layer below.

B_3 33 to 51 inches, reddish-brown (5YR 4/4; 3/4, moist) clay; nearly massive structure; noncalcareous; a few, fine concretions of calcium carbonate at the base of the layer; pH 7.9; grades to the layer below.

C_{ca} 51 to 84 inches, light-red (2.5YR 6/6) silty clay; very firm and compact; a few, fine concretions of calcium carbonate; grades to the layer below.

C 84 to 100 inches +, light-red (2.5YR 6/6) silty clay shale of the Hennessy formation; weakly consolidated; moderately compact; slightly calcareous.

The A horizons are grayish brown to dark grayish brown, and they range from 8 to 14 inches in thickness. The B_1 layer is thickest where the depth to clay is greatest. It may be absent locally. Parent materials are clays, weakly indurated clay shales, or clayey alluvial sediments.

Renfrow Series

Soils of the Renfrow series have developed on clay beds of the Wellington formation, which locally contains seams of sandstone. Although very similar to Kirkland silt loam, Renfrow silt loam occurs on stronger slopes and has a brown silt loam surface soil and a reddish-brown clay subsoil. The Kirkland and Renfrow soils are very slowly permeable; they are often called hardlands. A representative profile of Renfrow silt loam in a native pasture of tall and mid grasses (near the quarter section corner on the east boundary of section 27, T. 19 N., R. 2 W.) is as follows:

A_1 0 to 9 inches, dark-brown (7.5YR 4/2; 3/2, moist) silt loam; moderate, medium, granular structure; friable; permeable; many pores and pinholes; pH 6.0; grades to the layer below.

B_1 9 to 13 inches, dark-brown (7.5YR 4/2; 3/2, moist) silty clay loam; moderate to strong, medium, granular structure; firm; sides of peds are slightly shiny; pH 6.0; roots abundant throughout; grades to the layer below.

B_{21} 13 to 24 inches, dark-brown (7.5YR 4/3; 3/3, moist) clay; compound, coarse prismatic and moderate, medium, blocky structure; very firm; very hard when dry; peds are slightly shiny; pH 6.5; grades to the layer below.

B_3 24 to 32 inches, reddish-brown clay similar to layer above but streaked with red and a few black ferruginous films; lower part has yellowish-brown and light-gray mottles ¼ to ½ inch in diameter; moderate, coarse blocky and moderate, medium, prismatic structure; pH 7.0; occasional chips of partly weathered siltstone; grades to the layer below.

C 32 to 40 inches +, banded reddish-brown and light-gray clay and very fine grained sandstone with occasional thin seams of sandy shale; upper part finely mottled with yellowish red; mass is splotched with soft ferruginous films; a band of sandstone occurs at about 40 inches.

The surface soil is reddish brown in an adjoining eroded cultivated field. In the more strongly sloping Renfrow silt loam in Logan County, the B_{21} layer is reddish brown (5YR 4/3).

Chickasha Series

Chickasha soils have developed under tall grass from weathered sandstone and sandy shale. They occur on nearly level, broad ridgetops in an area around Guthrie and southwest toward Navina. A few areas occur on the ridgetops in the eastern part of the county among areas of Darnell and Stephenville soils. A representative profile of Chickasha loam in a cultivated field, on a weakly convex surface having a slope of about 2 percent (500 feet east of the southwest corner of section 24, T. 17 N., R. 1 E.) is as follows:

A_{1p} and A_1 0 to 10 inches, dark-brown (7.5YR 4/2; 3/2, moist) loam; moderate, medium, granular structure; friable; permeable; pH 6.8; grades through a 2-inch transition to the layer below.

[2] Symbols in parentheses are Munsell coordinates (hue, value, and chroma) of the colors observed.

B_{21} 10 to 21 inches, brown (7.5YR 4/3; 3/3, moist) sandy clay loam; fine, medium, subangular blocky structure; friable; permeable; porous; pH 7.0; grades to the horizon below.

B_{22} 21 to 33 inches, coarsely mottled, strong-brown (7.5YR 5/6) and red (3.5YR 4/6) sandy clay loam; moderate, coarse, granular structure; friable; permeable; pH 6.9; grades to the layer below.

B_3 33 to 50 inches, red (2.5YR 4/6; 3/6, moist) sandy clay loam; 10 to 20 percent of matrix consists of fine brown and reddish-brown mottles; occasional thin streaks of brown; many dark-brown ferruginous films, some of which are linings of old root channels; many fine pores; hard when dry but not compact; pH 6.4; grades to the layer below.

C 50 to 90 inches, red (2.5YR 4/6; 3/6, moist) sandy clay loam shale banded with white (2.5YR 8/1) and intermediate colors; appears to be weathered sandy shale; pH 6.8; below about 60 inches banded sandstone and sandy shale of the Wellington formation.

The A and B horizons are considerably less acid than those of other Chickasha soils, which normally are slightly acid.

Zaneis Series

Soils of the Zaneis series occur on distinctly convex areas. They are more sloping than the Chickasha soils and have a profile that is more reddish throughout. They have developed in silty shale erratically stratified with seams of clay and finely grained sandstone. The Zaneis is the most extensive series in Logan County. A representative profile of Zaneis loam in a native grass pasture having 4 percent slope (in the southwest corner of section 6, T. 17 N., R. 2 W.) is as follows:

A_{11} 0 to 4 inches, reddish-brown (5YR 4/3; 3/3, moist) light loam; moderate, medium, granular structure; friable; porous and permeable; pH 6.0; grades to layer below.

A_{12} 4 to 12 inches, reddish-brown (5YR 4/4; 3/5, moist) loam; moderate, medium, granular structure; many fine pores; pH 5.8; grades to the layer below.

B_1 12 to 18 inches, reddish-brown (2.5YR 4/4; 3/6, moist) clay loam; strong, medium, granular structure; friable; porous and permeable; pH 6.0; grades to the layer below.

B_2 18 to 33 inches, dark-red (2.5YR 3.5/6; 3/6, moist) silty clay loam; strong, medium, granular structure; friable to firm; pH 5.8; grades to the layer below.

C_1 33 to 45 inches, partly weathered red (2.5YR 4/6) silty shale with layers of reddish yellow and light gray; pH 6.2; grades to the layer below.

C_2 45 to 54 inches +, parent material of dark-red, nearly neutral silty shale that is part of the Garber sandstone formation.

This profile is near the ideal concept of Zaneis loam. However, there is considerable variation in Zaneis soil in the county. The B_2 horizon ranges from granular sandy clay loam to subangular blocky light clay. The soil depth ranges from 20 to 50 inches or more down to the weathered residuum.

The Zaneis soils are generally treeless, but scattered clumps of oak occur on shallow soils in the low hills. Elm, hackberry, and other lowland hardwoods grow along narrow drainageways.

Bethany Series

Soils of the Bethany series occur on nearly level uplands that are mantled by late Pleistocene sediments, deposited by wind or water or by a combination of the two. Bethany soils occur near the Cimarron River or its larger tributaries. The surface soil resembles that of the Kirkland series. A representative profile of Bethany silt loam in a cultivated field that has had little or no erosion (about 500 feet north of the railroad in the SE¼NE¼ sec. 33, T. 18 N., R. 1 W.) is as follows:

A_1 0 to 10 inches, grayish-brown (10YR 5/2; 3/2, moist) silt loam; moderate, medium, granular structure; friable; permeable; pH 6.0; grades to the layer below.

B_1 10 to 20 inches, brown (10YR 4/3; 3/3, moist) clay loam; compound, weak medium, prismatic and moderate, medium, subangular blocky structure; porous and permeable; pH 6.0; grades to the layer below.

B_{21} 20 to 30 inches, dark-brown (7.5YR 4/2; 3/2, moist) clay containing a few, fine mottles of yellowish brown and strong brown; moderate, fine to medium, blocky structure; very firm; somewhat compact; peds have a weak shine and have darker exteriors than interiors; pH 6.5; grades to the layer below.

B_3 30 to 44 inches, brown (7.5YR 4/5; 3/5, moist) heavy silty clay loam; moderate, medium, subangular blocky structure; firm but crumbly when moist, hard when dry; less compact than the B_1 and B_{21} horizons; many pores and pinholes; pH 7.0; grades to the layer below.

C 44 to 60 inches +, reddish-brown (5YR 5/5; 4/5, moist) silty clay loam; moderate, medium, subangular blocky structure; firm, hard when dry; many pores and pinholes; pH 7.5; little change with increase in depth.

The parent material is old alluvium from the Cimarron River. The upper part probably has been modified by loess. A few fine quartzitic pebbles occur throughout the lower material.

In places the Bethany soils grade toward the Kirkland, which occur on level clay beds farther from the river and have not been influenced by loess or alluvium. Included with the Bethany silt loam are many small areas of the Kirkland soils that have 18- to 22-inch layers of granular soil overlying a clay subsoil. These areas were too small to map separately.

Norge Series

Soils of the Norge series have developed from parent materials similar to those of the Bethany soils. Norge soils have a browner surface soil and a more reddish subsoil than the Bethany. Both Norge and Bethany soils are less permeable than Vanoss and Teller soils. Norge soils occur on gently sloping upland along Cottonwood Creek southwest of Guthrie. A few areas are south of the Cimarron River, where the mantle is thin over bedrock.

A representative profile of Norge loam in a wheat field that has a convex surface and about a 2 percent slope (800 feet west of the southeast corner of section 7, T. 15 N., R. 3 W.) is as follows:

A_{1p} and A_1 0 to 8 inches, reddish-brown (5YR 4/4; 3/4, moist) loam with a weak tendency to shear into coarse plates in the upper 4 inches; weak, medium, granular structure below 4 inches; friable; porous and permeable; pH 6.0; grades to the layer below.

B_1 8 to 15 inches, reddish-brown (5YR 4/4; 3/4, moist) clay loam with dark reddish-brown coatings on the peds; moderate, medium, subangular blocky and weak, medium, prismatic structure; firm but crumbly when moist; peds slightly shiny; many pores, worm casts, and wormholes; pH 6.2; fine roots abundant; grades to the layer below.

B_{21} 15 to 22 inches, reddish-brown (5YR 4/5; 3/5, moist) silty clay; compound, moderate, medium, prismatic and moderate, medium, subangular blocky structure; firm; hard when dry; pH 6.2; weak shine on peds; moderately to slowly permeable; occasional fine quartzitic pebbles; fine roots abundant; grades to the layer below.

B_{22} 22 to 32 inches, red (2.5YR 4/6; 3/6, moist) silty clay similar to B_{21} layer but lacks the clay films; pH 6.2; gradual transition to the layer below.

B_3 32 to 42 inches, red (2.5YR 4/6; 3/6, moist) clay loam with occasional fine pebbles and coarse grains of sand; weak, medium, subangular blocky structure; friable to slightly firm but crumbly when moist and slightly hard when dry; a few, small, yellowish-red spots; pH 6.5.

C 42 to 50 inches +, red clay loam containing appreciably more sand than B_3 layer and a few rounded quartzitic pebbles; layer is at the bottom of the mantle and is underlain by clay beds or sandy shale.

In a roadside ditch 1 mile northeast of Guthrie and about 100 feet above the Cimarron River, gravelly alluvium is exposed. The gravel is mainly of quartz and quartzite, but it includes a few pebbles of ferruginous sandstone that apparently came from Permian sandstone beds. The gravel ranges from 1/10 inch to 1 inch in diameter. It is well rounded, but a few pieces are subrounded and flat.

Vanoss Series

The soils of the Vanoss series have developed in mantled material on level to nearly level uplands. They are less sloping than the Teller soils and are dark to depths of about 20 to 24 inches.

Vanoss loam has developed on deposits of sandy clay loam. A representative profile of this soil in a cultivated field on a level terrace about 30 to 40 feet above the Cimarron River flood plain (0.3 of a mile north of the southwest corner of section 33, T. 18 N., R. 1 W.) is as follows:

A_1 0 to 15 inches, brown (7.5YR 4/2; 3/2, moist) loam; moderate, medium, granular structure; friable; porous and permeable; pH 6.2; grades to layer below.

B_{21} 15 to 26 inches, dark-brown (7.5YR 4/3; 3/3, moist) silty clay loam; strong, medium, granular structure; porous and permeable; pH 6.5; pinholes and fine root holes; grades to the layer below.

B_{22} 26 to 36 inches, brown (7.5YR 5/4; 4/4, moist) clay loam containing many fine mottles of strong brown; friable; permeable; pH 7.0; contains many pinholes and old root channels; grades to the layer below.

C_1 36 to 54 inches, brown (7.5YR 5/4; 4/4, moist) sandy clay loam; pH 7.0; grades to the layer below.

C_2 54 to 90 inches +, yellowish-red (5YR 5/8; 4/8, moist) light sandy clay loam containing a few medium spots of red and yellowish red; porous and permeable; many fine tubes; pH 7.5; little change with depth, except for slight increase in sandiness; this layer apparently Pleistocene alluvium, the upper part of which is mantled by loess.

Vanoss fine sandy loam occurs mostly north of the Cimarron River in the vicinities of Crescent and Lawrie. It has developed in sandier deposits than Vanoss loam and is associated with the lighter colored and more sandy Dougherty and Derby soils. A representative profile in a cultivated field is as follows:

A_{1p} 0 to 8 inches, light-brown (7.5YR 6/4; 5/4, moist) fine sandy loam; weak, medium, granular structure to structureless; very friable; permeable; pH 5.8; two thin zones of compacted soil occur at depths of about 5 and 7 inches; the lower one rests on the layer below.

A_1 8 to 13 inches, dark-brown (7.5YR 4/2; 3/2, moist) fine sandy loam; weak, medium, granular structure; porous and permeable; pH 6.0; grades to the layer below.

B_{21} 13 to 22 inches, brown (7.5YR 5/4; 4/4, moist) sandy clay loam; moderate to weak, medium, granular structure; friable; porous and permeable; sides of peds have a very weak shine; pH 6.0; grades to the layer below.

B_{22} 22 to 36 inches, sandy clay loam similar to layer above but slightly browner; peds do not have the slight shine as in the B_{21} layer; porous and permeable; pH 6.0; grades to the layer below.

C 36 to 60 inches +, reddish-brown (5YR 5/4; 4/4, moist) light sandy clay loam; granular structure; porous and permeable; little change with increase in depth; material appears to be sandy alluvium of Pleistocene age.

This soil has been influenced somewhat by very sandy material that has blown from nearby dunes—the parent material of the associated Derby soils.

Teller Series

Most of the Teller soils occur south of the Cimarron River. However, a few areas are to the north of the river, and some are along the smaller streams. Like the Vanoss, these soils have developed in more recent sediments that are mostly of clay loams and loams.

Teller very fine sandy loam on an alluvial-colluvial apron within an eroded upland above a tributary to Cottonwood Creek has the following representative profile:

A_{11} 0 to 7 inches, dark reddish-brown (5YR 3.5/2; 3/3, moist), heavy very fine sandy loam; moderate, medium, granular structure; friable; pH 5.9; grades indistinctly to layer below.

A_{12} 7 to 18 inches, reddish-brown (5YR 4/3; 3/3, moist) loam; moderate, medium, granular structure; friable; pH 5.4; contains one angular piece of ferruginous sandstone about 1 inch in diameter; grades indistinctly to layer below.

B_2 18 to 40 inches, reddish-brown (5YR 4/4; 3/4, moist), light sandy clay loam; moderate, medium, granular structure; friable; permeable; pH 5.8; at 24 inches structure is very coarse columnar; grades indistinctly to layer below.

C 40 to 70 inches, yellowish-red (5YR 5/6; 4/6, moist), light sandy clay loam; weak, medium to coarse, granular structure; friable; porous and permeable; pH 6.4 at depth of 55 inches; stratification not evident, but layer probably is Pleistocene alluvium; one angular piece of ferruginous sandstone is embedded at 50 inches; boundary abrupt.

C_u 70 to 90 inches +, light reddish-brown (5YR 6/4; 4/4, moist) clay loam; highly calcareous; numerous threads of whitish calcium carbonate; friable; permeable; in positions farther down the slope this layer is nearer the surface.

Many areas of the Teller soils have developed in more silty and less sandy material that appears to be loess. Surface textures range from fine sandy loam through loam to silt loam.

The subsoil in some areas is better developed and contains more clay. In these areas Teller soils resemble the Norge soils. The Noble and Minco soils, discussed under Azonal soils, resemble the Teller soils, but they have not developed B horizons.

RED-YELLOW PODZOLIC SOILS

The Red-Yellow Podzolic soils of Logan County formed under areas of post oak and blackjack oak. These areas are generally open and have much tall grass in the ground cover. The Red-Yellow Podzolic soils occur on sandy parent materials derived either from sandstone or from unconsolidated sands, as those found north of the Cimarron River in the Crescent area. The Stephenville and Dougherty series are the only members of this great soil group in the county. Both are characterized by light-colored surface layers and reddish-brown, somewhat more clayey subsoils. Both are normally slightly acid and not strongly weathered, whereas typical

Red-Yellow Podzolic soils are strongly acid and strongly weathered. Thus, the Stephenville and Dougherty series are gradational from typical Red-Yellow Podzolic soils to Reddish Prairie soils in some ways.

Stephenville Series

Soils of the Stephenville series occur on the smoother parts of the sandstone uplands south and east of Guthrie. They are well-developed soils of normal depth and are closely associated with large areas of the slightly developed, thin Darnell soils.

A representative area of Stephenville fine sandy loam is on a narrow ridgetop in the Sandstone uplands. The surface is convex, and the gradient is about 3 percent. The site (200 feet south of the quarter-section corner or the east boundary of section 25, T. 17 N., R. 1 E.) was originally a prairie glade, but it is now covered by post and blackjack oaks that have invaded from the surrounding Darnell soil. The profile is as follows:

A_1 0 to 7 inches, brown (7.5YR 4/3; 3/2, moist) fine sandy loam; an appreciable amount of organic matter; very friable; pH 6.6.

A_2 7 to 12 inches, reddish-brown (5YR 5/4; 3.5/4, moist) fine sandy loam; friable; many pores; pH 6.0.

B_2 12 to 27 inches, red (2.5YR 5/6; 4/6, moist) heavy sandy clay loam; almost massive structure; friable to firm; permeable; pH 5.2.

B_3 27 to 33 inches, red (2.5YR 5/6; 4/6, moist) light sandy clay loam; a few, fine, weathered fragments of reddish sandstone; pH 5.5.

C 33 to 48 inches +, light-red (10R 6/6; 4.5/6, moist) partly weathered sandstone and some seams of fine sandy loam; pH 6.0; well penetrated by tree roots.

The depth of areas of Stephenville fine sandy loam in Logan County ranges from 20 to 40 or more inches; the average depth is generally about 30 inches. In places this soil grades to the Noble soils, which differ in not having developed a B horizon. Many areas of Stephenville fine sandy loam are very small and occur in close association with broad areas of the Darnell soil, which is shallow, slightly developed, and underlain by sandstone. The Stephenville and Darnell soils are not strongly leached, as is indicated by their moderate to weakly acid reaction. The A_2 horizons are visible, however, for they are considerably lighter in color than the A_1 horizons.

Dougherty Series

The parent materials of the Dougherty soils have been transported from areas to the west and are somewhat higher in phosphorus than the native sandstone rocks in Logan County. Consequently, the Dougherty soils are generally somewhat more fertile than the Stephenville, which have developed on the native sandstone. After a few years of cultivation, the Dougherty and the Stephenville soils lose organic matter and become very light in color.

A typical area of Dougherty loamy fine sand is about 1½ miles from Crescent on a weakly convex surface having slopes ranging from 2 to 3 percent. The site is on undisturbed savanna within mantled upland covered by windblown sands from the Cimarron River. It is about 6 miles from the Cimarron flood plain and about 100 feet above the streambed, but it has no terrace configuration. The vegetation is scrubby post and blackjack oaks and a tall-grass ground cover. A representative profile, located 580 feet north and 120 feet west of the southeast corner of section 22, T. 17 N., R. 4 W., is as follows:

A_1 0 to 7 inches, brown (7.5YR 4.5/2; 3/2, moist) loamy fine sand; the upper part of the layer is slightly darker than the lower part; very weak granular structure; very friable; pH 5.8; grades to the layer below.

A_2 7 to 22 inches, light-brown (7.5YR 6/4; 5/4, moist) loamy fine sand; structureless; nearly loose; pH 5.9; grades through a 3-inch transition to the layer below.

B_2 22 to 37 inches, yellowish-red (5YR 5/6; 4/6, moist) sandy clay loam; weak, coarse prismatic structure; prism faces have moderately pronounced skins of dark reddish-brown clay; firm; moderately permeable; pH 5.8; grades to the layer below.

B_3 37 to 66 inches, brown (7.5YR 5/4; 4/4, moist), light sandy clay loam; weak, very coarse prismatic structure; friable; very hard when dry; pH 6.3; gradual transition to the layer below.

C 66 to 86 inches +, strong-brown (7.5YR 5/6; 4/6, moist) fine sandy loam; massive structure; friable; permeable; pH 6.7; fine roots throughout; noncalcareous and is little changed to the greatest depth of sampling; appears to be sandy wind-laid Pleistocene material.

The thickness of the A horizon ranges from 30 inches to as little as 6 or 8 inches. Some of the difference is due to erosion. Where the soil has been cultivated for many years, erosion has removed the surface layer and exposed the reddish sandy clay loam subsoil.

In a few places complete profiles of Dougherty soils overlie deeper and similar profiles. This indicates that a soil had formed prior to the deposition of the material in which the Dougherty soils have formed. In one place three or four separate, thin, reddish-brown B horizons were noted at different depths in a deep cut. The thickness of each ranged from 1 or 2 inches to as much as 10 inches.

In some places the Dougherty soil grades toward the Derby soils, which lack a developed B horizon. In others it grades toward Vanoss fine sandy loam, a darker soil that has developed under prairie grasses. In a few places, the Dougherty soil has a surface layer of fine loam and tends to grade toward the Teller soils.

Azonal soils

In this county, the azonal order is subdivided into the following great soil groups: Alluvial soils, Regosols, and Lithosols.

ALLUVIAL SOILS

Alluvial soils vary greatly from place to place because of the different sediments that made up the parent material. The color and the nature and arrangement of layers all vary in areas mapped as Yahola, Pulaski, Port, Mixed alluvial land, and Sand dunes, Lincoln material. Some variation also occurs in the parent material of the Reinach and Noble soils.

Yahola Series

In Logan County soils of the Yahola series—Yahola clay loam and Yahola very fine sandy loam—occur only in the flood plain of the Cimarron River. They are subject to occasional floods that carry sandy sediments from many areas west of Logan County.

Yahola clay loam occurs south of the Cimarron River in nearly level to slightly depressed areas where bottom lands join the upland. A representative profile in a field used for wheat on a slightly wavy to nearly level bottom land (in the SW¼NE¼ sec. 11, T. 16 N., R. 4 W.) is as follows:

- A_1 and A_{1p} 0 to 22 inches, dark reddish-brown (5YR 4/4; 3/4, moist) clay loam with thin seams of fine sandy loam; moderate, medium, granular structure; firm; permeable; pH 7.0. (From 0 to 4 inches is fine sandy loam which appears to have been deposited very recently; it represents normal overwash that occurs in parts of these bottoms.)
- C 22 to 36 inches +, reddish-brown (5YR 5/5; 4/5, moist) fine sandy loam; very friable; somewhat stratified in the upper part with very fine sandy loam and loam.

The reddish-brown fine sandy loam is the normal substratum for the Yahola series, and it occurs at various depths below the more finely textured surface materials. The thickness of clay loam over fine sandy loam is greater here than in many other areas of Yahola clay loam. In places the thickness of fine material ranges from 12 to as much as 36 inches.

Yahola very fine sandy loam is on slightly higher sites than Yahola clay loam. A typical profile, near that of Yahola clay loam, in a cultivated field having a weakly convex surface and slopes of about 1 percent, is as follows:

- A_1 and A_{1p} 0 to 10 inches, brown (7.5YR 5/3; 4/3, moist) very fine sandy loam; very weak granular structure; friable; slightly hard when dry; boundary fairly abrupt.
- AC 10 to 22 inches, light-brown (7.5YR 6/4; 5/4, moist) fine sandy loam; somewhat stratified with thin lenses of loamy fine sand; very friable; nearly structureless; grades to layer below.
- C 22 to 36 inches +, light-brown loamy fine sand and reddish-yellow fine sandy loam, stratified with thin bands of loam; friable; porous and permeable.

The profile is weakly alkaline. The surface layer of Yahola very fine sandy loam ranges from fine sandy loam to loam; in a few spots it is loamy fine sand. The color of the surface layer ranges from brown to reddish brown.

Included with this soil are a number of low, depressed swales containing the more clayey sediments deposited in slowly moving floodwaters. Miller clay, a soil not mapped in this county, occupies a few of these swales.

Pulaski Series

Soils of the Pulaski series occupy the upper parts of narrow drainageways flowing through areas of Darnell and Stephenville soils. An area representative of Pulaski fine sandy loam occurs in an old field now in johnsongrass on the flood plain of Walnut Creek (300 feet west of the southeast corner of section 24, T. 17 N., R. 1 E.). It has the following profile:

- C_1 0 to 40 inches, light-red (2.5YR 6/5) fine sandy loam, weakly stratified with slightly darker and slightly lighter colored material; noncalcareous; porous and permeable; grades to the layer below.
- A_{1b} 40 to 43 inches, dark reddish-brown (5YR 4/4) fine sandy loam; weak, medium, granular structure; this layer evidently a surface soil that formed during a short period of stabilization.
- C 43 to 75 inches, light-red (2.5YR 6/6) fine sandy loam; very much like the C_1 layer.
- C_b 75 to 85 inches +, dark reddish-brown (5YR 4/3) clay loam; appears to have been the original surface layer of a soil similar to Port clay loam; at depth of about 87 inches, color is browner and somewhat lighter in hue.

Red sandy shale of the Wellington formation is exposed in the bottom of the creek channel about 10 feet lower than the surface of the flood plain.

Erratic variations occur in Pulaski soil in other parts of the county. In many places this soil is sandy to considerable depths; in some others it has bands of dark-brown clay loam and light clay in the subsoil. The stream channels are filled with sand and in many places are elevated above the surrounding land. The drainage of adjacent land has therefore become poor. Low spots stay wet part of the year and are covered by willows and other water-loving plants.

Reinach Series

Soils of the Reinach series occupy the high-bottom lands along the Cimarron River that are not covered during ordinary floods. Reinach soils resemble the Yahola soils, but they differ from them in having darker and deeper A horizons and in being somewhat less stratified and erratically banded with various sediments.

Reinach very fine sandy loam in a large alfalfa field (500 feet south of the northeast corner of section 6, T. 16 N., R. 2 W.) has the following representative profile:

- A_1 0 to 18 inches, reddish-brown (5YR 4/3; 3/3, moist) very fine sandy loam; moderate, medium, granular structure; porous and permeable; pH 6.0; grades to the layer below.
- AC 18 to 30 inches, yellowish-red (5YR 5/5; 3.5/5, moist) very fine sandy loam; moderate, medium, granular structure; weak prismatic cleavage; porous and permeable; pH 6.0; grades to the layer below.
- C 30 to 60 inches +, yellowish-red (6YR 5/6; 3.5/6, moist) very fine sandy loam; very little structure; pH 6.5; no distinct stratification.

The A horizon of Reinach very fine sandy loam ranges from about 14 to 22 inches in thickness. Some areas in which the substrata are browner and less red grade toward the Canadian series (not mapped in Logan County). The characteristics of the Reinach soils vary less than those of other Alluvial soils in Logan County.

Port Series

This series is the most extensive of the Alluvial soils in Logan County. Textural types were not mapped separately in the county, and the unit mapped is called Port soils. The textures of the surface soils range from clay loam to fine sandy loam. Silt loam and clay loam, however, are the principal textures. Of these, clay loam is predominant. Fine sandy loams usually occur on natural levees adjacent to the stream channels. The more clayey textures usually are in backwater areas away from streams and adjacent to the upland. Port soils are moderately permeable. Texture alone is seldom the cause of difference in the use of Port soils.

A representative profile of Port silty clay loam in a well-drained, nearly level cultivated field (300 feet north of the northwest corner of section 13, T. 15 N., R. 4 W.) is described as follows:

- A_1 0 to 18 inches, reddish-brown (5YR 4/4; 3/4, moist) silty clay loam; moderate, medium, granular structure; firm; hard when dry, sticky when wet; not compact; pH 7.0; grades to the layer below.
- A_{1u} 18 to 28 inches, reddish-brown (5YR 5/4; 4/4, moist) light silty clay; moderate, medium, subangular blocky structure; firm; hard when dry, crumbly when moist; moderately permeable; pH 7.1; grades to the layer below.
- C 28 to 48 inches +, red (2.5YR 4/6; 3/6, moist) silty clay loam, weakly stratified with loam and silt loam; pH 7.2; material extends to a depth of at least 50 inches without evidence of change.

Buried brown horizons are common in the Port soils, and as many as two or three former soils may be observed in deep cuts along some stream channels.

Noble Series

Soils of the Noble series occur on alluvium or colluvium of the slopes below areas of Darnell and Stephenville soils. They are generally on gently concave slopes that range from 0 to 6 percent. They occur in the sandstone uplands in the southeastern part of the county.

A representative profile of Noble very fine sandy loam occurs on a site having a growth of post and blackjack oaks and a thin stand of tall grasses. It is on a slope between an area of Pulaski soils along Walnut Creek and areas of Darnell soils on the sandstone slopes above. The site is ¼ mile south of the northeast corner of section 25, T. 17 N., R. 1 E. The profile is as follows:

A_1 0 to 7 inches, reddish-brown (5YR 5/3; 3/3, moist) very fine sandy loam; weak, medium, granular structure in the upper three inches, moderate, medium, granular structure below; very friable; pH 6.7; many fine holes; grades to the layer below.

A_3 7 to 15 inches, reddish-brown (2.5YR 5/4; 4/4, moist) fine sandy loam; very friable; permeable; many fine pores and wormholes; pH 6.5; grades to layer below.

C 15 to 45 inches +, red (10R 5/6; 3/6, moist) fine sandy loam; becomes somewhat more finely textured below 40 inches; weak to moderate, granular structure; friable; porous and permeable; pH 6.0.

The color and texture of Noble soils are uniform. In places the C horizon approaches the texture of a light sandy clay loam, a condition that appears to be caused by differences in stratification rather than in development. In a few places, the surface horizon, which is enriched by organic matter, is underlain by a layer that is slightly bleached. Noble soils resemble the Stephenville in a general way. There is no sharp boundary between adjacent areas of Noble and Pulaski soils, because similar materials have formed the sediments underlying both of these series.

Sand Dunes, Lincoln Material

Sand dunes are a land type composed of materials classified as belonging to the Lincoln series. Lincoln soils usually have a light-brown loamy fine sand surface layer that is neutral or alkaline in reaction. The surface material grades to substrata of pink loamy fine sand.

This land type consists of about 75 percent of low, stabilized and partly stabilized dunes and 25 percent sandy flats and intervening swales. The texture of the sediments in the swales varies considerably.

REGOSOLS

Regosols are youthful, slightly developed soils that are forming in loam, loamy fine sand, and unconsolidated beds of clay. The loam and loamy fine sand have not been in place long; consequently, they are not greatly weathered. The beds of clay are on steep slopes and have not weathered deeply because water seldom percolates far into them. The soils are young and lack distinct characteristics. Profiles usually have only a darkened A horizon and an underlying, slightly weathered C horizon. The Regosols in this county are of the Vernon, Minco, and Derby series.

Vernon Series

Soils of the Vernon series are developing on steep slopes from beds of soft unconsolidated clay. Generally these beds are banded with sandstone, and both Vernon and Lucien soils are developing. However, in some parts of the county the beds of clay or of clay shale are nearly pure, and on these, the Vernon soils are dominant.

Vernon clay loam on a convex slope of about 7 percent gradient in native tall-grass pasture (NW¼NW¼ sec. 7, T. 17 N., R. 2 W.) has the following profile:

A_1 0 to 6 inches, reddish-brown (5YR 4/3; 3/3, moist) sandy clay loam; moderate, medium, granular structure; firm; crumbly when moist, hard when dry, many fine roots; pH 7.5; grades to the layer below.

AC 6 to 11 inches, reddish-brown (2.5YR 4/5; 3/5, moist) clay; weak, coarse prismatic and moderate, medium, blocky structure; extremely firm; sides of blocks are very shiny; very slowly permeable; pH 7.5; grades to the layer below.

C 11 to 20 inches, red (2.5YR 4/6) calcareous clay with a few fine lenses of shale; many light-pink splotches in the lower part of the horizon; this is a clay bed of the Garber formation, which has cuboidal breakage; upper part of horizon contains chips of sandstone that originally came from weathered strata of sandstone farther up the slope.

The A horizon ranges from heavy clay loam to heavy loam in texture and from about 4 to 10 inches in thickness. The texture of the A horizon in the profile described is more sandy than normal because of the sandstone on the higher slopes. Areas with the thickest A horizon are usually at the foot of slopes where accumulations of materials are greatest.

Minco Series

Soils of the Minco series are developing in recently deposited silt and loam near the flood plain of the Cimarron River.

Following is a representative profile of Minco loam on a cultivated 4- to 5-percent convex slope between a distinct high terrace and the high bottom land occupied by the Reinach soils along the Cimarron River flood plain:

A_1 and A_{1p} 0 to 20 inches, brown (7.5YR 5/3; 4/3, moist) loam; weak, medium, granular; very friable; many pores and pinholes; pH 5.8; grades indistinctly to the layer below.

A_3 20 to 40 inches, reddish-brown (5YR 5/4; 4/4, moist) loam; moderate, coarse prismatic and weak, medium, granular structure; friable; porous and permeable; pH 6.5; grades indistinctly to the layer below.

C_1 40 to 90 inches, yellowish-red (5YR 5/6; 4/6, moist) loam, much like the layer above; pH 7.5 at 60 inches; grades slowly to the layer below.

C_{ca} 90 to 150 inches +, yellowish-red (5YR 5/6; 4/6, moist) loam; calcareous; threads and films of segregated calcium carbonate occur to greatest depth observed but are more abundant at top of layer; these threads and films most abundant as coatings on vertical sides of coarse prisms; many fine pores; roots to depth of 96 inches.

The entire profile is permeable and porous and has many fine pinholes. The A_1 horizon ranges from about 16 to 24 inches in thickness. The underlying layers range from reddish brown to yellowish red. They are generally noncalcareous to a depth of at least 8 feet. There is no evidence of the movement of clay nor of the formation of a B horizon in these soils. They thus differ from the Teller soils of the Reddish Prairie group, which have weakly developed B horizons.

Derby Series

Soils of the Derby series are very slightly developed Regosols forming in the sandiest parent materials. Most Derby soils are north of the Cimarron River on sand that was blown from the flood plain. The native vegetation was tall grass and scattered clumps of post and blackjack oaks. Since the county was settled, oak has spread to about three-fourths of the Derby soils.

A representative profile of Derby loamy fine sand occurs under native tall grasses in an area of low stabilized dunes having convex slopes of about 8 percent gradient (¼ mile west of the center of section 10, T. 17 N., R. 2 W.). It is as follows:

A_1 0 to 12 inches, brown (7.5YR 5/3; 4/3, moist) loamy fine sand; loose; pH 6.9; grades to layer below.
C 12 to 70 inches, yellowish-red (5YR 5.5/6; 4/6, moist) loamy fine sand; loose; pH 6.9; grades to layer below.
C_u 70 to 80 inches +, red (2.5YR 5/6) fine sandy loam; friable; permeable.

Slopes range from 2 to 20 percent. The red fine sandy loam layer is erratic and in places is absent. It is not a characteristic layer of the Derby soils. The Derby soils are generally sands throughout, but thin erratic lenses of reddish sandy clay loam occur at depths below 30 inches in places. Derby soils are closely associated with and grade into Dougherty loamy fine sand. Derby soils also occur in areas of Vanoss fine sandy loam, where they occupy the low dunes on the landscape.

LITHOSOLS

Lithosols are only slightly developed soils over hard rocks. They are sometimes called skeletal soils because the covering of soil over consolidated parent materials is thin. Most Lithosols are on sloping to strongly sloping relief where much of the weathered material is removed as it forms. Thus, new rock is constantly exposed to weathering and only a very thin layer of soil develops. Lithosols strongly reflect the character of rock from which they form and the vegetation under which they develop. The Lucien and the Darnell series are the Lithosols mapped in Logan County.

Lucien Series

Soils of the Lucien series are developing mainly under tall grasses and from soft, finely grained sandstone and sandy shale. In Logan County, Lucien soils are mostly associated with the Vernon soils, which occur on beds of clay banded with sandstone. Lucien soils occur in only a few places that do not have appreciable areas of the Vernon soils on outcropping clay beds which roughly follow the contour of the slopes. They usually occupy the narrow ridgetops where sandstone is exposed or is near the surface. They are also along the edges of drainageways.

A typical area of Lucien fine sandy loam is in a pasture of tall grass overtopped by a thin cover of post and blackjack oaks and a few redcedars, on a convex slope of 6 percent gradient (NW¼NW¼ sec. 7, T. 17 N., R. 2 W.). The profile is as follows:

A_1 0 to 7 inches, dark reddish-brown (5YR 4.5/3; 3/3, moist) fine sandy loam; weak, granular structure; friable; permeable; pH 6.5; grades to the layer below.
AC 7 to 10 inches, reddish-brown (5YR 5/4; 4/4, moist) light sandy clay loam; moderate, medium, granular structure; many pores and wormholes; many fine roots; pH 6.2; grades to the layer below.
C_1 10 to 16 inches, red (2.5YR 5/6; 4/6, moist) soft weathered sandstone with seams of fine sandy loam; one-half of the mass is weathered sandstone, and the other half is fine sandy loam between the seams of sandstone; boundary abrupt.
D 16 to 20 inches +, soft, massive, moderately fine grained red sandstone banded with light-gray rocks that are visible in a nearby roadcut.

This soil is forming in the Hayward member of the Garber formation. There are a few outcrops of ledge rock in the area nearby.

The surface texture of Lucien fine sandy loam ranges from loam to fine sandy loam. The thickness over bedrock ranges from a few inches to as much as 20. Areas of Lucien soils that grade toward the Zaneis have a very thin clay loam B horizon.

Darnell Series

Darnell soils are forming under a thin cover of oak from medium soft sandstone on moderate to steep slopes. They occur in association with the Stephenville soils on the smoother areas. They occupy large areas in the southeastern part of the county.

A representative area of Darnell fine sandy loam occurs on a thinly forested, strongly convex slope of 8 percent gradient, with a thin ground cover of tall grass (NE¼NE¼ sec. 36, T. 17 N., R. 1 E.). It has the following profile:

A_1 0 to 7 inches, brown (7.5YR 5/4; 3.5/4, moist) fine sandy loam; weak, fine, granular structure; friable; permeable; pH 6.0; the material in the upper 3 inches is slightly darker than that below; grades to the layer below.
A_3 7 to 16 inches, pink (7.5YR 7/4; 5/4, moist), light fine sandy loam; nearly structureless; many pores; grades abruptly to layer below.
C 16 to 24 inches, partly weathered light-red (2.5YR 6.6/5; 4/7, moist) sandstone with a few seams of fine sandy loam; pH 7.0; distinctly hard below 22 inches.

The parent rock is light-red, neutral consolidated sandstone of the Wellington formation. Crushed sandstone of this formation has a fine sandy loam texture. The parent rock is stratified with dark-red (10R 4/4) shale and sandy shale that has a pH of 8.0 at a depth of 8 feet.

Darnell fine sandy loam has considerable variation in thickness of the A horizon and in the total thickness of soil over unweathered bedrock. The thickness of the A horizon may be as little as 3 inches or as much as 8. The total thickness of the soil over bedrock ranges from a few inches to about 20 inches.

Areas of Darnell soil grading toward the Stephenville have a thin B horizon of reddish sandy clay loam. Many areas of these transitional soils are on gentle slopes, especially around edges of large areas of Stephenville soils.

Analyses of Logan County Soils

The chemical and physical properties of stated soils in Logan County, Oklahoma are given in tables 15, 16, and 17.

TABLE 15.—*Soil reaction, organic carbon, and particle-size distribution of some soils of Logan County, Okla.*

Soil type and sample no.	Horizon	Depth	Reaction	Organic carbon	Very coarse sand 2–1 mm.	Coarse sand 1.0–0.5 mm.	Medium sand 0.5–0.25 mm.	Fine sand 0.25–0.1 mm.	Very fine sand 0.1–0.05 mm.	Silt 0.05–0.002 mm.	Clay 0.002 mm.	Fine silt 0.02–0.002 mm.	Fine gravel 2 mm.
		Inches	*pH*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Chickasha loam:													
50–OK–42–7–1	A_1	0–10	6.8	1.12	0	0.4	0.6	26.5	23.2	31.5	17.8	9.4	0
50–OK–42–7–2	B_{21}	10–21	7.0	.65	0	.3	.5	26.2	19.6	28.7	24.7	9.7	0
50–OK–42–7–3	B_{22}	21–33	6.9	.31	.1	.2	.3	33.2	22.3	19.7	24.2	5.7	0
50–OK–42–7–4	B_3	33–50	6.4	.19	.3	.4	.3	28.3	21.6	18.2	30.9	3.8	0
50–OK–42–7–5	C	50–90+	6.8	.04	0	.1	.3	26.2	24.9	26.7	21.8	6.2	0
Derby loamy fine sand:													
50–OK–42–16–1	A_1	0–12	6.9	.34	.8	13.7	22.2	25.7	16.1	17.2	4.3	2.7	0
50–OK–42–16–2	C	12–70	6.9	.12	.5	13.8	24.3	32.1	14.0	9.3	6.0	1.9	0
Kirkland silt loam:													
50–OK–42–13–1	A_1	0–10	6.2	1.60	0	.2	.4	1.3	10.7	64.9	22.5	19.4	0
50–OK–42–13–2	AB	10–12	6.2	1.12	.1	.2	.3	1.0	7.7	55.9	34.8	19.4	0
50–OK–42–13–3	B_{21}	12–24	6.5	.72	0	.1	.2	.8	6.1	50.3	42.5	20.0	0
50–OK–42–13–4	B_{22}	24–33	6.9	.52	0	.1	.2	.7	5.9	51.0	42.1	21.1	0
50–OK–42–13–5	B_{3ca}	33–51	7.9	.19	0	.1	.2	.6	4.3	49.1	45.7	22.4	0
50–OK–42–13–6	C_{1ca}	51–84	8.2	.02	.3	.2	0	.1	.8	52.6	46.0	39.7	5
50–OK–42–13–7	C	84–100	8.2	0	.5	.6	.4	.6	1.4	70.3	26.2	52.3	1
Minco loam:													
50–OK–42–5–1	A_1	0–20	5.8	.71	.1	.6	1.5	6.7	33.0	45.8	12.3	5.9	0
50–OK–42–5–2	A_3	20–40	6.5	.48	0	.5	1.5	5.5	25.1	49.3	18.1	8.8	0
50–OK–42–5–3	C_1	40–90	6.9	.18	0	1.1	3.1	9.2	30.2	43.7	12.7	7.5	0
50–OK–42–5–4	C_{ca}	90–150+	8.0	.12	0	.6	1.9	8.8	33.3	42.7	12.7	7.1	0
Port silty clay loam:													
47–OK–42–1–1	A_1	0–18	7.0	1.70	0	0	.1	.3	4.1	59.6	35.9	27.7	0
47–OK–42–1–2	A_{14}	18–28	7.1	.50	0	0	.1	.3	4.6	51.9	43.1	23.2	0
47–OK–42–1–3	C	28–48+	7.2	.26	0	0	.1	.2	9.1	54.2	36.4	17.4	0
Reinach very fine sandy loam:													
50–OK–42–4–1	A_1	0–18	6.1	.65	.2	3.7	6.7	18.5	23.5	32.4	15.0	6.7	0
50–OK–42–4–2	AC	18–30	6.0	.28	.5	4.5	7.1	20.5	21.9	30.1	15.4	5.8	0
50–OK–42–4–3	C	30–60+	6.5	.16	.1	1.0	4.0	22.0	27.6	32.0	13.3	6.2	0
Stephenville fine sandy loam:													
50–OK–42–10–1	A_p	0–7	6.6	.69	0	.2	.9	52.4	21.6	18.1	6.8	3.8	0
50–OK–42–10–2	A_2	7–12	6.0	.33	0	.1	.8	53.0	21.4	15.4	9.3	4.0	0
50–OK–42–10–3	B_2	12–27	5.2	.33	.1	.3	.8	44.4	13.5	16.5	24.4	5.5	0
50–OK–42–10–4	B_3	27–33	5.5	.19	.2	.3	.9	56.5	12.6	11.4	18.1	3.7	0
50–OK–42–10–5	C	33–48+	6.0	.10	0	.2	.8	70.4	11.0	4.0	13.6	2.0	0
Teller very fine sandy loam:													
50–OK–42–14–1	A_{11}	0–7	5.9	.69	0	.2	.9	36.8	27.9	21.3	12.9	5.4	0
50–OK–42–14–2	A_{12}	7–18	5.4	.69	0	.1	.8	35.2	26.5	18.4	19.0	4.8	0
50–OK–42–14–3	B_2	18–40	5.8	.38	0	.1	.7	31.4	28.3	21.4	18.1	5.7	0
50–OK–42–14–4	C	40–70	6.4	.22	.1	.1	.7	28.9	31.0	21.2	18.0	5.8	0
50–OK–42–14–5	D	70–90+	8.1	.11	.2	.9	1.2	20.7	33.2	26.8	17.0	9.9	0
Vanoss loam:													
50–OK–42–6–1	A_1	0–15	5.8	.80	.1	.7	1.4	4.4	19.8	51.7	21.9	14.3	.5
50–OK–42–6–2	B_{21}	15–26	6.0	.66	.1	.6	1.3	3.9	16.3	48.4	29.4	16.0	0
50–OK–42–6–3	B_{22}	26–36	6.4	.42	.1	1.0	2.0	6.2	18.0	42.8	29.9	14.1	0
50–OK–42–6–4	C_1	36–54	6.4	.20	.1	1.3	2.8	8.6	23.0	41.2	23.0	11.6	0
50–OK–42–6–5	C_2	54–90+	6.8	.09	.1	1.5	3.3	10.6	28.0	36.0	20.5	8.5	0

TABLE 15.—*Soil reaction, organic carbon, and particle-size distribution of some soils of Logan County, Okla.*—Continued

Soil type and sample no.	Horizon	Depth	Reaction	Organic carbon	Very coarse sand 2–1 mm.	Coarse sand 1.0–0.5 mm.	Medium sand 0.5–0.25 mm.	Fine sand 0.25–0.1 mm.	Very fine sand 0.1–0.05 mm.	Silt 0.05–0.002 mm.	Clay 0.002 mm.	Fine silt 0.02–0.002 mm.	Fine gravel 2 mm.
Zaneis loam:		*Inches*	*pH*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
50-OK-42-12-1	A_{11}	0–4	6. 0	1. 78	0. 1	0. 5	1. 1	13. 8	30. 6	38. 3	15. 6	9. 2	0
50-OK-42-12-2	A_{12}	4–12	5. 8	1. 14	. 2	. 4	. 6	13. 0	26. 8	34. 8	22. 2	9. 6	0
50-OK-42-12-3	B_1	12–18	6. 0	1. 01	. 2	. 4	. 5	11. 2	26. 4	35. 9	25. 4	10. 6	0
50-OK-42-12-4	B_2	18–33	5. 8	. 60	1. 1	. 6	. 4	5. 3	19. 7	39. 2	33. 7	16. 8	0
50-OK-42-12-5	C_1	33–45	6. 2	. 20	. 6	1. 1	. 7	4. 1	36. 7	34. 7	22. 1	14. 1	0
50-OK-42-12-6	C_2	45–54+	6. 2	. 11	. 5	1. 1	. 8	2. 4	27. 1	44. 8	23. 3	18. 5	0

TABLE 16.—*Chemical analyses of Dougherty loamy fine sand and Kirkland silt loam, Logan County, Okla.*

Soil type and sample number	Horizon	Depth	Reaction: Saturated paste	Reaction: 1:5 Soil-water suspension	Reaction: 1:10 Soil-water suspension	Organic carbon	Nitrogen	C/N ratio	Calcium carbonate equivalent	Cation-exchange capacity	Exchangeable cations: Ca	Exchangeable cations: Mg	Exchangeable cations: Na	Exchangeable cations: K	Exchangeable sodium percentage (ESP)
Dougherty loamy fine sand:		*Inches*	*pH*	*pH*	*pH*	*Percent*	*Percent*		*Percent*	*me/100 gm.*	*me/100 gm.*	*me/100 gm.*	*me/100 gm.*	*me/100 gm.*	
55-OK-42-17-1	A_1	0–7	5. 4	5. 8	6. 2	0. 64	0. 054	11. 9	0	5. 42	3. 01	0. 77	0. 09	0. 14	1. 66
55-OK-42-17-2	A_2	7–22	5. 2	5. 9	6. 3	. 17	. 019	9. 9	0	2. 13	3. 31	. 58	. 09	. 10	4. 23
55-OK-42-17-3	B_2	22–37	5. 4	5. 8	6. 0	. 27	. 033	8. 2	0	12. 50	5. 97	3. 15	. 09	. 26	. 72
55-OK-42-17-4	B_3	37–66	5. 8	6. 2	6. 3	. 13	. 019	6. 8	0	7. 52	3. 95	2. 54	. 09	. 18	1. 20
55-OK-42-17-5	C	66–88+	5. 8	6. 5	6. 7	. 11	. 017	6. 5	0	5. 24	2. 71	1. 95	. 09	. 18	1. 72
Kirkland silt loam:															
50-OK-42-13-1	A_1	0–10	5. 8	6. 0	6. 4	1. 42	. 157	9. 0	0	18. 50	8. 92	5. 11	. 17	. 52	. 92
50-OK-42-13-2	AB	10–12	5. 8	6. 2	6. 5	. 89	. 100	8. 9	0	27. 10	11. 89	9. 53	. 36	. 42	1. 33
50-OK-42-13-3	B_{21}	12–24	6. 0	6. 6	6. 9	. 64	. 072	8. 9	0	33. 00	14. 01	12. 00	. 81	. 42	2. 45
50-OK-42-13-4	B_{22}	24–33	6. 6	7. 1	7. 3	. 47	. 055	8. 5	0	32. 36	13. 88	12. 78	. 99	. 47	3. 06
50-OK-42-13-5	B_{3ca}	33–51	7. 4	8. 1	8. 4	. 22	. 030	7. 3	. 52	30. 81	20. 06	13. 56	2. 07	. 47	6. 72
50-OK-42-13-6	C_{1ca}	51–84	7. 8	8. 4	8. 7	. 16	. 020	8. 0	14. 06	21. 23	29. 89	7. 90	1. 59	. 36	7. 49

TABLE 17.—*Chemical composition of some soils of Logan County, Okla.*

Soil	Soil condition	Sample depth	pH	Total phosphorus	Soluble phosphorus	Organic matter	Total nitrogen	Available potash
		Inches		*Percent*	*Lb. per acre*	*Percent*	*Percent*	*Lb. per acre*
Chickasha loam	Virgin	0–6	6.0	0.0250	27.36	3.85	0.258	200
	Virgin	18–26	5.9	.0204	8.96	1.48	.186	166
	Cultivated, moderately eroded	0–6	5.7	.0174	16.96	1.13	.153	136
	Cultivated, moderately eroded	6–10	5.7	.0182	9.76	1.63	.188	110
	Cultivated, moderately eroded	10–20	6.2	.0174	6.56	1.57	.116	124
Derby loamy fine sand	Virgin	0–6	6.2	.0224	77.12	2.05	.190	516
	Virgin	6–24	6.5	.0144	46.16	.83	.072	80
	Virgin	24–40+	6.2	.0150	45.76	.55	.095	150
	Cultivated	0–6	6.5	.0170	63.36	1.00	.084	216
	Cultivated	6–24	6.7	.0136	30.56	.58	.081	96
	Cultivated	24–40+	5.9	.0132	21.76	.53	.044	178
Dougherty loamy fine sand	Virgin	0–6	5.8	.0164	40.16	1.69	.130	88
	Virgin	6–28	6.1	.0148	31.36	.45	.119	56
	Virgin	28–40	6.3	.0136	17.76	.07	.089	30
	Virgin	40+	5.9	.0136	27.36	.23	.117	132
	Cultivated	0–6	6.5	.0170	47.36	.61	.096	108
	Cultivated	6–24	6.4	.0144	22.16	.83	.123	42
	Cultivated	22–28	6.4	.0144	16.96	.32	.117	100
	Cultivated	28+	6.1	.0164	20.96	.55	.128	236
Kirkland silt loam	Virgin	0–6	6.0	.0250	18.56	2.55	.212	264
	Virgin	6–18	6.2	.0216	16.96	1.95	.120	230
	Virgin	18–26	6.5	.0216	12.96	1.50	.116	38
	Cultivated	0–6	5.6	.0204	16.16	1.68	.135	158
	Cultivated	6–15	6.0	.0210	16.16	1.55	.172	148
	Cultivated	15–24	7.1	.0182	11.36	1.15	.160	124
Minco loam	Virgin	0–6	6.2	.0268	64.96	1.98	.044	208
	Virgin	6–24	6.3	.0260	64.96	1.45	.188	144
	Virgin	24–48	6.7	.0210	24.96	1.18	.167	114
	Cultivated	0–6	6.5	.0224	64.96	.75	.158	304
	Cultivated	6–24	6.5	.0230	53.76	1.08	.162	138
Renfrow silt loam	Virgin	0–6	5.8	.0188	12.96	4.03	.154	144
	Virgin	6–14	5.7	.0204	12.96	1.89	.177	86
	Virgin	14–24	6.2	.0174	5.76	1.60	.158	90
	Cultivated, very severe erosion	0–6	6.1	.0158	14.56	1.28	.177	86
	Cultivated, very severe erosion	6–10	6.4	.0170	10.56	1.46	.047	92
	Cultivated, very severe erosion	10+	6.8	.0136	11.36	1.19	.175	68
Vanoss fine sandy loam	Virgin	6–24	6.0	.0188	14.56	1.70	.177	264
	Virgin	24–36+	5.8	.0182	4.96	1.80	.068	212
	Cultivated	6–24	5.5	.0228	20.96	1.71	.189	212
	Cultivated	24–36+	5.8	.0174	17.76	1.49	.182	154
Vanoss loam	Cultivated	0–6	5.2	.0182	30.56	1.58	.151	152
Yahola very fine sandy loam	Virgin	0–6	7.6	.0340	140.80	.83	.040	188
	Cultivated	0–6	7.9	.0326	132.80	.75	.050	240
	Cultivated	6–20+	7.9	.0294	136.80	.30	.116	108
	Cultivated (salt spots)	½–8	7.8	.0362	140.80	.73	.128	178
	Cultivated (salt spots)	8–24	8.1	.0326	140.80	.33	.116	72

Glossary

Acidity. The degree of acidity or of the soil mass expressed in pH values or in words as follows:

	pH		*pH*
Extremely acid	Below 4.5	Medium acid	5. 6–6. 0
Very strongly acid	4. 5–5. 0	Slightly acid	6. 1–6. 5
Strongly acid	5. 1–5. 5		

Alluvium. Sediments of sand, silt, or clay deposited by streams. May be homogenous and of purely local origin or of mixed origin, as that along major stream courses.

Alkaline. Soil high in exchangeable bases. The degree of alkalinity is expressed in pH values or in words as follows:

	pH		*pH*
Mildly alkaline	7. 4–7. 8	Strongly alkaline	8. 5–9. 0
Moderately alkaline	7. 9–8. 4	Very strongly alkaline	9. 1 and higher

Blocky. The shape of peds bounded by flat or rounded surfaces that are casts of the molds formed by the faces of surrounding peds. Roughly blocklike.

Calcareous. A soil containing calcium carbonate, or a soil alkaline in reaction because of the presence of calcium carbonate.

Colluvium. Soil material that has moved to the foot of strong slopes by gravity, frost action, soil creep, or local wash. Usually unsorted.

Columnar. The shape of many-sided peds bounded by flat or nearly flat surfaces. The horizontal dimension is limited and considerably less than the vertical; rounded caps on columns.

Concave. Applied to land surfaces which are curved like the interior of a circle or hollow sphere. On level areas, concave spots may be dished or swalelike.

Concretions. Roundish masses of segregated mineral matter often formed as concentric rings about a central particle. Calcium carbonate, ferromanganese, etc.

Convex. Applied to land surfaces that resemble segments of spheres when viewed from the outside.

Extremely firm. Cannot be crushed between thumb and forefinger; must be broken apart bit by bit.

Ferruginous. Containing iron; refers to dark concretions, films, and spots in soils.

Firm. Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Friable. Soil material crushes easily under gentle to moderate pressure between thumb and forefinger but coheres when pressed together.

Granular. Roughly spherical, firm, small aggregates, or peds; may be either hard or soft but generally are more firm than peds having crumb structure and are without the distinct faces of peds with blocky structure.

Loose. Noncoherent when slightly moist, even when pressed together.

Massive. No observable structure, but material is coherent when pressed together.

Neutral. Exchangeable hydrogen and bases are about equal; pH of 6.6 to 7.3.

Ped. An individual, natural soil aggregate such as a crumb, prism, or block, in contrast to a clod.

Permeable. The quality of a soil horizon that enables water or air to move through it.

Pinholes. Very fine holes. Usually closely related to porosity.

Porosity. The degree to which the soil mass is permeated with pores and cavities. Porosity can generally be expressed as a percentage of the whole volume of a soil horizon that is unoccupied by solid particles.

Prismatic. The shape of many-sided peds bounded by flat or nearly flat surfaces. The horizontal dimension is limited and considerably less than the vertical; peds are without rounded caps.

Single-grain soil. A structureless soil in which each particle exists separately, as in dune sand.

Subangular blocky. The shape of many-sided peds that have mixed rounded and plane faces and vertices mostly rounded. Larger than granules.

Subsoil. The B horizons (zone of accumulation) in soils with distinct profiles. Subsoil is usually more clayey than the layer above it and is, on the average, 8 to 16 inches below the surface.

Substratum. Any layer lying beneath the solum, or true soil. Term is applied to both parent materials and to other layers unlike the parent material; the material below the B horizon, or subsoil.

Surface soil. The soil ordinarily moved in tillage or its equivalent in uncultivated soil; usually about 5 to 8 inches of the darkened upper part of the soil (A horizon).

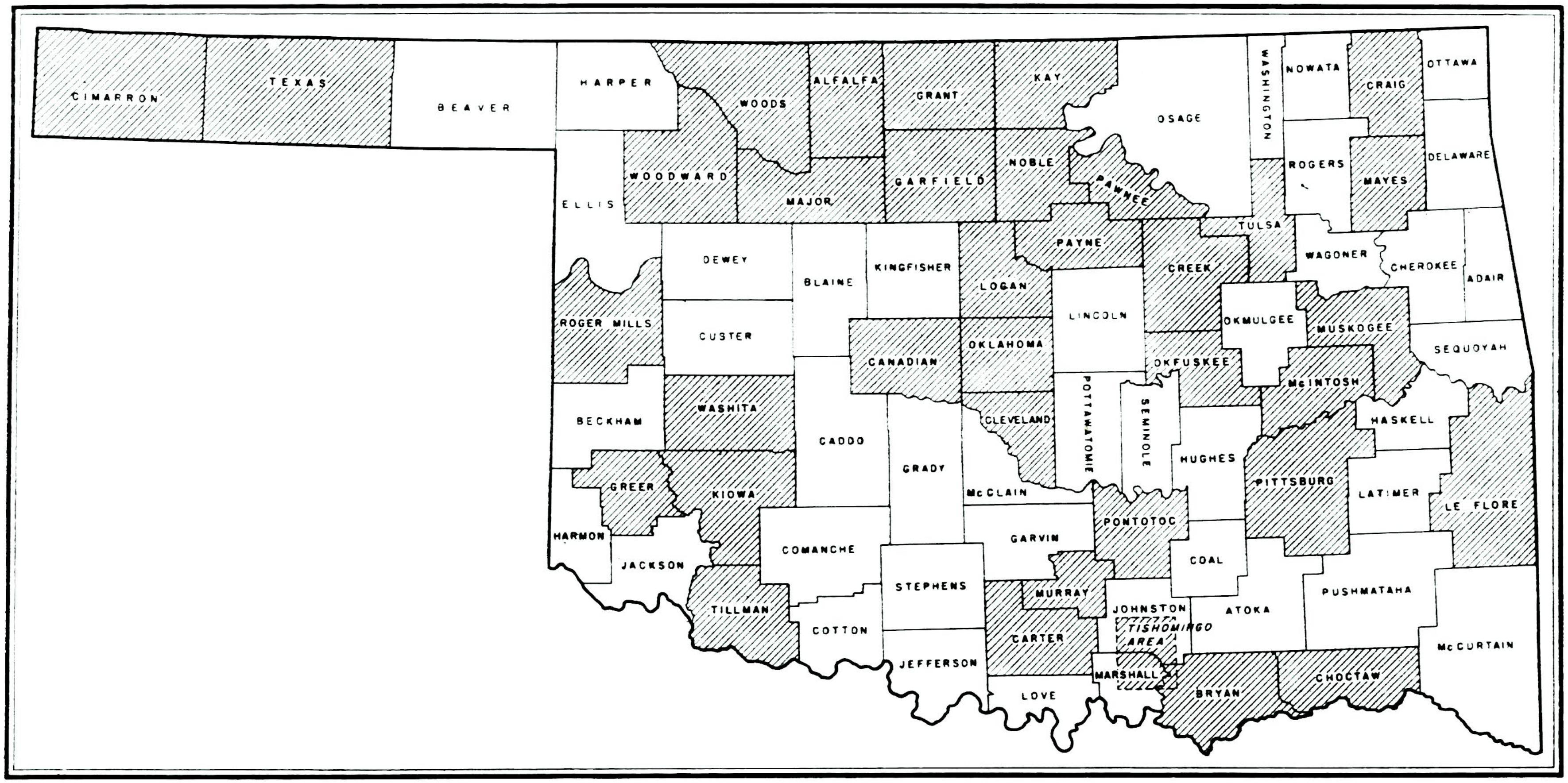
Texture. The relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically it refers to the proportions of sand, silt, and clay. The common textural classes are sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.

Upper subsoil. The part of the profile lying between the darkened A horizon and a more clayey subsoil layer below. It is known as the B_1, or transitional, horizon.

Very firm. Requires strong pressure to crush.

Very friable. Crushes under very gentle pressure but coheres slightly when pressed together.

O



Areas surveyed in Oklahoma shown by shading.

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquires

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).