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Soil Survey

Washita County Oklahoma

By
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United States Department of Agriculture, in Charge
and
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Oklahoma Agricultural Experiment Station

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
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SOIL SURVEY OF WASHITA COUNTY, OKLAHOMA

By A. W. GOKE, Soil Survey Division,[1] Bureau of Chemistry and Soils, United States Department of Agriculture, in Charge, and C. A. HOLLOPETER and C. F. FISHER, Oklahoma Agricultural Experiment Station

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United States Department of Agriculture in cooperation with the Oklahoma Agricultural Experiment Station

CONTENTS

COUNTY SURVEYED

Washita County is in southwestern Oklahoma (fig. 1). It is separated from the Texas Panhandle on the west by Beckham County. It is rectangular in shape, with the greatest length from east to west, and it includes a total area of 1,006 square miles, or 643,840 acres. Cordell, the county seat, is about 85 miles southwest of Oklahoma City.

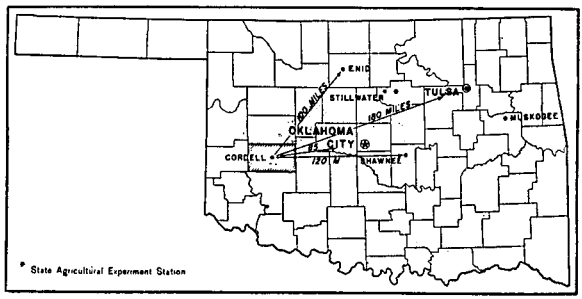

FIGURE 1.—Sketch map showing location of Washita County, Okla.

The county lies within the great area of rolling treeless lands just east of the Great Plains, known as the Central Lowland physiographic province. It is in the Osage Plains section, a

[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.

generally rolling grassland plain, and slopes to the southeast. Locally, this section is referred to as the red plains or rolling plains, in contrast to the High Plains, which lie about 100 miles west of Washita County.

Two general plains comprise most of the county. The most extensive plain forms most of the eastern and southern parts, and the other, or higher plain, forms the northwestern part. Although these plains merge in some places through gradual slopes, they are separated in most places by well-defined eastward- and southward-sloping escarpments and sloping rough lands, which are cut deeply by erosion.

The lower or main plain is strongly rolling to hilly in many sections, especially near the larger drainageways. The smooth drainage divides range from narrow to wide and have undulating surfaces. Washita River and large tributaries of that stream have cut deep, wide valleys with narrow, flat flood plains bordered by steep or moderately sloping valley walls. Severe geologic erosion in places has exposed the "Red Beds" or has allowed only a thin covering of soil to develop.

The higher plain in the northwestern part is undulating. Here deep beds of sand or sandy soils generally cover the "Red Beds" except for exposures along the shallow valleys. In many places the wind has blown the sandy materials into billows or dunes.

The elevation above sea level at Cloud Chief on the lower plain is about 1,400 feet and at Canute on the higher plain about 1,903 feet.[2] Other elevations [3] in the county are Cordell, in the central part, 1,532 feet; Bessie, in the north-central part, 1,529 feet; Foss, in the northwestern part, 1,622 feet; Dill, in the west-central part, 1,847 feet; and Rocky, in the south-central part, 1,638 feet. The elevation at Carnegie (Caddo County), near the point where the Washita River leaves Washita County, is 1,284 feet.

Most of the county is drained by the Washita River, but the southwestern part is drained by smaller tributaries of the Red River.

The uplands are natural grasslands, although in places the more sandy soils, particularly the deep sandy soils in the northwestern part of the county, have a native vegetation chiefly of small oak trees—mostly low shrubs—known as shin oak. Coarse bunchgrasses, such as species of *Andropogon*, generally predominate on the sandy soils, and short grasses, chiefly buffalo grass and grama, cover the heavier textured soils. The uncleared bottom lands support moderately large trees, including cottonwood, elm, and hackberry.

The area now included in Washita County was originally a part of the Cheyenne and Arapaho Indian Reservations of the Indian Territory and was opened for settlement by white men in 1892. Washita County was organized in 1907—the year Oklahoma became a State. Settlement was rapid, and land at first used for cattle ranching was soon fenced and opened up for farming. The settlers came mainly from the South and the Midwest.

The population is evenly distributed. Small towns and villages are situated so as to afford shipping points and trade centers in all

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[2] MARSHALL, R. B. RESULTS OF SPIRIT LEVELING IN OKLAHOMA, 1895 TO 1912, INCLUSIVE. U. S. Geol. Survey Bul. 564, 119 pp., illus. 1914.

[3] GANNETT, HENRY. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bul. 274, ed. 4, 1072 pp. 1906.

parts of the county. According to the United States census, the county had 29,435 inhabitants in 1930, of whom 26,499 were classed as rural. Of the rural population, 21,122, or 79.7 percent, were classed as rural-farm population. The census reported a farm population of 17,870 in 1935. Cordell had a population of 2,936 in 1930. Populations of other towns in the same year were as follows: Sentinel 1,269, Foss 524, Rocky 518, Dill 499, Bessie 415, and Canute 366.

Good transportation and marketing facilities for farm products are convenient for nearly all farms, and only a small section of the eastern part of the county lies more than 10 miles from a shipping point.

Three railroads serve the county and connect with important large cities and markets. The Atchison, Topeka & Santa Fe and the St. Louis-San Francisco Railways cross the central part from north to south. The Chicago, Rock Island & Pacific Railway crosses the northwestern part and borders the northeastern part just outside the county, and another branch of this system borders the eastern part of the southern boundary. Several paved highways pass through the county. United States Highway No. 66 extends through the northwestern part, a State highway passes east and west through the central part, and a State highway extends from north to south through the central part. County roads follow most of the section lines. The main county roads, although not surfaced, are graded and kept in good condition.

Schools and churches are situated at convenient points, and many farm homes are served by telephones and rural delivery of mail.

CLIMATE

Washita County has a temperate subhumid climate with low humidity and a wide range in temperature between summer and winter. Although the temperature is high during the day in summer, cool breezes generally moderate the temperature at night.

The mean annual precipitation is 29.88 inches, most of which falls during the growing season. Winter has the lowest seasonal rainfall. Irregular and insufficient rainfall sometimes reduces yields of crops, although absolute crop failures are rare. Summer droughts and hot winds sometimes injure growing crops. Sorghums and cotton withstand the effects of dry weather very well and are, therefore, important crops. Corn and alfalfa, however, do not withstand drought very well, and they are grown largely on the deep smooth-lying soils of the alluvial bottom lands and terraces, which have the most favorable moisture relationships. Small grains, largely wheat, usually mature before the drought becomes severe.

In 1910, one of the driest years on record, the annual rainfall was only 9.55 inches and May was the only month receiving nearly the normal amount of rainfall. In 1923, the wettest year on record, the annual rainfall was 40.24 inches. At this time the heaviest rainfall was in the spring and fall.

The average annual temperature for the county is 60.8° F. The coldest month is January with an average of 38.1°, and the warmest is July with an average of 82.3°. The highest temperature on record, 113°, occurred in August and the lowest, −14°, in January. The average length of the frost-free season is 215 days, extending from April 2, the average date of the last killing frost, to November 3, the

average date of the first. Frost has been recorded as late as May 1 and as early as October 11.

Very little snow falls and usually it remains on the ground only a short time before it melts. The average yearly fall is 6.6 inches, but in some seasons it is much less. Farm and outside work can be carried on during many days of winter.

The prevailing winds blow from the south and northwest. Sudden changes in the weather, locally called northers, accompanied by cold northerly winds, often occur and reduce the temperature as much as 50°. These cold periods last for 2 or 3 days. In spring, late light freezes sometimes injure fruit crops. The heaviest winds come during March and April, when most of the fields are freshly plowed and bare. Duststorms were severe in March and April 1935. At that time the air was heavily laden with dust, reducing visibility to a very short distance.

Table 1, compiled from the records of the United States Weather Bureau station at Cloud Chief in the southeastern part of Washita County, gives the normal monthly, seasonal, and annual temperature and precipitation data which are considered representative for the county.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Cloud Chief, Washita County, Okla.*

[Elevation, 1,400 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1923)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	39.5	82	−2	1.30	(1)	0.82	1.6
January	38.1	92	−14	.69	0.77	.35	1.6
February	42.5	94	−12	1.00	(1)	.32	2.0
Winter	40.0	94	−14	2.99	.77	1.49	5.2
March	52.4	102	−4	1.82	.48	2.58	1.2
April	60.4	99	22	3.34	(1)	5.73	.0
May	68.1	103	26	4.56	3.98	5.19	.0
Spring	60.3	103	−4	9.72	4.46	13.50	1.2
June	77.4	112	41	3.45	1.74	5.12	.0
July	82.3	112	52	3.02	.20	.57	.0
August	81.5	113	45	2.23	1.40	1.88	.0
Summer	80.4	113	41	8.70	3.34	7.57	.0
September	74.4	107	30	3.14	.35	6.94	.0
October	62.3	100	13	3.48	.63	9.65	(1)
November	50.7	87	8	1.85	(1)	1.09	.2
Fall	62.5	107	8	8.47	.98	17.68	.2
Year	60.8	113	−14	29.88	9.55	40.24	6.6

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

Farming succeeded cattle ranching as the important enterprise in the area now occupied by Washita County soon after this section was opened for settlement, and the land was fenced. The first data

for crops grown in Washita County were reported in the census of 1900, which gave crop yields for 1899. Corn was the chief crop, followed by cotton, coarse forage, wheat, and oats. Only about 100,000 acres were devoted to crops at that time. Subsequent to 1907, when the county was organized, land in crops increased rapidly. In 1919 wheat outstripped the other crops, encouraged doubtless by the high prices during the World War. Ten years later wheat dropped to second place and cotton led all other crops. Although cotton still led in 1934, the acreage in cotton declined almost half, the acreage in wheat increased considerably, and the acreage in corn contracted sharply.

The 1935 census reported 3,859 farms in the county with an average size of 163.5 acres. These farms occupied 631,018 acres, or 98 percent of the total land area. About 431,972 acres, or two-thirds of the total land area, represented cropland.

Wheat and cotton are the chief cash crops. Cotton is grown in all sections but to a greater extent on the sandy soils, whereas wheat is grown to greater extent on the heavier textured soils. The other crops are grown chiefly for feedstuffs for the farm livestock. Areas of land not well suited to cultivation are used to pasture livestock, both beef and dairy cattle. These animals are also fed the products grown on the farms. Considerable numbers of cattle and sheep graze in the fields of small grains during the winter, and many farmers derive revenue from leasing their grainfields to stockmen who ship in large numbers of animals for several months' grazing during winter. Sorghums produce by far the most feed for livestock. Grain sorghums and alfalfa are important crops on many farms, although they are grown on small acreages. Small quantities of fruits and vegetables grown on the farms are marketed locally.

Table 2 gives the acreages of the principal crops grown in Washita County, as reported by the Federal censuses, in 1899, 1909, 1919, 1929, and 1934.

TABLE 2.—*Acreages of the principal crops in Washita County, Okla., in stated years*

Crop	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Cotton	13,702	65,344	38,821	219,605	116,104
Wheat	7,393	43,834	173,663	91,966	101,053
Oats, threshed	2,656	20,189	21,042	12,701	15,054
Oats, cut and fed unthreshed				1,889	7,128
Corn	55,708	127,338	37,792	29,814	4,786
Barley	41	338	2,368	1,222	4,608
Grain sorghums		12,857	37,465	20,114	9,165
Sorghums for silage, hay, and fodder			[1] 22,971	27,609	59,315
Alfalfa	77	10,603	9,997	3,784	3,892
All other tame hay	3,117	1,525	4,685	2,543	[2] 3,112
Wild hay	6,349	3,495	2,611	1,324	

[1] For forage only.
[2] Includes wild hay.

According to the 1930 census report, the value of crops produced in 1929 was as follows: Cereals, $2,172,436; other grains and seeds, $12,577; hay and forage, $513,263; vegetables, $61,792; fruits and nuts, $69,970; and all other field crops (largely cotton), $7,843,519.

Dairy products (largely butterfat) sold in 1929 were valued at $519,438; poultry raised, at $506,215; and eggs produced, at $498,954. These values for livestock products were based on 6,114,397 gallons of milk produced, 2,078,976 dozens of eggs produced, and 666,393 chickens raised. In 1934 the production of milk was 5,965,683 gallons, the number of eggs produced 949,398 dozen, and the number of chickens raised 460,808. Many farmers sell cream to local cream stations, which ship it to Oklahoma City for use in manufacturing butter. Local creameries process some of the cream, but most of it is shipped out of the county. A large proportion of the poultry products, mainly chickens and eggs, is shipped to outside markets.

Livestock on farms on January 1, 1935, included 38,498 cattle, of which 17,410 were milked during 1934; 10.042 horses; 4,687 mules; 8,277 swine; and 2,888 sheep.

Commercial fertilizers are not used, as the generally dry climate does not favor their application. The natural fertility of the more smooth lying deep soils is, on the whole, fairly high, so that the chief problem in the production of crops is an adequate supply of soil moisture. Many of the more steeply sloping fields that are more or less severely eroded have low productivity.

In 1929, 3,459 farms reported the hire of labor at a total wage bill of $1,314,550, or $380.04 per farm reporting. A large proportion of the farm work is done by the operator with assistance from his family and resident laborers. Such crops as cotton sometimes are harvested by nonresident labor.

Tenants operated 52.2 percent of the farms in 1935, owners 47.6 percent, and managers 0.2 percent. Some farms rent on a share basis and some for cash. On the share basis, the tenant generally furnishes the farm equipment and delivers one-third of the grain and one-fourth of the cotton as rental.

Farms are well fenced and have fair to good improvements. The better homes and buildings belong to owner operators on the smoother lying deeper soils. Power is supplied largely by horses and mules, but some farmers use tractors.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [4] and its content of lime and salts are determined by simple tests.[5] Drainage, both internal and external, and

[4] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[5] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction. Lime (calcium carbonate) is detected by application of dilute hydrochloric acid.

other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal units are (1) series, (2) type, and (3) phase. In places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a map, but must be mapped as (4) a complex. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (5) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics, and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Tillman, Chickasha, and Cobb are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Chickasha fine sandy loam and Chickasha loamy fine sand are soil types within the Chickasha series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, some areas may be adapted to the use of machinery and the growth of cultivated crops and others may not. Even though there may be no important differences in the soil itself or in its capability for the growth of the native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and

township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The soils of Washita County have developed under a rather dry climate, beneath a vegetative cover of short grasses and tall bunchgrasses, and from two general kinds of parent materials, which consist chiefly of the outcropping beds of the upper formations of the Permian system ("Red Beds"). These are (1) the calcareous shale and clay materials and (2) the noncalcareous, or only slightly calcareous, soft sandstones.

Washita County lies in the great Reddish Chestnut soil zone, where the pedocalic soils predominate, but only beneath the heavy smooth-lying soils does a layer of accumulated calcium carbonate occur in the soil profile. These soils have developed from the heavier textured parent materials, are dark-colored, deep, and, although not calcareous, except in the subsoil, are, for the most part, nearly neutral in reaction. As a rule, their consistence is moderately firm, their texture is medium, and their productivity is comparatively high.

The soils developed from the more sandy parent materials have rather loose and permeable surface soils but somewhat heavier textured subsoils. These soils are noncalcareous, moderately productive, and, owing to favorable moisture relationships, are, where normally developed, rather certain in production even in rather dry seasons. Two general kinds of these soils cover large areas: (1) The normally developed soils on smooth surfaces and (2) the thin immature soils on more sloping surfaces where erosion has prevented normal development. A few small areas of sandy soils in the western part of the county support a cover of small shin oak trees, and a few small areas in the eastern part support a cover of blackjack oak trees.

Important and widely distributed soils of the valleys are developed from deep deposits of recent alluvium, which are mainly of silty and very fine sandy textures but also contain considerable clay. The alluvium has been deposited from floodwaters, which have carried the materials from the nearby uplands. These soils have approximately similar use capabilities but differ here and there in texture. Most of them are calcareous and rather highly productive.

Small areas of soils are nonarable because of rough or rough and stony conditions, or because they consist of sands that are too loose to use for crops. Such soils occur in widely scattered areas and are not important in the agriculture of the county.

On the basis of the relationships of physical characteristerics and common parent materials, the soils of this county are included in 15 series and 2 miscellaneous land types.

The soils comprise four natural groups, each of which is characterized by generally similar topographic position, lay of the land, soil color, structure, consistence, and fertility. The soils within each group vary considerably in productivity and use capabilities, although those of each group are in general best suited to certain crops and to certain types of land use. These groups are as follows: (1) Dark soils of the uplands, including Tillman silt loam, St. Paul silt loam, Hollister silt loam, Chickasha loamy fine sand, Chickasha fine sandy loam, Foard silt loam, and Calumet silt loam; (2) red and red-

dish-brown soils of the uplands, including Dill fine sandy loam; Dill loamy fine sand; Dill loamy very fine sand, shallow phase; Dill loamy fine sand, steep phase; Cobb fine sandy loam; Vernon very fine sandy loam; Vernon silt loam; Vernon silty clay loam; and Weymouth very fine sandy loam; (3) soils of the alluvial bottom lands and terraces, including Miller-Yahola silt loams; Yahola soils, undifferentiated; Yahola silty clay loam; Portland silty clay loam; and Reinach very fine sandy loam; and (4) miscellaneous soils and land types unsuited for cultivation, including rough broken land (Vernon soil material), rough stony land, Dill loamy fine sand, dune phase, and Derby fine sand.

The cultivated land embraces not only the most productive soils but also a very large part of the soils of moderate or low productivity. Some of the soils have a rather wide range in crop adaptations and are used for all the crops commonly grown, but others are more limited in their suitability to crops.

Wheat is one of the chief cash crops. It is generally the principal crop on the rather level lying dark soils, which locally are termed "tight land." These soils are extensive, especially in the southwestern and central parts of the county, and are members chiefly of the Tillman, St. Paul, and Chickasha series. Some oats are grown on these soils, largely for local feed, as it is reported that grain sorghums and corn do not do so well on them as oats, although small quantities of grain sorghums and corn are grown. Wheat yields well on the Portland and Reinach soils of the terraces, and it is grown probably with somewhat less success on some of the heavier reddish-brown soils of the uplands, especially on Weymouth very fine sandy loam and Vernon silt loam.

Cotton is also a very important cash crop. It is the most universally grown crop and is produced on a very large number of farms without much regard to differences of soils, as it does well on soils having a wide range in texture. Probably the dark-colored smooth-lying tight soils are used to less extent for cotton than the smoother areas of sandy soils. Cotton is the most important crop on the light sandy soils and on soils of the alluvial bottoms and terraces, many of which return rather high yields, even in dry seasons. The soils devoted chiefly to cotton are members of the Yahola, Miller, Dill, Cobb, and Chickasha series.

Grain sorghums, sorgo, and Sudan grass, the main feed crops, are grown on a large part of the loose sandy soils of the Dill series and on the sandy soils of the Chickasha, Cobb, and Weymouth series. Considerable quantities also are produced on the Yahola and Miller soils.

Corn does best on the Yahola and Miller soils of the alluvial valleys; elsewhere dry conditions generally prevent good yields.

Alfalfa grows successfully on many farms on soils of the alluvial bottom lands and terraces. It is a valuable crop, chiefly on the Miller and Yahola soils, as they allow better growth in dry seasons than do the other soils.

Only small quantities of fruits and vegetables are grown in the small home gardens, and yields are higher on the sandy soils.

Some livestock is raised and grazed on the nonarable soils, and large numbers of cattle are brought into the county in late fall to graze all winter on the wheat on many farms.

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In the following pages the soils of Washita County are described in detail, and their agricultural relationships are discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Washita County, Okla.*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
Tillman silt loam	42,880	6.7	Vernon silt loam	85,952	13.3
St. Paul silt loam	63,616	9.9	Vernon silty clay loam	2,304	.4
Hollister silt loam	7,552	1.2	Miller-Yahola silt loams	15,424	2.4
Chickasha fine sandy loam	9,216	1.4	Yahola soils, undifferentiated	21,824	3.4
Chickasha loamy fine sand	3,520	.5	Yahola silty clay loam	1,728	.3
Foard silt loam	3,392	.5	Portland silty clay loam	7,488	1.2
Calumet silt loam	1,472	.2	Reinach very fine sandy loam	10,816	1.7
Dill fine sandy loam	58,624	9.1	Rough broken land (Vernon soil material)	38,528	6.0
Dill loamy fine sand	11,008	1.7	Rough stony land	15,872	2.5
Dill loamy very fine sand, shallow phase	12,864	2.0	Dill loamy fine sand, dune phase	9,664	1.5
Dill loamy fine sand, steep phase	18,944	2.9	Derby fine sand	2,240	.3
Cobb fine sandy loam	40,000	6.2			
Weymouth very fine sandy loam	97,664	15.2	Total	643,840	
Vernon very fine sandy loam	61,248	9.5			

DARK SOILS OF THE UPLANDS

The normal dark soils have 8- to 12-inch dark-brown or dark grayish-brown medium-textured surface soils underlain by rather heavy textured subsoils, which are mainly brown. These soils occupy smooth or nearly level areas and are fertile and fairly productive. The reaction is about neutral, and the soils are developed from "Red Beds" material consisting of more or less calcareous shales and clays with thin interbedded layers of sandstone or shaly sandstone. They are suited to a wide variety of crops but are especially suited to and used for the production of small grains, mainly wheat and some oats.

Most of these soils are locally called tight land, because they pack hard in hot dry seasons and are firmer and more compact than the sandy soils in all seasons. Only very small areas are subject to excessive erosion, although the surface slopes enough in most places to allow free run-off. Water penetrates these soils somewhat more slowly than sandier soils of the other groups; they absorb and store less rain water; and crops on them suffer more in dry seasons.

The Tillman series includes soils that have a smoothly undulating surface, dark reddish-brown surface soils, and heavy brownish-red subsoils underlain by a layer of accumulated calcium carbonate. These soils have developed from shale and shaly clay of deeply weathered calcareous "Red Beds" material.

The St. Paul soils occupy smooth and almost flat areas. Their surface soils are dark brown and crumbly. Their subsoils consist of granular brown clay in the upper part and very heavy brown clay in the lower part, generally below a depth of 2 feet. The layer of accumulated calcium carbonate lies below a depth ranging from 3 to 4 feet and rests on heavy red calcareous clay and shaly clay of the "Red Beds" formation.

The Hollister soils have very dark brown surface soils grading through a thin horizon of very dark brown granular clay into dense

brown clay developed from deeply weathered calcareous "Red Beds" materials of shaly clay and clay. A definite layer of accumulated calcium carbonate is reached at a depth ranging from 3 to 4 feet.

The Chickasha soils have grayish-brown surface soils and brown or reddish-brown permeable subsoils that overlie the parent material of noncalcareous soft sandstone.

The Foard series includes the heavy dark claypan soils. The surface soils are rather dark and rest on dense brown clay subsoils, which, at a depth of several feet, grade into heavy calcareous clay of the "Red Beds" formation. Calcium carbonate is accumulated in the lower part of the subsoils just above the parent materials over the "Red Beds."

The Calumet soils also are claypan soils, but they are brown or grayish brown. The surface soils rest on dense brown clay subsoils developed on shale and calcareous clay of the "Red Beds" formation.

Tillman silt loam.—Tillman silt loam is an agriculturally important soil occupying large smoothly undulating areas in the central part of the county.

The surface soil is dark rich-brown or reddish-brown noncalcareous smooth crumbly heavy silt loam ranging from 6 to 10 inches in thickness. When dry, the material is friable. It grades into heavy but not dense reddish-brown or brownish-red noncalcareous clay. On drying, the exposed material separates naturally into small angular clods. Below a depth of about 24 inches the clay contains many concretions and soft lumps of calcium carbonate. This is the layer of accumulation which ranges from 1 to 2 feet in thickness and rests, at a depth of 4 to 5 feet, on red calcareous clay, the partly weathered "Red Beds" parent material.

Tillman silt loam is rather heavy textured but allows moderately free penetration of water in areas where the surface is not very sloping. The thickness of the surface soil and the darkness of coloration vary according to the degree of slope. On nearly flat areas the soil is slightly deeper and darker and the red color is less pronounced than on sloping areas. The smoother areas of this soil merge with nearly flat bodies of Hollister silt loam, whereas the sloping areas merge with the more steeply sloping bodies of the shallow Vernon soils.

The relief is gently undulating to gently rolling, the slope of most areas being less than 3 percent. Run-off is free, and where the surface is unprotected, sheet erosion rapidly removes the upper part of the surface soil. The heavy-textured subsoil impedes the downward penetration of water. This soil has developed from red shaly clay and other moderately heavy and calcareous materials of the "Red Beds" formation.

The large and small bodies of this soil aggregate a large total area. The larger areas are in the vicinities of Rocky, Sentinel, Cordell, and Bessie.

In its native state, Tillman silt loam is treeless grassland, except for a few scattered mesquite trees. It supports a cover of short grasses, principally buffalo grass and species of grama, with tall bunchgrasses in places.

Almost all of this soil, locally called tight land, is cultivated. It is considered a more suitable soil for wheat than for row crops, and, as a rule, it is used for wheat more largely than for other crops;

although oats, cotton, grain sorghums, and sorgo are also grown. From data obtained locally it is estimated that yields of wheat usually range from 10 to 18 bushels an acre but in occasional very dry seasons are lower. Oats yield from 20 to 40 bushels in most seasons, cotton 125 to 200 pounds of lint, and grain sorghums from 12 to 18 bushels.

St. Paul silt loam.—St. Paul silt loam is an extensive and productive dark soil occupying smooth areas in many parts of the county.

The surface soil is dark-brown silt loam, ranging from 6 to 10 inches in thickness, and in places contains much very fine sand. It is slightly cloddy when dry and is not calcareous. It grades into somewhat darker brown crumbly granular noncalcareous clay or silty clay loam. This granular material reaches to a depth ranging from 15 to 24 inches, where it passes into brown or reddish-brown heavy but crumbly silty clay, which is neither granular nor calcareous but breaks apart in distinct cubical particles, one-half inch in diameter. A 1- to 2-foot layer of reddish-brown crumbly clay containing concretions of calcium carbonate lies at a depth of 2½ or 3 feet and is underlain by calcareous "Red Beds" clay or parent material of calcareous clay. As mapped, areas are included in which the surface soil is very sandy, but the profile is otherwise practically the same, except that the lower part of the subsoil is slightly more red than the corresponding layer of the typical soil.

St. Paul silt loam occupies large smooth almost flat areas of considerable size on the broader, undissected, high drainage divides of the smoother high plains of the county. Surface drainage is slow, but water does not stand on the surface as a rule. The slow run-off produces slight but not generally serious sheet erosion.

The native vegetation consists chiefly of buffalo grass and several species of grama, with some of the coarser bunchgrasses of *Andropogon* and other species. Very little of the native vegetation remains, as practically all of this soil is cultivated.

The soil is highly esteemed as a productive smooth-lying soil that allows the use of improved farm machinery and is suited to a number of crops. Much of the rain water sinks into the soil with little loss through run-off, and the heavy subsoil holds a large quantity of moisture in reserve.

The principal crops are wheat, cotton, oats, and some grain sorghums. This soil usually is referred to as one of the tight lands of the county. In seasons of adequate moisture, cotton is reported to yield more than one-half bale an acre, wheat about 18 or 20 bushels, grain sorghums 20 to 30 bushels, and sorghum forage 1 to 3 tons. Some alfalfa is grown, although during most years the supply of moisture is insufficient for its growth, but under favorable conditions from 1 to 2 or more tons of hay an acre is cut. Oats are grown largely as a feed crop on many of the farms on the tight lands and yield from 20 to 40 bushels an acre.

Hollister silt loam.—Hollister silt loam is a dark smooth tight-land soil developed in nearly flat areas over deeply weathered "Red Beds" material of calcareous shaly clay.

The 4- to 8-inch surface soil is dark-brown heavy silt loam. It grades into a thin 2- to 4-inch layer of very dark granular clay that rests on very dense heavy dark-brown clay. On drying this clay becomes very tough and hard, and in exposed locations it separates

into angular large hard clods, which, with increased depth, are somewhat blocky. Below a depth of about 30 inches the heavy clay grades into yellowish-brown or pinkish-brown material with a somewhat more blocky or prismatic structure. Small quantities of calcium carbonate concretions are present, although the fine earth is not calcareous. At a depth of about 56 inches the material gives way to reddish-brown highly calcareous clay containing a large quantity of chalky material and hard concretions of calcium carbonate—a rich accumulation of calcium carbonate in what appears to be the upper weathered "Red Beds" material. This passes, at a depth of about 80 inches, into less calcareous "Red Beds" shaly clay.

Hollister silt loam is rather uniform in its characteristics, and the thickness of the surface soil and upper subsoil layers varies but little from place to place. It is almost a claypan soil, but it differs from Foard silt loam, a true claypan soil, in having the thin granular clay layer just beneath the surface soil and just above the dense clay.

Areas of this soil, some of which are several hundred acres in size, occur mainly in the southwestern part of the county. Surface drainage is slow, and penetration of moisture as well as underdrainage also is slow, because of the dense subsoil. The land has sufficient slope, however, to allow some sheet erosion. In some dry fields the surface soil is only a few inches thick and deep cracks reach from the surface into the heavy subsoil.

The native vegetation is largely buffalo grass and grama, which afford excellent pasturage.

Most of this soil is cultivated and is devoted chiefly to wheat, although cotton, oats, and sorghums are also grown. Crops suffer on this soil in dry weather before they do on lighter and more sandy soils. With adequate moisture, yields of wheat range from 15 to 20 or more bushels an acre, cotton ¼ to ½ bale, and oats 30 to 40 bushels. Grain sorghums do not yield so well as they do on the sandy soils.

Chickasha fine sandy loam.—Chickasha fine sandy loam is a brown sandy soil occupying several large smooth areas in the extreme southeastern part of the county.

The surface soil is brown fine sandy loam, about 12 inches thick, and it contains considerable very fine sand. It is sufficiently heavy to pack slightly on drying but, as a rule, is friable and permeable. The surface soil grades into brown fine sandy clay or fine sandy clay loam, which is underlain by soft red sandstone at a depth of several feet. The lower part of the subsoil is slightly red in places. Both the surface soil and the subsoil, as well as the parent material, are noncalcareous.

The land is smooth and almost flat, but surface drainage and underdrainage are good. Although the soil does not erode readily, some sheet erosion occurs in smooth unprotected fields.

In the virgin state the soil supports a thick growth of coarse bunchgrasses and some grama.

About 75 percent of this soil is in cultivation. It is more generally used for cotton and grain sorghums than for small grains, although some wheat and oats are grown. According to local information, the crops return very good yields when moisture conditions are favorable, and, because of the favorable moisture-holding capacity and ready supply of the soil moisture to growing plants, crops do not fail completely even in dry seasons. According to local estimates, in seasons

of favorable rainfall cotton yields from ⅓ to ⅗ bale an acre, corn 15 bushels, grain sorghums 20 bushels, oats 20 bushels, and wheat 12 bushels.

Chickasha loamy fine sand.—Chickasha loamy fine sand is a deep soil developed in small smooth areas in the northeastern part of the county, chiefly near Colony.

The surface soil consists of brown or pale reddish-brown loamy fine sand, about 14 inches thick, which, on drying, becomes rather tightly packed in some places, especially during long hot periods in summer. The subsoil is slightly reddish brown loamy fine sand, fine sandy loam, or, in places, fine sandy clay loam. The parent rock of massive soft sandstone is several feet below the surface.

The surface is smooth and almost flat, but drainage is good through the permeable surface soil and subsoil. As a large part of the rainfall is collected and absorbed, little moisture is lost by run-off. The soil retains moisture well and supplies it to plants in dry seasons, and crops to not suffer so quickly as they do on heavier textured soils. Although rather loose when plowed, this soil does not blow or drift very much, except where it is unusually light textured and has no vegetative cover. A heavy growth of native grasses, chiefly coarse bunchgrasses, covers the virgin soil.

Nearly all of this soil is farmed, and it seems to be a valuable general-purpose soil, as cotton, corn, small grains, and sorghums all grow successfully. Farmers report that in normal seasons cotton yields from ¼ to ½ bale, corn 10 to 20 bushels, wheat 10 to 15 bushels, and grain sorghums 20 bushels an acre. With ample moisture, sorgo produces from 1 to 3 tons of forage.

Foard silt loam.—Foard silt loam is a smooth dark heavy inextensive soil occupying small nearly flat areas in the southern part of the county.

The surface soil consists of dark-brown silt loam, from 6 to 10 inches thick, which is friable when moist but packs tightly on drying. It rests on dense tough dark-brown clay. In places, a 2- or 3-inch layer of dark slightly granular clay lies just beneath the surface soil. Neither the surface soil nor the subsoil is calcareous. Below a depth of 2½ or 3 feet the subsoil grades into brown heavy clay containing calcium carbonate concretions. This is the layer of calcium carbonate accumulation. Below a depth ranging from 4 to 5 feet the soil material is reddish-brown calcareous clay containing many concretions and lumps of calcium carbonate.

A few small areas of this soil lie along and near the southern county line, especially south and southwest of Rocky. Rain water sinks into the soil slowly, although it also runs off in most places very slowly. Underdrainage is very imperfect because of the dense subsoil. In dry seasons crops do not withstand droughty conditions so well on this soil as on some of the more permeable soils. The soil is formed from shale and clay of the "Red Beds" formations.

Buffalo grass and grama formed most of the native cover.

Practically all of this soil is in cultivation and is devoted chiefly to wheat. In normal seasons, wheat yields about 12 bushels and oats yield from 20 to 30 bushels an acre.

Calumet silt loam.—The surface soil of Calumet silt loam, a claypan soil, is dark-brown or dark grayish-brown silt loam, about 10

inches thick. In cultivated fields the air-dry soil is distinctly grayish brown. It rests on dense tough dark-brown clay, which grades into shaly clay of the "Red Beds" formation at a depth of several feet. In places concretions of calcium carbonate form an accumulation in the subsoil below a depth of about 24 inches. No calcareous material is in the surface soil or subsoil above this layer. A thin 1- or 2-inch dark-gray layer intervenes in places between the silt loam surface soil and dense clay subsoil. Here and there are spots of light-colored soil, which appear to contain salts and support little or no vegetation. In such spots the surface soil is a 3- or 4-inch layer of grayish-brown silt loam, which is underlain by dense tough brown clay containing glistening particles, probably of gypsum. Calumet silt loam is very similar to Foard silt loam, but it is somewhat lighter colored and the salt spots are a characteristic feature.

Calumet silt loam is of very small total extent. The principal area comprises several hundred acres along the southern county line, about 3 miles southwest of Rocky.

The surface is practically flat, and surface drainage is slow. Underdrainage is very deficient because of the dense clay subsoil. The native vegetation consists largely of buffalo grass and grama.

Most of this soil is in cultivation. Wheat is the chief crop, but cotton also is grown. The soil is difficult to cultivate, as it forms a hard crust on the surface on drying. At times this crust prevents the growth of very young plants, which cannot force their way to the surface as they germinate. Crops suffer quickly in periods of very dry weather, as the heavy subsoil does not collect and retain a large supply of moisture. In seasons of normal rainfall, when moisture is not especially deficient, cotton yields about 100 pounds and wheat about 8 bushels an acre.

RED AND REDDISH-BROWN SOILS OF THE UPLANDS

The red and reddish-brown soils of the uplands are extensive and together occupy by far the largest proportion of the land area of the county. Most of these soils are rather sandy and have grayish-brown or reddish-brown surface soils with red or reddish-brown subsoils. They are formed from sandstones and sandy or silty materials of the "Red Beds" formation, which, in places, are calcareous. The soils of this group may be subdivided into two subgroups on the basis of soil characteristics and value for producing crops. These are (1) deep loose sandy noncalcareous soils over soft noncalcareous sandstones and (2) shallow immature more or less calcareous soils developed from slightly calcareous shaly clay and sandy clay of the "Red Beds." To the first subgroup belong moderately productive soils, namely, Dill fine sandy loam; Dill loamy fine sand; Dill loamy very fine sand, shallow phase; Dill loamy fine sand, steep phase; Cobb fine sandy loam; and Weymouth very fine sandy loam. To the second subgroup belong soils of moderate to low productivity, namely, Vernon very fine sandy loam, Vernon silt loam, and Vernon silty clay loam.

The soils of the Dill series have red loose sandy surface soils with permeable somewhat heavier textured sandy subsoils. These are deeply developed over soft noncalcareous sandstones of the "Red Beds" formation. The soil contains no calcareous layer.

The Cobb soils have grayish-brown or reddish-brown surface soils containing considerable sandy material. The subsoils are red or reddish brown, crumbly, and also rather sandy and permeable. These soils have developed on rolling or undulating surfaces under a coarse-grass cover from soft sandstones, which lie, in most places, several feet beneath the surface. The subsoils are not so red as those of the Dill soils and not so dark as those of the Chickasha soils. There is no calcareous layer in these soils.

The Weymouth soils have reddish-brown surface soils resting on red or reddish-brown crumbly sandy clay subsoils. The subsoils grade, at a depth ranging from 12 to 24 inches, into slightly weathered sandy clay of the "Red Beds" formation, which in places is calcareous. No very definite layer of accumulated calcium carbonate has developed, although in places concretions of calcium carbonate in the material just above the "Red Beds" indicates an incipient development of such a layer.

The Vernon series includes very shallow red soils resting on calcareous sandy clay and shaly clay of the "Red Beds" formation. Both the surface soils and the subsoils are calcareous.

Dill fine sandy loam.—Dill fine sandy loam is an agriculturally important loose red sandy soil occurring in the northwestern part of the county. It is associated chiefly with Dill loamy fine sand and Dill loamy very fine sand, shallow phase.

The surface soil is dark brownish-red loose or friable loamy fine sand or light fine sandy loam, which, as a rule, contains a high proportion of fine sand. The thickness of this layer ranges from 6 to 14 inches and averages about 10 inches. The soil material is about neutral in reaction. The supply of organic matter is low. The surface soil grades into dark-red noncalcareous sandy clay, which is not of uniform texture, although it is everywhere friable, crumbly, and readily penetrated by water. In smooth nearly flat situations the subsoil is distinctly red sandy clay to a depth of several feet, whereas on slight swells and gently sloping low ridges it contains a large proportion of fine sand and is a fine sandy loam or fine sandy clay loam. No layer of the profile has an accumulation of calcium carbonate. The sandy clay material in places is reddish yellow or brown below a depth of 3 feet and rests on soft sandstone that lies several feet beneath the surface. This sandstone is noncalcareous, but in places calcium carbonate thinly coats the seams. Included in mapping are small areas of Dill loamy fine sand.

In general, Dill fine sandy loam is undulating, although some areas are nearly flat with occasional slight swells or low smoothly rounded ridges. This soil occupies the less eroded or dissected broad divides of a smooth high plain bordered by other soils, which are cut by minor drainageways constituting headwater tributaries of the larger drainage systems of this section.

Run-off is slight. The texture and consistence of the soil favor the storage of a very large proportion of the rain water and make the moisture readily available to growing plants. In some low places, seepage of water from higher areas causes wet conditions in rainy seasons, but, for the most part, underdrainage is adequate for growing crops.

Dill fine sandy loam is developed from a rather soft noncalcareous sandstone, which lies deeply buried in most places. In heavy winds the unprotected soil drifts readily. Low or basinlike areas show where the wind has swept away a large part of the surface soil and subsoil, leaving the sandstone near the surface. In many places wind-blown sand accumulates along fence rows.

On the virgin soil the native vegetation consists largely of coarse bunchgrasses, including species of *Andropogon*.

Nearly all of this soil is used for crops, chiefly cotton and grain sorghums, with some sorgo, Sudan grass, and other feed crops. It is too light and loose to be used successfully for small grains. A small acreage of corn is grown. Despite its loose consistence and only moderate productivity, this soil is rated as fairly good cropland, because crops do not suffer so early from lack of moisture in dry seasons as they do on heavy-textured soils. Cotton is the principal cash crop, and much of the farm land is strip cropped with cotton and sorghums, with the strips extending at right angles to the direction of the heavy winds. Ordinarily, cotton produces from ¼ to ½ bale an acre, grain sorghums 15 to 25 bushels, corn 10 to 20 bushels, and sorgo or grain sorghum forage 1 to 3 tons. Excellent sorgo sirup is made on many farms. Vegetables, fruits, and berries do well and are grown in the home gardens for home use and local sale. Many farmers on this soil feed a few dairy and beef cattle. The surplus dairy products are sold locally to buyers for shipment to manufacturing plants outside the county.

Dill loamy fine sand.—Dill loamy fine sand is a red loose sandy soil occupying many small areas in the northwestern part of the county, largely in association with Dill fine sandy loam.

The surface soil is reddish-brown or brownish-red loose loamy fine sand, ranging from 12 to 18 inches in thickness. In most places this material grades into red fine sandy loam or loamy fine sand, but in many places the lower part of the subsoil is red fine sandy clay loam. In places the material below a depth of 3 feet is more sandy than in the layer above and is yellow or reddish yellow. This material gives way to soft red sandstone at a depth of several feet beneath the surface. Neither the surface soil nor the subsoil is calcareous, but the reaction is probably about neutral. No layer has an accumulation of calcium carbonate. This soil resembles Dill fine sandy loam, from which it differs in having slightly lighter consistence. Where areas of that soil are too small to show separately, they are included on the map with Dill loamy fine sand.

This soil does not occupy such level land as does Dill fine sandy loam. The undulating surface is characterized by gentle swells with low smooth ridges and lower lying swales between. Water runs off slowly, but the loose soil absorbs it rapidly. Underdrainage is rather free, causing seepage in lower areas and in some very wet seasons an excess of water, which is unfavorable for early planting of crops.

This soil is developed from soft red sandstone and is subject to drifting in heavy winds where no protective cover remains, as may be seen from the slight wind-whipped ridges and accumulations of sand along fence rows. The native vegetation is chiefly coarse bunchgrass, largely species of *Andropogon*.

Probably half of this soil is used to pasture farm livestock, and the rest is cultivated. About half of the cultivated land is devoted to cotton and the other half to sorghums, peas, Sudan grass, and other feed crops. The same crops are grown as on Dill fine sandy loam, possibly with a lower proportionate acreage of cotton. The soil drifts readily and requires more protection from this hazard. It is moderately productive. Although suited to the same farm crops as Dill fine sandy loam, it returns generally somewhat lower yields than that soil. This is due to its lighter sandier texture, slightly lower content of plant nutrients and organic matter, looser seedbed, and more porous subsoil and substratum, all of which combine to allow somewhat freer leaching, as compared with those features of the fine sandy loam.

Dill loamy very fine sand, shallow phase.—Dill loamy very fine sand, shallow phase, is a shallow red soil occupying comparatively small areas in the western part of the county, chiefly south and southwest of Canute.

The 8-inch surface soil is red or reddish-brown loamy very fine sand. It grades into red loamy very fine sand, which, at a depth ranging from about 18 to 24 inches, passes into soft more or less weathered red sandstone. Neither the soil material, nor, as a rule, the parent material, is calcareous. The sandstone is not calcareous but contains fine white seams and particles of calcium carbonate. If this soil were calcareous it would be correlated with the Vernon series, but it is correlated with the Dill series as it is developed from the same sandstone that underlies other Dill soils and generally has no accumulation of calcium carbonate. In a few places calcium carbonate concretions occur in the lower part of the shallow soil, just over the sandstone, but this evidence of accumulation is slight.

The depth and texture of this soil vary, owing to more or less erosion by water and, to some extent, by wind. Sandstone almost outcrops in some places and lies from 2 to 3 feet beneath the surface in others. The surface soil has a fine sand texture in places.

Dill loamy very fine sand, shallow phase, occupies gently rolling and slightly to moderately sloping areas. It has rapid drainage and erodes severely where not protected.

Probably 60 percent of the soil is in cultivation, and the rest is used for the pasturage afforded by native grama, buffalo grass, and tall bunchgrasses. The soil is not highly productive and is used chiefly for growing sorghums and other feed crops and cotton. Crop yields on the representative areas of the soil are probably not much more than half those obtained on Dill fine sandy loam. It is estimated that in normal seasons cotton yields about 100 pounds of lint and grain sorghums yield about 10 bushels of grain and 1 ton of forage an acre.

Dill loamy fine sand, steep phase.—Dill loamy fine sand, steep phase, occupies small narrow areas on rather steep slopes of small deeply cut valleys, and soft sandstone lies only a few feet beneath the surface.

The surface soil is reddish-brown or brown loamy fine sand, about 10 inches thick. It grades into red or brownish-red loamy fine sand, which, below a depth ranging from 2 to 3 feet, rests on soft red sandstone. Neither the soil material nor the parent material is calcareous. The sandstone, for the most part, is noncalcareous, but it has fine seams of white calcareous material throughout.

This soil occurs chiefly in several small areas in the extreme northwestern and southeastern parts of the county.

Most of the steep slopes occupied by this soil are eroded and cut by gullies, as water drains rapidly from the surface. In some places there are deep accumulations of sandy material washed from higher slopes. Therefore, the texture of the soil and the depth to sandstone vary greatly from place to place.

The native vegetation is largely coarse bunchgrasses, and shin oak trees, ranging from 10 to 20 feet in height, grow in many places.

Probably less than half of this soil is in cultivation. In most places it is too steep to allow satisfactory cultivation, and, owing to the rapid run-off of rain water, it is not highly productive. The chief crops are sorghums and cotton, and yields are estimated to be about one-half of those obtained on Dill fine sandy loam.

Cobb fine sandy loam.—Cobb fine sandy loam is an extensive brown soil developed from soft sandstone, which lies at a depth of a few feet.

The surface soil is brown, with a pale-red hue, fine sandy loam or loamy fine sand, about 12 inches thick. This grades into reddish-brown or brownish-red material, which ranges from fine sandy loam to fine sandy clay but is predominantly fine sandy clay loam. In sloping areas soft red sandstone lies from 3 to 4 feet beneath the surface, but in most places it lies deeper. In eroded areas the surface soil is reddish brown.

The surface soil is rather loose and, where not protected, is subject to blowing in strong spring winds. The relief is undulating to rolling, and drainage is good. Some water erosion affects sloping areas, but probably wind erosion is equally severe in places, although these erosive agents have not prevented the successful use of the land.

Grama and coarse bunchgrasses make up most of the native vegetation. Probably 80 percent of this soil is in cultivation and is used largely for cotton, grain sorghums, and other feed crops. Some wheat and oats are grown in places. Good crop yields are reported on the smoother areas in seasons when soil moisture is adequate. Wheat ordinarily produces from 10 to 15 bushels on the smoother areas, grain sorghums 15 to 20 bushels, corn 10 to 20 bushels, oats 18 to 30 bushels, and cotton ¼ to ½ bale an acre.

Weymouth very fine sandy loam.—Weymouth very fine sandy loam is an extensive rather shallow soil developed over "Red Beds" material on high smooth gently rolling areas.

To a depth of about 8 inches, the surface soil is reddish-brown or brownish-red noncalcareous very fine sandy loam, grading into dark-red or dark brownish-red crumbly noncalcareous light clay or clay loam. At a depth ranging from 20 to 30 inches, this gives way to "Red Beds" material consisting of red calcareous shaly clay. In places a few concretions of calcium carbonate are just over the "Red Beds" parent material. The thickness of the surface soil and subsoil layers varies from place to place.

Water drains freely from the undulating to gently rolling surface. Erosion is not severe but has prevented deep development of the soil. Unless protected, the soil washes readily.

The native vegetation is largely grama and buffalo grass with some tall bunchgrasses. Probably 80 percent of the soil is in culti-

vation. The principal crops are wheat, cotton, and grain sorghums. Some oats, sorgo, and corn are grown. In seasons of normal rainfall, acre yields are 8 to 15 bushels of wheat, ¼ to ½ bale of cotton, and 15 to 25 bushels of oats. Grain sorghums yield from 12 to 18 bushels of grain and from 1 to 2 tons of forage an acre. In smooth locations corn yields from 15 to 20 bushels when moisture conditions are favorable. It is said that crops on this soil withstand drought fairly well.

Vernon very fine sandy loam.—Vernon very fine sandy loam is a very thin soil over calcareous "Red Beds" formations and occurs in many narrow sloping areas throughout the county. It has been subject to rapid run-off and geologic erosion.

The surface soil is red or reddish-brown calcareous very fine sandy loam, ranging in thickness from 3 to 8 inches, according as erosion is more or less severe. In most places the surface soil grades directly into partly weathered "Red Beds" materials of red calcareous fine sandy clay or shaly clay. In some places, however, a subsoil of yellowish-red very fine sandy loam, silt loam, or granular clay is developed over more or less calcareous interbedded shaly clay and shaly sandstone. The thickness of the surface soil and the subsoil, where developed, varies greatly, owing to erosion. In some areas the texture of the surface soil is fine sandy loam. In small areas the subsoil and parent material are so sandy and porous that the soil approaches the Quinlan soils in texture and consistence.

Most of the slopes range from 3 to 8 percent, but some are as steep as 12 percent. The soils are subject to very severe sheet erosion, with an occasional gully where cultivated. Perhaps they should be kept in close-growing crops or grass, in order to protect the more productive areas of land nearby.

Native buffalo grass, grama, and some of the tall bunchgrasses make up a thin to moderately thick cover. Although the soil does not afford abundant grazing, it is in many places better suited for this purpose than for the production of farm crops. Grass roots penetrate deeply into the crumbly subsoil and substratum. Most of the grasses are rather nutritious.

Much of the less steep land is farmed, as many areas form small parts of cultivated fields. Here the crops are mainly grain sorghums and sorgo, some cotton, and a little wheat. The inherent productivity is low, and much rain water is lost by run-off. Dry weather quickly injures crops and greatly reduces yields, as the moisture reserve is low. Yields differ widely according to degree of slope and erosion. On the less sloping areas of deeper soil under normal conditions of rainfall, probably from ⅕ to ⅖ bale of cotton, 5 to 10 bushels of wheat, and 10 bushels of grain sorghums, with possibly 1 ton of sorgo forage, are produced on an acre. It is probably impracticable to use much of this soil for cultivated row crops. It is generally better suited for pasture.

Vernon silt loam.—Vernon silt loam is a shallow red moderately heavy textured soil resting on calcareous "Red Beds" material. This soil occurs in both small and large areas in the northwestern part of the county.

The 3- to 8-inch surface soil consists of red or brownish-red calcareous silt loam. In some places this grades into red calcareous silt loam or silty clay loam, which, at a depth of about 12 inches, rests on

weathered shaly calcareous clay "Red Beds" material. Elsewhere the surface layer rests directly on the shaly "Red Beds" material. This parent material, which has weathered only slightly, consists of shaly clay interbedded with thin layers of shaly sandstone. Some calcareous material is present in these beds.

The relief is rolling. Most of the slopes range in gradient from 2 to 6 percent and allow rapid run-off, especially where the soil has packed hard in dry weather. Erosion has more or less thinned the surface soil and subsoil layers, largely according to the degree of slope and extent of cultivation. Both sheet and gully erosion are active.

Probably more than half of this soil is or has been cultivated, but some remaining virgin areas support a cover of native buffalo grass, grama, and bluestem. The soil is not highly productive, especially in areas that have been farmed for a long time and have lost a large part of the surface soil through erosion. In the areas of deeper soil where the surface is smooth and rainfall is adequate, probably from ⅕ to ⅖ bale of cotton, 8 to 12 bushels of wheat, 15 bushels of grain sorghums, and 1 to 2 tons of sorghum forage are produced on an acre; but yields differ greatly, even where the supply of moisture is ample. Vernon silt loam, as a rule, is somewhat less sloping than Vernon very fine sandy loam but has about the same or slightly higher average productivity. The prevention of erosion is the main problem on this soil.

Vernon silty clay loam.—Vernon silty clay loam is of small extent and of little agricultural importance in this county.

The surface soil is brownish-red or reddish-brown calcareous silty clay loam ranging from about 3 to 6 inches in thickness. It grades into red or brownish-red calcareous heavy clay, which rests, at a depth of about 2 feet, on "Red Beds" material of interbedded sandstone and shaly clay, with thin layers of limestone in places.

This soil occupies only a few very small areas in the extreme southern part of the county, a few miles southwest and southeast of Rocky.

The surface is gently sloping. Drainage from the surface is free, and erosion occurs where the soil is unprotected.

Most of the soil is in cultivation, and wheat is the principal crop. Yields vary considerably, as the soil is not highly productive and in dry seasons the store of moisture in the soil is not always adequate. Ordinarily yields of wheat range from 6 to 12 bushels an acre.

SOILS OF THE ALLUVIAL BOTTOM LANDS AND TERRACES

The group of soils of the alluvial bottom lands and terraces includes deep soils of the valleys, both of the present flood plains and the bordering higher benches, or old stream terraces, that lie above overflow. The soils are red or reddish brown, more or less calcareous, very fertile, and rather highly productive. They comprise alluvial materials washed mainly from the upland soils and soil materials of the "Red Beds" formation. These soils are especially well suited to alfalfa and corn, as well as to all other crops of the section, including cotton and sorghums, although some are not so well suited to wheat and oats as to the other crops.

The Yahola soils consist of red calcareous alluvial soil materials transported by floodwaters that drain and erode the red soils of the uplands. The subsoils are generally coarser and looser than the surface soils.

The Miller soils, also red calcareous alluvial soils, have a common origin with the closely associated Yahola soils, from which they differ mainly in having heavy-textured subsoils that are, as a rule, considerably heavier textured than the surface soils.

The Portland series comprises high-lying alluvial soils with brown or dark-brown surface soils and brown or reddish-brown subsoils. Compared with the Yahola or Miller soils, the Portland soils are darker, and they lie on higher smooth areas that are not frequently overflowed.

The Reinach soils have brown or reddish-brown surface soils and reddish-brown or brownish-red subsoils that generally are somewhat sandy and calcareous in the lower part. They consist of old alluvial soils that no longer are subject to periodic inundation.

Miller-Yahola silt loams.—Miller and Yahola silt loams are so closely associated throughout the Washita River and Cavalry Creek bottoms that it is not feasible to separate them on the soil map. On the surface the soils are very similiar in appearance, but they differ essentially in certain subsoil characteristics that are closely related to productivity.

The surface soil of Yahola silt loam is brownish-red smooth calcareous silt loam containing a large amount of silt and, in places, a considerable admixture of very fine sand. In most places this layer is 12 inches thick, but in some places it reaches to a depth ranging from 18 to 24 inches. It grades into a red calcareous subsoil, which ranges from fine sandy loam to loamy very fine sand. In some places the sandy subsoil includes thin layers of heavier soil material.

Miller silt loam has a surface soil very similar to that of Yahola silt loam. It is a brownish-red slightly compact calcareous silt loam, about 12 inches thick, which grades into red or brownish-red calcareous silty clay loam or heavy silt loam. This material reaches to a depth ranging from 3 to 4 feet, or deeper, and is, in places, underlain by reddish-brown or brownish-red very fine sandy loam. The chief difference between the two soils is the heavier subsoil of Miller silt loam.

In addition to these soils, spots of a few acres each, too small to map, of Miller silty clay and Yahola silty clay loam and a very few small areas of Yahola clay are included in the general area of the bottom lands.

These bottom-land soils constitute important areas of rich farm land, from one-fourth to three-fourths of a mile wide in the eastern and central parts of the county. They occupy chiefly the flood plains of the Washita River and Cavalry Creek and to less extent the bottom lands along other streams.

This land is almost flat and lies from 10 to 20 feet above the streams. Occasional overflows inundate the land but do not prevent its successful use for farm crops. In the higher situations along the stream banks the soils consist of more sandy materials and for the

most part are members of the Yahola series, whereas in the lower situations, especially adjacent to the upland, the soils are heavier and are chiefly members of the Miller series. All these soil materials have washed from slopes of the red soils of the region.

Underdrainage generally is good, especially beneath the Yahola soils, as the water passes freely through the sandy materials. In wet seasons the sandy subsoils and substrata allow a high water table, but in dry seasons the water table subsides to a depth of several feet. In the areas of soils with the more sandy subsoils, crops suffer from insufficient moisture during long-continued dry seasons.

The uncleared bottom lands are forested with elm, ash, cottonwood, and other trees. Probably 90 percent of the area of these soils is in cultivation, as they are rather highly productive under normal conditions. They are used chiefly for cotton and grain sorghums and to less extent for corn and alfalfa. With adequate moisture, yields are high as compared with those on other soils of the county, maximum yields of 1 bale of cotton an acre, 30 bushels of grain sorghums, and 30 bushels of corn being obtained. Average yields, however, are considerably lower. These soils are well adapted to growing alfalfa, and much of this valuable crop is grown, ordinarily yielding from 2 to 3 tons an acre in three or four cuttings. Grain sorghums, sorgo, and Sudan grass produce rather high yields of hay and forage, probably from 2 to 3 tons an acre of sorghum forage being produced during the most favorable seasons.

Yahola soils, undifferentiated.—Yahola soils, undifferentiated, are intricately mingled within narrow strips of bottom land along many of the small streams. They represent soil materials washed from the red soils of the rolling "Red Beds" plains of the region.

Yahola very fine sandy loam has an 8- to 15-inch red or reddish-brown calcareous very fine sandy loam surface soil containing a large quantity of silt. The surface soil generally is underlain by a somewhat lighter-textured yellowish-red calcareous very fine sandy loam or loamy very fine sand containing somewhat less silt and clay. This soil varies considerably in texture. In places a layer of red calcareous silty clay loam several inches thick forms the upper part of the subsoil.

The associated Yahola silt loam closely resembles Yahola very fine sandy loam but differs from it chiefly in having a red calcareous silt loam surface soil. Small areas of Miller silt loam, which could not be shown separately on the soil map, are included.

These soils occupy almost flat areas of the smooth stream bottoms, the more sandy soil generally lying near the stream and the heavier textured soil in the slightly lower situations farther back from the stream channel. These areas are overflowed occasionally but not enough to prevent successful cultivation.

The principal crops are cotton, grain sorghums, sorgo, and some corn. These soils are rather highly productive, although the lighter, looser, and more sandy soil is less so than the heavier textured soil. Crops suffer more quickly in dry seasons on the soil with a very loose sandy subsoil than on the heavier silt loam. In normal seasons cotton yields from ⅓ to ¾ bale an acre, grain sorghums 20 to 25

bushels, corn 20 bushels, and forage crops 1 to 3 tons of fodder. Alfalfa grows well on these soils and yields an average of about 2 tons of hay an acre in normal seasons of moderate rainfall. Farmers value these soils very highly, and practically all of their area is cultivated.

Yahola loamy fine sand consists of loose fine sandy alluvium, which is lighter textured and decidedly less productive than the other soils of alluvial materials. Its surface soil is reddish-brown calcareous loamy very fine sand several feet thick and differs very little from the subsoil, except that the former is slightly darker and heavier textured than the latter. Small areas of Yahola loamy very fine sand also occur in association with Yahola loamy fine sand. This soil differs from the loamy fine sand mainly in degree of fineness of the sand grains. The loamy fine sand occupies a few very narrow creek or branch bottoms in the extreme western and southeastern parts of the county. The surface is nearly flat, and drainage is good, although occasional overflows occur. Unlike the other Yahola soils, most of this soil is left uncultivated, owing to its looseness and low productivity. Coarse native grasses afford some pasturage.

Yahola silty clay loam.—Yahola silty clay loam occupies comparatively small areas, as a rule, farthest from the stream channel in the flood plain of the larger streams, mainly the Washita River and Boggy Creek. It is a rather heavy textured productive bottom-land soil.

This soil consists of a layer of chocolate-brown or reddish-brown calcareous silty clay loam, about 15 inches thick, grading into reddish-brown calcareous very fine sandy loam, which continues to a depth of several feet. As in all the Yahola soils, the texture of the subsoil varies considerably, but in general it is rather sandy and considerably lighter than the texture of the surface soil.

This land is almost flat. In places surface drainage is slow, but underdrainage is good. Despite occasional overflows, crops are produced, as a rule, without severe losses from floods. This soil consists of the finer soil materials washed from eroded soils of the "Red Beds" plains, occupied largely by the Vernon and associated soils.

Practically all of this soil is in cultivation. Cotton, grain sorghums, and alfalfa yield well, probably about the same as on the silt loams of the Miller and Yahola series. The soil is well suited to alfalfa.

Portland silty clay loam.—Portland silty clay loam is a heavy-textured rather dark soil occurring on high bottoms and on low second bottoms along some of the creeks.

The surface soil is brown or dark-brown crumbly silty clay loam about 18 inches thick. It grades into brown heavy but crumbly clay which, in turn, at a depth of 24 inches, grades into a layer of red calcareous clay several feet thick. The surface soil and subsoil down to the red clay are not calcareous.

In places this soil extends up the valleys of smaller tributary streams as high first bottoms. In some places the soil occupies the high bottoms, which are practically the only bottom lands of streams.

In such places the 6-inch surface soil is reddish-brown silty clay loam, underlain by very dark brown clay, which, in turn, is underlain by red calcareous silty clay at a depth of 18 inches. This soil occurs in some stream bottoms occupied by calcareous red soils of the Yahola and Miller series. Its dark color, noncalcareous upper layers, and, as a rule, generally somewhat higher position distinguish it from those soils. Portland silty clay loam is not extensive, but it occupies a number of small areas, chiefly in the valleys of Boggy and Elk Creeks.

The areas of this soil are smooth and almost flat. Although the soil occupies low benches several feet above the bottoms, it is overflowed occasionally. Both surface drainage and underdrainage are good.

Practically all of this soil is in cultivation, as it is highly esteemed for most of the crops grown, including alfalfa. Average acre yields are estimated from local information to be about ½ bale of cotton, 15 bushels of wheat, and 20 bushels of corn and grain sorghums. Alfalfa does well, and yields range from 1 to 2½ tons an acre, depending on moisture conditions.

This soil is composed of dark alluvial soil materials transported from the dark soils of the plains and deposited over the heavy thick beds of the calcareous red soil materials, which originally were washed from soils of the "Red Beds" areas.

Reinach very fine sandy loam.—Reinach very fine sandy loam occupies comparatively small areas on smooth flats lying above ordinary overflow in some of the larger stream valleys.

The surface soil is reddish-brown heavy very fine sandy loam, from 15 to 18 inches thick, which is not calcareous and contains considerable silt. It grades into red or reddish-brown lighter very fine sandy loam, which, as a rule, is calcareous and contains, in places, layers of a finer textured and friable material. The subsoil, in places, ranges from silt loam to silty clay loam, or even silty clay. Small areas of Reinach silt loam and Reinach silty clay loam are included with areas of this soil in mapping.

The soil consists of old alluvium deposited by overflows during a period when the streams were flowing at a higher level. The materials originated from soil materials of the "Red Beds" plains.

The position of this soil is on benches or terraces that lie from 10 to 30 feet above the lower first bottoms of some streams, or on high bottoms along streams that have no lower bottoms. Overflows generally do not reach most areas of this soil except from some local tributaries draining the higher lying adjacent uplands.

Practically all of the land is in cultivation. This is a valuable and highly productive soil, suited to most of the crops commonly grown. The principal crops are cotton, grain sorghums, and some wheat. Local information reports yields of wheat ranging from 7 to 20 bushels an acre, the lower yield being in very dry seasons. Cotton yields about ⅖ bale an acre, corn and grain sorghums from 15 to 20 bushels, and alfalfa about 3 tons.

MISCELLANEOUS SOILS AND LAND TYPES UNSUITED FOR CULTIVATION

Scattered small bodies of miscellaneous soils and land types are considered nonarable because of their steep and rough relief or because their loose deep sandy character subjects them to wind blowing where unprotected. The total area of nonarable land is small.

This group comprises rough broken land (Vernon soil material), rough stony land, Dill loamy fine sand, dune phase, and Derby fine sand.

The Derby soils have grayish-brown surface soils and yellow, yellowish-brown, or reddish-brown friable subsoils. The soil layers are not calcareous, and the parent material is largely wind-blown loose sandy material.

Rough broken land (Vernon soil material).—Rough broken land (Vernon soil material) includes the deeply eroded and steeply sloping valley walls and gullied slopes cut into the surface of the "Red Beds." In places white gypsum beds outcrop on the eroded slopes. Small areas of ridges and escarpments are included, which represent outcropping "Red Beds" formations and are composed of small broken sandstone fragments, together with shale and clay. Small included areas in which some soil has developed are chiefly Vernon very fine sandy loam.

In most places this land supports a thin cover of native grasses, largely coarse bluestem and other tall bunchgrasses, with some buffalo grass and grama, chiefly blue, hairy, and side-oats grama. Some species of *Aristida* also grow where the surface soil is exceptionally thin and severely eroded.

This nonarable land is used only for pasturing livestock. Some range cattle of beef breeds are raised and grazed. The pasture is moderately good. The land occurs in small areas and strips throughout much of the eastern part of the county and in fairly large areas in the western part.

Included with this land on the map are a few very small areas of steep slightly stony land on the upper slopes of an escarpment near the southern county line. Here the soil consists of a thin layer of brown clay over a bed of broken flat fragments of dolomitic limestones. Small stony fragments are scattered through the fine earth and on the surface.

Rough stony land.—Rough stony land designates small eroded ridges, escarpments, and valley walls that have been almost entirely denuded of soil, and even of soil materials, with the consequent exposure of loose beds of broken soft and hard white fragments of gypsum. The slopes range from moderate to steep, but the land is not very rough. The stony material crumbles readily when exposed to weathering. As little grass grows on this land, its value is low even for pasture. Many small bodies of this rough land are in the eastern part of the county.

Dill loamy fine sand, dune phase.—Dill loamy fine sand, dune phase, is a very sandy dunelike soil occurring in small areas in the western part of the county, mainly in association with Dill fine sandy loam. Small areas of that soil are included on the map.

The 10-inch surface soil consists of red or reddish-brown loamy fine sand. It grades into red, light-red, or reddish-yellow loamy fine sand which continues to a depth of many feet. Neither the surface soil nor the subsoil is calcareous, although the material is about neutral in reaction.

This soil occupies steeply sloping high ridges and mounds, ranging from 10 to 30 feet higher than the general level of the surrounding land. The material is wind-blown drifted sandy material from the adjacent sandy Dill soils, which has been caught and held in place by the native coarse bunchgrasses. Drainage is good, as the porous surface soil and subsoil allow rapid underdrainage.

Most of this soil is used for such pasturage as bluestem and other coarse grasses afford, although a few areas on the smoother locations are cultivated, mostly to sorgo or grain sorghums. The inherent productivity is only moderate. Where cleared of grasses and wild plum bushes, the soil blows and drifts severely in spring winds, and it is better suited for pasture than for cultivation. If it were protected from wind blowing, berries and small fruits might be grown with fair success.

Derby fine sand.—To a depth ranging from 6 to 12 inches the surface soil of Derby fine sand is loose gray or grayish-brown fine sand. It grades into pale-yellow or reddish-yellow loose fine sand, which continues to a depth of several feet. Both the surface soil and the subsoil have a very slightly acid reaction, and no calcium carbonate is in the surface soil or subsoil.

A few small areas of this soil, chiefly in the northeastern part of the county near the county line, appear to comprise the western limit of larger areas lying to the east. Theoretically, this soil belongs to the pedalferic soil zone. Here, however, it lies at about the dividing line between the Pedalfers and Pedocals and, therefore, closely resembles Tivoli fine sand, the pedocalic equivalent of Derby fine sand.

The surface is undulating to rolling. Water drains rapidly downward through the surface soil and subsoil. Chiefly coarse grasses with scattered blackjack oak trees make up the native vegetation. A few small areas in the west-central part of the county, associated with areas of Dill loamy fine sand, dune phase, support a cover of small shin oak trees.

Because of the loose character of this soil, it drifts considerably in strong winds in places where it has no protective cover. For this reason, and because of its low productivity, nearly all of the land remains in uncleared pasture. Small areas used for growing sorgo and grain sorghums produce low yields of grain and forage when moisture conditions are favorable.

PRODUCTIVITY RATINGS

The estimated average acre yields of the principal crops obtained on each soil in Washita County under prevailing practices over a period of years are given in table 4.

TABLE 4.—*Estimated average acre yields of the principal crops on each soil in Washita County, Okla.*[1]

Soil (soil types, phases, complexes, and land types) [2]	Cotton, lint	Corn	Wheat	Oats	Grain sorghums	Grain-sorghum and sorgo hay and forage	Alfalfa	Pasture [3]
	Pounds	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Tons*	*Tons*	
Calumet silt loam	100	------	8	15	5	1	------	Fair.
Chickasha fine sandy loam	175	12	12	20	20	2	------	Do.
Chickasha loamy fine sand	150	10	12	20	20	1.8	------	Do.
Cobb fine sandy loam	140	12	10	20	16	1.5	------	Do.
Derby fine sand	------	------	------	------	4	.4	------	Poor.
Dill fine sandy loam	175	12	------	------	18	1.8	------	Fair.
Dill loamy fine sand	160	10	------	------	15	1.5	------	Do.
Dill loamy fine sand, dune phase	------	------	------	------	4	.6	------	Poor.
Dill loamy fine sand, steep phase	100	------	------	------	10	1	------	Do.
Dill loamy very fine sand, shallow phase	100	------	------	------	10	1	------	Fair.
Foard silt loam	110	------	12	20	10	1	------	Good.
Hollister silt loam	120	------	12	22	10	1	------	Do.
Miller-Yahola silt loams	240	20	------	20	25	2.5	2.5	Fair.[4]
Portland silty clay loam	200	20	15	25	20	2	2	Good.
Reinach very fine sandy loam	185	15	15	25	20	2	2.5	Do.
Rough broken land (Vernon soil material)	------	------	------	------	------	------	------	Fair.
Rough stony land	------	------	------	------	------	------	------	Poor.
St. Paul silt loam	160	12	16	30	20	1.5	1	Good.
Tillman silt loam	140	8	14	25	15	1	------	Do.
Vernon silt loam	110	------	8	15	14	1	------	Fair.
Vernon silty clay loam	100	------	9	12	10	1	------	Do.
Vernon very fine sandy loam	80	------	6	10	10	1	------	Do.
Weymouth very fine sandy loam	120	8	8	16	14	1.3	------	Good.
Yahola silty clay loam	200	20	------	25	20	2	2.5	Do.
Yahola soils, undifferentiated [5]	220	20	------	15	20	2	2	Fair.

[1] These estimates are based on production under prevailing practices of management, as interpreted from Agricultural Adjustment Administration records in the county agent's office, interviews with farmers, and observations made during the course of the field survey.

[2] The soils are listed in alphabetical order.

[3] Very limited data allow only very general comparisons on a local basis as to the carrying capacity of the individual soil types.

[4] This soil is rated fair for pasture because the uncultivated areas are timbered. It would be rated good if cleared.

[5] These estimated yields refer to the better areas of silt loams and very fine sandy loams that are included in this soil complex. Areas of loamy fine sand also included are much less productive.

The yield estimates are based on reports of farmers and Agricultural Adjustment Administration records. Yields may differ on the same soils from county to county, inasmuch as practices of management may also differ. Actually, the details of management practices differ from farm to farm, and the estimated yields in table 4 are only approximate as they apply to a particular farm. Management practices are not well defined in Washita County, but as referred to here they include extensive methods of producing cash crops without the use of fertilizers or definite rotations including leguminous crops. Under such practices, soil productivity will not be maintained at the same level. It is to be expected that with continued tillage crop yields will be lessened unless improved practices of soil management and improved plant varieties are introduced. Thus, the yields of crops by soil types, as reported here, are not an indication of the ability of the respective soils to continue to produce these yields at these levels without improved management practices.

In order to compare directly the yields obtained in Washita County with those obtained for the same crops in other parts of the country, yield figures have been converted in table 5 to indexes based on stand-

ard yields of reference. The soils are listed in the order of their general productivity under prevailing farming practices, the most productive soils being at the head of the table.

TABLE 5.—*Productivity ratings of the soils of Washita County, Okla.*

Soil (soil types, phases, complexes, and land types)[1]	Crop productivity index[2] for—								General productivity grade[4]	Local classification[5]
	Cotton	Corn	Wheat	Oats	Grain sorghums	Sorghums for forage	Alfalfa	Pasture[3]		
Miller-Yahola silt loams	60	40	----	40	60	60	60	Fair[6]	5	Good cropland.
St. Paul silt loam	40	25	65	60	50	40	25	Good		
Yahola soils, undifferentiated[7]	55	40	----	30	50	50	50	Fair		
Yahola silty clay loam	50	40	----	50	50	50	60	Good		
Portland silty clay loam	50	40	60	50	50	50	50	do		
Reinach very fine sandy loam	45	30	60	50	50	50	60	do		
Chickasha fine sandy loam	45	25	50	40	50	50	----	Fair	6	Fair cropland.
Tillman silt loam	40	15	55	50	35	25	----	Good		
Dill fine sandy loam	45	25	----	----	45	45	----	Fair		
Chickasha loamy fine sand	40	20	50	40	50	45	----	do		
Hollister silt loam	30	----	50	45	25	25	----	Good		
Foard silt loam	25	----	50	40	25	25	----	Good	7	Fair to poor cropland.
Dill loamy fine sand	40	20	----	----	35	35	----	Fair		
Cobb fine sandy loam	35	25	40	40	40	40	----	do		
Weymouth very fine sandy loam	30	15	30	30	35	30	----	Good		
Vernon silt loam	25	----	30	30	35	25	----	Fair	8	
Calumet silt loam	25	----	30	30	15	25	----	do		
Vernon silty clay loam	25	----	35	25	25	25	----	do		
Vernon very fine sandy loam	20	----	25	20	25	25	----	do		
Dill loamy very fine sand, shallow phase	25	----	----	----	25	25	----	do		
Dill loamy fine sand, steep phase	25	----	----	----	25	25	----	Poor		
Dill loamy fine sand, dune phase[8]	----	----	----	----	10	15	----	Poor	9	Grazing land.
Derby fine sand[8]	----	----	----	----	10	10	----	do		
Rough broken land (Vernon soil material).	----	----	----	----	----	----	----	Fair	10	
Rough stony land	----	----	----	----	----	----	----	Poor		

[1] The soils are listed in the approximate order of their general productivity under the average current practices, the most productive first.

[2] The soils of Washita County are given indexes that indicate the approximate average production of each crop in percentage of the standard of reference. The standard represents the approximate average yield obtained without the use of amendments on the more extensive and better soil types of the regions in which the crop is most widely grown. The indexes are largely estimates, as yield data by soil types are yet too fragmental to be adequate.

[3] Very limited data allow only very general comparisons on a local basis as to the carrying capacity of the individual soil types.

[4] This classification indicates on a national basis the comparative general productivity of the soils under dominant current practices. Refer to text for further explanation.

[5] This is a comparative grouping on a local basis to indicate the physical suitability of the soils for farming or grazing uses.

[6] This soil is rated fair for pasture because the uncultivated areas are timbered. It would be rated "good" if cleared.

[7] These indexes refer to the better areas of silt loams and very fine sandy loams that are included in this soil complex. Areas of loamy fine sand also included are much less productive.

[8] Although classified as "grazing land," small areas of these soils are used for tilled crops, principally sorghums.

NOTE: Absence of indexes shows that the crop is not commonly grown on the particular soil type.

The ratings in table 5 compare the productivity of each of the soils for each crop to a standard, namely, 100. This standard index represents the approximate average acre yield obtained without amendments on the more extensive and better soil types of the regions in which the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as is

the soil with the standard index. Soils given amendments, such as lime, commercial fertilizers, and irrigation, and unusually productive soils of small extent, may have productivity indexes of more than 100 for some crops. The following tabulation gives some of the acre yields that have been set up as standards of 100. They represent the long-time average yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:		
Cotton	pounds	400
Corn	bushels	50
Wheat	do	25
Oats	do	50
Grain sorghums	do	40
Sorghums for forage	tons	4
Alfalfa	do	4

The order of the general productivity of the soils and the productivity grade numbers assigned in the column "General productivity grade" have been based upon a weighted average of the indexes for the various crops, using the approximate areal extent and the value of the various crops in the county as bases. Since it is difficult to measure mathematically either the exact significance of a crop in local agriculture or the importance and suitability of certain soils for particular crops, the weightings were set up for the natural soil groups and were used only as guides. Certain minor modifications dictated by personal judgment were permitted in listing the soils in their order of general productivity. General productivity grade numbers are determined as follows: If the weighted average occurs between 90 and 100, the soil type is assigned a grade of 1; if it occurs between 80 and 90, a grade of 2 is given, etc. The weights in percentage given each crop index to arrive at the general productivity grade for each soil group are shown in table 6.

TABLE 6.—*Percentage weighting of crop indexes*

Soil group	Cotton	Corn	Wheat	Oats	Grain sorghums	Sorghums for forage	Alfalfa
Dark soils of the uplands	25		50	10	5	10	
Red and reddish-brown soils of the uplands:							
Deep members	60				20	20	
Shallow members	40		10	5	20	25	
Soils of the alluvial bottoms	60	5		5	10	10	10
Soils of the terraces	50	5	10	5	10	10	10
Miscellaneous land types							

It will be noted that the ratings of the soils are rather low in comparison with the better soils of the United States. This is not altogether due to a lack of suitability of the soils in Washita County to the crops grown or to a lack of fertility. The irregularity of the moisture supply from year to year and the extensive methods of management under which the crops are grown account in large part for the comparatively low yields. In contrast, the fact that a soil is well adapted to a particular crop does not necessarily mean that that crop will be grown extensively on it. Economic considerations, such as the relation of the price of the crop to the cost of production, are of prime importance.

Productivity tables do not present the relative roles that soil types, because of their extent and the pattern of their distribution; play in the agriculture of the county. The tables give a characterization to the productivity of individual soil types. They cannot picture the total quantitative production of crops by soil areas without the additional knowledge of the acreage of the individual soil types devoted to each of the specified crops.

Economic considerations have played no part in determining the crop productivity indexes. Therefore, they cannot be interpreted into land values except in a very general way. Distance to market, relative prices of farm products, and other factors influence the value of land.

The right-hand column in table 5 summarizes in a simple way the productivity and use capabilities of the various soils by placing them in a few groups on the basis of their relative suitability for farming and grazing.

LAND USES AND AGRICULTURAL METHODS

The soils of Washita County vary in characteristics and potential capacities for production, but most of them are capable of producing fairly good yields of many kinds of crops, and they sustain, on the whole, a fairly successful agriculture A large part of the county is smooth and has deep fertile soils, which produce fairly high yields in years when moisture conditions are favorable, without the use of fertilizers or other amendments. A considerable part is covered by thin, sloping, or very sandy soils, which produce only fair yields even under the most favorable moisture and other climatic conditions. A small part of the county consists of land that is too broken or has soils too thin, eroded, or sandy to be used for cultivated crops, and it is of value only for grazing.

The chief problem—inadequate soil moisture during periods of drought—has been solved in part by the use of climatically suited crops or the adoption of agricultural practices to evade the unfavorable climatic conditions as much as possible.

The dark soils of the uplands, including the so-called tight lands, or silt loams, are smooth and deeply developed. They are very fertile and allow the use of improved farm machinery. Although well suited to many crops, they are more generally used for wheat and other small grains because they are better suited to these crops than are many of the lighter, looser soils. These soils do not have such favorable moisture relationships as do some of the more sandy soils, but the small grains are harvested before the more injurious periods of dry hot weather occur. Some cotton and grain sorghums are grown on these soils, but they are grown more extensively on the lighter sandy soils.

The red and reddish-brown soils of the uplands are of two general divisions: Deeply developed soils that are moderately productive and have favorable moisture relationships, enabling crops to withstand droughty conditions; and shallow slightly developed soils that are not very productive and do not have favorable moisture relationships. The deep fine sandy loam and very fine sandy loam soils collect and retain a large part of the rain water and readily give up the soil moisture to growing plants. On these soils large quan-

tities of cotton and grain sorghums are grown. The less favorable soils of this group return low yields and probably are best used for the production of sorgo or other sorghums, which some farmers grow more or less successfully. Some farmers, however, find it better to leave in pasture grasses the soils that have rapid run-off and are subject to rapid erosion.

The soils of the alluvial bottoms and terraces return the best yields of corn and alfalfa, and many farmers successfully grow small acreages of these crops. These soils also produce excellent yields of the other common crops, which are grown to a considerable extent, especially cotton and sorghums. Small grains are not so extensively grown as on the soils of the uplands, because of too rank growth and lodging.

The very thin soils, the very deep loose sands, and rough broken land are nonarable and are used almost entirely for grazing livestock. The pastures are of native grasses, most of which are nutritious and afford valuable forage for livestock.

No commercial fertilizers or other soil amendments are used, and no definite crop rotations are systematically practiced. Severe rapid water erosion on the sloping soils, especially on soils developed from "Red Beds" materials, carries away much of the valuable soil material and plant nutrients. Some of these steeper sloping soils are protected by cover crops and terraces, but much of the land remains unprotected. Wind erosion is sometimes severe on the lighter sandy soils and sometimes injures crops in the spring. Improved farm implements are used, and the crops are efficiently tilled.

The land is flat broken in summer for wheat, which is sown at any time from September 15 to November 15, depending on soil moisture conditions. The hard winter wheats are grown, and the chief varieties are Turkey, Kanred, and Blackhull. Cotton is planted about April 15, and grain sorghums from April 1 to early in May. Oats are sown mostly in the spring and sometimes as early as the middle of February.

RECOMMENDATIONS FOR THE MANAGEMENT OF THE SOILS OF WASHITA COUNTY[6]

Two important factors that should be considered in the development of a good system for the management of the soils of Washita County are proper land use and water conservation. A successful farm program will also depend to a very great extent on the natural productivity of the soil and the selection of crop varieties adapted to the prevailing climatic conditions.

The two most important crops are wheat and cotton. Under average conditions, cotton and grain sorghums are planted on sandy land and wheat on the medium- to fine-textured soils. Crop rotations are not practiced on many farms because it is more profitable to plant cotton or wheat on good land every year than to include in a rotation crops that have a lower acre value. Planting cotton or wheat on the same land year after year is not an objectionable procedure if the soil will supply sufficient plant nutrients to maintain production at as high

[6] By H. J. Harper, professor of soils, Agronomy Department, Oklahoma Agricultural and Mechanical College.

a level as climatic conditions will allow and if plant diseases or insect pests do not interfere with the growth of the crop.

When crop yields begin to decline, every farmer should realize that the fertility of the soil has been reduced to a point where some plant nutrient is not available in sufficient quantities to meet the requirement of the crop that is growing on the land. When this condition develops, it will be necessary to increase the fertility of the soil or to grow crops having a lower nutrient requirement or a stronger feeding power for the insoluble nutrients in the soil.

Cotton, cowpeas, and grain sorghums, are grown more extensively on the sandier soils, which occur chiefly in the northwestern and eastern parts of the county, than on the fine-textured soils, where wheat is the major crop. Some corn is grown on the deep sandy soils in the eastern part and on the bottom lands along the Washita River. Hot dry weather at tasseling time and erratic rainfall are the important limiting factors in the production of corn in this county. Early-maturing varieties of corn adapted to the region should be grown in preference to late-maturing varieties. Grain sorghum is superior to corn for the production of grain or forage under average conditions. This crop can be planted during the latter part of June so that the grain will mature in late summer and early fall. On bottom lands, late planting will also reduce the hazard from overflow that may severely damage or destroy a crop of corn, which generally is planted early in the season so as to mature before hot dry weather. Results obtained from experiments conducted in Kiowa County indicate that darso and Blackhull kafir will produce good yields of grain in this section, and that hegari and Blackhull, Sunrise, or Shrock kafir can be recommended for the production of forage. Soybeans will not produce so much forage as cowpeas. Blackhull wheat has produced better yields than the Kanred or Turkey varieties over a 10-year period. Experiments indicate that Acala 8 and Mebane strains of cotton are superior to many other varieties and can be recommended for this county.

The results of an experiment conducted on the reformatory farm at Granite, Okla., for a period of 5 years to determine the effect of time of plowing on the yield of winter wheat and barley are given in table 7. Plowing in July provides a more favorable soil condition for the absorption of summer rainfall, and the quantity of available plant nutrients in the soil at planting time is higher as a result of the more favorable opportunity for the decomposition of soil organic matter than on land plowed at a later date. A better seedbed can also be prepared when land is plowed early and normal rainfall occurs during the summer.

TABLE 7.—*Effect of time of plowing on the yield of winter wheat and barley on the reformatory farm at Granite, Okla.*

Time of plowing	Acre yield	
	Wheat	Barley
	Bushels	*Bushels*
July	16.8	22.9
August	14.0	20.7
September	11.9	13.7

Other experiments indicate that disking is nearly as effective as plowing in the preparation of a late seedbed for winter wheat on land where no tillage has taken place between harvest and September 1. The economic value of chiseling as a method for water conservation has not been studied experimentally in comparison with other methods in this area. Studies at other locations in the State indicate that the density of the subsurface soil is an important factor in the efficient use of stored water. The use of large sweeps, which stir the soil and leave the stubble and other organic residues on the surface of the ground to protect the land from the destructive effect of run-off or wind erosion, may prove to be superior to other methods of summer tillage in the preparation of land for wheat or other small-grain crops. Crops growing on soils with friable sandy clay subsoils are not affected so much by drought as are similar crops growing on soils with dense clay subsoils; consequently the effect of various tillage methods on crop production may be somewhat confusing unless subsoil conditions on the different areas are known and their effect on plant development determined.

ORGANIC MATTER AND NITROGEN

Every bushel of wheat removes approximately 1¼ pounds of nitrogen from the soil, and each bale of cotton removes approximately 35 pounds of nitrogen. The nitrogen in cereal crops and in cotton is absorbed by plant roots when this element is liberated in an available form as a result of the decomposition of organic matter in the soil; consequently the continued production of soil-depleting crops will gradually decrease the potential productivity of the soil. Although a study of crop records will reveal that no appreciable decline in average yield has occurred on many soils, the change in fertility of cropped and virgin soils will give a better picture of what is happening to the quantity of plant nutrients and organic matter in the cultivated land of Washita County than any other comparison that can be made. Composite samples of cultivated soil collected from 14 fields were compared with 14 samples of soil collected from adjacent areas of meadow or pasture land. These samples were analyzed for total nitrogen, organic matter, and phosphorus. A determination also was made for readily available phosphorus by extraction with fifth-normal sulfuric acid. The average results of these analyses are given in table 8.

TABLE 8.—*Loss of plant nutrients in soils of Washita County, Okla., as a result of cultivation*

[Average of 14 comparisons]

Soil condition	Nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
	Pounds [1]	*Pounds* [1]	*Pounds* [1]	*Pounds* [1]
Virgin	2,650	55,400	640	92
Cropped	1,580	35,200	570	86
Loss through cultivation	1,070	20,200	70	6

[1] Pounds per acre in soil 6⅔ inches deep.

A study of the data presented in table 8 shows that the cropped land contains 40 percent less nitrogen and 36 percent less organic matter than the virgin soil. This reduction has occurred as a result of cultivation and the removal of soil-depleting crops. A smaller loss has taken place in total and available phosphorus; this information, however, indicates that the fertility in the cultivated land of Washita County is gradually disappearing. Sooner or later the problem of soil fertility must receive more consideration than it has in the past, because crop yields in the future will depend more on the fertility of the soil and less on the abundance or distribution of the rainfall than at present.

CONSERVATION OF WATER AND SOIL

Water conservation is one of the important problems in the successful management of the soils of Washita County. When water is retained on the land where it falls or the rate of run-off is slow and does not remove any appreciable quantity of surface soil, soil conservation is not an important problem except on those areas subject to wind erosion. Although low rainfall frequently interferes with plant development in this county, the efficiency of the rainfall on many soil types is low under normal conditions because local showers of a torrential nature are common. Contour tillage should be practiced more extensively on a high percentage of the row-crop land, in order to increase the penetration of rain water and reduce the loss of surface soil by sheet or gully erosion. Soils of the uplands devoted to wheat do not suffer so much erosion by run-off as do soils planted to cotton, grain sorghums, or other row crops where the rows are run parallel with the fence for the sake of convenience. Wheat provides a good vegetative cover for the land during the spring and early summer; consequently, abundant rainfall may not cause much damage to the soil. A higher percentage of the water, however, will be lost from upland fields planted up and down the slope as compared with those drilled on a contour. Five hundred pounds of water is required to produce 1 pound of wheat and straw. One thousand tons of water must be absorbed by wheat roots and evaporate from the leaves to produce 20 bushels of wheat.

Where moisture is the greatest limiting factor in crop production, preventable loss of water by run-off results in financial loss or at least a decrease in total farm income. Farmers who practice water conservation obtain better average yields than those who make no especial effort to conserve rain water on land where the physical or chemical properties of the soil do not limit production. Approximately 700 pounds of water is required to produce 1 pound of dry matter in the form of cotton and cotton plant. Experiments with cotton conducted in Greer County in 1935, which was a very dry season, show that 320 pounds of seed cotton per acre was produced when rows were planted up and down the slope, and 848 pounds of seed cotton was obtained from rows planted on a contour. Similar results were obtained with kafir, of which 318 pounds of grain per acre was produced in rows planted up and down the slope, and 1,250 pounds of grain was produced in rows planted on a contour. Since water is frequently an important limiting factor in crop production in this section and is supplied without cost in the form of rain, farm-

ers who do not provide every possible economic means of absorbing the rainfall on their land are reducing the total income that they might receive if a system of farming were followed in which more of the rain water could be absorbed by the soil to be used immediately or stored for later use.

On cultivated land with a slope of more than 2 percent, terrace ridges may be needed to prevent the concentration of run-off, which may cause serious loss of soil and the formation of gullies on erodible soil. This condition frequently occurs on wheatland during the summer or fall, following a succession of rains. Many wheat farmers object to the presence of terrace ridges in a field, because they interfere to some extent with the operation of certain types of machinery. Conservation of the soil for the use of future generations should not be forgotten. When a type of farming is followed in which soil losses exceed the rate of soil development, the standard of living of that community will gradually decline with the decrease in farm income. Soil development is a slow process in a semiarid climate, and when the greater part of the surface soil has been removed by erosion the land should be used for pasture, although some of the eroded sandy soils will continue to produce more forage under tillage than will be produced for a considerable time by native grasses.

A terrace ridge is of most value in the conservation of rainfall on gentle slopes where run-off will spread over a large area on the upper side of the ridge. On the more porous soils, terrace ridges should be constructed at proper intervals without any fall, and all the water should be held on the land. Where impervious subsoils interfere with the infiltration of water into the deeper layers of soil, the channel on the upper side of the terrace ridge should have a fall of approximately ½ to 1 inch per 100 feet. Run-off at terrace outlets should be discharged onto pasture land or a meadow strip in such a manner that it will not cause erosion of the soil.

Farmers who are interested in improving the carrying capacity of grazing land should give careful consideration to the possibilities of water conservation, since water escaping as run-off might be used to increase the production of grass and, consequently, to increase the farm income. The excess water draining from cultivated fields will improve the growth of grass on pasture land if it can be absorbed by the soil. The diversion of run-off from natural drainage channels onto pasture land should be practiced wherever opportunity allows, unless the water carries too much soil material in suspension or the cost of constructing diversion ditches is too great.

Controlled grazing will reduce the amount of run-off on pasture land, because a good vegetative cover will slow up the rate at which water will move across the surface of the ground and will allow more of it to penetrate into the soil. Contour furrows on overgrazed pastures may be valuable, especially on land where buffalo grass is present, since this grass will quickly cover the disturbed soil and take advantage of water that is impounded in the furrows.

STRIP CROPPING AND OTHER METHODS FOR CONTROLLING WIND EROSION

Wind erosion is a problem on the sandy soils in this county when tillage methods that leave the land unprotected during late winter and early spring are used. Planting row crops in an east-west direction

is a common practice to protect the young plants from the destructive effect of sand grains carried along the surface of the ground by the wind. Strip cropping with grain sorghums is an effective method for the development of barriers to protect adjacent strips where early tillage may be required to prepare a good seedbed for cotton and other crops. Three common crops, grown in strips on sandy land, are grain sorghums, cotton, and cowpeas. Rye would be a valuable crop to use in a strip-cropping system, because it makes a good vegetative cover in the fall and winter under average conditions and the land is protected during the spring and summer when torrential rainfall is most likely to occur. On more productive soils, wheat may be interplanted between strips of kafir, cotton, and cowpeas, in place of rye.

Occasionally on comparatively shallow sandy soil, some of the subsoil that contains a higher percentage of clay may be mixed with the surface soil by deep chiseling or listing. The presence of the clay in the surface soil will not only have an immediate beneficial effect in retarding soil movement but will also aid in holding the sand grains together after more thorough mixing occurs as a result of tillage. Under average conditions the surface of sandy land cannot be maintained in a rough condition, which is essential in the control of soil movement by the wind. Harrowing when the land is wet will tend to produce comparatively stable masses of soil, which do not easily disintegrate and which resist wind action until they are destroyed by succeeding rains. Methods of tillage that will leave the greater part of the vegetative cover on or near the surface of sandy soils should be used wherever possible, in order to reduce the damage from wind erosion. The rate of oxidation of organic matter in sandy soils is more rapid than in fine-textured soils; consequently, sandy soils are lower in total nitrogen under average conditions. The use of cropping systems that will maintain a good supply of fresh organic matter in sandy soils is important in the solution of the problem of wind erosion, since a sandy soil low in organic matter is affected to a greater extent by wind erosion than is a similar soil containing a good supply of organic matter.

A combination of terrace ridges and strip cropping can be recommended on fine-textured soils where row crops and small grain are grown in a rotation. The combined effect of strips of stubble or strips protected by basin lister furrows on a contour will give better protection to the land than is obtained when all the field is planted to row crops. Small grain planted on a contour will retard run-off and protect the land from sheet erosion; however, terrace ridges in addition to sown strips are needed on large fields to protect the land from severe erosion by run-off.

PHOSPHORUS AVAILABILITY

Although the total quantity of phosphorus in the soils of this county is not above the average for Oklahoma, the availability of the inorganic phosphorus in the majority of these soils is high. A profitable response from the application of a phosphate fertilizer would not be obtained when field crops adapted to this region are grown on soil that is medium to very high in available phosphorus. A study of 126 samples of surface soil collected from different parts of Washita County indicate that 68 of the samples are very high in readily

available phosphorus, 37 are high, 14 are medium, and only 7 are low in this important element. The soils that are low in readily available phosphorus are very sandy. Most of these soils are low in organic matter, and the problem of soil improvement will not be solved by the addition of a phosphate fertilizer, because phosphorus is not the chief limiting factor in plant development. The average medium- or fine-textured soil in this county is not deficient in readily available phosphorus as determined by extraction with a dilute acid solution.

Some of the surface soils have a comparatively large content of calcium carbonate, and the availability of phosphorus to plants under such conditions may be very low, especially when the soil is deficient in organic matter. Chemical tests of plant tissue or field experiments are more reliable than chemical tests of soil for the determination of phosphorus availability under such conditions.

SOIL REACTION

In regions of limited rainfall, calcium carbonate is present in many soils in varying quantities within 1 or 2 feet of the surface. This condition occurs because the total quantity of rain is not sufficient to carry the dissolved material to a greater depth. A study of 102 samples of surface soil collected from different parts of Washita County was made to determine to what extent leaching had occurred. Forty-eight of these soils contained free calcium carbonate and were basic in reaction. Thirty soils were neutral in reaction, which means that they are neither acid nor basic. Nineteen were slightly acid, four were medium acid, and one was strongly acid. Sandy soils do not retain as much moisture as fine-textured soils, and they also absorb a higher percentage of the rainfall; consequently, a given quantity of water will penetrate to a greater depth in sandy soils than in soils containing a higher percentage of clay. As a result of the greater penetration of water and a smaller quantity of total bases in the soil, some acidity will be found in sandy soils, whereas fine-textured soils will not be acid under the same conditions.

Crops like wheat, cotton, grain sorghums, and cowpeas do not have a high lime requirement and will make a good growth on acid soil when temperature and moisture conditions are favorable and a good supply of available plant nutrients is present. Since these crops occupy a high percentage of the cultivated land in this county, the problem of correcting soil acidity will not be important, so far as soil management is concerned, except on those areas where crops like alfalfa and sweetclover may be planted.

CHEMICAL COMPOSITION OF SOILS

A study of the chemical composition of the soils of Washita County indicates that most of the sandier soils are lower in total plant nutrients and readily available phosphorus than the fine-textured soils. Data on the chemical analyses of several soil profile samples are given in table 9. Some of the samples were collected from cultivated land and others from virgin areas, and this fact should be taken into consideration when comparisons are made. Variations within a soil type and differences in management of similar soils for a considerable

period may explain differences in the chemical composition of the soils and consequent differences in yields of crops

TABLE 9.—*Chemical composition of soils in Washita County, Okla.*

SOILS OF THE UPLANDS

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Percent*	*Percent*	*Percent*	*Parts per million*
Calumet silt loam:[1]							
6188	SW¼ sec. 33, T. 8 N., R. 18 W.	0–5	7.0	0.101	2.10	0.028	80
6189		5–18	7.9	.070	1.29	.027	120
Calumet silt loam:[2]							
6206	SW¼ sec. 33, T. 8 N., R. 18 W.	0–5	6.5	.092	1.74	.028	100
6207		5–18	8.0	.078	1.34	.026	80
6208		18–48	8.0	.039	.59	.017	110
Dill loamy fine sand, steep phase:[2]							
6192	SE¼ sec. 31, T. 11 N., R. 19 W.	0–8	6.7	.099	2.40	.021	60
6193		8–17	6.9	.047	.81	.019	60
Dill fine sandy loam:[2]							
6173	NW¼ sec. 21, T. 11 N., R. 20 W.	0–12	7.5	.053	.90	.011	20
6174		12–30	7.0	.067	.85	.016	18
6175		30–55	7.2	.036	.28	.013	54
Dill fine sandy loam:[2]							
6168	NE¼ sec. 11, T. 10 N., R. 20 W.	0–11	6.5	.101	2.39	.015	24
6169		11–17	6.2	.078	1.36	.013	8
Dill fine sandy loam:[2]							
6176	SE¼ sec. 18, T. 10 N., R. 19 W.	0–14	7.3	.039	.53	.012	30
6177		14–24	7.0	.039	.41	.011	24
6178		24–36	7.2	.045	.52	.012	20
Dill loamy fine sand:[1]							
6196	SW¼ sec. 31, T. 10 N., R. 19 W.	0–6	7.7	.061	1.10	.013	36
6197		6–18	7.2	.042	1.23	.012	36
Hollister silt loam:[2]							
6150	SW¼ sec. 16, T. 8 N., R. 18 W.	0–5	6.4	.114	.230	.028	56
6151		5–13	6.8	.137	.184	.023	48
6152		13–24	7.3	.061	.99	.021	48
6153		24–36	7.9	.045	.48	.013	50
6154		36–50	8.1	.039	.39	.013	60
Cobb fine sandy loam:[1]							
6159	SW¼ sec. 9, T. 10 N., R. 19 W.	0–11	6.3	.109	2.47	.018	24
6160		11–17	8.7	.073	1.79	.018	6
St. Paul silt loam:[2]							
6161	SW¼ sec. 14, T. 8 N., R. 18 W.	0–6	6.7	.101	2.36	.028	60
6162		6–16	6.7	.098	1.87	.025	56
6163		16–24	6.4	.073	1.35	.022	48
6164		24–30	----	.075	1.16	.019	48
6165		30–36	6.9	.056	.89	.025	60
St. Paul silt loam:[1]							
6157	SW¼ sec. 15, T. 10 N., R. 19 W.	0–10	6.4	.112	2.27	.022	36
6158		10–19	6.5	.087	1.54	.022	24
St. Paul silt loam:[2]							
6222	SW¼ sec. 10, T. 10 N., R. 19 W.	0–5	7.0	.075	1.50	.018	66
6223		5–10	8.1	.092	1.62	.022	40
6224		10–20	----	----	----	----	----
6225		20–36	8.2	.061	.90	.015	80
6226		36–55	9.0	.053	.49	.010	30
Tillman silt loam:[1]							
6147	SE¼ sec. 31, T. 11 N., R. 16 W.	0–5	6.8	.134	3.32	.041	60
6148		5–8	6.6	.131	2.07	.030	56
6149		8–15	6.9	.089	1.65	.027	60
Tillman silt loam:[2]							
6140	SW¼ sec. 30, T. 11 N., R. 16 W.	0–5	6.8	.112	2.46	.038	48
6141		5–8	6.9	.098	1.73	.037	52
6142		8–24	7.6	.061	1.15	.031	52
6143		24–50	8.3	.045	.82	.038	120
Dill loamy very fine sand, shallow phase:[2]							
6170	SW¼ sec. 32, T. 11 N., R. 20 W.	0–10	8.1	.081	1.27	.024	80
6171		10–18	8.1	.064	1.28	.029	110
6172		18–26	8.5	.050	.96	.038	110

[1] Virgin soil.
[2] Cropped soil.

TABLE 9.—*Chemical composition of soils in Washita County, Okla.*—Con.

SOILS OF THE UPLANDS—continued

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Percent*	*Percent*	*Percent*	*Parts per million*
Vernon silt loam:[1]							
6145	NE¼ sec. 24, T. 9 N., R. 20 W.	0–6	7.3	0.159	2.83	0.042	52
6146		6–15	7.5	.115	1.96	.049	56
Vernon silt loam:[2]							
6209	SW¼ sec. 25, T. 10 N., R. 17 W.	0–2	8.2	.084	1.62	.034	90
6210		2–8	8.2	.073	1.32	.042	60
6211		8–19	8.2	.047	.68	.051	150
Vernon silt loam:[2]							
6215	NE¼ sec. 24, T. 9 N., R. 20 W.	0–6	8.0	.120	2.22	.041	260
6216		6–9	8.2	.122	2.05	.048	180
6217		9–18	8.3	.089	1.18	.054	120
Vernon silt loam:[1]							
6218	NE¼ sec. 31, T. 9 N., R. 18 W.	0–6	8.0	.204	4.14	.044	120
6219		6–17	8.2	.123	2.53	.044	240
Vernon very fine sandy loam:[2]							
6212	SW¼ sec. 20, T. 9 N., R. 16 W.	0–7	8.1	.084	1.53	.048	120
6213		7–13	8.3	.081	1.31	.049	120
6214		13–20	8.6	.050	.73	.048	180
Vernon very fine sandy loam:[1]							
6190	SW¼ sec. 28, T. 9 N., R. 17 W.	0–6	8.0	.173	3.42	.048	160
6191		6–19	8.2	.112	2.12	.051	120
Vernon very fine sandy loam:[1]							
6198	NW¼ sec. 26, T. 10 N., R. 19 W.	0–8	8.2	.109	2.35	.022	90
6199		8–24	8.2	.059	.73	.015	60
Weymouth very fine sandy loam:[2]							
6183	NE¼ sec. 30, T. 11 N., R. 15 W.	0–7	7.1	.075	1.19	.033	180
6184		7–27	7.2	.073	1.06	.036	180
6185		27–36	7.7	.050	.62	.043	160
6186		36–52	8.3	.047	.65	.054	130
Weymouth very fine sandy loam:[1]							
6166	NE¼ sec. 33, T. 11 N., R. 15 W.	0–12	7.4	.104	1.97	.031	130
6167		12–24	7.5	.087	1.51	.039	120
SOILS OF THE TERRACES AND BOTTOM LANDS							
Reinach very fine sandy loam:[2]							
6203	SW¼ sec. 31, T. 8 N., R. 14 W.	0–12	7.2	0.073	1.64	0.030	180
6204		12–29	7.5	.056	1.13	.031	180
6205		29–51	7.0	.053	.85	.038	240
Yahola very fine sandy loam:[2 3]							
6220	NE¼ sec. 27, T. 11 N., R. 16 W.	0–18	8.0	.075	1.49	.043	300
6221		18–36	8.1	.031	.45	.027	280

[1] Virgin soil.
[2] Cropped soil.
[3] Included on the map with Miller-Yahola silt loams.

Since sandy soils absorb water more readily than fine-textured soils, the lime content of the sandier soils is lower than that of the fine-textured soils. In a study of the pH values, which indicate the presence or absence of lime and other basic materials, it will be seen that the surface soil of the Vernon soils, which are relatively young, is similar in reaction to the subsoil. Natural erosion has removed the surface soil from these areas at a rate that is at least equal to the rate of leaching, whereas many of the fine-textured soils with a deeper profile may have a very slightly acid or neutral reaction in the surface soil with an abundance of calcium carbonate in the subsoil. Such a condition is not unfavorable for crop production, and a profitable response from ground limestone will not be obtained under average conditions.

Many of the sandy soils are rather low in total nitrogen and organic matter. The problem of increasing or maintaining the nitrogen con-

tent of the upland soils is a difficult one, because legume crops, except cowpeas, are not well adapted to the prevailing climatic conditions. Experiments conducted in western Oklahoma indicate that planting sweetclover in rows and cultivating it once or twice during the first season to control weeds is a procedure that can be followed to increase the nitrogen content of these soils. Dry subsoils and an abundance of available nitrogen following the growth of the sweetclover may reduce the yield of wheat, unless the wheat is drilled in rows at wide intervals to reduce the total number of plants that would have an opportunity to mature. A dense growth of vegetation would suffer because of the limited supply of water in the soil.

Neutral and slightly acid soils are seldom deficient in available potash, and since the majority of the soils that have been analyzed in this county are high to very high in available phosphorus, crop production in the immediate future will depend to a very great extent on conservation of the soil, efficient utilization of rainfall, and development of a cropping system as needed to replace the nitrogen removed by the production and sale of cash crops.

Only two soils of the terraces and bottom lands were analyzed in this study. These soils are high in mineral nutrients and are not appreciably affected by erosion. Alfalfa can be grown on them under average conditions; consequently, a cropping system in which alfalfa or sweetclover is grown will solve the nitrogen problem on them.

MORPHOLOGY AND GENESIS OF SOILS

Washita County lies within the Reddish Chestnut soils zone of the subhumid climatic region of southwestern United States. This is a moderately dry climatic area with an average annual rainfall of about 29 inches. The eastern edge of the county lies very near the eastern limit of pedocalic soil development, although the normal heavy soils are characterized by a well-defined horizon of calcium carbonate accumulation within the soil profile. The light sandy soils, especially those that are not underlain by layers of heavy materials, are considerably leached and do not have the developed characteristic features of normal Pedocals so far as this accumulation is concerned. The soils have developed under a grass cover—the fine-textured soils from heavy and calcareous formations chiefly under a cover of short grasses, and the sandy soils from the more siliceous formations chiefly under a growth of coarse bunchgrasses.

In most of the county the exposed "Red Beds" of Permian age and other formations have weathered to furnish the parent materials for large areas of the soils. The Quartermaster formation, Cloud Chief gypsum, Day Creek dolomite, and Whitehorse sandstone are among the formations that have largely influenced the development of the physical characteristics. Deep sandy beds in some places and shale and sandstones in others have provided the parent materials. Loose sands and sandy clays of Quaternary or Tertiary age overlie the "Red Beds" materials in places and have given rise to a number of soils. In some of the dissected areas of "Red Beds," erosion allows little soil development.

In the smoother areas shales and calcareous beds have produced dark soils, some of which are tight and some granular or moderately sandy.

The normal soil here, which reflects the regional environment, is St. Paul silt loam. The soil profile is as follows:

1. 0 to 8 inches, dark-brown noncalcareous heavy silt loam. This appears to contain considerable organic matter and on drying in cultivated fields is crumbly and friable.
2. 8 to 18 inches, very dark brown or almost black granular noncalcareous heavy silty clay loam or clay, very permeable and crumbly.
3. 18 to 36 inches, dark-brown heavy noncalcareous clay, gradually becoming less dark with depth. This material is not granular but consists of small angular clods and is crumbly when moist.
4. 36 to 50 inches, brown or reddish-brown heavy clay containing concretions of calcium carbonate. This is the horizon of calcium carbonate accumulation.
5. 50 inches +, parent material of only slightly weathered "Red Beds" clays. This material is slightly calcareous.

The transition from each horizon to the next is gradual.

In some very flat smooth areas the granular subsurface layer of the dark soil is absent, and the surface soil of dark-brown silt loam rests directly on a very dark brown dense heavy tough clay. This is Foard silt loam, a soil with a claypanlike tough subsoil. Where spots of saline materials are present, the surface soil is somewhat light colored (grayish brown), and the subsoil is dense brown clay. The soil in these flat areas is included in the Calumet series. In other smooth areas the soil is dark, and the surface soil closely resembles the surface soil of Foard silt loam, but a thin slightly granular layer intervenes between the surface soil and the dense subsoil. Such soil is included in the Hollister series. Associated with the dark soils but developed on more generally sloping areas are the Tillman soils. These have dark-brown or dark reddish-brown surface soils and reddish-brown or brownish-red heavy but not dense subsoils, which grade into a layer of brownish-red material containing some calcium carbonate concretions, and this, in turn, grades into "Red Beds" clays. The Tillman soils represent a less advanced stage of development than the St. Paul, Foard, or Hollister soils. All have developed from "Red Beds" shales and clays or sandy clays.

The sandy soils developed from the highly siliceous parent materials are well represented by Dill fine sandy loam. The profile is as follows:

1. 0 to 8 inches, dark reddish-brown or brownish-red loose fine sandy loam, low in organic matter. The material is not calcareous, and the reaction probably is nearly neutral.
2. 8 to 24 inches, dark-red loose noncalcareous fine sandy loam.
3. 24 to 40 inches +, red very friable noncalcareous fine sandy clay loam.

No horizon of calcium carbonate accumulation is present in this or other soils of the Dill series.

Other soils composed of sandy materials but differing in some characteristics from the Dill soils are the Cobb and Chickasha soils.

Vernon silt loam is a typical member of the group of thin immature soils developed on "Red Beds" material. It has the following profile:

1. 0 to 6 inches, red calcareous friable silt loam, low in organic matter.
2. 6 to 12 inches, red slightly calcareous silty clay loam.
3. Partly weathered "Red Beds" material of calcareous shaly clay containing layers of shaly sandstone.

All the Vernon soils are shallow and low in productivity. They occupy gently undulating to steeply sloping land, and geologic erosion has prevented mature development.[7]

Soils that have attained a somewhat more advanced stage of development from similar parent materials, have a thicker solum, and a slightly darker surface soil, as compared with the Vernon soils, are placed in the Weymouth series.

Soils formed from recent alluvium occupy narrow flat flood plains in many of the stream valleys. Most of the soil materials have been deposited by overflow waters and have been washed from the upland slopes, largely of the red soils and "Red Beds" formations. The Yahola soils have light sandy subsoils, and the Miller soils have heavy clay or clay loam subsoils. In places, former flood plains in high valley positions now lie above the present flood plains where streams have cut to a lower level. Soils on these second bottoms, or terraces, have long been subjected to the soil-developing influences of the regional environment and have acquired many characteristics of normally developed soils of the smoother uplands. Members of the Reinach series are the principal soils with this kind of development.

SUMMARY

Washita County includes an area of 1,006 square miles in southwestern Oklahoma. It lies at the eastern edge of the subhumid region, where the pedocalic soils normally develop. Physiographically, it is within the Central Lowland on the Osage Plains, locally called the rolling plains, which are about 100 miles east of the High Plains.

A rolling relief characterizes a very large proportion of the county, although a large part of a slightly higher lying area in the northwestern part, as well as some divides, is smooth and nearly flat to undulating. The elevation of the uplands ranges from about 1,300 to 1,900 feet above sea level, and the general regional slope is from northwest to southeast.

The climate is mild, with long, warm summers and moderately cold, short winters. Although the annual rainfall averages about 30 inches, soil moisture is at times inadequate for the best growth of crops, when the seasonal and annual rainfall are very low. The average frost-free season extends over a period of 215 days.

In 1935, nearly two-thirds of all the land in the county was in cultivation. Cotton, the chief crop, was harvested from about one-fourth of the cropland and wheat from almost one-fourth. Sorghums, corn, oats, alfalfa, and miscellaneous crops are grown on the rest of the land in crops.

The soils of the county may be considered as belonging to four groups, the soils in each group having general features and characteristics that are approximately similar. These are (1) dark soils of the uplands, (2) red and reddish-brown soils of the uplands, (3) soils

[7] Analyses of Vernon soils are contained in the following publication: MIDDLETON, H. E., and BYERS, HORACE G. PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SOILS FROM THE EROSION EXPERIMENT STATIONS. U. S. Dept. Agr. Tech. Bul. 316, 51 pp. 1932.

of the alluvial bottom lands and terraces, and (4) miscellaneous soils and land types unsuited for cultivation.

The dark soils of the uplands are members of the Tillman, St. Paul, Hollister, Chickasha, Foard, and Calumet series. Most of them are silt loams, or so-called tight-land soils; only the Chickasha soils are sandy. The soils of this group are smooth-lying, deep, and, for the most part, rather highly productive. Their principal use is for the production of wheat and other small grains, but other crops also are grown.

The red and reddish-brown soils of the uplands are of two general subgroups, as regards soil development and inherent productivity. One subgroup includes smooth, deep, and fairly productive soils, chiefly fine sandy loams and loamy fine sands belonging to the Dill, Cobb, and Weymouth series. These soils are less suited to wheat and small grains than the dark soils and are used chiefly for cotton, grain sorghums, and other feed crops. Fruits and vegetables also do well. The second subgroup includes shallow soils of rather low productivity—the very fine sandy loam, silt loam, and silty clay loam of the Vernon series. These are red soils thinly developed over "Red Beds" materials. They are probably better suited to pasture grasses or sorghums than to other farm crops.

The soils of the alluvial bottom lands and terraces are members of the Miller, Yahola, Portland, and Reinach series. They occupy high bottoms subject to occasional overflow, but not much loss is sustained by the periodic inundations. Their high productivity and generally favorable moisture relationships render them the best soils for growing corn and alfalfa in this section where the supply of soil moisture is irregular. Other crops are also grown successfully.

The miscellaneous soils and land types unsuited to cultivation comprise broken and rough land and very sandy or thin soils of very low productivity. These soils and lands are rough broken land (Vernon soil material), rough stony land, Dill loamy fine sand, dune phase, and Derby fine sand. They are suited only for the pasturage afforded by the native grasses or by pasture grasses that may be introduced.

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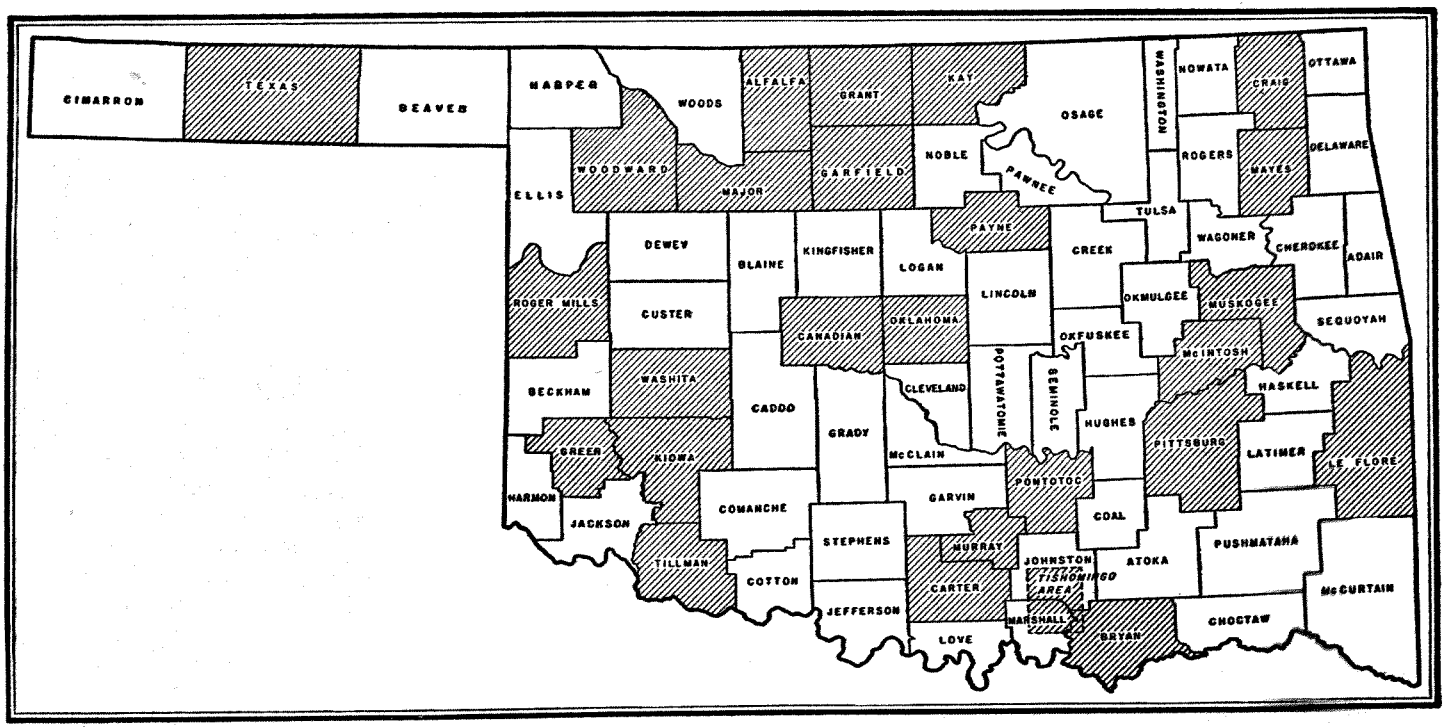

Areas surveyed in Oklahoma shown by shading.

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