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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey

of

Woodward County, Oklahoma

By

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United States Department of Agriculture, in Charge

and

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Oklahoma Agricultural Experiment Station

Bureau of Chemistry and Soils

In cooperation with the
Oklahoma Agricultural Experiment Station

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SOIL SURVEY OF WOODWARD COUNTY, OKLAHOMA

By E. G. FITZPATRICK, United States Department of Agriculture, in Charge, and W. C. BOATRIGHT, Oklahoma Agricultural Experiment Station

COUNTY SURVEYED

Woodward County is situated in the northwestern part of Oklahoma (fig. 1). It is separated from the Texas Panhandle on the west by Ellis County and from Kansas on the north by Harper and Woods Counties. Woodward, the county seat, is approximately 125 miles northwest of Oklahoma City and 160 miles northeast of Amarillo, Tex. The county is rectangular in shape with a triangular northern extension on the east side. It includes an area of 1,233 square miles, or 789,120 acres.

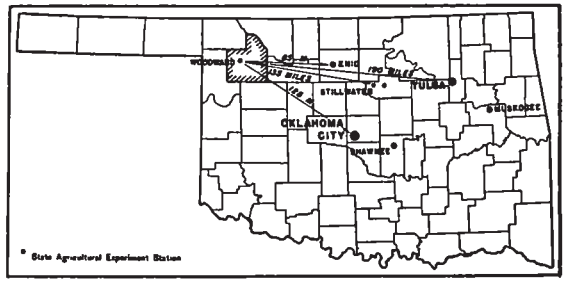

FIGURE 1.—Sketch map showing location of Woodward County, Okla.

Woodward County is at the eastern margin of the Great Plains where this great region merges eastward with the prairies of the Central Lowland physiographic area. Physiographically, it consists of two plains separated by a very distinct escarpment which faces northeastward and crosses the county diagonally from the center of its northern boundary line to approximately 12 miles north of its southeastern corner. The larger plain, which comprises the southwestern three-fourths of the county, has a rolling to dunelike relief, and the general slope descends gradually to North Canadian River which crosses the county diagonally from northwest to southeast. The smaller plain, occupying the northeastern part of the county, slopes northeastward toward Cimarron River which forms the northeastern boundary. Undissected parts of this plain have smoother relief than that of most of the larger plain, but only a comparatively small area of the plain is undissected. The escarpment separating the two physiographic regions consists of a belt of very rough broken land ranging from 1 to 6 miles in width. This escarpment is less pronounced at its southeastern end. Generally speaking, the upper edge of the escarpment marks the boundary between the sandy Tertiary and Quaternary geological materials and the finer textured Permian rocks which underlie the smaller plain.

The sandy character of the underlying geologic materials has given rise to generally light textured soils on the larger plain. These soils

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absorb water very rapidly. There is, therefore, very little run-off to cause dissection of the plain, and a large part of the plain is entirely devoid of streams. A belt of sand dunes lies along the northeastern side of North Canadian River. The river channel apparently has been shifted gradually southwestward, probably because the sandy material from the dry river bed has been blown by the prevailing southwesterly winds and accumulated in dunes on the northeastern side of the river, thereby checking any movement of the river in that direction. The relief of this plain is not great, as the few streams have cut comparatively wide and very shallow valleys.

The smaller plain, lying on the watershed of Cimarron River, has very strong relief, brought about because Cimarron River has cut its bed approximately 400 feet deeper than has North Canadian River. This dissection has been furthered because the geologic materials and soils are heavier textured and, therefore, there is more run-off of surface water than on the more sandy soils of the larger plain. The smaller plain is separated from Cimarron River by an escarpment facing northeastward, which has been produced by erosion of the comparatively resistant beds of gypsum, which are responsible for the existence of the smaller plain because they have delayed erosion, although many intermittent streams flowing northeastward have cut through the gypsum and connected the two escarpments, leaving isolated remnants of the original plain.

The escarpment dividing the two plains consists of a sharp slope dissected by V-shaped gullies and valleys. The river escarpment is marked by a very distinct bluff, or cliff, of gypsum, ranging from 6 to 50 feet in height, with V-shaped gullies and valleys below.

The elevations [1] of various towns on the larger plain are as follows: Woodward, 1,900 feet; Supply, 2,000 feet; Mooreland, 2,000 feet; Sharon, 2,048 feet; and Curtis, 2,060 feet. Quinlan, located on the smaller plain, has an elevation of 1,725 feet; and Belva, situated below this plain, has an elevation of 1,580 feet.

Woodward County is in the subhumid belt of the United States, where the native vegetation consists largely of many species of grasses, which differ according to moisture conditions, texture, and relief of the soils. The heavier textured soils support a heavy sod consisting largely of buffalo grass, blue grama, side-oats grama, and bluestem, also a scattered growth of pricklypear and various species of plants belonging largely to the Leguminosae and Compositae families. The principal grasses on the lighter textured soils are bluestem and Indian grass, and also a growth of sand sage. Some of the lightest textured soils in places support a growth of trees consisting of post oak, blackjack oak, elm, hackberry, gum elastic (shittim wood), soapberry, and wild plum. Most of the trees are small and are thinly scattered. Two townships in the southwestern part of the county support a shrubby growth of dwarf oak trees (*Quercus* sp.), locally called "shin oaks." A few mesquite trees grow on the heavier soils in the northeastern part of the county. Cottonwood, willow, elm, and persimmon trees, and sumac shrubs grow along the larger stream courses.[2]

[1] Data on elevations from the State highway department and the Atchison, Topeka, & Santa Fe Railway.

[2] Vegetation identified by author, using Grey's Manual of Botany. Many of the identifications were verified by S. F. Blake, Bureau of Plant Industry, U. S. Department of Agriculture.

The principal pests in cultivated fields are Johnson grass, crabgrass, Bermuda grass, and sandbur (*Cenchrus tribuloides*), sunflower, buffalo-bur, horsemint, ragweed, cocklebur, and thistle. The growth of weeds generally is not very rapid because of the low rainfall.

A list of plants identified in Woodward County follows. The common names are given where possible.

Scientific name	*Common name*
Agropyron smithii	Bluestem, or western wheatgrass.
Andropogon saccharoides	Silver beardgrass, or whitetop.
Aplopappus ciliatus and *A. spinulosus*	Goldenweed.
Aristida sp.	Three-awn (wire grass).
Artemisia dracunculoides	False tarragon.
Artemisia ludoviciana	Louisiana wormwood, or sweet sage.
Aster (several species)	Aster.
Berlandiera texana	
Bidens frondosa	Beggarticks.
Brauneria sp.	Niggerhead.
Callirhoe sp.	Poppy mallow.
Cassia deprcssa	Partridge-pea.
Cephalanthus occidentalis	Buttonbush.
Cirsium discolor	Thistle.
Commelina sp.	Dayflower.
Coreopsis tinctoria	Tickseed.
Croton texensis	Croton.
Desmanthus illinoensis	
Elymus sp.	Wild-rye.
Eragrostis cilianensis (*E. major*)	Stinkgrass.
Erigeron canadensis	Horseweed.
Eriogonum annuum	Eriogonum, buckwheat-brush.
Eupatorium serotinum	Thoroughwort.
Euphorbia marginata	Snow-on-the-mountain.
Eustoma russellianum	
Froelichia campestris	
Gaillardia pulchella	Gaillardia.
Grindelia squarrosa nuda	Gumweed.
Helianthus maximiliani	Perennial sunflower.
Hymenopappus tenuifolius	
Ipomea leptophylla	Bush morning-glory.
Kuhnia sp.	
Liatris squarrosa	Blazing-star.
Lobelia cardinalis	Cardinalflower.
Lygodesmia juncea	Rush skeletonplant.
Meibomia scssilifoliam	Tick-trefoil.
Mentzelia sp.	
Monarda sp.	Horsemint.
Morongia uncinata (*Schrankia uncinata*).	Sensitive-rose.
Oenathera serrulata	Rocky Mountain bee plant, or evening-primrose.
Othake sphacelatum	
Panicum capillare	Witchgrass.
Parosela sp. (*Dalea* sp.)	Peabush.
Pluchea camphorata	Salt-marsh fleabane.
Polygonum pensylvanicum	Smartweed.
Psilostrophe villosa	
Psoralea tenuiflora	Peabush.
Ratibida columnaris	Prairie coneflower.
Rhus trilobata	Lemonade sumac, or ill-scented sumac.
Salvia azurea	Salvia.
Senecio riddellii	Riddell's groundsel.
Solidago gymnospermoides	Goldenrod.
Thelesperma gracile	
Thelesperma trifidum	
Vernonia marginata	Ironweed.

The land included in Woodward County was a part of the Louisiana Purchase. It was later included in the land set aside for the Cherokee Indian Nation in that part called the Cherokee Outlet. It was, at that time, occupied by roving bands of Indians whose food and shelter were largely obtained from the large herds of buffalo. With the advent of railroads westward, the buffaloes were exterminated by hunters, and the Indians were forced to go to the reservations for a livelihood. As the Cherokee Outlet was not a settled reservation, this large body of land was left vacant. After the close of the Civil War, cattlemen from Texas found it profitable to drive cattle northward, and many of them grazed their herds for several months in this Indian land. This led to the establishment of many large cattle ranches in this section, and an organization of cattlemen, called the Cherokee Strip Livestock Association, leased the Cherokee Outlet from the Indians from 1883 to 1890. In 1890, the United States Government required that all cattle be removed from the Outlet, and this land was bought from the Cherokee Nation and opened for settlement in 1893. It was a part of the Oklahoma Territory which, combined with the Indian Territory, was admitted to the Union as a State in 1907. It was at that time that Woodward County was organized with its present boundaries. Settlement was very rapid. A large part of the settlers came from Texas, Kansas, Missouri, and Middle Western States. Practically all of the settlers were white people whose ancestors came largely from northern Europe.

The county seat of Woodward County is the city of Woodward, which had a population of 5,056 in 1930. The populations of other towns in the county, in the same year were as follows: Quinlan, 231; Mooreland, 706; Mutual, 177; Supply, 230; and Sharon, 227.

The Wichita Falls and Forgan branch of the Missouri, Kansas & Texas Railway serves Woodward County, connecting it with main-line roads running to Oklahoma City and Fort Worth. The county is also served by a main line of the Atchison, Topeka & Santa Fe Railway, which connects it with Amarillo, Tex., and Wichita, Kans. A branch of this same railroad crosses the northern tip of the county and provides transportation to Alva and eastward.

Woodward County is crossed by improved State highways and one Federal highway—United States Highway No. 270—which connect points in the county with Oklahoma City, Clinton, the Oklahoma Panhandle, and Amarillo, Tex. The main county roads generally are kept in good condition, and some of the more sandy roads have a surfacing of clay. The local roads follow section lines except in the rougher areas. They serve as outlets to the better highways maintained by the county and State. In places the local roads become very rough during protracted periods of dry weather, but generally they are in fair condition.

Telephone lines are located along most of the main county and township roads, but a large part of the county does not have telephone service. Schools and churches at convenient points serve the local requirements of the rural sections. A junior college is located at Woodward.

The Southern Great Plains Experiment Station of the Bureau of Plant Industry, United States Department of Agriculture, is near Woodward. Several lines of investigation, for the purpose of bene-

fiting the agriculture of the region, are being pursued at this station. Breeding and selection of sorghums of superior quality and yielding ability have received considerable attention, and several rather important strains of grain sorghums have been developed and are now grown commercially. Much valuable work also has been done with small grains, particularly wheat, and some work has been conducted with broomcorn, Sudan grass, rye, and oats. The growing of grapes, fruit, ornamental shrubbery, and trees has received considerable attention. A great deal of work is being done on breeding and testing grasses for revegetation.

The Bureau of Dairy Industry, United States Department of Agriculture, also maintains an experiment station adjoining the station mentioned. This station, in cooperation with the Oklahoma Agricultural Experiment Station, has done considerable work in the improvement of dairy cattle and in methods of feeding and caring for dairy herds.

Farmers in Woodward County and in other parts of the southern Great Plains can obtain a great deal of valuable information by studying the results of the work at these stations.

Industries, except those directly related to agriculture, have not been developed to any great extent. Bentonite, or fuller's earth, is mined in one locality, and large deposits of sand, gravel, and gypsum occur in many parts of the county. Soft white accumulations of calcium carbonate, locally called caliche, occur in beds of considerable extent, and in places this material is fairly good for surfacing roads. Some attempt is being made to refine and market salt which occurs in the northern part of the county.

CLIMATE

Woodward County has a distinctly continental, subhumid climate. It is characterized by low humidity and wide differences in temperature between day and night, also between summer and winter. Temperatures are rather high during midsummer days, but the nights nearly always are cool. Low humidity and the usual breeze make the temperatures seem much lower than the thermometer indicates. Hot dry winds often occur during the summer, and occasionally, when they are of long duration, they parch the vegetation, regardless of the amount of moisture in the soil. The average length of the frost-free season is 208 days—from April 6 to October 31. Frost has occurred as late as April 22 and as early as September 26. The winters generally are mild, but they are usually marked by several cold spells, locally called northers, which are characterized by strong northerly winds accompanied by a sharp drop in temperature and occasionally by cold rain or snow. These cold spells rarely last more than 2 or 3 days at a time.

Field work can be performed during a large part of the winter, because of the small amount of precipitation and the loose sandy character of most of the soils. The average annual rainfall is 23.99 inches. It is generally fairly well distributed throughout the growing season, but droughts are more or less common. The climate, therefore, rather definitely limits the kinds of crops that may be successfully grown and even makes it advisable to grow crops to which many of the soils are not particularly suited. Drought-resistant crops, such as grain sorghums, wheat, broomcorn, and Sudan

grass, are the principal staple crops adapted to withstand the climatic conditions of the county. Late frosts make many fruit crops uncertain in this locality.

Table 1, compiled from the records of the United States Weather Bureau station at Mutual in southern Woodward 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 Mutual, Woodward County, Okla.*

[Elevation, 1,850 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1914)	Total amount for the wettest year (1915)	Snow, average depth
	° *F*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	37.0	82	−10	0.85	0.75	0.22	3.2
January	34.9	87	−17	.52	0	.58	1.0
February	40.1	90	−3	.85	.35	3.26	2.8
Winter	37.3	90	−17	2.22	1.10	4.06	7.0
March	48.5	95	−2	1.43	.12	1.08	.7
April	57.5	100	22	2.57	1.27	4.38	0
May	65.9	103	32	2.81	2.93	4.52	0
Spring	57.3	103	−2	6.81	4.32	9.98	.7
June	75.8	115	41	3.28	.67	6.33	0
July	81.3	114	50	2.06	1.40	4.67	0
August	80.5	112	42	2.58	3.37	3.51	0
Summer	79.2	115	41	7.92	5.44	14.51	0
September	73.2	109	28	3.07	1.36	5.49	0
October	60.9	97	16	2.38	1.58	3.71	(1)
November	48.0	95	1	1.59	0	(1)	.2
Fall	60.7	109	1	7.04	2.94	9.20	.2
Year	58.6	115	−17	23.99	13.80	37.75	7.9

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

Cattle ranching on the free and open range was the first agricultural acivity in this county, but, with the opening of the land to homesteading, the later settlers engaged in farming, which was developed rapidly in proportion to settlement of the country.

Early settlers in the late nineties brought with them the farming practices commonly followed in the Middle West, but many of these practices were not suited to the subhumid climate of this section. Beef cattle and hogs were raised extensively, and corn at first was the most important crop, although a considerable acreage was devoted to forage crops. Soon wheat became generally produced, but at first it was limited to a small total acreage. Grain sorghums and other forage crops, such as sorgo and Sudan grass, have always been important, but by 1920 wheat occupied the largest acreage, and at present it occupies about 50 percent, or a little more, of all the land in cultivation. Although the growing season generally is rather short for the production of cotton, this crop is grown on a small acreage on a few farms with some success.

The 1935 census reports 1,838 farms in the county, which occupied 92.3 percent of the land. On these farms, in 1934, crops were harvested from 178,475 acres, or 22.6 percent of all the land in the county; 64,291 acres were classed as crop failure; 33,015 acres as idle or fallow land; and 80,578 acres as plowable pasture; making a total of 356,359 acres, or about 45 percent of all the land in the county, available for cultivation that year.

According to the 1930 census report, the value of all agricultural products in 1929, excluding livestock, was as follows: Cereals, $2,000,000; other grains and seeds, $22,903; hay and forage, $311,336; vegetables (including potatoes and sweetpotatoes), both those sold and those produced for home use, more than $72,000; fruits and nuts, $62,339; and all other field crops, $132,617. In the same year, the dairy products sold were valued at $420,522, poultry and eggs, $544,791, and the value of all domestic animals on farms was $2,671,712. Domestic animals on farms included 40,256 cattle, 9,728 hogs, 3,742 sheep and lambs, 8,622 horses and colts, and 1,968 mules and mule colts.

The farming system on most of the farms is built around livestock raising and fattening. Some large tracts of land are still used for grazing, and beef cattle, mainly of the Hereford breed, are the chief range animals. Many farms include some land unsuited for cultivation, and this is used for grazing land. Some livestock are fed on roughage and other feed grown on the farm. Most of the crops, except wheat, which is the main cash crop, are fed to livestock.

Several large cattle ranches are in the broken country in the northern part of the county and in the sandy rolling country northeast and northwest of Woodward, where high-grade Hereford cattle are kept. The minimum allowance of pasture land is about 10 acres a head, but this varies, and supplemental feeding is almost universally practiced during the winter. The supplemental feed consists mainly of cottonseed cake and coarse forage of sorgo and grain sorghums. Some native hay is fed on ranches where it is harvested from the bottom-land areas. Most of the cattle are not finished but are shipped to the Middle West for fattening. Although some of the livestock is marketed for local use, a large proportion is shipped to Wichita, Kans., and Kansas City, Mo.

Dairying is of considerable importance on the general farms. Holstein-Friesian is the principal breed of dairy cattle, and a rather large number of Guernseys and Jerseys are kept. Local creameries process a large proportion of the sour cream and milk, and considerable quantities are shipped to Wichita, Kans.

Hogs, chickens, and turkeys are raised for home consumption and local markets. The surplus is generally marketed at local packing plants, where the animals and fowls are dressed, iced, and shipped to Oklahoma City, Wichita, and Kansas City. Duroc-Jersey and Poland China hogs and Plymouth Rock and Rhode Island Red chickens are the predominating breeds.

Farmers on the larger cattle ranches produce saddle horses for their own use. Sheep and goats have not found favor in this section, which is primarily a cattle country, but there is much brushland in the county that could be used to better advantage for these animals.

Broomcorn is baled on the farms and sold to local broom factories or shipped to Wichita, Kans. Wheat and some of the grain sorghums

are shipped to outside markets. A large part of the wheat goes to flour mills located at Alva, Enid, and Wichita, Kans.

Table 2 gives the acreage of the principal crops grown in Woodward County, Okla., as reported by the Federal censuses, from 1899 to 1934.

TABLE 2.—*Acreage of the principal crops in Woodward County, Okla., in stated years*

Crop	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Corn	13,981	92,064	18,781	26,159	1,890
Wheat	2,259	27,196	130,423	154,703	95,876
Grain sorghums	----------	22,282	52,345	26,826	22,532
Oats	234	4,562	8,100	3,137	1,455
Rye	----------	----------	6,654	1,049	1,609
Coarse forage	15,853	19,251	27,204	18,723	27,538
Alfalfa	325	2,910	3,006	2,983	3,374
All tame and cultivated grasses	----------	5,884	4,434	4,734	7,594
Broomcorn	----------	13,251	5,034	4,919	----------
Cotton	----------	----------	----------	2,701	3,801

Commercial fertilizers are not used, as the climatic conditions are often unfavorable. Some farmers apply manure to some of the land, but this is not a common practice. The surface layer of the heavy dark soils occurring in small depressions is distributed over sandier knolls by some farmers, in order to add to the fertility of the land and to help check wind erosion.

Farm labor generally is plentiful, but most of the farmers hire additional labor only during harvest, and many farmers merely exchange their own labor for that of their neighbors during harvest time. The 1930 census reported that on approximately 56 percent of the farms the average labor expenditure was $221.46 a farm.

Agricultural statistics indicate that the average size of farms in 1900 was 524.1 acres; in 1910, 227.1 acres; in 1920, 353.3 acres; in 1930, 404.7 acres; and in 1935, 397.3 acres. As some large cattle ranches are included as farms, these figures exaggerate the actual size of the general farms, but they do give an indication of the trend. The greater number of general farms average about 160 acres in size, and there are many ranging from 320 to 640 acres.

According to the census of 1935, 40.8 percent of the farms are operated by tenants, 58.8 percent by owners and part owners, and 0.4 percent by managers. The farms in cultivation are leased on a share basis, as crop returns are subject to such violent fluctuations that cash rent has not found favor in this section except where applied to grassland. The tenant generally furnishes all equipment, bears the expense of the crop, and delivers one-third of the crop to the elevator as the landlord's share. When the landlord furnishes seed and equipment, he generally receives one-half of the crop. Leases generally terminate the first of September. On farms where wheat is not grown, the leases usually terminate in November or December.

Most of the farms are fenced and have a three- or four-room frame house, a small barn, a chicken house, and a windmill. Mechanical equipment on the average farm includes a one-way 8-foot disk plow, a 12-foot grain drill, a header, a binder or combined harvester, a two-bottom lister, a two-row planter, a two-row cultivator, a corn binder, and a wagon or truck. Power is supplied by horses or a 10–20 or 15–30 tractor. The choice between horses and tractors depends on

the relief of the land and the relative prices of wheat and mechanical equipment. Horses are much more plentiful than tractors and seem to be increasing in popularity.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil survey 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 and 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[8] and its content of lime and salts are determined by simple tests. Drainage, both internal and external, and other external features, such as the 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. Areas of land, such as coastal beach or bare rocky mountain sides that have no true soil, are called (4) 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 St. Paul, Pratt, and Weymouth are names of important soil series in Woodward 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, Pratt fine sandy loam and Pratt loamy fine sand are soil types within the Pratt 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.

[8] 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.

A phase of a soil type is a subgroup of soils within the type, which differ from the type in some minor soil characteristic that may, nevertheless, have an important practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for a soil type, there may be areas which are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important differences in the soil itself or in its capability for the growth of 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 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, 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

Most of the soils of Woodward County have been developed from highly siliceous formations, and they are dominantly of sandy texture. These soils have been developed under a coarse grass cover in an area of light rainfall. Due to their development in a subhumid climate, the normal soils have a distinct layer, or horizon, of carbonate of lime accumulation in the profile from 2 to 4 feet below the surface. The soils that have no heavy-textured subsoil horizons are so porous that this horizon is absent, or but slightly developed, as the carbonate of lime has been thoroughly leached from the surface soil and subsoil. Most of the topsoils are brown, as the heavier normal soils have a larger content of organic matter than the very sandy soils which are grayish brown. The smooth heavier soils are well supplied with available plant nutrients and are very productive. The lighter textured soils with deep loose sandy subsoils are only moderately productive, and the eroded soils and very loose deep sands in many places are unsuited to the production of cultivated crops. These light-textured soils are also subject to blowing and drifting when bare of vegetation.

Soil-moisture relationships are more important to agriculture on arable soils than any other factor, as the rainfall here is comparatively low and the conservation of soil moisture is essential. The soils with moderately heavy subsoils are capable of retaining a larger amount of moisture than the soils with deep sandy subsoils, and this factor may cause yields to be much higher, even where other factors are practically similar. Many of the sandy soils that are rather loose and light are used satisfactorily for the production of small grains, because of their good moisture-holding and moisture-delivering functions, although otherwise they would be considered unsuited for such crops.

The soils have developed from Red Beds formations of clays and fine sands and from deep beds of sands and sandy clays which overlie the Red Beds and probably are of Tertiary and Quaternary forma-

tions. The soils have developed, therefore, from parent materials over unconsolidated fine earth with, in places, some soft gypsum beds lying near and outcropping at the surface. The soils developed from the Red Beds are more or less red, and, where smooth, are very productive, but where sloping they erode rapidly and are, in places, so severely eroded that they are too rough to cultivate. The soils on the higher sandy plain, that have developed from the very sandy beds, are loose and subject to drifting in heavy winds if cleared and unprotected. The comparatively small areas of the smooth soils that are moderately heavy, though sandy, are very productive. Figure 2 is a generalized map showing the distribution of soils, in nine groups, in Woodward County, Okla.

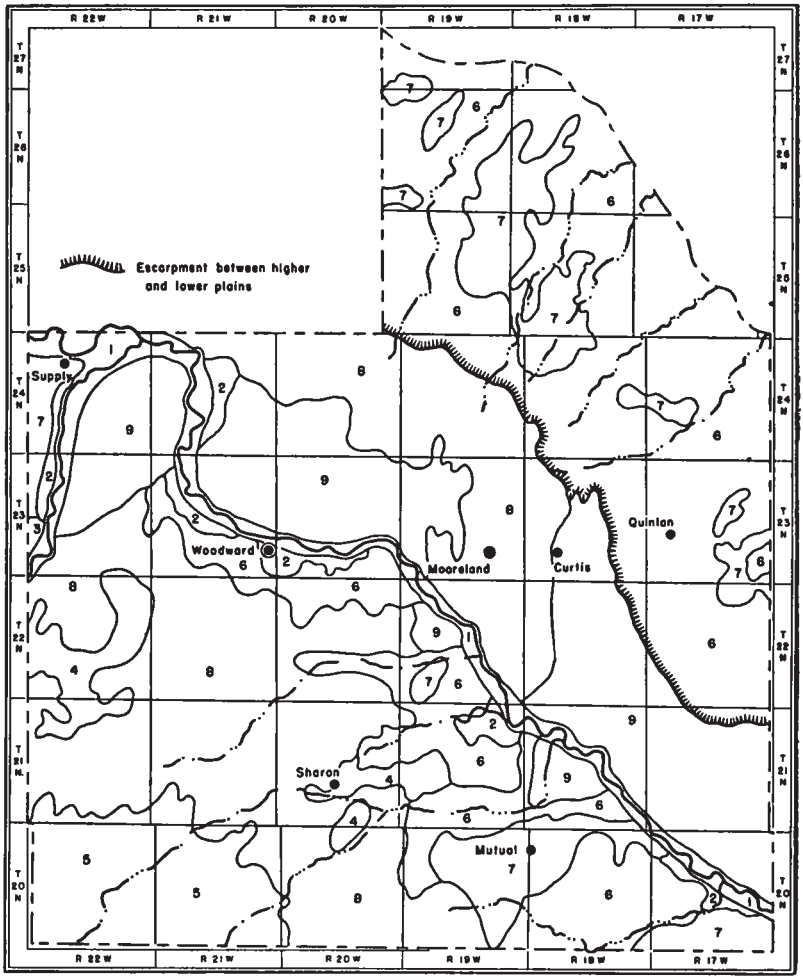

FIGURE 2.—Sketch map indicating the distribution of soil groups in Woodward County, Okla.: 1, Alluvial soils subject to overflow (Lincoln and Yahola); 2, soils of the stream terraces above overflow (Canadian and Reinach); 3, gray shallow soils on remnants of the High Plains (Potter); 4, heavy dark soils on remnants of the High Plains (Abilene); 5, sandy soils on remnants of the High Plains (Miles); 6, red and reddish-brown soils on rolling to broken relief (Quinlan and Weymouth); 7, heavy dark soils with red lower subsoils (St. Paul); 8, sandy soils generally suited to cultivation (Pratt); 9, sandy soils generally unsuited to cultivation (Enterprise and Pratt).

On the basis of general suitability of the soils for agricultural use and of their capabilities in production, the soils of related features are arranged (for discussion) in four groups as follows: (1) Moderately heavy sandy soils of the uplands; (2) light-textured sandy soils of the uplands; (3) soils of recent alluvial deposits; and (4) soils and lands unsuited for cultivation.

Wheat is the most important crop. It occupies more than one-half of all the land in cultivation and is grown on practically all of the cultivated soils. Not a very large acreage of the soils could be considered as the best soils for small grains, but, owing to the favorable moisture relationships of many of them, wheat is grown successfully in most years. Even on some very light textured sandy soils, such as Pratt loamy fine sand, this crop is grown extensively, but the heavier soils, such as St. Paul very fine sandy loam, produce the highest yields. Although wheat is grown on some of the very light textured soils, such as Miles loamy fine sand, smooth phase, which are especially subject to blowing, it is doubtful whether the extension of such crop practices can be recommended. Sudan grass and other forage crops do well on all the cultivable soils, and the lighter sandy soils are better suited to these crops than to small grains. Alfalfa does fairly well on the smooth heavier sandy soils, and yields are in proportion to the available supply of soil moisture. Some of the better drained alluvial soils are well suited to this crop.

Some fruits, vegetables, and various vine crops, such as melons, sweetpotatoes, and others, do well and are grown for home use on many farms.

The soils of this county best suited to practically all crops grown are those having normal deep topsoils and heavy subsoils. The soils unsuited to cultivation differ considerably in their suitability for grazing, according to the character of the native vegetation they support.

In the following pages the soils of Woodward County are described in detail, and their agricultural relationships are discussed; their location and distribution are 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 Woodward County, Okla.*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
St Paul very fine sandy loam	61,120	7.7	Lincoln clay	2,176	0.3
Abilene very fine sandy loam	5,184	.7	Lincoln loamy fine sand	12,608	1.6
Abilene very fine sandy loam, depression phase	512	.1	Yahola very fine sandy loam	4,800	.6
Pratt fine sandy loam	45,568	5.8	Yahola clay loam, saline phase	1,984	.2
Potter fine sandy loam	18,176	2.3	Enterprise fine sand	15,616	2.0
Reinach very fine sandy loam	10,560	1.3	Enterprise fine sand, dune phase	67,648	8.6
Weymouth very fine sandy loam	70,848	9.0	Lincoln fine sand	9,408	1.2
Canadian loamy fine sand	8,256	1.0	Pratt loamy fine sand, rolling phase	113,728	14.4
Pratt loamy fine sand	113,600	14.4	Riverwash	4,800	.6
Pratt loamy fine sand, shallow phase	4,160	.5	Quinlan very fine sandy loam, eroded phase	50,240	6.3
Miles loamy fine sand	30,144	3.8	Vernon clay loam, eroded phase	11,520	1.5
Miles loamy fine sand, smooth phase	13,312	1.7	Potter fine sandy loam, eroded phase	2,176	.3
Quinlan very fine sandy loam	36,288	4.6	Rough broken land	57,344	7.3
Vernon clay loam	1,216	.2	Total	789,120	------
Lincoln fine sandy loam	16,128	2.0			

MODERATELY HEAVY SANDY SOILS OF THE UPLANDS

In the soils of this group the chief relationship is in texture and structure, also approximately the same suitability for crops. The topsoils are fine sandy loams and very fine sandy loams, which merge below with heavier but moderately friable crumbly subsoils that retain moisture well. The surface soils are brown or reddish brown, and the soils of normal development are not calcareous in the surface soils and upper part of the subsoils. They are smoothly undulating, well drained, and moderately drought resistant. The subsoils are yellowish brown, brown, reddish brown, and red.

The soils of this group occur in many widely separated areas, and some of them are of small total extent. The group includes St. Paul very fine sandy loam; Abilene very fine sandy loam; Abilene very fine sandy loam, depression phase; Pratt fine sandy loam; Potter fine sandy loam; Reinach very fine sandy loam; and Weymouth very fine sandy loam.

St. Paul very fine sandy loam is the most nearly normal important plains soil of the county, and it is probably the most productive and generally the most valuable for all crops, except Reinach very fine sandy loam which is of small extent. Abilene very fine sandy loam and Abilene very fine sandy loam, depression phase, although ranking nearly as high as the St. Paul soil, are of very small extent. Potter fine sandy loam is a shallow soil which is subject to exhaustive erosion in places, but much of it is in cultivation. Weymouth very fine sandy loam is, in places, very shallow, susceptible to erosion, and, on the whole, somewhat lower in productiveness than St. Paul very fine sandy loam.

St. Paul very fine sandy loam.—St. Paul very fine sandy loam, known locally as "hard land" and "tight land", is hard or tight only in comparison with the surrounding looser sandy soils. The 7-inch surface soil is dark-brown very fine sandy loam which is moderately granular and friable. It grades below into a dark chocolate-brown granular layer of silt loam or light-textured clay loam which, on drying, separates naturally into rather large hard blocks. The dry aggregates, when crushed, show a lighter color. Neither topsoil nor the upper part of the subsoil is calcareous. At a depth of about 30 inches, the subsoil grades into reddish-brown noncalcareous silt loam which is much lighter in color than the material in the horizons above and does not break into block-shaped clods when dry. Below a depth of about 38 inches, the material is red or reddish-brown calcareous crumbly clay loam containing spots of white carbonate of lime. This grades below, at a depth of about 50 inches, into the partly weathered fine-grained sandstone or sandy clay of the Permian Red Beds. In places the white carbonate of lime occurs at a depth of 24 inches.

St. Paul very fine sandy loam covers an area of 95.5 square miles in Woodward County. It occurs in undulating and nearly flat areas on the smooth flats around Mutual, Richmond, Supply, Golden Belt School, Quinlan, and Sunny Slope School, chiefly in the southeastern and northern parts of the county. This soil has good surface drainage, and the permeable layers provide good underdrainage. Its occurrence in comparatively large areas makes it possible for the farmers to lay out large fields and use power machinery.

The surface soil absorbs rain water readily, and the comparatively heavy subsoil aids in the retention of a considerable reserve of moisture for use of crops in dry seasons. Yields of crops vary considerably in proportion to the moisture conditions. Acre yields of wheat range from 5 to 35 bushels, with an average of 14 bushels. Wheat has followed wheat continuously on some fields of this soil with no marked reduction in yields in 30 years, according to local information.[4] Grain sorghums yield from 10 to 40 bushels an acre, with an average of about 25 bushels. Alfalfa yields from 1 to 2 tons an acre. Broomcorn yields range from 100 to 500 pounds an acre, with an average of about 350 pounds. Sour cherries seem to do very well on this soil. Ornamental trees, such as Chinese elm, black locust, hackberry, and catalpa, also do well.

This soil is well suited to vegetables which are able to endure the climatic conditions of the county, principally potatoes, peas, beans, cowpeas, cantaloups, cucumbers, beets, carrots, radishes, summer squash, and Swiss chard. Water from wells located on this soil is generally unsuited for irrigation purposes, and the crops must depend on the natural precipitation. Summer fallow of one-half of the garden plot would greatly increase the yields of vegetables.

This is considered the best soil in the county for wheat, and it is used largely for the production of that crop. Probably about 97 percent of the land is in cultivation, and approximately 70 percent of the cultivated land is cropped to wheat, 20 percent to grain sorghums and broomcorn, 5 percent to corn, and 2 percent to alfalfa. The rest is in virgin pasture. The native vegetation consists of a heavy sod of buffalo grass, blue grama, some side-oats grama, and an occasional clump of pricklypear.

Abilene very fine sandy loam.—The surface soil of Abilene very fine sandy loam is loose friable dark-brown very fine sandy loam about 6 inches thick. It is underlain to a depth ranging from 18 to 26 inches by dark-brown rather compact clay loam which, on drying, breaks apart into hard cubes or wedge-shaped clods. This material grades into lighter brown clay loam which extends to a depth ranging from 30 to 36 inches. It breaks into irregular clods with shiny surfaces. The soil in this and in the layers above is not calcareous, but below this, to a depth of approximately 48 inches, it is yellowish-brown and gray mottled very calcareous clay. The profile of this soil is somewhat similar to that of St. Paul very fine sandy loam, but the parent material does not appear to be of Red Beds material.

Most of this soil occurs on the divide between Persimmon and Salt Creeks east of Sharon, in the south-central part of the county. Approximately 95 percent of the land is cultivated, and it is estimated that about 65 percent of the cultivated land is cropped to wheat, 20 percent to grain sorghums and broomcorn, and 10 percent to corn. The remainder is in native pasture.

Under natural conditions this soil supports a thick growth consisting chiefly of buffalo grass, blue grama, and some side-oats grama. It is a very productive soil inherently, and yields are good when the moisture supply is sufficient. It is particularly suited to the production of wheat because of its heavy subsoil which is able to retain mois-

[4] The information relating to cropping systems and crop yields was obtained from local farmers.

ture until needed. Acre yields of wheat range from 5 to 35 bushels, with an average of 14 bushels; and grain sorghums yield from 5 to 40 bushels, with an average of 20 bushels. Fruits and vegetables are grown to a small extent for home use. Water from wells on this soil is suitable for irrigation purposes and would increase the productivity of gardens materially. This land is rated as of about the same productivity as St. Paul very fine sandy loam.

Abilene very fine sandy loam, depression phase.—The 6-inch topsoil of Abilene very fine sandy loam, depression phase, is very dark grayish-brown very fine sandy loam. It grades into dark-brown crumbly clay loam or sandy clay loam, containing white lumps of carbonate of lime. At a depth of about 18 inches, this material passes into light-gray highly calcareous fine sandy loam which grades into yellow fine sand below a depth of 30 inches.

During seasons of favorable moisture supply, this soil is very productive. It occupies small depressed areas which receive run-off water from higher lying soils, and during wet seasons much water accumulates on the surface and affects the crops injuriously. Crops grown on this soil are very subject to damage from drought during some seasons.

The total area of Abilene very fine sandy loam, depression phase, is less than 1 square mile. Most of the land is in cultivation and is cropped mainly to wheat and grain sorghums. Because of its small total extent and the very small individual areas which comprise a small proportion of the fields in cultivation, crop yields cannot be estimated accurately.

The native vegetation on this soil consists largely of such weeds as tickseed, smartweed, snow-on-the-mountain, and ironweed.

Pratt fine sandy loam.—The topsoil of Pratt fine sandy loam is dark-brown or very dark brown loose friable fine sandy loam about 8 inches thick. The subsoil is reached through a gradual transition from the topsoil. It is very dark brown crumbly clay loam to a depth ranging from 18 to 26 inches, is slightly darker than the surface soil, and, although rather permeable, is not loose or very porous. When dry the subsoil material breaks into comparatively hard irregular horizontal plates and blocks. This layer grades into brown fine sandy clay or fine sandy loam, containing a few white lumps and streaks of carbonate of lime. The root holes and cracks in this layer are coated with lime. In most places this layer ranges from 9 to 14 inches in thickness and grades into yellowish-brown or light-brown loamy fine sand containing a few small lumps of lime. In some places the material in the underlying layer is heavy.

Pratt fine sandy loam covers a total area of 71.2 square miles. It is fairly well distributed in a number of areas over the high sandy plain which occupies a large part of the western and central parts of the county. Several comparatively large areas are in the vicinities of Mooreland and Sharon, and south of Tangier.

Areas of this soil are smooth and almost flat. The uncultivated areas support heavy growths of buffalo grass and bluestem and smaller quantities of side-oats grama. The soil appears to be well supplied with plant nutrients and produces good crop yields during seasons of sufficient rainfall.

This soil is more suitable for the production of wheat than are such light-textured soils as Pratt loamy fine sand, as the heavier texture of the subsoil enables it to retain moisture to better advantage. It is also well adapted to the sorghums and broomcorn. Alfalfa is grown to a small extent, and fair yields are obtained during seasons of adequate rainfall. Approximately 80 percent of the land is cultivated. Wheat is grown on about 40 percent of the cultivated land, grain sorghums and broomcorn on 30 percent, and corn on 10 percent. Approximately 15 percent remains in native grasses and is used for pasture. Wheat yields range from 5 to 30 bushels an acre, with an average of 12 bushels; grain sorghums from 10 to 40 bushels, with an average of 20 bushels; broomcorn from 100 to 350 pounds with an average of about 200 pounds; sorghums grown for hay from 1 to 3 tons; and alfalfa from 1 to 2 tons. Fruit trees and grapes do fairly well but generally they are grown on lighter textured soils. Vegetable crops for home use are successful, particularly if irrigated. The water from wells in this soil generally is suitable for irrigation purposes. Some of the more drought-resistant vegetables will succeed during most seasons without irrigation, provided they are kept clear of weeds. Cowpeas, beans, radishes, Swiss chard, cucumbers, watermelons, beets, carrots, and summer squash are the principal vegetables grown.

In general, Pratt fine sandy loam is more productive than Pratt loamy fine sand, with which it is associated, because of the heavier texture of the loam and its occurrence on smoother surfaces. It is less subject to wind and water erosion and is less apt to have its fertility dissipated by continuous cropping than the loamy fine sand.

In a few places, a variation of this soil, not sufficiently important to map separately, differs from the typical soil mainly in that it has a red very fine sandy loam subsoil.

Potter fine sandy loam.—Potter fine sandy loam locally is called "white rock land" or "ashy land." The surface soil, to a depth of 4 or 6 inches, is grayish-brown calcareous fine sandy loam containing small white irregular fragments of chalky calcium carbonate. This material grades into somewhat heavier material, in which the white lime fragments are more abundant and larger. At a depth ranging from 10 to 15 inches this layer, in turn, rests on grayish-white caliche—a soft chalky formation of carbonate of lime.

This soil occurs in the western part of the county on the flat tops and slopes of mesas and on smooth elevations comprising remnants of an old high plain that has been largely removed by erosion. The principal bodies are south of Tangier.

The surface soil and subsoil layers are thin, and no large reserve of soil moisture can be held; consequently, in dry seasons crops suffer quickly, but in seasons of well-distributed rainfall good crop yields are produced. Approximately 70 percent of the land is in cultivation, and about 35 percent of the cultivated area is cropped to wheat and 35 percent to sorghums and broomcorn. About 30 percent is unplowed and remains in native grasses which are used for pasture. Acre yields of wheat average 8 bushels and of grain sorghums about 15 bushels. Fruit and vegetables are rarely suc-

cessful on this soil because of its droughty nature and shallow topsoil. During dry seasons yields of all crops are very small. Chlorosis is a common ailment of plants on this soil. It is especially noticeable on ornamental and shade trees.

Reinach very fine sandy loam.—Reinach very fine sandy loam has developed on old alluvial terraces made up of soil materials deposited by streams which originate largely in the Permian Red Beds. The soil is similar to St. Paul very fine sandy loam, but the lower subsoil layer is lighter in texture. The surface layer, to a depth of 10 or 12 inches, is dark reddish-brown or chocolate-brown very fine sandy loam. In places the texture of small included areas is fine sandy loam. The surface soil is loose, friable, and basic, although it seems to be free of calcium carbonate. It grades into calcareous reddish-brown or red very fine sandy loam, containing a few small white specks and spots of lime, which extends to a depth ranging from 3 to 5 feet and merges below with red or reddish-brown calcareous fine sandy loam. In a few areas this soil is more brown in the subsoil, and in such places the soil approaches the Canadian soils in character.

Reinach very fine sandy loam occurs in small areas in the valleys of North Canadian River and some of its larger tributaries. The largest area is at Moscow School, and smaller areas are in the vicinities of Supply, Sharon, and Richmond. Most of the land is well above overflow, but in some places it may be slightly overflowed during exceptionally high floods.

This is a very deep soil, and it is probably the most productive one in the county. It is used successfully for almost every crop grown in this general region and produces good yields more often than do the upland soils, largely because it receives run-off water from higher lying upland slopes. This land is a little more productive than St. Paul very fine sandy loam for some crops. Corn and alfalfa, which generally are not very successful in this county, often produce good crops on this soil. Fruit trees and vegetables grow well. Yields of wheat, milo, kafir, and broomcorn are about the same as those obtained on St. Paul very fine sandy loam. Average yields of corn are about 15 bushels an acre, and alfalfa yields from 1 to 3 tons.

Weymouth very fine sandy loam.—Weymouth very fine sandy loam is similar to St. Paul very fine sandy loam, and it also is developed from Red Beds materials. The areas are more sloping, however, and the soil is lighter colored and more shallow. Locally it is called "red sandy loam." The 5- or 6-inch topsoil is dark chocolate-brown or slightly reddish brown noncalcareous very fine sandy loam which is loose and friable and is easily cultivated under normal moisture conditions. This material grades into dark chocolate-brown noncalcareous very fine sandy loam, granular clay loam, or silt loam, which extends to a depth of about 15 inches. The material has a tendency to separate into columns when dry and is much lighter in color when crushed. In places this layer contains a few calcareous concretions or fragments of calcium carbonate. It grades into light reddish-brown or red very fine sandy loam which contains

many white or light-gray particles of carbonate of lime. At a depth of about 30 inches, this material, in turn, rests on the slightly weathered Permian Red Beds materials of red or light reddish-brown sandy strata of soft weathered sandstone or very fine sandy loam.

Weymouth very fine sandy loam covers a total area of 110.7 square miles. It occurs in rather large areas in the vicinities of Richmond, Mutual, Quinlan, Plain View School, and Sunny Slope School. It is associated with St. Paul very fine sandy loam and Quinlan very fine sandy loam.

This soil approximates St. Paul very fine sandy loam in productivity and in crop adaptation. It is more subject to erosion, however, and consequent reductions in yields under cultivation, because of its occurrence in more rolling areas, but the surface slope is not so steep as to prevent the use of power machinery. The fairly smooth relief and comparatively heavy texture of this soil have favored the production of wheat. Approximately 90 percent of the land is in cultivation, about 55 percent of which is cropped to wheat; 26 percent to row crops, including grain sorghums, broomcorn, and sorgo; and 9 percent to corn. About 10 percent is in native grass. Wheat yields about 11 bushels an acre, grain sorghums about 20 bushels, broomcorn 300 pounds, and alfalfa 1½ tons. Fruits and vegetables do fairly well. In most places, the well water in areas of this soil is unsuited for irrigation. The native vegetation consists of several grasses—chiefly blue grama, buffalo grass, some side-oats grama, and bluestem.

Included with Weymouth very fine sandy loam in mapping are a number of small areas, in which the surface soil and subsoil have a total thickness ranging from 12 to 20 inches. The soil material rests on gypsum rock, and in places the surface is dotted with outcrops of this rock. Most of the areas of this kind are along the border between rough broken land and the typical soil. This included soil is nonarable because it is shallow and contains so many rock outcrops. It covers an area of approximately 9 square miles. It is used only as pasture land and supports a fair growth of buffalo grass, blue grama, and side-oats grama.

LIGHT-TEXTURED SANDY SOILS OF THE UPLANDS

The soils of this group have a generally low or very moderate productive capacity and are only fairly suitable for producing crop yields. Most of them are similar in texture, structure, and general physical characteristics, although one or two soils differ in that they have heavier topsoils and subsoils. The topsoils, for the most part, are light brown or grayish brown and red, and the subsoils consist of very permeable sand or sandy materials which are so porous that the normal accumulation of a calcareous horizon in the profile has not been developed.

These soils are used for about the same crops as the heavier and stronger soils, and, when moisture conditions are favorable, fair yields are produced. In fact, some of the soils seem to be fairly drought resistant, and good yields of the sorghums, broomcorn, Sudan grass, and other forage crops are successfully produced. Wheat, although it produces only a low average yield, is grown to considerable extent on some of these soils.

The series represented by soils in this group are the Canadian, Pratt, Miles, and Quinlan. One heavy soil of the Vernon series is included also, because it has about the same value for the production of crops.

The Pratt soils are the most extensive soils of the rolling plains in the county. The two in this group are Pratt loamy fine sand and Pratt loamy fine sand, shallow phase. They are cultivated to a rather large extent, although in places they are subject to considerable drifting of soil material in heavy winds. They represent soils developed from old deep sandy beds of unconsolidated materials. The Canadian soils have developed from old alluvium on high terraces in the valleys which are no longer overflowed. Canadian loamy fine sand is of moderate productiveness but not of great extent. The Miles soils are light-brown loose sands underlain with red sandy clay. Miles loamy fine sand is somewhat less suited to cultivation than Miles loamy fine sand, smooth phase. These soils support a thick growth of small shin oak trees in places. Although developed from parent materials somewhat similar to those producing the Pratt soils, they differ in the red color of the deeply covered sandy clay layer and seem to be looser and to contain less organic matter than the Pratt soils. The Quinlan soils, developed from very sandy Red Beds materials, are red and are susceptible to severe erosion. They differ from the Vernon soils in that they have much more friable subsoils and substrata. Quinlan very fine sandy loam is included with this group, as its somewhat thinly developed surface soil and porous subsoil do not enable such favorable production of crops as do the heavier soils of the first group. Vernon clay loam has a thin red heavy surface soil overlying red clay.

Canadian loamy fine sand.—Canadian loamy fine sand is similar in general appearance to Pratt loamy fine sand, but it occurs on smoother high terraces of old alluvium in stream valleys which lie above overflow. The surface soil is 8 or 10 inches thick and consists of dark-brown loamy fine sand or fine sandy loam, containing a few rounded gravel in places. The topsoil grades into brown fine sandy loam or loamy fine sand, containing a few white lime concretions and rounded gravel. This layer, which is calcareous, extends to a depth ranging from 25 to 35 inches and grades into loose yellowish-brown loamy fine sand or vellow fine sand. The texture of the surface soil is somewhat variable, ranging from loamy fine sand to very fine sandy loam, but most of it is loamy fine sand.

This soil occurs in several fair-sized areas along Wolf Creek south of Supply and along North Canadian River northwest of Woodward. A few smaller areas are along some of the tributaries of Canadian River in the southern part of the county. This soil receives run-off from higher land and generally has a larger supply of moisture than the higher upland soils. For that reason it is able to produce fair crops of corn and alfalfa, even in very dry seasons, as these crops need more moisture than frequently is available in the upland soils.

Approximately 30 percent of the land is cropped to wheat, 30 percent to grain sorghums and broomcorn, 15 percent to corn, and 10 percent to alfalfa. Yields are slightly higher than on Pratt loamy fine sand. Yields of wheat average about 9 bushels an acre and of alfalfa from 1 to 3 tons. Fruits and vegetables do well. Water from wells in this soil is suitable for irrigation purposes.

Pratt loamy fine sand.—Pratt loamy fine sand is the most extensive agricultural soil in the county. It is locally called "sandy land" or "black sandy land." The surface soil is dark grayish-brown or very dark grayish-brown loamy fine sand ranging from 12 to 16 inches in thickness. It is neutral or faintly acid in reaction. It is loose and friable, is easily worked, and absorbs moisture very readily. The subsoil is brown or grayish-brown noncalcareous loamy fine sand which, below a depth ranging from 30 to 36 inches, passes into yellowish-brown or yellow loamy fine sand containing occasional darker streaks of organic material leached from the topsoil. The material in this layer also is noncalcareous. It grades, at a depth ranging from 40 to 50 inches, into loose yellow fine sand which is merely slightly weathered unconsolidated sand of the underlying Tertiary or Quaternary formations. In places there is a layer of heavier material in the subsoil, and in some places this contains, or is underlain by, white streaks and spots of carbonate of lime.

This soil covers a total area of 177.5 square miles. In general the relief is gently rolling or undulating (pl. 1, *A*). The soil is rather widely distributed throughout the sandy parts of the county. It occurs in large areas of irregular shape and also in smaller circular or oval areas. Large areas are south of Woodward, around Tangier, and around and northwest of Mooreland.

The virgin soil supports a fairly heavy growth of sand sage and such grasses as bluestem, sand bluestem, blue grama, and species of Panicum. In places there is a scattered growth of hackberry, shittim wood, and elm trees.

This soil is not particularly suited to the production of wheat because of its light texture, but, as the climate of the county is particularly suitable to wheat, the crop is grown on land where soil adaptation is not especially good. This soil is better suited to the growth of grain sorghums, broomcorn, cowpeas, peanuts, watermelons, and grapes than to small grains because of the sandy character of the surface soil and subsoil. Approximately 40 percent of the land is cropped to wheat; 30 percent to such row crops as grain sorghums, broomcorn, and sorgo; and 8 percent to corn; about 20 percent is left in pasture; and the remaining 2 percent is cropped mainly to peanuts, cowpeas, watermelons, peaches, grapes, apples, and sweetclover. This sandy soil is particularly suited to the growth of trees; cherries, plums, peaches, apples, and apricots grow well, although apricots and peaches do not yield very well. Watermelons do very well during some seasons. Most of the water obtained from wells in this soil is suited for the irrigation of small garden plots.

Acre yields of wheat range from practically nothing to 30 bushels, with an average of 6 bushels; milo, from 5 to 35 bushels, with an average of 15 bushels; broomcorn, from 100 to 300 pounds; and corn, from almost nothing to 25 bushels, with an average of 8 bushels.

The principal problem in handling this soil is the prevention of wind and water erosion. The comparatively loose light-textured surface soil is very easily disturbed by running water or wind. Grain or row-crop stubble generally is left on the land, in order to check wind erosion during the early spring. Terracing doubtless would be of great value in checking water erosion.

Pratt loamy fine sand, shallow phase.—Pratt loamy fine sand, shallow phase, differs from the typical soil in that it has a somewhat red subsoil composed of Red Beds material, at a depth ranging from 14 to 30 inches. This soil occurs where only a thin coating of the sandy Tertiary or Quaternary material overlies the Permian Red Beds. The upper part of the red subsoil is very sandy, but with increase in depth the material becomes heavier and the lower part of the subsoil is very fine sandy loam. The 12- to 15-inch surface layer is grayish-brown loamy fine sand. It is underlain by a subsurface layer of yellowish-brown loamy fine sand.

Most of this soil occurs in small areas along the edges of small stream valleys where erosion has removed a large part of the sandy beds that originally covered the Red Beds. It also occurs on lower slopes, where sand from higher lying areas has washed down or blown over the Red Beds. The principal areas are in the valleys of Indian, Persimmon, and Bent Creeks.

This soil is slightly more productive than typical Pratt loamy fine sand, owing probably to the heavier material in the subsoil. Crop adaptations and yields are similar to those on the typical soil. Approximately 30 percent of the land is cropped to wheat and 30 percent to sorghums and broomcorn. About 40 percent remains as virgin grassland.

Miles loamy fine sand.—Miles loamy fine sand is in general appearance similar to Pratt loamy fine sand, rolling phase. It differs from that soil in a few important details because it has developed under a vegetation consisting largely of small scrubby oak trees, locally called shin oak, or dwarf chestnut oak (*Quercus* sp.). The surface soil is loose and structureless grayish-brown loamy fine sand, ranging from 13 to 16 inches in thickness. This passes into yellowish-brown or grayish-yellow loamy fine sand, which, at a depth of 24 inches, grades into reddish-yellow or reddish-brown fine sandy clay. This material becomes yellowish-red with increase in depth and is very hard when dry. Below this is loose yellowish-brown fine sandy loam or fine sand. No calcium carbonate occurs in this soil, and the reaction is slightly acid. The parent material seems to be of Tertiary age.

The typical soil occurs on such rolling relief that most of it is not cultivated. It occurs in association with Miles loamy fine sand, smooth phase, and these two soils cover the greater part of Irwin Township in the southwestern corner of the county. The Miles soil is used to some extent as pasture for cattle and sheep, but livestock must be kept off the land during the spring when young shoots are coming out on the shin oak, as these are said to be poisonous to livestock at that time.

Miles loamy fine sand, smooth phase.—The smooth phase of Miles loamy fine sand differs from the typical soil principally in relief. It occurs in smoothly rolling or almost flat areas. In some places it differs also in that the depth to the heavier red subsoil layer is slightly greater. This soil occurs in fairly large areas associated with typical Miles loamy fine sand. In many places it is cultivated, but as it is light textured and extremely subject to blowing, many areas have been abandoned after they have been cultivated a few years. Approximately 25 percent of the land is cropped to wheat

and about 25 percent to grain sorghums and broomcorn, and the remainder is virgin soil on which livestock are pastured on the native vegetation. Crop yields are similar to those obtained on Pratt loamy fine sand.

Quinlan very fine sandy loam.—Quinlan very fine sandy loam is the "red land" of Woodward County. It occurs in rolling areas with moderate to steep slopes where erosion has prevented normal development of a brown topsoil. The 7-inch topsoil is brownish-red or reddish-brown loose calcareous very fine sandy loam. It grades into red calcareous granular very fine sandy loam which, at a depth ranging from 18 to 24 inches, grades into the soft slightly weathered sandy beds or shaly sandstone of the Permian Red Beds.

This soil is shallow and somewhat deficient in organic matter and available plant nutrients. The subsoil layer is very thin and so porous that it is quickly leached after rains. The land is very easily cultivated, except on the steeper slopes, and moderate yields of wheat and sorghums are produced. Both surface soil and subsoil are extremely susceptible to erosion, and fields should be protected by every means possible from this menace which rapidly carves gullies. Large areas of land now too gullied and broken by erosion to cultivate were at one time covered by this soil.

Quinlan very fine sandy loam occurs in extensive areas southeast of Mutual, south and northwest of Quinlan, southwest of Moscow School, and east of Woodward.

Approximately 70 percent of the land is in cultivation, about 35 percent of which is cropped to wheat, 28 percent to sorghum crops and broomcorn, and 8 percent to corn. About 30 percent of the land is in native grass pasture. Acre yields of wheat range from practically nothing to 30 bushels, with an average of about 8 bushels; grain sorghums from 8 to 35 bushels, with an average of 16 bushels; and broomcorn, from 100 to 250 pounds, with an average of 150 pounds.

Vernon clay loam.—Vernon clay loam is a red soil similar to Quinlan very fine sandy loam, but both topsoil and subsoil are much heavier in texture. Vernon clay loam is developed from heavy calcareous shales of the Red Beds. The surface soil is brown or reddish-brown very fine sandy loam or clay loam to a depth of 1 or 2 inches. This material is calcareous, friable, and breaks into thin horizontal plates when the virgin soil is broken. Below this is reddish-brown or red calcareous heavy clay which is slightly yellow when crushed. This material is merely the slightly weathered red shale of the Permian Red Beds.

This soil, which is very inextensive, occurs in small areas in the upland bordering Cimarron River. Approximately 30 percent of the land is cultivated to wheat, and the remainder is used for pasture. This is not considered a very productive soil. Reliable figures on crop yields are not obtainable because of the small extent of the soil. Yields of wheat are probably about 6 bushels an acre, of sorghums about 12 bushels, and of Sudan grass about 1 ton. The soil is unsuited to trees, except mesquite and possibly bois d'arc. It supports a growth of buffalo grass, side-oats grama, and blue grama, some pricklypear, snow-on-the-mountain, and a few small mesquite trees.

SOILS OF RECENT ALLUVIAL DEPOSITS

Within this group are placed the soils of the stream bottoms. These consist of deep deposits of soil materials that have been washed from soils of the uplands and transported by stream action to their present location. Although alluvial soils, as a rule, are highly productive and have excellent moisture relationships which enable crops to grow well in dry seasons, the alluvial soils of Woodward County are not used for crops to a great extent, and, for the most part, they are not especially desirable soils in many places. This is because of the great admixture of sand with little of the finer earth particles, the poor drainage of some of them, and the accumulations in places of saline materials which are present in sufficient quantities to affect plant growth unfavorably. The soils of this group are not extensive and are unimportant in the agriculture of the county. They occur in many very small intermingled areas which are difficult to differentiate and show on a map of the small scale used in this survey.

The soils of this group are represented by several types of the Lincoln and the Yahola series. The Lincoln soils are brown, calcareous, and comprise materials washed from the brown soils of the rolling plains and High Plains northwest of the county; and the Yahola soils consist mostly of soil materials washed from red soils of the Permian Red Beds. They are red and have indefinite subsoils of intermixed layers of sand and heavier soil materials.

Lincoln fine sandy loam.—Bottom-land soils consisting largely of sediments eroded from brown soils of the same general character as those of the Pratt and associated soils are members of the Lincoln series. Lincoln fine sandy loam has a topsoil of brown calcareous fine sandy loam 6 or 8 inches thick and a subsoil of stratified sediments in layers of materials ranging in texture from clay to fine sand and in color from grayish brown to almost black. This layer, which extends to a depth of approximately 30 inches, is variable because of the mixed origin and the various conditions under which the material was deposited by streams. Below this is yellowish-brown fine sand that is generally saturated with water.

This soil occurs in long narrow bodies along North Canadian River and along the streams emptying into this river from the south and west. The land is subject to overflow and largely for that reason and because it is not highly productive, it is generally used for native-grass hay and pasture, although approximately 35 percent of it is in cultivation. The cultivated land is cropped to grain sorghums, broomcorn, Sudan grass, and corn. Some Johnson grass and bluestem are cut for hay. Acre yields of wheat average about 10 bushels, grain sorghums about 22 bushels, broomcorn between 300 and 400 pounds, and corn about 10 bushels. Fruits and vegetables do well. Cherries, apples, plums, grapes, blackberries, and dewberries are successful in places. The soil is easily worked and is fairly productive, but, when subjected to unusual overflows, crops are sometimes injured or destroyed.

A dark phase of Lincoln fine sandy loam covers such a small total acreage that it is not mapped separately. It differs greatly from the typical soil. The surface soil is very dark grayish-brown calcareous fine sandy loam 5 or 6 inches thick containing an appreciable amount of soluble salts. Below this and extending to a depth

ranging from 28 to 30 inches, is very dark gray or black clay loam or fine sandy clay loam. This layer also is calcareous and contains soluble salts and small white lumps of carbonate of lime. Below a depth of 30 inches, the material is gray fine sandy clay loam containing yellowish-brown mottlings and white lumps of lime. This layer is generally saturated with water. This included soil covers a total area of approximately 4 square miles, principally in long narrow belts along the upper parts of North Persimmon, South Persimmon, and Indian Creeks. It is used only for native hay and pasture. Yields of hay range from 1 to 2 tons an acre.

Another phase of Lincoln fine sandy loam, which includes a few small areas, is a wet poorly drained soil having a dark surface soil. It is used only for native hay and pasture. The native vegetation consists largely of sedges, cattails, saltgrass, bluestem, and silver beardgrass. This included soil covers an area of approximately 6 square miles and occurs in long narrow areas along streams.

Lincoln clay.—Lincoln clay is similar to the dark marshy phase of Lincoln fine sandy loam, except in texture of the surface soil. The surface soil of the clay consists of dark-brown calcareous clay from 8 to 12 inches thick. This is underlain by brown or light-brown calcareous clay or clay loam, which rests on yellowish-brown fine sand at a depth ranging from 15 to 20 inches. The material in this layer is of single-grain structure and is saturated with water.

This soil is subject to overflow and lies in rather poorly drained situations. It occurs principally along the bottoms of Wolf Creek and North Canadian River. It is used only for native hay and pasture and produces rather luxuriant growths of bluestem, sand bluestem, silver beardgrass, and blue grama.

Lincoln loamy fine sand.—Lincoln loamy fine sand differs from Lincoln fine sandy loam principally in texture. The 6- to 10-inch surface soil is loose and friable grayish-brown calcareous loamy fine sand. It grades into yellowish-brown or yellow fine sand which is often saturated with water, as the water table is high.

This soil occurs in comparatively large areas along the bottoms of North Canadian River and Wolf Creek. It is subject to overflow and is used for pasture. It supports a fair growth of sand bluestem, bluestem, sand sage, and blue grama.

Yahola very fine sandy loam.—Yahola very fine sandy loam consists of sediments from red soil materials, deposited by streams which have their origin in the section occupied by Quinlan and Vernon soils. The surface soil is reddish-brown calcareous very fine sandy loam about 6 inches thick. Below this is brownish-red or red calcareous loam with interbedded layers of sandy texture.

This soil occurs in long narrow belts along the smaller streams in the northeastern part of the county. Most of it is included in large cattle ranches, but small patches are cultivated to corn, grain sorghums, vegetables, and fruits. The land is subject to overflow, and crop production is uncertain. Excellent yields are obtained when crops are not damaged by overflow. Corn yields approximately 15 bushels, grain sorghums 20 to 30 bushels, and Sudan grass from 1½ to 2 tons an acre. Farmers invariably plant their vegetable gardens and orchards on this soil, if any is present on their farms. Cherries, plums, grapes, and potatoes do very well, and

sweet corn, if planted early, produces fair crops in many seasons. Most of this soil is covered with a growth of trees consisting of elm, post oak, blackjack oak, chestnut oak, hackberry, and shittim wood.

Yahola clay loam, saline phase.—Yahola clay loam, saline phase, is a stream-bottom soil occurring in small strips along the course of Cimarron River. It consists of a mixture of fine-earth soil materials originating from both red soils and sandy soils of the plains uplands. It contains an appreciable amount of soluble salts. The texture of the surface soil is variable because of variations in the source of materials and the conditions under which they were deposited. The surface soil is chocolate-red calcareous clay loam ranging from 8 to 20 inches in thickness. Below this the material grades into reddish-yellow or reddish-brown loose calcareous fine sandy loam.

The soil is subject to overflow, as it occupies low flat areas. Judging from surface appearances and the presence of saltgrass, the amount of soluble salts possibly is sufficient to prevent the growth of farm crops. The native vegetation consists chiefly of wild-rye, bluestem, saltgrass, and sedge grasses, and these plants afford good pasturage for cattle.

SOILS AND LANDS UNSUITED FOR CULTIVATION

In this group are included nine kinds of soils and land, which, because of some inherent characteristic or feature of relief, are almost entirely unsuited for cultivation. The group may be divided into two subgroups: (1) Those soils too loose and deeply sandy for use in farming because of difficulty of cultivation, extreme permeability which prevents retention of moisture, and low content of plant nutrients; and (2) soils which have been so deeply eroded that the land is physically nonarable or the soil layers are so thin that they contain only a slight store of essential plant nutrients.

To the loose-sand group belong Enterprise fine sand; Enterprise fine sand, dune phase; Lincoln fine sand; Pratt loamy fine sand, rolling phase; and riverwash. With the eroded-land group are included Quinlan very fine sandy loam, eroded phase; Vernon clay loam, eroded phase; Potter fine sandy loam, eroded phase; and rough broken land.

The soils of the sand group show little true soil development, owing to their porous condition which allows rapid leaching; and the soils of the eroded group are so thin and the parent material is so near the surface that soil development is but slightly advanced. The native vegetation on the sands is largely very coarse grasses and in places some trees, and the grazing value is not high. The more nutritious grasses, some of the short-grass types, grow on the eroded soils which are heavier. Due to rapid run-off of rain water, however, these soils do not have such favorable moisture conditions for growing grasses as the sands.

Enterprise fine sand.—Enterprise fine sand is a deep sandy plains soil on which some small trees have encroached. The 8-inch topsoil consists of grayish-brown loose fine sand. This grades into yellow or yellowish-brown loose fine sand which continues to a depth of several feet. No indication of calcium carbonate was found by field test in any part of the soil, but both the topsoil and subsoil materials are about neutral in reaction.

Enterprise fine sand occupies a fair-sized area in the southeastern part of the county, extending from Pleasant Hill School to the county boundary south of Cedardale.

The relief ranges from undulating to rolling, and, although in places some ridges and elevations indicate wind-blown features, it is not particularly dunelike. Doubtless this soil comprises old wind-blown sandy beds of sedimentary origin, which possibly have been blown from the water-laid deposits of sandy materials in the local stream valleys.

The native vegetation consists chiefly of small trees, largely blackjack oak, not more than 20 feet high. Some wild plums, wild grapes, and other shrubs also grow on this soil, and coarse grasses grow in places.

Most of this land is used as pasture for livestock. Approximately 5 percent of the soil is cultivated. The principal crops grown on the cleared areas are Sudan grass, sorgo, and grain sorghums. Sudan grass and sorgo yield about 1 ton an acre, and grain sorghums yield from 5 to 8 bushels. Stubble generally is left on the land during the winter and spring, as the soil drifts readily in heavy winds, where unprotected by growing vegetation. Possibly some pasture grasses could be introduced which would enhance the value of the land for pasture. Grapes possibly could be grown, particularly if the ground were covered by cardboard or some other material which would prevent blowing of the sand. The underground water supply is good.

Enterprise fine sand, dune phase.—The topsoil of Enterprise fine sand, dune phase, is light grayish-brown loose and incoherent fine sand. In most places it ranges from 4 to 8 inches in thickness, but in some places it is as much as 24 inches thick. In general, the material, below a depth of several inches, is yellow or dull brownish-yellow loose fine sand which continues to a depth of several feet. There is no indication of calcium carbonate in the surface soil, subsoil, or substratum.

This soil occurs in a number of areas on the high rolling divides of the upland plains in various sections of the county. Its total area is 105.7 square miles. Like the typical soil, this phase represents a greatly reworked wind-blown deposit of sandy material comprising old sedimentary deposits. The relief is distinctly hummocky and dunelike (pl. 1, *B*), but the dunes have been captured by vegetation and the sand is not continually blown about, except in small spots where the vegetation has been removed. The surface soil and subsoil absorb all the rain water, and moisture conditions are favorable to the growth of many coarse grasses and herbaceous plants.

The principal native vegetation includes sand bluestem and similar coarse grasses, together with considerable sand sage (*Artemisia* sp.), wild plum, ill-scented sumac, and in places small shin oak shrubs. The land is used only for grazing, and, although the coarse grasses which dominate the pasture plants are not so highly nutritious as the short grass of the heavier soils, they are luxuriant even in very dry seasons in the low places between the dunelike elevations and afford some forage when better grasses in other places may have been destroyed by drought.

Owing to the very slight content of plant nutrients and to the physical difficulties involved in cultivation, little attempt is made

to use this soil for farm crops. Possibly more valuable grazing and browse plants in time will be introduced to provide a more satisfactory basis for using the land for grazing livestock. Good well water occurs in places at a depth ranging from 30 to 40 feet.

Lincoln fine sand.—The surface soil of Lincoln fine sand is gray or light grayish-brown fine sand several inches thick. The subsoil is grayish-brown or yellowish-brown fine sand which continues to a great depth. Both topsoil and subsoil are calcareous and are of single-grain structure.

This soil occurs in the bottom-land areas of North Canadian River. The relief is rolling or dunelike, and possibly some areas are not overflowed, although the soil is of alluvial derivation. In places it has been reworked somewhat by wind.

The land supports a scant growth of bluestem, sand bluestem, and other coarse grasses and some sand plum, saltcedar, and other small trees. The soil is useful only for the scant pasturage afforded by the coarse grasses. It is too loose and too subject to blowing where unprotected to use for farm crops, even though it may contain sufficient plant nutrients to produce yields of valuable crops.

Pratt loamy fine sand, rolling phase.—The topsoil of the rolling phase of Pratt loamy fine sand consists of brown or grayish-brown loose fine sand which is slightly coherent when moist and very loose and incoherent when dry. The topsoil is about 6 inches thick and grades into yellowish-brown slightly loamy fine sand, and this, at a depth of about 20 inches, merges with a bed of brownish-yellow or yellow slightly loamy fine sand which is many feet thick. Neither the topsoil, subsoil, nor substratum contains an appreciable amount of calcium carbonate.

This soil occurs in large areas on the high rolling divides of the plains to a distance several miles north and south of Woodward in the western part of the county, and in places adjoining or within the North Canadian River Valley. It occupies a total area of 177.7 square miles. It is closely associated with Enterprise fine sand, dune phase, and with Pratt loamy fine sand.

The relief is rolling with some fairly steep slopes, and long billowy ridges and slightly dunelike areas indicate a wind-worked material consisting originally of sandy beds of sedimentary origin. Drainage is thorough and is effected mainly by rapid underdrainage through the loose sandy soil and substrata.

Practically all of this soil is used for pasture. The native grasses are sand bluestem, Indian grass, and others. Sand sage also is abundant. Owing to the tendency of the soil to drift in winds and also to the low inherent fertility, this soil is, for the most part, considered unfit for cultivation. A few small areas are included in cultivated fields, and probably the sorghums and other forage crops do better than any other crops.

Riverwash.—Riverwash consists of miscellaneous mixtures of sand and gravel, occurring in and at the edges of the larger stream beds. The principal area is in the bed of Cimarron River. This material is generally barren of vegetation and has no agricultural value. In places it is salty. The land is subject to occasional inundation and reassortment of the loose sandy beds. It lies in narrow strips and is of slight extent.

Quinlan very fine sandy loam, eroded phase.—Quinlan very fine sandy loam, eroded phase, is virtually semirough broken land and consists of exposed soil parent materials and Red Beds with little or no soil development (pl. 1, *C*). In places where erosion is least on the less steep slopes, the remaining topsoil consists of a thin layer of red or reddish-brown very fine sandy loam. This material passes, through a short transitional layer, into weathered Red Beds material of very fine sandy loam or sandy clay, which is the parent material and consists of slightly weathered materials that pass, within a slight depth, into the unchanged Red Beds of unconsolidated sandy materials or soft sandstone. In places, a very large part of the land has no soil material and the Red Beds material is exposed.

This soil, or rough land, occurs in large areas in the eastern part of the county northwest and south of Quinlan. The relief ranges from moderately to very steeply sloping and, in general, is characterized by hilly and steeply rolling ridges, deeply cut by numerous gullies and narrow deep valleys. The eastward-facing escarpment, which divides the sandy Tertiary and Quaternary deposits from the Permian Red Beds outcrops, consists almost entirely of this soil. Drainage is rapid, and exhaustive erosion is rapidly cutting the surface soil and washing away the soil in every rain.

The soil is useful only for grazing land, and the grasses, although they do not everywhere form a heavy cover, are nutritious and valuable for livestock. They are chiefly buffalo grass and several species of grama. The narrow deep ravines support a growth of some trees, and these deep-cut valleys and gullies afford good shelter for livestock during cold weather.

Vernon clay loam, eroded phase.—The eroded phase of Vernon clay loam corresponds to the eroded phase of Quinlan very fine sandy loam in its relation to the typical soil. It differs from the Quinlan soil mainly in texture. It consists largely of eroded, heavy, more or less weathered, calcareous shales which lie near, and outcrop at, the surface. This soil is so shallow and is so badly eroded that the land is suitable only for pasture.

The topsoil is red clay loam a few inches thick, but in many places the red clay of the Red Beds is exposed at the surface. Some short grasses and other plants afford moderate grazing for livestock. This soil is a modified form of rough broken land, as the relief is steeply sloping and hilly, and many gullies and ravines have been cut by erosion.

Potter fine sandy loam, eroded phase.—Potter fine sandy loam, eroded phase, consists of eroded areas of Potter fine sandy loam, from which the greater part of the topsoil and subsoil has been washed away, leaving chalky fragments of caliche and a small quantity of gray soil material.

This soil is not extensive. It occurs in a few scattered areas a few miles southwest of Woodward and south of Tangier. The relief ranges from moderately to steeply sloping. The land supports only a thin stand of grasses. It is useless for cultivation and has little value as grazing land for livestock. Trees do not do well on this soil.

Rough broken land.—Rough broken land consists of rough, broken, and eroded land that is similar in some respects to Quinlan very

fine sandy loam, eroded phase, and Vernon clay loam, eroded phase. It differs from those soils in that it has very steep blufflike slopes, from which some stony material, largely a crystalline form of gypsum, outcrops. Practically all of it is in the northeastern part of the county, where it occupies some good-sized areas. It consists, for the most part, of deeply cut, gullied, and eroded Red Beds materials.

This land has about the same agricultural value as the other eroded soils, but it supports slightly less grass because of the steep bare slopes and, in places, the abundance of stones. Some juniper trees grow in places.

PRODUCTIVITY RATINGS

In table 4 the soils of Woodward County are rated according to their ability to produce the more important crops grown in northwestern Oklahoma and are listed in the order of their relative general productivity.

TABLE 4.—*Productivity rating of soils in Woodward County, Okla.*

Soil [1]	Crop productivity index [2] for—											Principal crop or use of land
	Corn	Wheat	Rye	Oats	Grain sorghums	Sorghums (forage)	Alfalfa	Cotton	Broomcorn	Wild hay	Pasture	
Reinach very fine sandy loam	30	50	35	45	60	60	45	25	60	50	45	Wheat, alfalfa, sorghums.
St. Paul very fine sandy loam	10	55	40	45	60	50	40	20	60	50	50	Wheat.
Abilene very fine sandy loam	10	55	40	45	50	50	35	20	60	50	50	Do.
Pratt fine sandy loam	25	50	35	45	50	50	40	25	35	45	40	Wheat, sorghums.
Weymouth very fine sandy loam [3]	10	45	35	40	50	50	35	15	50	45	35	Wheat, grain sorghums.
Yahola very fine sandy loam	30	30	30	30	60	50	30	20	50	35	25	Wheat, sorghums, vegetables, fruits, pasture.
Abilene very fine sandy loam, depression phase.	15	30	25	30	50	50	35	15	40	10	20	Sorghums.
Potter fine sandy loam	---	30	25	25	35	25	---	---	20	30	30	Wheat, sorghums.
Lincoln fine sandy loam [3]	20	40	35	35	55	60	35	20	60	50	30	Sorghums, pasture, alfalfa.
Canadian loamy fine sand	20	35	35	35	40	40	45	15	40	30	25	Wheat, sorghums.
Quinlan very fine sandy loam	---	30	30	30	40	40	---	15	25	---	30	Pasture, sorghums.
Pratt loamy fine sand, shallow phase	15	25	30	25	35	40	30	15	35	30	20	Wheat, sorghums, pasture.
Pratt loamy fine sand	15	25	30	25	35	30	25	15	35	30	15	Do.
Miles loamy fine sand, smooth phase	15	25	25	25	35	35	---	15	35	25	15	Do.
Vernon clay loam	---	25	30	25	30	35	---	---	35	35	25	Pasture, wheat.
Miles loamy fine sand	---	10	15	10	15	15	---	10	15	20	15	Pasture.
Enterprise fine sand	---	20	25	20	15	25	---	---	---	20	10	Do.
Lincoln clay	---	---	---	---	---	---	---	---	---	30	25	Do.
Lincoln loamy fine sand	---	---	---	---	---	---	---	---	---	30	20	Do.
Yahola clay loam, saline phase	---	---	---	---	---	---	---	---	---	20	15	Do.
Quinlan very fine sandy loam, eroded phase	---	---	---	---	---	---	---	---	---	---	25	Do.
Vernon clay loam, eroded phase	---	---	---	---	---	---	---	---	---	---	25	Do.
Rough broken land	---	---	---	---	---	---	---	---	---	---	20	Do.
Pratt loamy fine sand, rolling phase	---	---	---	---	---	---	---	---	---	---	15	Do.
Lincoln fine sand	---	---	---	---	---	---	---	---	---	---	15	Do.
Potter fine sandy loam, eroded phase	---	---	---	---	---	---	---	---	---	---	15	Do.
Enterprise fine sand, dune phase	---	---	---	---	---	---	---	---	---	---	10	Do.
Riverwash	---	---	---	---	---	---	---	---	---	---	---	Waste land.

[1] Soils are listed in the approximate order of their general productivity in the county, the most productive first.

[2] Soil types inherently most productive for the specified crop in the United States are given the index 100. The soils in Woodward County are given indexes which give the approximate production in percent of the standard.

[3] Ratings refer to the better portions of this soil.

This rating compares the productivity of each of the soil types, phases, and miscellaneous land classes in the county for each crop to a standard—100. This standard represents the inherent productivity of the most productive soil type, or types, in the United States for that crop. A soil estimated to be one-half as productive for a given crop as the type with the standard rating is given a rating of 50. In a few instances unusually productive soils of limited acreage are given a rating above 100 for a specified crop. Inherent productivity is conceived to be that level of productivity at or near that existing when the virgin condition became adjusted to tillage practices.

The productivity indexes in table 4 are based on the yields obtained under current farming practices without irrigation, drainage, terracing, and the use of commercial fertilizers. As a result, no attempt has been made to give additional ratings for the inherent productivity of the soil. It is probable that the productivity of much of the land in Woodward County could be nearly doubled by irrigation; and drainage, terracing, and fertilization would doubtless increase productivity in many instances. It will be noted that the indexes of soils are comparatively low. This is largely the result of low rainfall as compared with that in the section occupied by the standard soil. Some of the better soils of this county with sufficient rainfall would probably be given a rating above 100 for some crops.

Economic considerations have played no part in determining the productivity indexes, so they cannot be interpreted directly 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.

Following is a tabulation of the important crops of the county and the acre yield which has been set up as a standard of 100 for each crop:

Crops	*Bushels*
Corn (grain)	50
Oats	50
Wheat	25
Rye	25
Grain sorghums	40
	Tons
Sorghums for forage	4
Alfalfa	4½
Wild hay	1
	Pounds
Broomcorn	600
Cotton	400
	Cow-acre-days per year[5]
Pasture	100

[5] "Cow-acre-days" is a term used to express the carrying capacity of pasture land. It is the numerical equivalent of the number of animal units supported by 1 acre during a given period of days. In Oklahoma the grazing season is long, the livestock running on pasture the entire year, though they are greatly benefited by supplementary feed at times when the pasture is not growing.

LAND USES AND AGRICULTURAL METHODS

In the use of land and agricultural methods employed, the farmers of Woodward County have found that a system combining livestock raising and wheat growing has proved the most dependable, although some small areas of land are devoted to a few other commercial crops, such as broomcorn and truck crops.

The principal factor in crop production in this county is the supply of moisture, as the county lies in a region having only a moderate average annual rainfall which varies greatly in distribution, not only from year to year but from season to season. Furthermore, in many seasons a period of drought occurs at a critical stage of crop growth and causes reduced crop yields, even though the annual or seasonal precipitation may be high. The crops grown and methods employed have, therefore, been selected with reference to the drought resistance of crops and to moisture-conserving systems of cultivation. Agricultural operations are further complicated by losses of soil moisture through high transpiration from growing crops and high evaporation caused by low atmospheric humidity, high wind velocity, high temperatures, and a fairly high elevation above sea level.

The crops which have proved to do best, after about 40 years of farming in this county, are chiefly wheat and some of the sorghum crops, including grain sorghums, sorgo, and broomcorn. Sudan grass also may be grown successfully.

The soils of this county are, for the most part, of limited productive capacity, although small areas of smooth moderately heavy sandy soils produce well when moisture conditions are favorable, as they seem to be well supplied with the essential plant nutrients. Some of the very light sandy soils are used for wheat, but the yields are low. As a rule, the sandy soils have the capacity to absorb and retain a large proportion of the rain water, and most of the stronger soils have the ability to resist droughty conditions and maintain plant growth in some rather dry seasons.

During the heavy winds common in the spring, the soils blow and drift to some extent when not protected and, at times, cause considerable damage, to young plants. Some protection is afforded by listing the land in ridges extending at right angles to the prevailing winds.

The soils and climatic conditions are better suited to the sorghums than to wheat, and large quantities of grain sorghums, sorgo, Sudan grass, and broomcorn are grown.

At the Woodward field station of the United States Department of Agriculture, considerable work has been done on testing the various crops of the general region. In experiments with grain sorghums [6] it is reported that low yields are due to periods of drought in July and August rather than to annual or seasonal deficiencies of rainfall. In a test of five strains of milo the highest average yield for a period of 8 years was of Dwarf Yellow milo, with an average of 22.8 bushels an acre. In a test of six varieties of kafir for a period of 8 years, the highest yield was from Sunrise kafir which averaged 26.3 bushels an acre. Several other grain sorghums averaged only slightly lower than these.

Dwarf Yellow milo, Reed kafir, and feterita are the outstanding sorghums for grain production in this section.[7] Dwarf Yellow milo has produced an average yield of 24.8 bushels an acre over a period of 18 years. Wheatland and Beaver milo are preferable for harvesting with the combine.

[6] SIEGLINGER, J. B. GRAIN-SORGHUM EXPERIMENTS AT THE WOODWARD FIELD STATION IN OKLAHOMA. U. S. Dept. Agr. Bull. 1175, 66 pp., illus. 1923.

[7] KILTZ, B. F., SIEGLINGER, J. B., OSBORN, W. M., BARNES, B. F., and FINNELL, H. H. SORGHUMS FOR GRAIN AND FORAGE. Okla. Agr. Expt. Sta. Bull. 210, 47 pp., illus. 1933.

Varieties recommended for combination grain and forage production or bundle feed are Sunrise and Santa Fe kafir, and Bishop (kafir-milo hybrid), Spur feterita, hegari, and Chiltex (cross of feterita and Blackhull kafir).

Sorgo varieties best suited to this part of the country are Orange, Sumac, and Red Amber.[8] In a number of tests with broomcorn the varieties which proved best suited were Acme, Evergreen Dwarf, and Scarborough, and the best dates for planting were from June 15 to July 1. For a number of varieties tested, average yields ranged from about 252 to 479 pounds an acre.[9] The hard red winter wheats, such as Kharkof, Turkey, Kanred, and Blackhull, are the best varieties for this county. Shallow plowing immediately after harvest is an important factor in conserving the summer rainfall in this section. Wheat yields are determined largely by the moisture content of the soil at seeding time. Wheat generally is drilled between September 15 and October 15 at the rate of 45 pounds an acre. Summer fallow is not practiced to any great extent, but possibly it would be of value during extended periods of drought. Additions of manure, the growing of green-manure crops, and the use of commercial fertilizers are not advisable if the following crop is to be wheat.

The fruit best suited to climatic conditions in this county is the sour cherry, and the varieties which have proved successful are Montmorency, Dyehouse, Early Richmond, and English Morello.[10] Apples do well when planted in subirrigated situations. Pear trees are able to withstand the climatic conditions, but the prevalence of fire blight has discouraged the planting of any variety except Kieffer which is a large pear of poor quality except for canning. Peaches bear about once in 4 or 5 years, and the crop may be poor even though it escapes late spring frosts. American plums and hybrid plums (crosses between the sand cherry and American and Japanese varieties) appear to be best suited to this section. Apricots are useful only as ornamental trees, and a crop may be expected about once in 10 years.

Jujubes, or Chinese dates, have proved very successful at the Southern Great Plains Experiment Station. Sui Men, Lang, and Li are the most promising varieties. Persimmons do very well. The Early Golden probably is the best cultivated variety. A few wild persimmon trees grow along the creek valleys, and some of them bear abundantly. Grapes generally are very successful on the sandy soils, and wild grapes grow on such soils in many places. Beacon, America, Delaware, Extra, Carman, Ellen Scott, Edna, Armalaga, Catawba, Goethe, and Last Rose are varieties of grapes which appear to be suited to this section. Concord grapes are not recommended. Blackberries and dewberries are successful in subirrigated situations or where irrigated, but they do not succeed unless they have some source of moisture other than the natural rainfall.

Vegetable crops which have proved fairly successful are beans, cowpeas, onions, radishes, beets, carrots, summer squash, potatoes, cantaloups, watermelons, cucumbers, Swiss chard, peas, okra, and early

[8] VINALL, H. N., GETTY, R. E., and CRON, A. B. SORGHUM EXPERIMENTS ON THE GREAT PLAINS. U. S. Dept. Agr. Bull. 1260, 88 pp., illus. 1924.

[9] SIEGLINGER, J. B. BROOMCORN EXPERIMENTS AT THE UNITED STATES DRY-LAND FIELD STATION, WOODWARD, OKLA. U. S. Dept. Agr. Tech. Bull. 51, 32 pp., illus. 1928.

[10] LOCKE, L. F. VARIETIES OF FRUIT AND NUTS FOR THE SOUTHERN GREAT PLAINS. U. S. Bur. Plant Indus. 23 pp., illus. 1932. [Mimeographed.]

A, Wheat on Pratt loamy fine sand, *B*, dunelike area of Enterprise fine sand, dune phase, *C*, typical area of Quinlan very fine sandy loam, eroded phase.

varieties of sweet corn. All these vegetables do better if irrigated. It appears that a system of summer fallow for one-half of the garden space each year would tend to greatly increase yields.

RECOMMENDATIONS FOR THE MANAGEMENT OF WOODWARD COUNTY SOILS[11]

The more important considerations in the management of cultivated land in Woodward County are conservation of moisture, protection of the soil from wind erosion, prevention of damage from run-off water, and addition of a maximum amount of organic residues to the soil. Most important of these is the conservation of moisture. Closely allied with this is the selection of crops which are able to withstand drought. These considerations are discussed to some extent in the foregoing section on Land Uses and Agricultural Methods.

In the production of small grains or row crops it is essential that no moisture be lost through the growth of weeds. Plowing immediately after harvest of small grains is of value in turning under crop residues, controlling weeds, and putting the soil in shape to absorb moisture. If the soil is very dry at harvest time, the plowing probably should be dispensed with. Deep plowing is not advisable because the soil dries to the depth reached by the plow. If weeds establish a growth during the summer on small-grain land, it is advisable to use some type of cultivator to remove them. The duck-foot cultivator and rotary-rod weeder are valuable for this operation, because they leave a cloddy surface.

Most of the row crops are produced without the use of a hoe, as hoeing increases the cost of production. The customary practice is to cultivate the crop about three times, using first a harrow, then a go-devil cultivator, and then a regular disk or duck-foot cultivator. No doubt the yields of row crops would be increased considerably if the weeds were hoed out.

The supply of moisture in the soil at planting time is of primary importance in the production of wheat and rye. These crops have a good chance of succeeding when the soil is moist to a depth of 3 feet at seedtime. When the soil is dry or is wet to a depth of only a few inches the chances of success are slight, and small grains should not be planted. Under such conditions, it is advisable to wait and put in row crops, because winter precipitation cannot be expected to supply the deficiency.

Most of the soils in this county contain a high proportion of sand. Under such conditions, the decomposition of organic matter goes on rapidly and the growth of vegetation is limited because effective rainfall is low, consequently, the potential fertility, as far as nitrogen is concerned, is less than that in central and eastern Oklahoma. In some heavier soils, however, the potential fertility and nitrogen content are higher than in most of the soils in eastern Oklahoma. In a pioneer agriculture, crops are harvested and no residues are returned to the soil. This has caused a further reduction in nitrogen and organic matter which is difficult to replace in soils where moisture is a limiting factor in plant development. The average chemical composition of 12 virgin soils and 12 samples of surface soil

[11] This section of the report was written by H. J. Harper, professor of soils, Agronomy Department, Oklahoma Agricultural and Mechanical College.

collected from adjacent areas of land which has been in cultivation about one generation are given in table 5.

TABLE 5.—*Losses of plant nutrients in Woodward County soils as a result of cultivation*

[Average of 12 comparisons]

Soil condition	Nitrogen [1]	Phosphorus [1]	Organic matter [1]
	Pounds	*Pounds*	*Pounds*
Virgin	1,990	600	39,800
Cropped	1,440	550	28,800
Loss through cultivation	550	50	11,000

[1] Pounds per acre in soil 6⅔ inches deep

About 28 percent of the nitrogen and organic matter which was present in the virgin soils has disappeared as a result of cultivation. The loss of phosphorus has not been so rapid as the loss of nitrogen. The maintenance of organic matter and nitrogen is an important problem which must be solved, in order to maintain the productivity of these soils. Alfalfa can be grown on the better types of bottom land in this county, and good crops are produced where the water table is not too high. Since alfalfa requires about three times as much water as grain sorghums to produce 1 pound of dry matter, it does not produce high yields on upland soils under normal conditions in this region of low rainfall. Sweetclover and cowpeas are two legumes which will make a fair growth on upland soils during seasons when the rainfall is normal or above normal.

Results of experiments conducted at the Woodward field station indicate that wheat, kafir, and cowpeas are the most productive crops for the upland soils. Cultivation is required for the production of these crops, and, as tillage increases the rate of decomposition of the organic matter in the soil, the growth of a legume crop planted in rows and cultivated does not add much nitrogen to a soil because a loss of organic matter takes place which equals the residual effect of a legume crop that is turned under for green manure. Poor inoculation also occurs during seasons of deficient rainfall, consequently legumes cannot add much nitrogen to the soil under such conditions.

Sweetclover has been grown successfully on many of the upland soils in this county, when moisture conditions have been favorable for the development of the young plants during the first season. Sweetclover requires twice as much moisture to produce 1 pound of dry matter as do grain sorghums, consequently it will not yield more than one-half as much tonnage per acre as kafir. Sweetclover increases the available nitrogen content of the soil, because no tillage is necessary during the period when it is on the land, and better conditions for the development of nodules prevail during the cool weather in spring and fall. When residues from sweetclover are turned under and subsequent crops are planted, a vigorous vegetal growth results, and this may be undesirable during seasons when the rainfall is low. The subsoils frequently are dry after sweetclover and alfalfa are grown, and unless sufficient rain falls to replace the subsoil moisture which has been removed, the available moisture in the

soil is not sufficient to meet the requirements of the increase in transpiration that takes place because of a marked increase in leaf area. Due to the so-called "burning" effect of the legume crop, lower yields of wheat frequently are obtained following the growth of sweetclover and alfalfa than on adjacent land where wheat is planted every year. Planting wheat in rows about 12 or 14 inches apart will help to eliminate this difficulty by reducing the total number of plants per unit area. When legumes are grown, they can be used more profitably for forage than as a green-manure crop.

The problem of soil acidity in this county is not important. Sixty-two samples of surface soil from this county have been tested, of which 38 samples contained free calcium carbonate, 17 were neutral in reaction and contained enough calcium for the growth of sweetclover and other lime-loving crops, 6 were slightly acid; and only 1 had a pH below 6. The absence of an acid condition in these soils is due to low effective rainfall and high evaporation which prevents excessive leaching. The rate of erosion is sufficiently rapid in many areas to remove the surface layers of soil as leaching occurs and to expose nonacid subsurface material on which soil development takes place.

The availability of phosphorus in the soils of this county is not a serious problem. Although only a small number of soils were examined, results seem conclusive—14 samples were very high in readily available phosphorus, 15 samples were high, 4 samples contained a medium amount of this important plant nutrient, 1 sample was low, and 1 sample was very low. Both the soils which were low in phosphorus were very sandy, and they have developed on parent material that is low in total plant nutrients. The problem of phosphorus fertilization will not be important for general crop production in this area for a long time. On some of the loamy fine sands, phosphorus is one of the limiting factors in plant development, and the nitrogen content of these soils also is low. Such areas should not be cultivated because of the danger from wind erosion, but when they are cultivated, poor crops are produced. No method has been found which can be used to increase the productive capacity of these lands in competition with more fertile soil where cost of production is low because of the high content of available plant nutrients still present in them. Results of experiments in which sodium nitrate and ammonium sulphate were applied as a top dressing to wheat show that they have not produced profitable increases in yield.

Nonsymbiotic fixation of nitrogen by soil organisms is apparently the most important process which will help to maintain the productive capacity of land in this county. The amount of nitrogen which is added to the soil annually by biological activity has not been determined experimentally, but it is known that it is not large, as chemical analyses of cropped soils show that the total nitrogen content of cultivated land is gradually decreasing and that a balance between the removal of nitrogen by crops and the addition of nitrogen by biological activity has not yet attained an equilibrium.

The use of summer fallow in a cropping system has not been an economical practice in Woodward County. This system is destructive of soil organic matter and it does not insure a good crop the following season. It seems probable that in some instances the high moisture content of the soil following summer fallow induces an ex-

cessive growth of vegetation early in the season and that the plants suffer more than smaller plants during droughts.

Another important consideration in the management of Woodward County soils is the control of wind erosion. Strip cropping with grain sorghums on row-crop land is effective under normal conditions, if the sorghum plants are left standing over the winter. Where small grain is grown in large fields and the relief is rolling, southern slopes are exposed to the direct action of the prevailing wind, and the vegetative cover may be destroyed by drifting sand during periods when the moisture supply is low during fall and winter. Wind erosion carries sand from these exposed areas onto other land, and severe damage may occur over large fields under such conditions, whereas strips of wheat interplanted between strips of kafir would reduce the damage to a minimum and also reduce the economic hazards of a one-crop system of farming. This practice, may, however, increase the injury done by chinch bugs. On sandy soils it is advisable to let the stubble from row crops remain on the land during the winter and spring, in order to reduce the hazard of wind erosion, and the topsoil should be kept in a cloddy condition during this time, in order to reduce the harmful effects of wind erosion. Windbreaks, such as trees or picket fences, on the west and south sides of fields help to prevent the spread of wind erosion from adjacent fields. For further information on this subject refer to Farmers' Bulletin 1771.[12]

Studies on the chemical composition of typical profiles collected from different soil types in Woodward County are given in table 6.

TABLE 6.—*Partial chemical composition of soils in Woodward County, Okla.*

UPLAND SOILS

Soil type and sample no.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
St. Paul very fine sandy loam:		*Inches*		*Percent*	*Percent*	*Percent*	*Parts per million*
3175	NE¼ sec. 7, T. 20 N., R. 18 W.	0–8	8.0	0.084	2.39	0.038	90
3176		8–15	7.8	.058	1.59	.034	80
3177		15–36	7.8	.039	1.11	.037	80
3178		36–48	8.3	.024	.80	.046	112
Miles loamy fine sand:							
3211	NE¼ sec 32, T. 21 N., R. 21 W.	0–10	7.4	.038	2.11	.021	1
3212		10–18	6.8	.064	1.04	.016	0
3213		18–30	6.9	.037	1.15	.017	1
Pratt fine sandy loam:							
3196	NE¼ sec. 27, T. 23 N., R. 19 W.	0–6	7.5	.099	3.10	.036	80
3197		8–26	7.5	.060	1.73	.027	48
3198		26–36	8.1	.034	.62	.020	12
3199		36+	8.3	.046	.26	.013	20
Pratt loamy fine sand:							
3187	NW¼ sec 32, T. 23 N., R. 18 W.	0–14	6.9	.030	1.37	.022	10
3188		14–30	6.9	.045	.91	.016	10
3189		30–40	6.8	.026	.88	.018	0
3190		40–50	6.8	.036	.53	.013	0
Quinlan very fine sandy loam:							
3170	SW¼ sec. 32, T. 23 N , R 17 W.	0–6	8.2	.090	2.13	.041	90
3171		6–20	8.3	.056	1.35	.044	60
Weymouth very fine sandy loam:							
3203	NW¼ sec. 33, T. 23 N., R. 17 W.	0–6	8.2	.090	2.21	.041	130
3204		6–11	8.2	.076	1.75	.047	130
3205		11–24	8.3	.044	1.11	.046	64
3206		30–50	8.3	.022	.46	.036	128

[12] CHILCOTT, E. F. PREVENTING SOIL BLOWING ON THE SOUTHERN GREAT PLAINS. U. S. Dept. Agr. Farmers' Bull. 1771, 29 pp., illus. 1937.

TABLE 6.—*Partial chemical composition of soils in Woodward County, Okla.*—Con.

TERRACE AND BOTTOM-LAND SOILS

Soil type and sample no.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Percent*	*Percent*	*Percent*	*Parts per million*
Canadian loamy fine sand:							
3183	NE¼ sec. 7, T. 23 N., R. 22 W.	0–10	7.9	0.017	1.11	0.012	56
3184		10–30	8.9	.034	1.33	.026	10
3185		30+	8.4	.008	.64	.016	24
Lincoln fine sandy loam:							
3164	NW¼ sec. 26, T. 22 N., R. 19 W.	0–12	8.3	.094	2.19	.041	90
3165		12–20	8.9	.059	1.64	.032	90
3166		20–36	9.3	.008	.64	.011	28
Lincoln loamy fine sand:							
3181	SE¼ sec. 25, T. 22 N., R. 19 W.	0–7	9.0	.024	.84	.011	48
3182		7–36	8.2	.010	.22	.012	40
Yahola very fine sandy loam:							
3200	SE¼ sec. 2, T. 24 N., R. 17 W.	0–8	8.2	.044	1.42	.038	128
3201		8–15	8.4	.039	.80	.037	130
Reinach very fine sandy loam:							
3192	SW¼ sec. 3, T. 21 N., R. 19 W.	0–10	8.0	.092	2.22	.035	72
3193		10–36	8.5	.037	1.04	.037	96
3194		36–48	8.5	.013	.77	.030	64

All the samples tested proved neutral to basic in reaction. In places Miles loamy fine sand shows some acidity in the A_2 and B layers of the soil profile. This soil is older than the Pratt soils, and scrub oaks grow on most of the areas under natural conditions. The presence of sagebrush indicates that the soil is basic in reaction. This type of vegetation is most abundant on Pratt loamy fine sand and Pratt loamy fine sand, rolling phase. The nitrogen content of the soils of this county is considerably below the average for Oklahoma soils, but the availability of the nitrogen is high, and good crops are produced when moisture conditions are favorable for plant growth. The total phosphorus content of these soils is correlated rather closely with the texture—the fine sandy loams containing more phosphorus than the loamy fine sands. The availability of the phosphorus is high, except in Miles loamy fine sand and Pratt loamy fine sand, both of which would respond to phosphorus fertilization when moisture is not a limiting factor in plant development.

The problem of soil management on pasture land is largely a matter of moisture conservation and prevention of overgrazing. Shallow lister furrows on a contour on overgrazed land, in order to catch run-off water, combined with restricted grazing to allow the grasses which are present or introduced grasses to develop a vigorous growth, is the only treatment that can be recommended under present conditions. The use of contour ridges is valuable on the Weymouth, Potter, Quinlan, and Vernon soils. Run-off is slight on the other soils, and contour ridges would be of little value on them.

MORPHOLOGY AND GENESIS OF SOILS

Woodward County lies within the southern Chernozem soil region. It has an annual rainfall of approximately 24 inches. Most of the soils have developed under a grass vegetation. The smooth heavier soils, for the most part, are fairly high in organic-matter content and

have the well-defined horizon of carbonate accumulation in the soil profile. The soils of this region have developed from two distinct types of geological formations, namely, the unconsolidated sands of Tertiary and Quaternary origin and the partly consolidated fine-grained sandstones and heavier shales and some unconsolidated sandy beds of the Permian Red Beds. The Permian Red Beds occur in the northeastern quarter of the county, in two townships in the southeastern corner, in the northwestern corner near Supply, and in a few other places where erosion by streams has removed the overlying sandy mantle of the Tertiary or Quaternary formations. The remainder, or approximately two-thirds, of the county is covered by the sandy Tertiary and Quaternary deposits.

Practically all the soils developing from the Tertiary and Quaternary deposits are mature sandy soils. Large areas of them, however, are porous to so great a depth and are so readily leached that some characteristics peculiar to the regional environment have not been produced, as indicated by the absence of the horizon of calcium carbonate accumulation, the lack of the dark color in the topsoil, and other characteristics.

Pratt fine sandy loam may be considered representative of the medium-textured mature soil developed from these formations. It has developed on fairly smooth and almost flat areas under a heavy sod of buffalo grass, blue grama, and side-oats grama. Following is a description of a typical profile of this soil:

1. 0 to 8 inches, dark-brown or very dark brown noncalcareous fine sandy loam matted with grass roots and showing some tendency to lamination. The material in this layer is very loose and friable.
2. 8 to 20 inches, dark-brown or very dark brown noncalcareous clay loam which is slightly darker and more compact than the material in the surface horizon. It breaks irregularly into horizontal plates, from 1 to 6 inches in thickness, and in places breaks vertically into irregular columns. Cleavage planes are not very distinct and apparently are not coated with clay. The plates break into clods of irregular sizes and shapes, and the material is much lighter in color when crushed. Organic matter apparently occurs as a coating on the finer aggregates. Worm casts and holes are lined with dark organic matter.
3. 20 to 36 inches, brown fine sandy clay or fine sandy loam, with a few soft white lime concretions and small streaks of carbonate of lime coating root and worm holes. This is the zone of lime accumulation and is calcareous throughout. No cleavage planes are present.
4. 36 to 50 inches +, yellowish-brown or light-brown loamy fine sand containing a few small lime concretions. The material of this horizon is noncalcareous and consists of partly weathered sandy Tertiary or Quaternary materials. In places heavy lenses or strata occur in this and other horizons of the profile.

Typical of the more sandy mature soils is Pratt loamy fine sand. This soil occurs on gently rolling relief and has developed under a vegetation consisting largely of coarse tall grasses, such as *Andropogon* and *Panicum* species. Following is a description of the profile of this soil:

1. 0 to 15 inches, very dark grayish-brown noncalcareous loamy fine sand. This has practically a single-grain structure and is somewhat streaked with organic matter. The reaction is neutral or slightly acid.
2. 14 to 32 inches, brown noncalcareous loamy fine sand with a single-grain structure. A few streaks of darker material from the surface horizon occur in animal burrows and root holes.

3. 32 to 42 inches, yellowish-brown or yellow noncalcareous loamy fine sand. Darker streaks of organic matter from horizons above are more distinct because of greater contrast in color. This material has a single-grain structure.
4. 42 to 65 inches +, yellow noncalcareous fine sand with a single-grain structure.

This soil has developed from such light-textured material that most of the very fine earth and calcium carbonate has been leached from the topsoil and subsoil. A soil of similar character, but even lighter in texture, is Enterprise fine sand which is so loose and composed almost entirely of siliceous sand that it has no very definite soil character. The dune phase of this soil is practically intrazonal.

Occurring in the southwestern corner of the county are areas of sandy soils developed from about the same type of parent material as that beneath the Pratt and Enterprise soils, but which are covered by a growth of dwarf shin oak. This soil, Miles loamy fine sand, to some extent has the characteristics of a forested soil, in that the topsoil is so light colored that it does not indicate development under a grass cover. A description of the profile follows:

1. 0 to 15 inches, grayish-brown neutral or faintly acid loamy fine sand with a loose single-grain structure.
2. 15 to 22 inches, light grayish-yellow loamy fine sand which is faintly acid. It has a single-grain structure but is slightly more compact.
3. 22 to 30 inches, reddish-yellow or reddish-brown fine sandy clay loam. This is apparently a horizon of illuviation with an accumulation of both clay and iron. The material is rather hard and vitreous when dry but very friable when moist.
4. 30 to 70 inches, yellowish-brown fine sandy clay or fine sandy loam. A few red streaks of clay from the horizon above extend down cracks and root holes. The material in this horizon generally becomes lighter textured with depth. The lower part of the subsoil is loamy fine sand.

Another sandy soil in this county is of slight development, and the soil layers are thin. This soil belongs to the Potter series. It occupies the higher lying plains and areas comprising remnants of a plain which existed here at some earlier age. The material is calcareous to the surface and has white fragments of hardened calcium carbonate in the surface soil. The subsoil consists almost entirely of white caliche, or soft calcium carbonate. This soil occurs on high mesalike areas and also on slopes lying immediately below the mesas. The caliche, which has resisted erosion, is apparently the indurated zone of lime accumulation of a former well-developed soil. Potter fine sandy loam might well be considered a mutilated soil at the present time.

Alluvial soils, comprising sandy materials of brown or grayish-brown color, have been included in the Lincoln series. High-lying old stream terraces of the same materials are included in the Canadian series. These soils have been developed to the extent that their characteristics correspond to those of soils developed from the older upland formations.

Some areas between soils developed from sandy beds and those developed from the Red Beds are classed as Pratt fine sandy loam and Pratt loamy fine sand, shallow phase. These soils have developed from sandy thin beds of light materials but are underlain

at slight depths by the Red Beds materials. They occupy areas where a large part of the sandy materials which overlie the Red Beds has been removed by erosion or where sandy material from higher lying areas has washed down and covered the Red Beds to slight depths.

In this county the mature soil developed from typical Red Beds materials has been correlated as St. Paul very fine sandy loam. This soil occupies smooth and undulating areas and supports a heavy growth of short grasses and some bunch grasses. The general profile of the soil is fairly typical of the southern Chernozems. Following is a description of a typical profile of this soil:

1. 0 to 7 inches, dark-brown noncalcareous very fine sandy loam containing many grass roots and showing some tendency toward lamination. The material is slightly lighter colored when crushed and is loose and friable.
2. 7 to 28 inches, dark chocolate-brown noncalcareous silt loam or heavy very fine sandy loam, with a slight indication of blocky structure. Shiny colloidal material is on the outsides of these large structural aggregates and in worm and root holes. Worm casts are very plentiful. When crushed, the material is much lighter in color.
3. 28 to 38 inches, reddish-brown noncalcareous silt loam. No cleavage lines are present. Worm casts are plentiful.
4. 38 to 50 inches, red calcareous clay loam containing spots and streaks of gray or white lime accumulation. This zone of lime accumulation is in places very distinct, but in most places it is very faint.
5. 50 to 70 inches, red or brownish-red clay loam or very fine sandy loam. This is the slightly weathered red calcareous sandstone of the Permian Red Beds. In most places the stone is only faintly consolidated.

Developed from this same parent material and occupying gently rolling relief is Weymouth very fine sandy loam. This is a semimature soil which has not developed to the stage attained by St. Paul very fine sandy loam. The soil profile is more shallow, and the surface soil is lighter in color. The zone of carbonate of lime accumulation is not distinct, nor is it well developed. On the more strongly rolling relief, Quinlan very fine sandy loam represents a still more youthful stage of development, in which the topsoil has been very slightly developed from the same Red Beds material. This soil is red and calcareous in the surface soil. Vernon clay loam, a youthful red soil developed from the heavier shales of the Red Beds, resembles the Quinlan soils in color and degree of development, but the soils have been separated on the basis of the structural features of the subsoils and parent materials. High-terrace and alluvial soils composed of materials from the Red Beds have been included in the Reinach and Yahola series.

The differences in soils developed from Tertiary and Quaternary deposits seem to be caused primarily by differences in texture of parent materials, and, as a rule, these differences have influenced the soil development.

From the descriptions of the soils it will be noted that the more extensive soils and larger soil areas do not have such well-defined characteristics of soil development that they reflect the influences of pedocalic environment to such a degree that the line separating the Pedocals and the Pedalfers in this region can be shown clearly. Doubtless this condition is due to the highly siliceous character and low lime content in the parent materials.

From the studies of the soil profiles and relationships in soil development to environment it would seem that the well-defined accumulations of calcium carbonate in the soil profile would occur in different kinds of soil textures located, with reference to this county, about as follows: Fine sands, at least 150 miles west of Woodward County; loamy fine sand, between 50 and 100 miles west; fine sandy loams, slightly east; very fine sandy loams, from 75 to 100 miles east; and clays, from 100 to 150 miles east.

SUMMARY

Woodward County includes an area of 1,233 square miles in northwestern Oklahoma. It lies at the eastern part of the Great Plains region within the rolling-plains section and about 20 miles east of the high-plains section. It is at the western edge and in the southern part of the great physiographic area known as the Central Lowland of north-central United States.

The relief over most of the county ranges from undulating to rolling, with considerable areas of rough, broken, deeply dissected lands. The southwestern three-fourths of the county occupies a high rolling sandy plain lying at an elevation of approximately 2,000 feet above sea level. This plain is separated by an escarpment, extending southeast-northwest, from a lower more generally dissected plain.

The climate is of the continental type, characterized by long warm summers and moderately cold short winters. The average annual precipitation is approximately 24 inches and the average frost-free season is 208 days. Soil moisture is dominantly important on all soils, although some soils are of only very moderate productive capacity. In 1934, crops were harvested from 22.6 percent of all the land. Wheat was grown on about one-half of the land in cultivation, and sorghums occupied a very large proportion of the remainder.

Two general groups of arable soils occupy the upland areas—the moderately heavy productive sandy soils and the sandy soils of light texture which range from moderate to low in productiveness.

The group of heavier upland soils comprises, for the most part, the brown very fine sandy loams of the St. Paul, Abilene, Pratt, Reinach, and Weymouth series. St. Paul very fine sandy loam is the most productive upland soil of extensive and normal development. It is the dark, typical, highly granular, plains soil and is nearly all in cultivation, as it is well suited to many kinds of crops. The other soils of the group also are used largely for the general farm crops. They are fairly drought resistant, as they are smooth and permeable and retain a considerable amount of the rainfall.

The soils of the light-textured sandy group are of the Canadian, Pratt, Miles, and Quinlan series. These soils are used to a considerable extent, although, on the whole, they are less productive than the heavier textured soils. They are fairly drought resistant and, although better suited to sorghums than to small grains, are used extensively for growing wheat, but with generally lower yields. These soils are deep, sandy, and loose, and, where unprotected, they are somewhat subject to blowing in heavy winds.

The alluvial soils along the streams form a group of inextensive soils included in the Lincoln and Yahola series. These soils are of limited value for cultivated crops and are not utilized largely in this county.

The nonarable soils comprise deep loose sands and rough eroded lands, and they are more or less valuable for grazing range livestock. Large areas are divided into pasture units of ranches.

The soils of the county have been developed under a pedocalic influence. Due to the deep loose beds of sandy parent material containing little calcium carbonate and, in places, to erosion, large areas of many soils show only very indefinite characteristics of the pedocalic environment. These soils do not have the zone of accumulated calcium carbonate in the profile that occurs in the soils of normal development.

The county lies in the eastern belt of the Great Plains, wherein the normal soils are included with the southern Chernozems. Of these, the heavier sandy soils have characteristics more consistent with the influences of the environment, and St. Paul very fine sandy loam is considered the true southern representative of this soil zone, which crosses the United States in a broad north-south belt extending from Canada to the Gulf of Mexico.

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