Soil Survey

Series 1935, No. 5. Issued March, 1939

Garfield County Oklahoma

By
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and
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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In cooperation with the
Oklahoma Agricultural Experiment Station

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By E. G. FITZPATRICK, Bureau of Chemistry and Soils, in Charge, and W. C. BOATRIGHT and L. E. ROSE, Oklahoma Agricultural Experiment Station

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COUNTY SURVEYED

Garfield County is in the northwestern part of Oklahoma (fig. 1). It is separated from the State of Kansas by Grant County. Enid, the county seat, is approximately 70 miles northwest of Oklahoma City and 110 miles west of Tulsa. The county is rectangular in outline and has an area of 1,049 square miles, or 671,360 acres. It lies on the border of the eastern humid prairies where they merge westward with the broad subhumid plains.

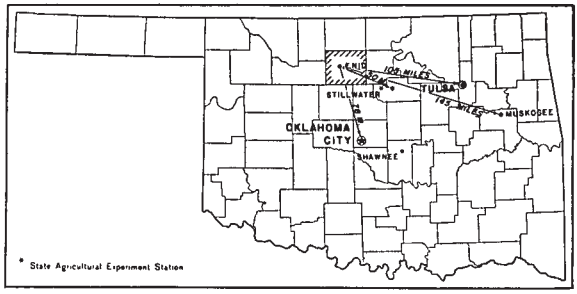


FIGURE 1.—Sketch map showing location of Garfield County, Okla.

The principal physiographic divisions of the county consist of two fairly smooth plains with an eastward or southeastward slope of approximately 6 feet to a mile.[1] The higher plain, which lies about 100 feet above the lower plain, occupies the western one-third of the county. The dividing line between the two plains enters the county 3 miles south of its northwest corner, extends east to southeast for several miles, turns south toward Enid, and continues in a southerly direction to the southern county line. In the western part, the separation between the two plains is marked, in places, by a very pronounced escarpment, such as that several miles northwest of Enid, and the land slopes northward. Farther south, however, the dividing line is merely a gently descending eastward slope.

The greater part of the western, or higher, plain is undulating to gently rolling. Although not thoroughly dissected, it is nearly everywhere well drained. Within this plain are two comparatively large areas of sandy soils with hummocky or dunelike relief, in which the surface configuration has been modified by the wind.

[1] Data on elevations obtained from unpublished sheets of the U. S. Geological Survey.

Another physiographic feature on this plain is a large salty flat which appears to be the bed of an old lake. This lake apparently was the result of waters impounded by a natural dam across the course of Turkey Creek formed by the shifting of sands or by the uplift of the section immediately south of the flat. Later, the water broke through a divide to the east. Eventually the lake was drained so that now the flat is seldom covered with water. Turkey Creek controls the drainage of the western plain. This stream and its tributaries have carved wide shallow valleys. The plain is not dissected thoroughly enough for the drainage to develop a dendritic character. Most of the valleys range from 10 to 40 feet in depth and have smoothly rolling sides, very few of which are too steep for the growth of cultivated crops. The hummocky areas of sandy soils are almost devoid of drainage channels, as rain water is absorbed very rapidly. The greater part of this plain has been correlated geologically in the upper Enid formation of the Permian age and consists of horizontal beds of red sandy shale and sandstone.[2] The hummocky sandy areas of this plain have been indicated by geologists as deeply laid surficial formations of Quaternary age.

The eastern, or lower, plain includes larger areas of smooth land than does the western plain. These are flat or gently undulating broad divides. Drainage of this plain is provided by Red Rock, Black Bear, Skeleton, and Otter Creeks and their tributaries, which have carved wide shallow valleys to a depth ranging from 40 to 75 feet. Small areas of steep land occur along the edges of the valleys, where drainageways are cutting back into the plain. The basin of Otter Creek in the southeastern part of the county is more rolling and more thoroughly dissected. The valleys are narrow and deep in this section. Red Rock and Black Bear Creeks flow eastward into Arkansas River, and Otter and Skeleton Creeks flow southward into Cimarron River. The eastern plain is underlain by heavy red shales of the lower Enid formation of Permian age. In the southeastern part of the county the surface formation is a red sandstone.

Enid, which lies near the line separating the eastern and the western plains, is at an elevation of 1,244 feet above sea level. The elevation in the southwestern part of the county is approximately 1,200 feet, and in the southeastern part it is approximately 1,000 feet.

The native vegetation (*1*, *3*, *4*, *6*, *8*)[3] consists principally of grasses.[4] There are four distinct associations or plant communities in this county.

The typical prairie type of association occurs on the medium- to heavy-textured upland soils. When this part of the county was first settled the association was dominated by little bluestem (*Andropogon scoparius*) with bluejoint turkeyfoot (*A. furcatus*), commonly called tall bluestem, sand bluestem (*A. halii*), silver beardgrass (*A. saccharoides*), blue grama (*Bouteloua gracilis*), side-oats grama (*B. curtipendula*), and buffalo grass (*Buchloe dactyloides*) as associ-

[2] U. S. Geological Survey map of Oklahoma.

[3] Italic numbers in parentheses refer to Literature Cited, p. 47.

[4] Vegetation identified by the author using Gray's New Manual of Botany (*4*); Coulter and Nelson's Manual of Rocky Mountain Botany (*1*); Gates' Wild Flowers in Kansas (*3*); Mattoon, Phillips, and Gibbs' Forest Trees of Oklahoma (*8*); and Hitchcock's Manual of the Grasses of the United States (*6*). Many of the identifications were verified by S. F. Blake, Bureau of Plant Industry, U. S. Department of Agriculture.

ated species. Continued pasturing has removed the bunchgrasses, and at present the dominant vegetation on pastures is buffalo grass and blue grama. Bluestem grasses persist on ungrazed roadsides.

The plant association on salty soils is dominated by desert saltgrass (*Distichlis stricta*). The other grasses are similar to those on the typical prairie soils and grow in greater abundance where the salt content of the soil is less. *Sesuvium* sp. and a few other salt-loving plants that are not grasses are common in these areas.

Another type of plant association grows on deep loose sandy soils northwest of Enid and in the southwestern part of the county. It is dominated by blackjack oak (*Quercus marilandica*). Associated species are little bluestem, sand bluestem, Indian grass (*Sorghastrum nutans*), *Panicum* species, Johnson grass (*Sorghum halepense*), field sandbur (*Cenchrus pauciflorus*), commonly called grassbur, and hairy grama (*Bouteloua hirsuta*).

The fourth plant association occurs along the stream courses, on the alluvial soils. It consists of American elm (*Ulmus americana*), chinquapin oak (*Quercus muhlenbergia*), post oak (*Q. stellata*), blackjack oak, hackberry (*Celtis occidentalis crassifolia*), gum elastic (*Bumelia lanuginosa*), commonly called chittimwood, willow (*Salix* sp.), cottonwood (*Populus deltoides virginiana*), and Chickasaw plum (*Prunus angustifolia*). Associated with the trees are several species of grass, principally bluestem. Common shrubs are fragrant sumac (*Rhus aromatica*), smooth sumac (*R. glabra*), and roughleaf dogwood (*Cornus asperifolia*), commonly called smallflowered dogwood.

Grasses of minor importance are wild-rye (*Elymus robustus*), western wheatgrass (*Agropyron smithii*), stinkgrass (*Eragrostis major*), cheat (*Bromus* sp.), crabgrass (*Digitaria sanguinalis*), Bermuda grass (*Cynodon dactylon*), witchgrass (*Panicum capillare*), and three-awn (*Aristida* sp.).

A list of the flowering plants identified in the county follows. The common names are given where possible.

Scientific name	Common name
Acerates angustifolia	Green milkweed.
Acerates viridiflora	Do.
Achillea lanulosa	Western yarrow.
Allionia linearis	Umbrellawort.
Allionia nyctaginea	Wild four-o'clock.
Allium canadense	Wild garlic.
Allium nuttallii	Wild onion.
Amorpha canescens	Leadplant.
Anemone sp	Anemone.
Argemone squarrosa	Pricklepoppy.
Artemisia ludoviciana	Louisiana wormwood, sweet sage, or cudweed.
Asclepias arenaria	Sand milkweed.
Asclepias speciosa	Milkweed.
Asclepias tuberosa	Butterflyweed.
Asclepidora viridis	Oblong-leaved milkweed.
Aster sp	Aster (several species).
Astragalus mollissimus	Woolly loco.
Astragalus missouriensis	Milkvetch.
Baptisia vespertina	Blue wild-indigo.
Baptisia leucophaea	Large-bracted wild-indigo.
Callirhoe alceoides	Light poppy-mallow.
Callirhoe involucrata	Purple poppy-mallow.
Capsella bursa-pastoris	Shepherds-purse.

Scientific name	Common name
Cirsium undulatum	Wavy-leaved thistle.
Claytonia virginica	Springbeauty.
Cleome serrulata	Rocky Mountain beeplant.
Cleomella angustifolia	Cleomella.
Commelina crispa	Curly-leaved dayflower.
Convolvulus arvensis	Field bindweed.
Coreopsis tinctoria	Calliopsis.
Cristatella jamesii	Cristatella.
Croton texensis	Texas croton.
Croton glandulosus	Croton.
Cucurbita foetidissima	Gourd.
Delphinium virescens	Prairie larkspur.
Desmanthus illinoensis	Illinois mimosa.
Echinacea angustifolia	Niggerhead, or purple coneflower.
Engelmannia pinnatifida	Engelmannia.
Eriogonum annuum	Annual eriogonum.
Euphorbia marginata	Snow-on-the-mountain.
Eustoma russellianum	Prairiegentian.
Evolvulus nuttallianus	Evolvulus.
Froelichia campestris	Froelichia.
Froelichia gracilis	Do.
Gaillardia pluchella	Gaillardia, or Indian blanket.
Galium aparine	Bedstraw.
Gaura coccinea	Scarlet gaura.
Gaura parviflora	Small-flowered gaura.
Geranium carolinianum	Carolina geranium.
Geum vernum	Yellow avens.
Glycyrrhiza lepidota	Wild licorice.
Gutierrezia sarothrae	Broomweed.
Hedeoma hispida	Mock pennyroyal.
Helianthus annuus	Common sunflower.
Helianthus rigidus	Sunflower.
Hibiscus trionum	Flower-of-an-hour.
Houstonia angustifolia	Narrow-leaved houstonia.
Hymenopappus corymbosus	Hymenopappus.
Ipomoea leptophylla	Bush morning-glory.
Jussiaea diffusa	Creeping primrose-willow.
Lactuca sp.	Wild lettuce.
Lepachys columnaris (*Ratibida columnaris*)	Prairie coneflower.
Lepidium densiflorum	Peppergrass.
Lepidium texanum	Do.
Leptoglottis nuttallii (*Schrankia uncinata*)	Sensitive rose.
Liatris punctata	Gayfeather, or blazing-star.
Linaria texana	Toadflax.
Linum rigidum	Yellow flax.
Linum sulcatum	Do.
Lippia cuneifolia	Fogfruit.
Martynia louisiana	Devil's-claw, or unicornplant.
Meibomia illinoensis	Illinois tick trefoil.
Melilotus alba	White sweetclover.
Melilotus officinalis	Yellow sweetclover.
Mentzelia decapetala	Prairie lily.
Mentzelia oligosperma	Stickleaf.
Monarda sp.	Horsemint.
Oenothera albicaulis	White evening-primrose.
Oenothera lacinata	Cut-leaved evening-primrose.
Oenothera serrulata	Rocky Mountain beeplant, or evening-primrose.
Oenothera speciosa	Showy evening-primrose.
Opuntia sp.	Pricklypear.
Orobanche ludoviciana	Broomrape.
Oxalis corniculata	Yellow woodsorrel.
Oxalis violacea	Violet oxalis.
Parosela aurea	Golden parosela.
Parosela enneandra	Parosela.

Scientific name	Common name
Petalostemon purpureus	Purple prairie clover.
Penstemon grandiflorus	Large-flowered beardtongue.
Physalis sp	Groundcherry, or nightshade.
Phytolacca americana	Pokeweed.
Plantago aristata	Large-bracted plantain.
Plantago purshii	Plantain.
Polanisia trachysperma	Large-flowered clammyweed.
Polygala sp	Milkwort.
Polygonum pennsylvanicum	Smartweed.
Psoralea argophylla	Silver-leaf psoralea.
Psoralea cuspidata	Psoralea.
Psoralea tenuiflora	Peabush, or few-flowered psoralea.
Rudbeckia hirta	Black-eyed-susan.
Ruellia ciliosa	Hairy ruellia.
Sabbatia campestris	Prairie rosegentian.
Salvia azurea	Salvia, or blue sage.
Sida hederacea	Round-leaved sida.
Silene antirrhina	Sleepy catchfly.
Sisyrinchium campestre	Blue-eyed-grass.
Solanum carolinense	Horse-nettle.
Solanum rostratum	Buffalobur.
Solidago sp	Goldenrod (several species).
Sophora sericea	Coralbean.
Specularia leptocarpa	Venus looking glass.
Specularia perfoliata	Do.
Spermolepis patens	Spermolepis.
Sphaeralcea coccinea	Red false mallow.
Stenosiphon linifolius	Stenosiphon.
Strophostyles leiosperma	Small wild bean.
Teucrium canadense	Wood sage.
Thelesperma gracile	Rayless thelesperma.
Thelesperma trifidum	Thelesperma.
Tradescantia bracteata	Long-bracted spiderwort.
Tragopogon pratensis	Yellow goatsbeard.
Tribulus terrestris	Puncture-vine.
Verbena bracteosa	Verbena.
Verbena stricta	Hoary verbena.
Vernonia baldwini	Ironweed.
Yucca glauca	Yucca.

Garfield County is located in what originally was called the Cherokee Strip in Indian Territory. The Chisholm Trail, which later became famous as a route for the driving of cattle from Texas to the railroad at Wichita, Kans., passed through this section. Ranch headquarters were established, and by the late seventies this was an important range country. The Cherokees decided they would derive revenue from the land and required cattlemen to pay rent for the range. This led to the organization of the Cherokee Strip Livestock Association to deal with the Indians. The Federal Government bought this land from the Cherokee Nation in 1893 and opened it to settlement at noon on September 16, 1893. The settlers were largely from Kansas, Texas, Missouri, and other Middle Western States. Most of them were white people whose ancestors originally came from northern Europe. A great many were of German descent. Garfield County was established in 1907, at the time Oklahoma became a State.

According to the Federal census, Enid, the principal city and county seat, had a population of 26,399 in 1930. The populations of other towns in the same year were as follows: Garber, 1,356; Covington, 927; and Waukomis, 445.

The county is exceptionally well provided with railroad facilities. Radiating from Enid are 10 lines of the Chicago, Rock Island & Pacific Railway, the St. Louis-San Francisco Railway, and the Atchison, Topeka & Santa Fe Railway; and no part of the county is more than 8 miles from a railroad.

United States Highways Nos. 81, 60, and 64, all which are paved, cross the county. Graveled roads have been constructed at intervals of 10 or 12 miles throughout the county. Good graded dirt roads occur at intervals ranging from 2 to 5 miles in most parts, and ungraded roads follow most of the section lines except in a few of the rougher localities.

Telephone communication is available along the main roads, particularly in the area northeast of Covington. Electricity is available in the towns and on farms located along the main power lines connecting the towns. All parts of the county have rural free delivery of mail.

The towns are well supplied with grade schools and high schools, and there are a few consolidated schools in the rural sections. As a rule, the rural sections have two-room schools from 3 to 5 miles apart. Churches are in all towns; in some of the rural sections school buildings are utilized as churches.

A plentiful supply of good drinking water is available at a depth ranging from 80 to 120 feet in the sandy areas northwest of Enid and southwest of Drummond. Enid obtains its water supply from wells drilled in the sandy beds nearby. In other parts of the county, fair supplies of underground water are obtained at various depths, some as much as several hundred feet, but the water generally contains some dissolved gypsum. It is locally called "gyp" water and has a salty or slightly disagreeable taste, but it is not considered unhealthful. Drinking water occurs at a slight depth in the bottom lands. As the wind blows almost constantly, windmills are generally used for pumping water. Many farmers build earth dams, in order to obtain a supply of water for their livestock.

This county is largely an agricultural, rather than an industrial county, and most of the industries are directly related to the processing and utilization of agricultural products. The principal establishments of this type in Enid are flour mills, feed mills, creameries, milk condenseries, poultry-packing plants, meat-packing plants, bakeries, broom factories, and mattress factories.

CLIMATE

The climate is distinctly continental and is characterized by rather wide fluctuations of temperature. The rainfall is fairly well distributed during the year, but the wettest months are from April to October, inclusive. Rather severe droughts are common. The average wind velocity is 11.6 miles an hour.

The summers are decidedly warm, and temperatures of 105° F. often occur. Hot southerly winds sometimes scorch the vegetation in summer. The winters are fairly mild and open, but they are characterized by numerous short cold periods, or so-called northers, which are accompanied by strong northerly winds, suddenly lowered temperature, and, occasionally, light rain or snow. The temperature

sometimes drops below zero. After about 3 days these cold periods are relieved by southerly winds.

The sun shines approximately 70 percent of the possible time. The average frost-free season extends from March 30 to October 31, a period of 215 days. Late frosts often destroy or seriously injure fruit crops. The latest frost of record is May 1, and the earliest, October 10.

The choice of crops in this section is limited to those that are able to withstand drought. Winter wheat is the most important crop of this type. It remains semidormant during the comparatively dry winter and is matured by the early summer rains. Early spring-sown oats and barley are grown to some extent. These crops make little demands on the moisture supply until early summer. Sorgo, grain sorghums, and Sudan grass withstand drought by rolling their leaves and closing their stomata to cut down transpiration. Their extensive root systems also aid in resisting drought. Some alfalfa, cowpeas, cotton, and corn are grown. During many years the frost-free season is too short for the profitable production of cotton. The rainfall is not favorably distributed for the growing of corn.

Important climatic data, compiled from the records of the United States Weather Bureau station at Enid, are given in table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Enid, Garfield County, Okla.*

[Elevation, 1,269 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1936)	Total amount for the wettest year (1915)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	37.1	75	−3	1.18	2.10	0.17	3.2
January	35.7	82	−11	1.06	.23	.55	2.5
February	39.4	92	−20	1.18	.05	4.11	3.6
Winter	37.4	92	−20	3.42	2.38	4.83	9.3
March	50.0	100	9	1.60	.00	1.20	.9
April	58.4	95	21	3.26	.62	4.30	(1)
May	67.1	102	28	4.34	2.61	7.87	.0
Spring	58.5	102	9	9.20	3.23	13.37	.9
June	76.8	110	43	4.24	2.39	12.11	.0
July	81.8	112	50	2.74	.15	3.58	.0
August	81.5	113	45	3.48	.48	5.98	.0
Summer	80.0	113	43	10.46	3.02	21.67	.0
September	73.7	109	35	3.06	5.67	5.20	.0
October	60.9	100	17	2.92	2.52	1.79	(1)
November	48.8	92	9	1.60	.10	.31	.4
Fall	61.1	109	9	7.58	8.29	7.30	.4
Year	59.3	113	−20	30.66	16.92	47.17	10.6

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

Prior to 1893, the land included in Garfield County was open range. Before the advent of the white man in 1850, herds of buffalo, deer,

elk, and antelope roamed the range. The first white inhabitants of this territory were ranchers, and cattle raising was the most important agricultural enterprise during pioneer days. After the land was formally opened to settlement by white men in 1893, it was rapidly taken up, and small areas were put in cultivation on almost every quarter section. The settlers came largely from Kansas and the Middle West, where corn and wheat were the principal crops. They first attempted the types of farming to which they were accustomed, but droughts and hot dry winds eliminated corn as an important crop. Owing to high wheat prices and the introduction of power machinery, the production of wheat became the chief farm enterprise, and it still dominates the agriculture. This change has been accompanied by a marked decrease in the production of corn, a slight decrease in the production of grain sorghums, and an increase in the size of farms and the percentage of tenancy.

Selected data from the Federal census given in table 2 indicate the trend of agriculture in this county.

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

Crop	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Wheat	193,928	132,538	324,285	341,262	269,215
Oats	17,812	51,478	41,574	32,711	31,543
Corn	66,436	153,540	8,655	19,954	338
Barley	4,357	293	1,141	1,804	5,705
Grain sorghums	4,238	6,453	5,725	3,883	2,943
Cotton	467	1,929	92	1,478	1,773
Wild grasses cut for hay	24,978	15,048	9,679	7,502	[1] 5,609
Alfalfa	548	10,991	16,547	10,471	12,190
Sorghums for silage, hay, or fodder			6,353	9,284	13,700
Other tame hay	2,316	24,342	5,429	3,924	3,189
	Trees	*Trees*	*Trees*	*Trees*	*Trees*
Apples	105,902	104,742	16,712	5,821	1,702
Peaches	541,411	214,763	17,189	11,660	5,733
Cherries	41,584	27,967	5,335	4,090	2,653
	Vines	*Vines*	*Vines*	*Vines*	*Vines*
Grapes	257,649	133,600	13,170	12,488	4,817

[1] Includes tame and wild grasses.

Following the growing of crops, the next important agricultural activity is the raising of cattle for market. A great many farms have some rough or rolling land that is not suited to crop production, and these areas are utilized as grazing land. There were 56,568 head of cattle in the county on January 1, 1935. The Hereford is the most common breed of beef cattle, but a few farms are stocked with Aberdeen Angus and Shorthorns. The ranges are stocked at the rate of one cow to 3 acres of good pasture. Supplemental feeding of sorgo, grain sorghum, and cottonseed cake is practiced on most ranches during the winter. Most of the cattle are shipped as feeders and stockers instead of being finished, as the supply of corn for fattening is insufficient. Considerable numbers of cattle are partly finished and slaughtered locally or are shipped to Oklahoma City or Wichita, Kans.

Dairying is an important enterprise on many farms. particularly on those near Enid and Garber. Both whole milk and cream are produced for market. The dairy products produced on farms remote from centers of population generally are sold in the form of cream.

The dairy cattle are largely Holstein-Friesians, but there are also a number of Jerseys and Guernseys.

Chickens are raised on most farms because they can be fed low-grade and shattered wheat that otherwise would be wasted. Rhode Island Red, White Leghorn, and Plymouth Rock are the common breeds. A few Bronze turkeys are raised. Poultry products are sold for local consumption, and some eggs and dressed poultry are shipped to Oklahoma City and Wichita. Production of poultry was formerly a much more important farm activity here than it is at present. The hatching of baby chicks for sale has received considerable attention, and commercial hatcheries produce baby chicks for local and eastern markets.

On many farms hogs are raised for a home supply of meat and lard, but their production on a commercial scale is limited by the scarcity of corn. The number of hogs on the farms on January 1, 1935, was 9,683.

In the period of prosperity following the World War, the use of tractors increased markedly, and the use of horses decreased correspondingly. Recently this trend has been reversed. Work animals are of mediumweight Percheron, Clydesdale, and mixed breeds. They average somewhat heavier than the horses in the southern part of the State.

Very little fertilizer is used, partly because most of the soils do not need it greatly and partly because the response, especially to commercial fertilizer, is often negative under conditions of light rainfall. Excessive fertilization induces rapid growth of crops which may exhaust all the available moisture and and leave the large plants to die. On the other hand, plants grown on moderately fertile land are smaller and therefore require less moisture. A phosphorus fertilizer is the principal type needed. The content of readily available phosphorus is said to be low in the soils of the southeastern and eastern parts of the county.[5] The sandy soils need manure or nitrogenous fertilizers in addition to phosphorus.

Labor was once a very large item of expense, particularly at harvest time. The combined harvester, tractor, and other labor-saving devices have eliminated a great deal of the expense for labor. Wheat generally is harvested by the farmer and his family or neighbor. Laborers are paid from $1 to $1.25 a day at present (1935).

The land included in this county was settled originally in units of one-quarter of a section (160 acres). The development and use of power machinery later made it economically advantageous for one farmer to handle a larger acreage, and this has encouraged the expansion of the size of farms. The average size increased from 172.5 acres in 1900 to 213.5 acres in 1935. Land generally is sold, however, in units of 160 acres, locally called quarters. Farms of 160 and 320 acres are the most common.

Farm tenancy increased after the introduction of power machinery because it became profitable to rent additional land and utilize the expensive machinery to the utmost. According to the United States census reports, the percentage of tenancy increased from 17 percent in

[5] From unpublished data furnished by H. J. Harper, professor of soils, Oklahoma Agricultural and Mechanical College.

1900 to 48.3 percent in 1935. Under the most common terms of rental the landlord receives one-third of the crop delivered at the elevator. For farms which include highly productive soils, the tenant is, in some instances, required to pay a bonus in addition to the customary one-third of the crop. Cash rent is not common except for pasture land, the rental of which ranges from 50 cents to $1 an acre a year.

The equipment on a wheat farm of 160 or 320 acres consists of a 10–20 or 15–30 tractor, an 8-foot one-way plow or a lister, a 12-foot drill, a combine harvester, and a 2-ton truck. From four to eight horses may be substituted for the tractor, and a binder or header with wagons or header boxes for the combine harvester. A trailer may be used instead of a truck. Farmers handling large acreages often use binders during the early harvest and change to the combine as the crop becomes more mature. If grain sorghums and Sudan grass are grown, a lister, corn planter, cultivator, corn binder, and wagon are needed. A mowing machine and rake may take the place of the corn binder. The mechanical equipment on most farms is kept in good condition because the wheat crop may be lost if harvesting is delayed on account of faulty machinery. The average investment for machinery on a farm in this county was $1,038 in 1930. The high cost of farm equipment has operated against the farmer with small capital.

Most of the farms have fairly good farmsteads consisting of a two- to four-room frame house, a windmill, a chicken house, and a small barn. The livestock farms have more pretentious barns. There are practically no silos, because corn is not a successful crop. The average investment in buildings on the farms in Garfield County in 1930 was $1,970 a farm.

SOIL-SURVEY METHODS AND DEFINITIONS

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

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [6] and its content of lime and salts are determined by simple tests.[7] 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, special 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

[6] 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.

[7] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

grouped in mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as rough broken land 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. Pond Creek, Grant, Reinach, Kirkland, and Oswego are names of important soil series in this county.

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

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that 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 difference 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 are medium textured and comparatively fertile. The heavier soils, which developed under a grass cover, are not very highly leached. Most of the soils are fairly well supplied with the plant nutrients necessary for the production of crops. Additions of commercial fertilizers, manure, or lime generally are unnecessary

and, in some instances, may be detrimental if moisture conditions are unfavorable. Phosphatic fertilizers give fair returns on some of the soils, particularly in the southwestern part of the county. Lighter textured soils in the southwestern part and northwest of Enid, however, respond to additions of nitrogen, manure, and phosphorus fertilizers. Nitrogenous fertilizers and manure on the medium-textured soils sometimes reduce yields by inducing rapid growth which exhausts the supply of moisture early in the season.

Figure 2 is a generalized land-type map of the county.

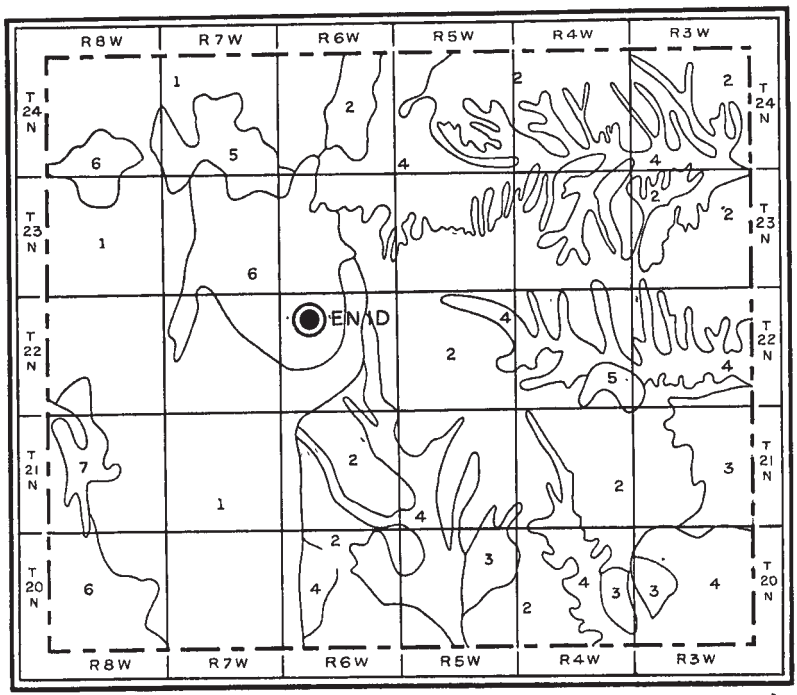


FIGURE 2.—Generalized land-type map of Garfield County, Okla.: 1, Smooth agricultural land having a permeable crumbly subsoil; 2, smooth agricultural land with a claypan subsoil; 3, undulating to rolling agricultural land; 4, rolling to strongly rolling land; 5, hilly nonarable land; 6, sandy land; 7, saline land.

The surface soils of most of the soils in this county are brown, reddish-brown, or grayish-brown very fine sandy loams to a depth ranging from 6 to 20 inches. The material is somewhat darkened by the presence of organic matter that has accumulated through the decay of grass remains and is generally darker in the smoothly undulating areas than in the more rolling areas. Some of the soils occurring in very flat areas have a gray surface soil. The color and texture of the subsoils vary according to the degree of slope and the type of underlying rock. A heavy claypan, locally called hardpan, is present in the subsoil of some soils in the eastern part of the county. This claypan occurs only in smoothly undulating or flat areas. A thin brownish-gray layer overlies the claypan.

The lower subsoil layers of most of the soils are reddish brown or brownish red—the color of the underlying shales and sandstones. The sandy soils northwest of Enid and southwest of Drummond, however, have yellowish-brown subsoils and have developed from Quaternary sands. In some soils a distinct layer, or horizon, lying from 3 to 6 feet beneath the surface, contains more or less calcareous material representing an incipient zone of accumulated material as a result of soil development. This is a characteristic of pedocalic soil development, and its indefinite extent is indicative of the transitional zone between the soil regions of pedocalic and pedalferic influence within which the county lies.

Differences in productivity of the soils in the sandy group are related largely to the texture of the soils. The heavier textured soils are, as a rule, more productive and, therefore, more valuable. The productivity of many soils is influenced largely by variations in surface slope. Soils occurring on the steeper slopes are more red and more shallow than elsewhere as a result of greater run-off and, hence, produce lower yields than other soils. Erosion of the surface soil on slopes also prevents the accumulation of large amounts of organic matter in these soils.

The heavy subsoils prevalent throughout this county are favorable to the production of small grains. The movement of moisture is slower in heavier textured subsoils, and, therefore, the moisture is used more slowly by the plants. This helps wheat plants to survive the dry winters, as they spend the winter in a semidormant condition, during which time little moisture is required. The wheat is matured by early rains. Winter wheat is the dominant crop in this section, because it is particularly adapted to the climatic and soil conditions. Oats are sown in late winter or early spring, and the heaviness of the subsoil is not quite so important a factor in the growth of that crop. Spring-sown oats and barley are of less importance than winter wheat. Late spring-sown crops of minor importance are grain sorghums, alfalfa, sorgo (sweet sorghum), and Sudan grass. Some cotton, cowpeas, peanuts, and watermelons are grown on the more sandy soils.

For purposes of discussion, the soils of the county are placed in the following groups on the basis of soil character: (1) Brown Prairie soils with friable subsoils, (2) brown Prairie soils with dense heavy subsoils, (3) reddish-brown Prairie soils with friable subsoils, (4) red Prairie soils with both heavy and friable subsoils, (5) grayish-brown sandy soils with very friable subsoils, (6) brown soils with saline subsoils, (7) alluvial soils, and (8) miscellaneous nonarable land.

The different soils in each county covered by a soil survey are classified according to their physical and chemical characteristics and are given names in order to facilitate their description and orderly arrangement in the scheme of soil correlation and classification. In the following pages, the soils of the county are described and their agricultural relationships are discussed. The location and distribution of each soil 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 Garfield County, Okla.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Pond Creek silt loam	20,032	3.0	Reinach loamy fine sand	3,200	0.5
Grant very fine sandy loam	99,840	14.9	Pratt fine sandy loam	3,072	.5
Reinach very fine sandy loam	39,040	5.8	Pratt loamy fine sand	18,944	2.8
Reinach silty clay loam	2,112	.3	Pratt loamy fine sand, dune phase	5,504	.8
Kirkland silt loam	167,680	25.0	Drummond very fine sandy loam	9,344	1.4
Oswego silt loam	37,184	5.5	Drummond clay	1,792	.3
Carwile loam	8,384	1.3	Yahola very fine sandy loam	22,464	3.4
Carwile fine sandy loam	20,288	3.0	Lincoln loamy fine sand	4,992	.7
Renfrow silt loam	52,672	7.8	Enterprise fine sand, dune phase	5,056	.8
Renfrow clay loam	8,320	1.2	Rough broken land (Vernon soil material)	27,840	4.1
Nash very fine sandy loam	11,904	1.8			
Vernon very fine sandy loam	37,824	5.6			
Vernon clay loam	63,872	9.5	Total	671,360	

BROWN PRAIRIE SOILS WITH FRIABLE SUBSOILS

Included in this group are the most valuable agricultural soils of Garfield County. The surface soil of most of these soils is brown or dark-brown very fine sandy loam and ranges from 10 to 20 inches in thickness. The subsoil is moderately heavy but is not a claypan. These soils occur on smooth divides and in gently undulating areas of the western one-third of the county and along high terraces in the larger stream valleys. They are adapted to the production of the principal crops grown, and their smooth relief makes them well suited to the use of heavy types of machinery. Fertilizers are not needed on these soils. The land is not subject to severe erosion. Acre yields of wheat range from 13 to 18 bushels, depending on the soil type. Included in this group are Pond Creek silt loam, Grant very fine sandy loam, Reinach very fine sandy loam, and Reinach silty clay loam.

Pond Creek silt loam.—Pond Creek silt loam is considered the most productive soil in the county. It is a dark Prairie soil occurring on flats in the western part, principally in the vicinity of Carrier, west of Enid, and west of Waukomis, in association with Grant very fine sandy loam.

The surface soil to a depth of 6 inches is dark-brown loose friable silt loam which is easily kept in good tilth. The material in this layer is somewhat lighter colored under cultivation. Between depths of 6 and 14 inches is dark-brown or very dark brown silt loam that breaks into large irregular blocks where exposed in cut banks. These blocks, in turn, break horizontally into easily broken plates, from one-half to 2 inches in thickness. The material is slightly lighter colored when crushed. In cultivated fields this layer appears darker than the surface layer. Beneath this is brown or dark-brown silty clay loam continuing to a depth ranging from 24 to 30 inches. This material breaks into irregular blocks that are smaller than those in the layer above. Below this layer is dark-brown heavy clay loam which breaks into distinctly cubical clods from 1 inch to 1½ inches in diameter. The surfaces of the clods are not shiny as are the surfaces of the clods in claypan soils. A gray layer of limy material is reached at a depth ranging from 40 to 50 inches. Red sandy shales or red sandstone of the upper Enid formation of Permian Red Beds underlie the soil at a depth of several feet. Both surface soil and subsoil are about neutral in reaction.

As this soil occupies flat divides, it is not subject to losses of moisture and surface soil through run-off and erosion. Few areas are poorly drained.

This is a very fertile and productive soil, and it is particularly adapted to the production of wheat, oats, and sorghum. Acre yields of wheat range from 5 to 40 bushels, with an average of 18 bushels; alfalfa averages 1¼ tons; and oats from 5 to 60 bushels an acre, with an average of approximately 38 bushels. Approximately 50 percent of this soil is cultivated to small grains, 4 percent to sorghums, 13 percent to alfalfa, and 19 percent is in pasture. Buffalo grass and blue grama are the principal pasture grasses. The carrying capacity of pasture is approximately 3 to 3½ acres for each cow, with supplemental feeding during the winter.

Grant very fine sandy loam.—Grant very fine sandy loam occupies smoothly undulating uplands in the western part of the county, and a few small areas are in the extreme southeastern part.

The 6-inch surface layer is brown friable very fine sandy loam which is very easily kept in good tilth. It is underlain to a depth of 9 or 10 inches by brown heavy very fine sandy loam which, in dry exposed cuts, breaks into five-sided blocks, or prisms, from 4 to 8 inches in diameter, some of which are wedge-shaped. These may be broken easily between the thumb and fingers, and the material is lighter colored when crushed. Below this is brown silty clay loam which continues to a depth of 18 or 20 inches. This material breaks into blocks similar to, but somewhat harder than, those in the overlying layer, although they may be broken with the hands. These blocks, in turn, break into small aggregates or clods from one-sixteenth to one-fourth inch in diameter. Between depths of 18 or 20 inches and approximately 40 inches is reddish-brown silty clay loam which breaks into irregular clods. The clods are broken with difficulty between the thumb and fingers when the soil is dry, and the material is light reddish brown when crushed. Below a depth of 40 inches is reddish-brown clay loam that is slightly less compact than the material above. In places, a slightly gray layer of carbonate of lime occurs in the subsoil at a depth ranging from 40 to 60 inches. Red sandy shale or sandstone of the Permian Red Beds is reached at a depth ranging from 6 to 10 feet. Most of these rocks are of the upper Enid formation, but some are of the lower Enid formation. Both surface soil and subsoil are practically neutral in reaction. Plate 1, *A*, shows a profile of this soil.

The occurrence of this soil on gently rolling to undulating uplands subjects it to slight losses of moisture and surface soil through run-off. The soil is very productive and is well adapted to the principal crops grown in this section. Yields of wheat range from 5 to 35 bushels an acre and average 17 bushels. Oats yield about 35 bushels. Yields of grain sorghums average approximately 20 bushels an acre, and yields of sorgo cut for hay range from 1 to 3 tons. Alfalfa yields about 1½ tons. Approximately 70 percent of this soil is used for the production of small grains, 4 percent for sorghums, 6 percent for alfalfa, and 13 percent is in native pasture. The native vegetation is largely buffalo and blue grama grasses (pl. 1, *B*). The carrying capacity of the pasture is about 3 to 3½ acres for each cow, with supplemental feeding during the winter.

Reinach very fine sandy loam.—Reinach very fine sandy loam is a brown soil developed on terraces or very high stream bottoms. It lies along the flood plains of all the larger streams, especially those of Turkey, Skeleton, Red Rock, and Black Bear Creeks, at a height ranging from 5 to 25 feet above the stream channel, and it is above ordinary overflow. This soil is very similar to Grant very fine sandy loam.

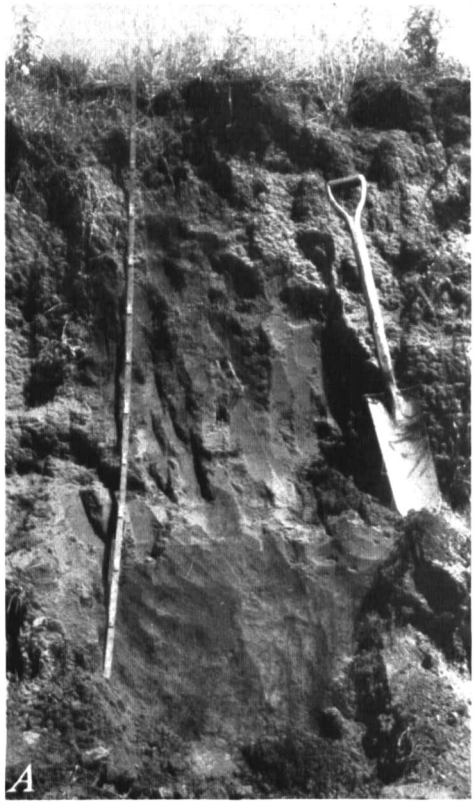
The surface layer extends to a depth of 12 inches and is brown, dark-brown, or, in some places, faintly reddish brown very fine sandy loam. The material in this layer is very friable and is easily kept in good tilth. In exposed cuts it breaks into indistinct prisms. It is underlain to a depth ranging from 24 to 30 inches by brown or grayish-brown very fine sandy loam or silty clay loam, which is more distinctly prismatic in structure. The subsoil below this is very friable, but, in a few places, the subsoil is heavy and almost a claypan in character. The surface soil and subsoil are noncalcareous. In a great many places there is a dark layer in the subsoil, which appears to be an old surface soil buried by overflow and deposition of silt. As many as three successive soil profiles have been observed in deep cuts in this soil.

Reinach very fine sandy loam is one of the most highly productive soils in the county. It is well supplied with the nutrients necessary for plant growth and is suited to all the principal crops ordinarily grown, as well as to alfalfa. It occurs on flat terraces, most of which are cut by one or more deep stream channels. The channels, or gullies, cannot be crossed by farm implements, and the result is some waste land and irregular-shaped fields. Yields of wheat on this soil average approximately 16 bushels to the acre. Sorghums for hay or rough forage produce from 2 to 3 tons, and alfalfa produces 2 tons of hay. Approximately 63 percent of the land is cropped to small grains, principally wheat, 3 percent to sorghums, 1 percent to Sudan grass, 11 percent to alfalfa (pl. 2, *A*), and most of the remaining 22 percent is in pasture. The native pasture is composed of buffalo and blue grama grasses. It will support a cow on each 3 acres, provided there is some supplemental feeding during the winter.

Reinach silty clay loam.—Reinach silty clay loam occupies small scattered areas on high bottoms or terraces along the edges of valleys, especially the valley of Red Rock Creek. This soil is composed principally of eroded material washed from the red Vernon soils on the valley slopes.

The topmost 6 inches of the cultivated soil is reddish-brown friable granular silty clay loam or clay loam, which is neutral in reaction. Below this and continuing to a depth ranging from 18 to 24 inches is compact brownish-red or red clay, which breaks into hard clods from one-eighth to one-half inch in diameter. The material in this layer is calcareous. It gives way to dark reddish-brown less compact calcareous clay loam. The lower part of the subsoil, in a few places, contains strata of sand and of darker material. This soil is not subject to appreciable erosion or losses of moisture through run-off. In places, it is covered by a thin layer of material washed from adjacent higher land.

This soil is suited to the principal crops grown in the county, as well as to alfalfa. The average acre yields are as follows: Wheat,



A, A cut exposing a profile of Grant very fine sandy loam. A very slight gray lime zone is present at a depth of 42 inches. *B*, Native vegetation on Grant very fine sandy loam.

A, Alfalfa on Reinach very fine sandy loam; *B*, harvesting wheat on Kirkland silt loam.

about 15 bushels; grain sorghums, about 22 bushels; and alfalfa, about 2 tons. Practically all of this soil is cropped, largely to wheat and alfalfa. The native vegetation probably consisted chiefly of bluestem grasses.

BROWN PRAIRIE SOILS WITH DENSE HEAVY SUBSOILS

The soils in this group are valuable agricultural soils. The material in the upper 10 to 18 inches of them is brown or grayish brown and is of medium texture. It is underlain by rather heavy, tough, or dense claypan or semiclaypan subsoils. These soils are sometimes referred to locally as hardpan soils, but they are not true hardpans. Ordinarily, fertilizers are unnecessary. The land is not subject to severe erosion. Because of their comparatively heavy subsoils, these soils are particularly suited to the production of wheat, yields of which range from 12 to 16 bushels to the acre, and they are fairly productive of the other crops adapted to this section. The smooth divides and gently undulating uplands of the eastern part of the county, where these soils occur, are well suited to the use of heavy machinery. They cover a total area of 364.9 square miles. Included in this group are Kirkland silt loam, Oswego silt loam, Carwile loam, and Carwile fine sandy loam.

Kirkland silt loam.—Kirkland silt loam is the most extensive soil in the county. It is a brown soil that is similar to Oswego silt loam, with which it is associated in the eastern part, but it occurs on gently undulating areas instead of on flats and its claypan layer is not so dense and heavy as that of the Oswego soil.

The surface layer is dark-brown friable silt loam, about 9 inches thick, which is easily maintained in good tilth. It grades into dark-brown silty clay loam. This material, in exposed cuts, breaks apart naturally into five-sided prisms that, in turn, break horizontally in some places forming blocks, or plates, 2 or 3 inches thick. These blocks are crushed easily between the thumb and fingers into soft granules or clods from one-eighth to one-fourth inch in diameter. Below a depth of 16 inches is a 2- to 4-inch layer of clay loam. This material breaks into irregular clods, from one-eighth to one-half inch in diameter, which are coated with gray and are brown in the interior. Abruptly underlying this layer is chocolate-brown or dark-brown heavy clay or claypan, which breaks into roughly cubical clods from 1 to 2 inches in diameter. These clods cannot be broken with the bare hands if the soil is dry. The reaction of the material in this layer is slightly acid. Below a depth of about 25 inches the material is slightly less compact and lighter colored. In most places, a few white fine concretions of calcium carbonate are present in the subsoil at a depth ranging from 36 to 45 inches. Below this depth is brownish-red and brown mottled clay which nearly everywhere is calcareous. The clay grades into red heavy shales of the lower Enid formation of the Permian Red Beds at a depth of several feet.

Kirkland silt loam is a fertile soil that is particularly adapted to the production of small grains. Its heavy clay subsoil retains moisture during the dry winter and releases it to plants very slowly, and its smooth surface allows the use of improved machinery and implements. Losses due to erosion are slight, but some water is lost

through run-off. Yields of wheat range from 5 to 35 bushels an acre, with an average of 15 bushels (pl. 2, *B*). Sorgo yields approximately 2 tons of hay an acre, and Sudan grass and alfalfa yield about 1½ ton each. From observations and studies of crops on this soil, during the course of the survey, it is estimated that 96 percent of the land is cropped to small grains, 0.65 percent to sorghums, 0.45 percent to alfalfa, 0.15 percent to Sudan grass, and 2.5 percent is in native pasture. The native pasture consists largely of buffalo and blue grama grasses. The original growth was largely bluestem. According to local information, the carrying capacity of pasture on this soil is about 3 acres for each cow.

Oswego silt loam.—Oswego silt loam is a brown or grayish-brown soil occurring on upland flats in the eastern two-thirds of the county, in association with the more extensive Kirkland silt loam. The principal areas are those on the flat divide in the vicinity of Breckinridge. Areas occur on the divides in the vicinities of Garber, Covington, Hunter, and Cropper. This is locally called hardpan land or ashy land and is a claypan soil.

The 6-inch surface layer consists of grayish-brown friable silt loam that is mildly acid in reaction. In uncultivated virgin areas this material breaks naturally into thin plates. It grades into rather friable grayish-brown silty clay loam which, in some places, breaks into blocks similar to those formed by the material in the corresponding layer of Kirkland silt loam. Beginning at a depth ranging from 9 to 12 inches and continuing to a depth of 16 or 18 inches, the subsurface material is light grayish-brown or brown slightly acid clay loam which, on drying, separates naturally into irregular clods from one-half to one-fourth inch in diameter. The clods are coated with gray and are brown in the interior. This layer rests abruptly on a very dark brown or almost black heavy clay or claypan, which, in dry weather, cracks vertically, forming large irregular square-topped prisms. The cracks are coated with grayish-brown material at the top and with black organic material farther down. The clods or prisms cannot be broken with the hands when the soil is dry. The material gradually becomes lighter colored and less compact with depth, and, at a depth of 30 inches, it consists of dark-brown clay containing a few small white or gray accretions of calcium carbonate. The fine earth, however, is noncalcareous. The accretions become larger and more numerous at a depth of about 36 inches and disappear below a depth ranging from 40 to 50 inches. This material grades into weathered shale at a depth ranging from 48 to 55 inches. The parent material is yellowish-brown clay with rusty-brown, brown, and black mottlings and apparently grades into red heavy shales of the lower Enid formation of the Permian Red Beds, at a depth of several feet below the surface.

The heavy subsoil of Oswego silt loam makes it well suited to the production of wheat. It is, however, not so productive of that crop as is Kirkland silt loam. Because of its very flat surface, poor drainage sometimes delays planting and harvesting. Calliopsis, locally called wild flax, is a very noxious weed on this soil and reduces crop yields by depleting the soil moisture. This soil is considered rather fertile, and the crops grown on it usually withstand periods of drought very well. Yields of wheat average about 14 bushels an acre; of sor-

ghum cut for hay, approximately 2 tons an acre; and of alfalfa, about 1½ tons. Some farmers claim that alfalfa dies out on this soil 2 or 3 years after planting. Apparently this occurs only in places where the land is either exceptionally flat or slightly depressed. About 80 percent of this land is used for small grains, 2 percent for sorghums, 5 percent for alfalfa, and 12 percent for native grasses. The pastures consist largely of buffalo grass and blue grama.

Carwile loam.—Carwile loam is similar to Carwile fine sandy loam, but it is slightly heavier in texture and darker. It is associated with Carwile fine sandy loam and Pratt loamy fine sand in flat or slightly hummocky areas. The principal areas are in the vicinity of Enid, northwest of Enid, and northwest of Carrier. This is not an extensive soil.

The surface soil, to a depth of 6 or 8 inches, is dark grayish-brown friable granular loam which is slightly acid in reaction. It grades into grayish-brown or brown clay loam faintly mottled with brown and grayish brown. A few fine rounded quartz gravel are present in this layer in many places. In exposed cuts the material breaks into irregular prisms. The soil material is brown when crushed. Below a depth of 12 or 15 inches and continuing to a depth ranging from 18 to 24 inches is a layer of gray, brown, and rusty-brown mottled and spotted sandy clay loam. The pulverized soil is yellowish brown. This material is very compact when dry but is not a claypan. It breaks into irregular cubical clods from 1 inch to 1½ inches in diameter. Below this is a layer of rusty-brown and gray or bluish-gray mottled sandy clay loam containing numerous light-gray accretions of lime, which become less numerous with depth. The fine earth is not calcareous. The material in this layer grades into the unconsolidated sands and clays of Quaternary age.

Run-off is very slight on this soil, owing to the flat surface.

Carwile loam is adapted to the principal crops grown in this county. Yields of wheat range from 5 to 25 bushels an acre with an average of 13 bushels; grain sorghums, 17 bushels; sorgo cut for hay, 2 tons; and alfalfa, 1½ tons. About 80 percent of the land is utilized for the production of small grains, 8 percent for sorghums, and 8 percent for alfalfa. About 4 percent is in native pasture, the carrying capacity of which is about 3 acres for each cow.

Carwile fine sandy loam.—Carwile fine sandy loam is a dark grayish-brown Prairie soil associated with the sandy soils. It occurs in somewhat flat or slightly hummocky areas, the largest of which are north of Enid, northwest of Carrier, and in the vicinity of Drummond.

The 6- or 8-inch surface layer is dark grayish-brown friable fine sandy loam which is neutral in reaction. To a depth of 12 or 15 inches the subsurface soil is brown and dark grayish-brown spotted or mottled loam. The mottlings of darker material consist largely of insect casts which probably originated in the surface layer. This material in dry exposed cuts breaks into irregular prisms from 2 to 4 inches in diameter. The subsoil is brown noncalcareous fine sandy clay loam or clay loam, extending to a depth of 30 inches. The crushed material is yellowish brown. Below this and continuing to a depth ranging from 36 to 40 inches is a layer of brown or yellowish-brown sandy clay loam which grades into gray and rusty-brown

mottled fine sandy clay that, in some places, is calcareous. This material, in turn passes into the unconsolidated sands and clays of Quaternary or Tertiary age.

The relief is comparatively flat, consequently run-off and erosion are very slight. The soil is moderately fertile and is adapted to the principal crops grown in this section. Yields of wheat average about 12 bushels an acre, oats 28 bushels, sorgo cut for hay 1½ tons, and Sudan grass 1 ton. Approximately 48 percent of this soil is devoted to small grains, 13 percent to sorghums, 1½ percent to Sudan grass, 7 percent to alfalfa, 7 percent to orchards and gardens, and the remaining 23½ percent to native pasture. The original native grasses were bluestems, but now buffalo grass dominates in the pastures. The carrying capacity of these pastures is 3½ acres a cow.

REDDISH-BROWN PRAIRIE SOILS WITH FRIABLE SUBSOILS

The soils of this group have a somewhat lower agricultural value than those of the preceding group. The surface layers are composed of reddish-brown or brown very fine sandy loam or clay loam and range from 8 to 13 inches in thickness. The subsurface soils are variable in texture but generally friable. No claypans are present in these soils. Soils of this group produce fair yields of wheat, but they are somewhat better suited to the growing of grain sorghums, sorgo, Sudan grass, and to pasture. Acre yields of wheat range from 9 to 12 bushels.

The gently rolling to rolling relief subjects these soils to greater losses of water through run-off and to losses caused by erosion. They contain somewhat less organic matter, nitrogen, and readily available phosphorus than do the soils of the preceding groups. The most extensive areas are in the southern part of the county and in the vicinity of Kremlin. The group includes Renfrow silt loam, Renfrow clay loam, and Nash very fine sandy loam, which combined cover 10.8 percent of the county.

Renfrow silt loam.—Renfrow silt loam is a brown or reddish-brown soil occupying sloping or rolling areas in the more thoroughly dissected parts of the county, particularly in the southeastern part in the vicinity of and southwest of Hayward. Several bodies lie east of Waukomis and in the vicinity of Kremlin. This is a fairly extensive soil. It borders Kirkland silt loam on one side and Vernon clay loam and Vernon very fine sandy loam, on the other, and it is intermediate in character and in stage of development between the Kirkland and the Vernon soils.

The 6- to 10-inch surface layer consists of brown friable easily tilled silt loam with a faint red hue. The subsurface material, to a depth of 15 to 18 inches, is reddish-brown heavy very fine sandy loam or silty clay loam, which, in exposed dry cuts, breaks naturally into indistinctly prismatic clods. The material of this layer assumes a much lighter color after it is crushed. Below this is reddish-brown clay loam or clay which breaks into irregular clods from one-half to three-quarters of an inch in diameter. At a depth of about 20 or 24 inches the material, in most places, is brownish-red clay loam, but in small spots it is light clay. This material, in turn, grades into weathered red shales or sandstones of the lower Enid formation

of the Permian Red beds. A few areas of this soil in the vicinity of Garber are somewhat more shallow and more red than typical.

Renfrow silt loam is a moderately fertile soil. Owing to its rolling relief, it is subject to losses of moisture and surface soil through run-off and erosion, especially where poorly managed. The soil is adapted to the principal crops grown in the county. Results of chemical analyses indicate that its content of readily available phosphorus is low.[8] It also contains somewhat less organic matter and nitrogen than do the soils of the preceding group. Yields of wheat range from 5 to 25 bushels an acre, with an average of 12 bushels; oats, an average of 17 bushels; and alfalfa and sorgo, 1½ to 2 tons of hay. Approximately 57 percent of this soil is used for the production of small grains, 4 percent for sorghums, 4 percent for alfalfa, and 26 percent for native hay and pasture. The native pasture grasses, which originally were bluestems, now consist of buffalo grass and blue grama, which will support a cow on each 4 acres. Native hay is cut largely from bluestem and side-oats grama grasses.

Renfrow clay loam.—Renfrow clay loam is a reddish-brown Prairie soil with gently rolling to rolling relief. It resembles Renfrow silt loam, but its surface soil is slightly more red and is heavier in texture than the corresponding layer of that soil. The largest areas are south and east of Kremlin.

The surface soil to a depth of 6 inches is reddish-brown silty clay loam becoming more red with depth. It is loosely granular and friable despite its heavy texture and is calcareous in most places. Between depths of 6 inches and 15 or 20 inches the subsoil is reddish-brown or chocolate-brown fairly compact clay which breaks into irregular sharp-edged shiny-faced clods that are not prismatic in outline. The subsoil also becomes more red with depth. It grades into weathered red heavy shales of the lower Enid formation of Permian age. The shales underlying this soil are, in most places, calcareous.

Renfrow clay loam is a moderately fertile soil and is particularly adapted to the production of wheat, yields of which average 10 bushels an acre. Oats produce about 20 bushels. Approximately 73 percent of the land is used for the growing of small grains, 8 percent for sorghums, and 19 percent is in native pasture, the carrying capacity of which is about 4½ acres to each cow.

The rolling relief and comparatively heavy texture are characteristics conducive to a high percentage of run-off and large losses of surface soil through erosion, especially where the land is poorly managed. Terracing and strip cropping are necessary in order to maintain the productivity of the cultivated land.

Nash very fine sandy loam.—Nash very fine sandy loam is a reddish-brown shallow soil associated with Grant very fine sandy loam in the northwestern part of the county and in the vicinities of Waukomis and Bison. This is not an extensive soil. It is more red and less productive than Grant very fine sandy loam.

The 6- or 8-inch surface layer is brown or reddish-brown friable very fine sandy loam. Below this is slightly heavier and more

[8] Statement by H. J. Harper, professor of soils, Oklahoma Agricultural and Mechanical College.

compact reddish-brown very fine sandy loam which breaks naturally into indistinct prismatic clods in dry exposed cuts. The color becomes more red with depth, and the subsoil, which begins at a depth of 12 or 15 inches, is red or brownish red. Calcareous red weathered sandy shale or sandstone of the upper Enid formation of Permian age underlies the soil at a depth ranging from 30 to 36 inches.

This is a moderately fertile soil. Its rolling relief, however, subjects it to losses of moisture and surface soil through run-off and erosion, unless carefully managed. Terraces or strip cropping are needed to protect the land when the native-grass sod is plowed under. It is adapted to the principal crops grown in this section and is particularly suited to sorghums and Sudan grass. Yields of wheat average 10 bushels an acre, grain sorghums 15 bushels, sorgo for hay 2 tons, and Sudan grass 1½ tons. Very little alfalfa is grown. About 47 percent of the land is devoted to small grains, 22 percent to grain sorghums, and 20 percent to native pasture. The original native grasses were bluestems but now are largely buffalo grass and blue grama. The carrying capacity of the pasture is 3½ acres to each cow.

RED PRAIRIE SOILS WITH BOTH HEAVY AND FRIABLE SUBSOILS

This group includes some of the less valuable agricultural soils of the county. The surface soils are reddish-brown or brownish-red very fine sandy loam or clay loam, and the subsoils are red or brownish-red clay loam or silty clay loam. These are shallow soils with a comparatively low content of available plant nutrients. They are fair wheat-producing soils but are utilized mainly for pasture. Considerable acreages on the slopes along shallow valleys are devoted to oats, sorghums, and Sudan grass. The steepness of the land makes the use of heavy machinery very difficult, and the land should be left in native grass or seeded to perennial grasses for pasture. Run-off losses of both soil and water are severe on these soils where cultivated. The reaction of the soils is neutral or slightly alkaline, and, in places, the subsoil and parent material are decidedly calcareous. An area of 15.1 percent of the county is covered by the soils of this group, which are classified as Vernon very fine sandy loam and Vernon clay loam.

Vernon very fine sandy loam.—Vernon very fine sandy loam is a reddish-brown Prairie soil occurring on strongly rolling or fairly steep slopes of small valleys, locally called breaks, particularly those on the south side of Red Rock Creek north of Garber, the south side of Black Bear Creek south of Garber, and along 4D, Crows Nest, and Otter Creeks. Smaller areas are along Buffalo and Turkey Creeks.

The topmost 6 or 8 inches of this soil is friable reddish-brown very fine sandy loam which is neutral in reaction. Between depths of 6 inches and 10 or 12 inches the subsurface material is brownish-red or slightly dark brownish-red heavy friable granular very fine sandy loam. No prismatic clods are present in this soil. The subsoil is brownish-red or red heavy very fine sandy loam or clay loam and extends to a depth ranging from 18 to 30 inches. Below this lies the weathered red sandy shales or sandstones of Permian age. This rock may be of either the lower or the upper Enid formation.

This soil is subject to severe losses of surface soil and water through erosion and run-off where cultivated. It is best suited to native

pasture, but considerable areas are cropped. Acre yields of wheat average approximately 8 bushels; oats, 12 bushels; grain sorghums, 13 bushels; and sorgo for hay, 1½ tons. Small grains (largely oats) are grown on approximately 28 percent of this land, sorghums on 3 percent, and pasture occupies 63 percent. Alfalfa is seldom grown. The native pasture is largely of buffalo and blue grama grasses which support cattle at the rate of 5 acres for each cow. Chemical analyses indicate that the content of available phosphorus in this soil is generally low, according to data obtained at the Oklahoma Agricultural and Mechanical College.

Vernon clay loam.—Vernon clay loam is a reddish-brown or red soil which occupies small narrow areas along the breaks of Red Rock, Otter, Black Bear, and Skeleton Creek Valleys in the eastern two-thirds of the county. It is similar to Vernon very fine sandy loam, but the texture of both surface soil and subsoil is heavier than is characteristic of that soil. Its total area is much greater than that of Vernon very fine sandy loam.

The surface soil is only 4 or 5 inches thick and consists of reddish-brown or brownish-red friable granular clay loam, slightly mottled with yellowish red. This grades into the slightly weathered red heavy clay shales of the lower Enid formation of Permian age, which may be either calcareous or noncalcareous.

The steep relief subjects this soil to erosion and to losses of water through run-off. For these reasons, the best use for this land is for native grass rather than for cultivated crops. Some areas, nevertheless, are cultivated, usually in conjunction with other soils. Yields of wheat are said to average 9 bushels to the acre. Approximately 25 percent of the land is cropped to small grains, 3 percent to sorghums, and 66 percent is in native pasture or hay land.

GRAYISH-BROWN SANDY SOILS WITH VERY FRIABLE SUBSOILS

The soils included in this group are some of the less valuable sandy soils of the county. The surface soils range from 12 to 18 inches in thickness and consist of grayish-brown loamy fine sand or fine sandy loam, which becomes yellowish brown with depth. The subsoils are yellowish-brown fine sandy loam or fine sand. A diversified agriculture is practiced, with wheat the dominant crop, although the soils are comparatively poor for the production of wheat. Other important crops are sorghums, peanuts, cowpeas, watermelons, and fruits. In general, the relief ranges from rolling to slightly hummocky and billowy, but, in some places, the land is almost smooth. The land generally is smooth enough for the use of power machinery. Additions of manure or nitrogen and phosphorus fertilizers are desirable on these soils. Water erosion is not a problem, and stream courses are few, because water penetrates the soils very rapidly. Heavy winds cause the soils to drift, and crops are often injured in the spring. The principal areas of sandy soils are in the southwestern part of the county and northwest of Enid, and smaller areas border streams heading in the vicinity of Enid. They cover a total of 4.6 percent of the county. The group includes Reinach loamy fine sand, Pratt fine sandy loam, Pratt loamy fine sand, and Pratt loamy fine sand, dune phase.

Reinach loamy fine sand.—Reinach loamy fine sand is a high-bottom, or terrace, soil occurring in small bodies along the valley of streams that head in the sandy sections—Sand, Skeleton, and Turkey Creeks, and smaller northward-flowing streams in the vicinity of Hillsdale. Its total area is only 5 square miles.

To a depth ranging from 6 to 10 inches the soil material is brown noncalcareous friable fine sandy loam or loamy fine sand, which is underlain by light-brown or grayish-brown sandy loam that becomes lighter colored with depth. At a depth of 15 or 18 inches the upper subsoil layer consists of yellowish-brown fine sand. The lower subsoil layer is variably stratified material and in most places is composed of alternating layers of dark- and light-colored soil materials. The darker material represents old surface soils that have been buried by more recent depositions.

This is a moderately productive soil. It is suited particularly to the production of alfalfa, sorghums, Sudan grass, cowpeas, peanuts, and watermelons; nevertheless the principal crop is wheat, yields of which average about 11 bushels an acre. Alfalfa yields 1½ tons. About 50 percent of the land is used for small grains, 8 percent for alfalfa, and 25 percent for pasture. The rest is used for miscellaneous crops or lies fallow.

In a few small areas the soil has a slightly heavier texture and greater productivity than typical Reinach loamy fine sand. This included soil represents a condition intermediate between the typical soil and Reinach very fine sandy loam. An important area of this kind is 2 miles east of Enid.

Pratt fine sandy loam.—Pratt fine sandy loam resembles Carwile fine sandy loam, but its subsoil is not so heavy as that of the Carwile soil. It occupies a few small scattered areas northwest of Enid.

The surface soil, to a depth of 6 inches, is grayish-brown or brown loose friable fine sandy loam. It is underlain, to a depth ranging from 16 to 20 inches, by slightly lighter brown fairly compact fine sandy loam which, in exposed cuts, breaks into prismatic clods from 4 to 6 inches in diameter. Below a depth of about 20 inches the material is yellowish brown and ranges from fine sandy loam to clay loam in texture. It is neutral in reaction. This material grades downward into unconsolidated sands and clays.

This soil has a somewhat hummocky or billowy relief. Water erosion is not a serious problem, as water is absorbed rapidly and run-off is slight. The soil is adapted to the principal crops grown in this section, but its uneven surface discourages the use of heavy machinery. Yields of wheat average approximately 11 bushels to the acre, grain sorghums 16 bushels, and Sudan grass 1½ tons. Approximately 69 percent of this soil is devoted to small grains, 7 percent to alfalfa, 7 percent to hay and pasture, and the rest to miscellaneous crops and fallow land. The native pasture has a carrying capacity of 5 acres for each cow.

Pratt loamy fine sand.—Pratt loamy fine sand is a grayish-brown sandy soil. Fairly large areas are northwest of Enid and in the southwestern part of the county. A part of this land, possibly all of it, supported a growth of blackjack oak when this section was first settled.

The 6- or 8-inch surface layer is grayish-brown or dark grayish-brown loamy fine sand which is acid in reaction. Beneath this and extending to a depth ranging from 16 to 20 inches is the subsurface layer of fine sand or loamy fine sand faintly mottled or spotted with brown and yellowish brown. This is underlain by yellowish-brown fine sand of single-grain structure which becomes somewhat lighter colored with depth and grades into unconsolidated sands and clays of Quaternary and possibly of Tertiary age.

This is a soil of comparatively low fertility, partly because of its light texture. The content of organic matter and nitrogen is comparatively low. Additions of manure and of phosphorus fertilizers cause increases in crop yields when moisture conditions are favorable.

The land ranges from almost flat to gently undulating or slightly hummocky. Water erosion is not a serious problem, but, unless protected, the soil drifts in the heavy spring winds.

Wheat yields on this soil average approximately 8 bushels to the acre. The land is much better adapted to the production of peanuts, watermelons, cowpeas, and grapes. Approximately 60 percent is cropped to small grains, 10 percent to sorghums, 18 percent is in pasture, and the rest is in miscellaneous crops and fallow land. Some areas are cleared of timber in order to allow the growth of grasses and thereby increase the value of the land for grazing. Bluestem, Indian grass, bluejoint turkeyfoot, locally called tall bluestem, and hairy grama are the principal pasture grasses. According to local farmers, the carrying capacity of the pasture is low, about 10 acres being required for each cow.

Pratt loamy fine sand, dune phase.—Pratt loamy fine sand, dune phase, is similar to typical Pratt loamy fine sand, but it is less valuable than that soil for the production of crops because of its rolling or hummocky relief. The best use of this soil, therefore, is for native-grass pasture. Many small areas are cultivated in places where their exclusion would result in irregular-shaped fields. Soil blowing is a problem in the cultivated areas. Yields of wheat probably average not more than 6 bushels an acre. Approximately 21 percent of this land is devoted to wheat, 10 percent to sorghums, and 59 percent to hay and pasture; the rest is in miscellaneous crops or lies fallow. The soil covers a small total area. The largest bodies are northwest of Enid and southwest of Drummond.

BROWN SOILS WITH SALINE SUBSOILS

The group of brown soils with saline subsoils consists of soils of low productive capacity. Areas in which these soils occur are very irregular and have a spotted appearance. The surface soil is grayish-brown very fine sandy loam or clay, in most places ranging from 1 to 10 inches in thickness, but in some places it has been entirely removed by erosion. The subsoil is dark-brown or reddish-brown clay loam or clay, which breaks to a cubical or columnar structure. These soils occur along small stream courses and on some of the higher stream terraces. Two soil types, Drummond clay, and Drummond very fine sandy loam with a combined area of 17.4 square miles, comprise this group. The largest bodies are those west of Drummond on the bed of an old lake.

According to field analyses with the Wheatstone bridge, the total soluble salts in the topmost 1 foot of soil averages 0.29 percent, and the total in the profile to a depth of 3 feet is 0.42 percent. The concentration of salts in the surface soil is not sufficient to inhibit the growth of most plants, but the concentration in the subsoil prevents normal growth of any plants except salt-resistant species. Yields of wheat are said to average about 6 bushels to the acre, and fair crops are produced under optimum moisture conditions. Most of the land, however, is in pasture. The native vegetation is dominated by saltgrass.

Drummond very fine sandy loam.—Drummond very fine sandy loam is an alluvial soil or, in some places, an old lake-bed soil. It is a Solonetz soil or a Solonetz-Solonchak complex. The more important areas are those on the low flat west of Drummond. Smaller areas are in the vicinity of Horner School and in other parts of the county.

Despite its nearly flat relief, erosion has removed much of the surface soil in places, leaving a very uneven or hummocky surface. For this reason, the soil profile is variable. The surface soil may be 10 inches thick or may be entirely absent, but it averages 5 inches in thickness and is brown or grayish brown. In most places, it rests on clay or silty clay, which breaks into small round-topped columns. In many places the columns are coated with gray near the top, or brown or faint reddish brown, are about 2 inches long, and range from ½ to 1 inch in diameter. Between depths of about 7 and 14 inches is a layer of reddish-brown clay loam which breaks into irregular blocks or prisms 1 inch in diameter. Below this is calcareous reddish-brown clay loam streaked with white calcium carbonate in mycelium form. This material grades downward into old alluvial deposits of variable character. The subsoil is salty.

The productive capacity of this soil is very low. The large quantity of soluble salts in the subsoil is unfavorable to plant growth. In addition, drainage is poor in places, especially during wet seasons. Very little of the land is cultivated. Acre yields of wheat may be a complete failure or may be as much as 6 bushels, depending on the salt content and the rainfall. About 13 percent of the land is cultivated to wheat, 3 percent is in sorghums, 79 percent is in pasture, and the remainder is largely fallow. Saltgrass is the dominant pasture grass, and many other salt-loving plants grow. The less salty areas are covered with buffalo grass and bluestem.

Drummond clay.—Drummond clay is a heavy salty soil occurring on the low flat west of Drummond. This soil covers a small total area. The upper part of the soil is not quite so salty as the corresponding layers of Drummond very fine sandy loam. The surface soil to a depth of 6 inches is dark chocolate-brown clay which breaks into irregular sharp-angled prismatic blocks. Below this is a layer of reddish-brown or brownish-red clay which breaks in a similar manner, but the cleavage lines are less definite. White mottlings of gypsum and calcium carbonate are present at a depth ranging from 15 to 24 inches. The soil is calcareous from a depth of 6 inches downward. The dark chocolate-brown or reddish-brown calcareous clay subsoil is salty to the taste. About 37 percent of the land is used for the production of wheat, the average yield of which is about 7 bushels; and the rest is in pasture. Crop failures are common,

as a result of too much or too little moisture. The native grasses include saltgrass, blue grama, buffalo grass, and bluestem.

ALLUVIAL SOILS

The alluvial soils are developed on the narrow first bottoms along most of the streams from materials washed from areas of the dark and red Prairie soils. They are calcareous in places and probably are nowhere strongly acid. The two soils of this group—Lincoln loamy fine sand and Yahola very fine sandy loam—cover a combined area of 42.9 square miles.

The surface layers consist of grayish-brown or reddish-brown very fine sandy loam or loamy fine sand. The subsurface layers are yellowish brown or reddish brown. Although these soils are inherently fertile they do not produce high average yields because of losses sustained from overflows. In places the land is so cut by drainage or stream channels that cultivation is impossible. Most of the arable areas are very narrow and, for that reason, are rarely cultivated. Garden vegetables and fruits may be grown very successfully and alfalfa does well in the arable areas.

Yahola very fine sandy loam.—Yahola very fine sandy loam is a first-bottom soil occurring along most of the streams, especially Skeleton, Red Rock, Turkey, Black Bear, and Otter Creeks. The soil is mixed in character and, as mapped, includes many small areas of soils of various sandy textures. Along the stream courses the land in places is so cut by drainage channels and steep stream banks that it cannot be cultivated to field crops. Such land commonly is utilized for pastures and gardens. This is a good soil for garden vegetables and fruit.

The surface soil of the arable land, to a depth of 18 inches, is brown or faintly reddish brown loose friable very fine sandy loam which is neutral in reaction. It grades into reddish-brown or chocolate-brown very fine sandy loam or loamy fine sand. Layers of darker material occur in the lower part of the subsoil.

Definite data on crop yields on this soil are not obtainable because of the small size of the areas, but, according to reports of the farmers, acre yields of about 6 bushels of wheat and from 1 to 3 tons of alfalfa are obtained. Approximately 22 percent of the land is used for small grains, 5 percent for sorghums, 6 percent for alfalfa, 63 percent for pasture, and the rest for miscellaneous crops.

Lincoln loamy fine sand.—Lincoln loamy fine sand is an inextensive first-bottom soil bordering streams that head in the sandy sections, particularly along the upper reaches of Skeleton Creek, along Sand Creek, and along a few smaller creeks that originate northwest of Enid. This soil is very variable and, as mapped, includes overflow land, steep banks, and gullies along stream courses. The surface is cut so badly and the land is in such small patches that most areas of this soil are utilized for pastures or gardens.

To a depth of 6 inches this soil is brown sandy loam or loamy fine sand which is rather loose and subject to blowing. Between depths of 6 inches and 12 inches is a layer of light-brown or grayish-brown sand or loamy fine sand, and below this is pale yellowish-brown or yellow sand. Mottlings of gray and yellow are present in places at a depth

ranging from 50 to 60 inches. The soil is noncalcareous and faintly acid in reaction.

This soil produces good orchards and fair or good gardens. As a rule fertilizers and manure are needed on the gardens. Approximately 6 percent of the land is used in the production of sorghums, and 82 percent is in pasture. The rest is fallow or is devoted to miscellaneous crops.

MISCELLANEOUS NONARABLE LAND

Miscellaneous nonarable land comprises badly eroded and gullied land and a very sandy soil with a dunelike or very hummocky relief. This land is either so rough or so loose physically that cultivation generally is not practicable, and it is utilized for pasture. The members of this group are classified as Enterprise fine sand, dune phase, and rough broken land (Vernon soil material). They cover a combined area of 51.4 square miles.

Enterprise fine sand, dune phase.—Enterprise fine sand, dune phase, is a sandy forested soil with a dunelike relief, occurring mainly in the extreme southwestern part of the county. A few small bodies are northwest of Enid. The land generally is considered nonarable because of its uneven surface and the light texture of the soil. Where cultivated and unprotected by vegetation the soil drifts in the heavy spring and summer winds.

The surface soil, to a depth of 6 or 8 inches, is grayish-brown fine sand which is acid in reaction and is underlain by grayish-brown or yellowish-brown fine sand. Between depths of 12 inches and about 30 inches is a layer of yellowish-brown fine sand, and below this is pale yellowish-brown fine sand.

This soil is covered with blackjack oak trees and a thin undergrowth of bluestem, tall bluestem, Indian grass, and hairy grama, together with wild plum, fragrant sumac, and shrubs. Approximately 16 percent of the land is used for the production of wheat, 3 percent is fallow land, 6 percent is used for the growing of sorghums, and the rest is in pasture. Only the smoother areas are cultivated. Goats probably would find considerable browse on the native vegetation. The pasture has a carrying capacity of about 15 acres for each cow.

Rough broken land (Vernon soil material).—Rough broken land (Vernon soil material) includes land that is so rough, steep, broken, and gullied that it cannot be cultivated. In a few places the very fine sandy loam or clay loam surface soil resembles that of the typical Vernon soils, but in most places it has been removed entirely by erosion, exposing the weathered red shales and soft sandstones. This material is developed from both the lower and the upper Enid formations. The principal areas lie within a strip about 2 miles wide extending in a southeast-by-east direction from a point near the northwestern corner of the county to Sunny Slope School northwest of Enid. In this locality all the drainageways have cut rather deep narrow valleys that are rough and broken, and the section has been described previously as an escarpment leading down from the upper Enid formation to the lower Enid formation. Several smaller areas are immediately south of Enid. The total area of this land is 43.5 square miles. The native vegetation is fairly

luxuriant and provides pasture of a fair grade, the carrying capacity of which is about 5 acres for each cow. Although this land is steeply sloping, gullied, and eroded, it is not so rough or so broken as that mapped as rough broken land in other counties of the State.

LAND USES AND AGRICULTURAL METHODS

In this section of moderate rainfall it is necessary to produce crops which resist drought and to use methods calculated to prevent unnecessary losses of moisture. The chief crops adapted to the conditions in this county are winter wheat, spring-sown oats, grain sorghums, Sudan grass, and alfalfa. The broad areas of smooth moderately heavy textured soils which comprise nearly two-thirds of the county are particularly suited to the production of wheat and the use of heavy machinery. For these reasons, wheat is by far the most important crop grown. Other crops are grown for the purpose of diversification of farm enterprises and to provide feed. The raising of livestock and poultry is important on most farms, particularly on those which include areas of rough land.

Most of the soils are moderately productive during most seasons and highly productive during seasons of well-distributed and plentiful rainfall. In general, the soils are supplied with the essential plant nutrients and do not need the addition of fertilizers or lime. Some of the soils in the eastern part, however, are moderately low in content of readily available phosphorus, and some of the very sandy soils are naturally low in the supply of available plant nutrients. Although yields on the sandy soils are moderately low, as a rule, the capacity of these soils to absorb and retain a large proportion of the rain water allows the production of crops during some rather dry seasons.

Soil blowing rarely causes much damage, even on the sandy soils. Occasionally crops are injured from this cause during dry springs. Plowing or listing furrows at right angles to the prevailing winds affords some protection.

The Oklahoma Agricultural Experiment Station maintains a field station at Carrier in the western part of Garfield County and has obtained considerable valuable data regarding crops and soils in this county. The Southern Great Plains Field Station at Woodward and the substation of the Kansas Agricultural Experiment Station at Fort Hays have obtained much valuable information regarding small grains and sorghums.

The hard red winter wheats, such as Blackhull, Kharkof, Turkey, and Kanred, are the principal varieties grown. Shallow plowing immediately after harvest, to kill weeds and put the surface soil in condition to absorb moisture, is the most important practice in the production of wheat here, as weeds growing through the summer deplete the soil moisture to such an extent that chances of success with wheat the following season are very low. Wheat yields are determined largely by the soil moisture content at seedtime. At Fort Hays, Kans., it was found that when wheat was planted in a dry, or nearly dry, soil the average yield was 5.3 bushels an acre; when the soil was wet to a depth of only 1 foot, 8.3 bushels; when the soil

was wet to a depth of 2 feet, 16.9 bushels; and when the soil was wet to a depth of 3 feet or more, 26.5 bushels (*5*). At this station it was found that summer fallow was not advisable because it resulted in too rapid early growth, which exhausted the moisture supply more rapidly than roots could be extended into the soil. Additions of manure or commercial fertilizers and the growing of green-manure crops are not recommended where wheat is to be grown.

Darso is the outstanding variety of grain sorghum in this part of the State. It is popular because of its sweet stalk and its ability to resist injury from insects and birds. The Pearl and Red varieties of kafir and schrock yield well. The most satisfactory planting dates for sorghums seem to be between May 1 and May 15, as late plantings frequently are damaged severely by chinch bugs. Darso has given best results at 6-inch spacings in the row (*7*). The Sumac and Orange varieties of sorgo are good for forage in this section.

The principal fruit suited to the climate in this county is the sour cherry. Montmorency, Dyehouse, Early Richmond, and English Morello are the varieties which have proved successful at Woodward.[9] Apples have proved fairly successful on the sandy soils. The chief varieties of apples are Winesap, Delicious, Jonathan, and Yellow Transparent. Fire blight has almost destroyed the possibility of producing pears, with the exception of the Bartlett which is grown extensively for canning. Grapes also may be grown successfully on the sandy soils. Extra is the principal commercial variety recommended for this county (*2*). Other important varieties are Moore Early, Campbell Early, Muench, Delaware, Niagara, Catawba, and Beacon.

The vegetable crops successfully grown are beans, cowpeas, onions, radishes, beets, carrots, summer squash, okra, potatoes, cucumbers, Swiss chard, peas, and sweet corn. These vegetables, as a rule, grow better on light-textured soils, such as fine sandy loams and loamy fine sands. If supplied with irrigation water, they are more successful on very fine sandy loams and silt loams. Cantaloups and watermelons are grown with success.

PRODUCTIVITY RATINGS

As it is desirable to know the relative suitability and productive capacity of the soils for the several important crops of the county, a table has been prepared showing the relative ratings in percentages for each soil for each important crop as compared to the standard of 100 percent given to represent the production of the crop on the most ideal land for that crop in the United States. The ratings are based on the ability of the land to produce under capable and proper management, but without irrigation, drainage, or the addition of soil amendments or fertilizers.

In constructing a table of relative productivity it was first necessary to list the average acre yields of the several important crops grown on each of the soils, which are given in table 4.

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

TABLE 4.—*Average acre yields of the principal crops on the soils of Garfield County, Okla.*

Soil type	Wheat	Rye	Oats	Grain sorghum	Sorghums for forage	Alfalfa	Pasture
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Tons*	*Tons*	*Cow-acre-days* [1]
Pond Creek silt loam	18	18	38	23	2	1½	60
Grant very fine sandy loam	17	17	35	20	2	1½	60
Reinach very fine sandy loam	16	16	35	20	2	2	60
Reinach silty clay loam	15	14	32	20	2	2	50
Kirkland silt loam	15	15	33	19	2	1½	60
Oswego silt loam	14	14	32	17	2	1½	50
Carwile loam	13	13	30	17	2	1½	50
Carwile fine sandy loam	12	12	28	17	1½	1½	45
Renfrow silt loam	12	12	27	16	1½	1½	50
Renfrow clay loam	10	10	20	14	1	1	45
Nash very fine sandy loam	10	11	20	15	1¼	1	45
Vernon very fine sandy loam	8	9	18	13	1	½	40
Vernon clay loam	9	10	20	13	1	½	40
Reinach loamy fine sand	11	12	23	16	1½	1½	40
Pratt fine sandy loam	11	12	23	16	1½	1¼	45
Pratt loamy fine sand	7	8	16	12	1	½	20
Pratt loamy fine sand, dune phase	6	7	15	10	¾	----	15
Drummond very fine sandy loam	5	5	12	8	½	----	20
Drummond clay	7	7	18	10	½	----	25
Yahola very fine sandy loam	6	7	14	10	1½	1½	40
Lincoln loamy fine sand	5	5	10	10	1	1	20
Enterprise fine sand, dune phase	4	4	6	6	½	----	10
Rough broken land (Vernon soil material)	----	----	----	----	----	----	35

[1] 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.

Of the crops grown in this county, the following indicate the standard of 100 as determined by average acre yields for each crop on the soils of the United States best suited to the crop: Wheat, 25 bushels; rye, 25 bushels; oats, 50 bushels; grain sorghums, 40 bushels; sorghums for forage, 4 tons; alfalfa, 4 tons; and pasture, 100 cow-acre-days.

Table 5 gives the relative productivity ratings of each of the soils for each of the important crops produced in the county.

TABLE 5.—*Productivity of soils in Garfield County, Okla.*

Soil type	Crop productivity index [1] for—						
	Wheat	Rye	Oats	Grain sorghum	Sorghums for forage	Alfalfa	Pasture
Pond Creek silt loam	70	70	75	60	50	40	60
Grant very fine sandy loam	70	70	70	50	50	40	60
Reinach very fine sandy loam	65	65	70	50	50	50	60
Reinach silty clay loam	60	60	65	50	50	50	50
Kirkland silt loam	60	60	65	45	50	40	60
Oswego silt loam	55	55	65	40	50	40	50
Carwile loam	50	50	60	40	50	40	50
Carwile fine sandy loam	50	50	55	40	40	40	45
Renfrow silt loam	50	50	55	40	40	40	50
Renfrow clay loam	40	40	40	35	25	25	45
Nash very fine sandy loam	40	45	40	35	30	25	45
Vernon very fine sandy loam	30	35	35	30	25	10	40
Vernon clay loam	35	40	40	30	25	10	40
Reinach loamy fine sand	45	50	45	40	40	45	40
Pratt fine sandy loam	45	50	45	40	40	35	45
Pratt loamy fine sand	30	30	30	30	25	10	20
Pratt loamy fine sand, dune phase	25	25	30	25	20	0	15
Drummond very fine sandy loam	20	20	25	20	15	0	20
Drummond clay	30	30	35	25	15	0	25
Yahola very fine sandy loam	25	30	30	25	40	40	40
Lincoln loamy fine sand	20	20	20	25	25	25	20
Enterprise fine sand, dune phase	15	15	10	15	15	0	10
Rough broken land (Vernon soil material)	0	0	0	0	0	0	35

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

The fact that a soil is well adapted to a particular crop does not necessarily mean that crop will be grown extensively on it. Economic considerations, such as the relation of the price the crop will bring to the cost of producing it, are of prime importance. The farmer must produce a crop that will return the greatest net income regardless of the special suitability of his soil for the crop. Generally it is not advisable to have an entire farm devoted to a single crop. The kinds of crops grown are influenced to some extent by custom and by the type of farming implements the farmer has at his disposal.

Table 6 was prepared after a detailed study of the crops grown on each type of soil in the county during 1935. The proportion of the land in the various crops is an indication of the adjustment of agricultural production, both to the productivity of the soils and to the economic influences of the section and of the county as a whole.

TABLE 6.—*Land utilization of the soil types in Garfield County Okla., during 1935* [1]

Soil type	Small grains [2]	Sorghums	Alfalfa	Fallow land [3]	Miscellaneous crops	Pasture
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Pond Creek silt loam	50	4	13	9	5	19
Grant very fine sandy loam	70	4	6	4	3	13
Reinach very fine sandy loam	66	3	10	2	2	17
Reinach silty clay loam	50	12	----	----	----	37
Kirkland silt loam	95	1	----	1	----	2
Oswego silt loam	75	2	5	5	1	12
Carwile loam	66	10	10	----	4	10
Carwile fine sandy loam	54	12	5	1	8	20
Renfrow silt loam	57	4	4	7	2	26
Renfrow clay loam	46	8	----	27	----	19
Nash very fine sandy loam	47	22	----	7	4	20
Vernon very fine sandy loam	28	3	----	6	----	63
Vernon clay loam	25	3	----	5	1	66
Reinach loamy fine sand	50	----	8	6	10	25
Pratt fine sandy loam	69	----	7	15	2	7
Pratt loamy fine sand	60	10	----	6	6	18
Pratt loamy fine sand, dune phase	21	10	----	----	10	59
Drummond very fine sandy loam	13	3	----	4	1	79
Drummond clay	37	----	----	----	----	63
Yahola very fine sandy loam	22	5	6	4	7	56
Lincoln loamy fine sand	----	6	----	6	6	82
Enterprise fine sand, dune phase	16	6	----	3	----	75
Rough broken land (Vernon soil material)	----	----	----	----	----	100

[1] Figures on land utilization were obtained by making a crop map covering 99,350 acres in the county and comparing it with the soil map.

[2] Small grains consist of approximately 90 percent wheat and 10 percent oats.

[3] Fallow land includes land leased to the Government in A. A. A. program and also some land that is being prepared for oats.

RECOMMENDATIONS FOR THE MANAGEMENT OF THE SOILS OF GARFIELD COUNTY [10]

From 70 to 75 percent of the cultivated land in Garfield County is planted to wheat each year; consequently soil management is closely associated with problems that affect the production of this crop. Continuous cropping of land to wheat can be practiced as long as the potential fertility of the soil will supply the plant nutrients required for producing good crops. Every bushel of wheat contains approximately 1¼ pounds of nitrogen. This nitrogen comes

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

from the soil; consequently, changes in soil fertility which occur as a result of exploitative practices can be measured by comparing the chemical composition of cropped land with soil obtained from adjacent areas of pasture, native meadow, or land that never has been cultivated. Samples of surface soil obtained from 39 fields in different parts of the county were analyzed for total nitrogen, total phosphorus, readily available phosphorus, and organic matter. These results are given in table 7.

TABLE 7.—*Loss of plant nutrients in soils of Garfield County, Okla., as a result of cultivation*

[Average of 39 comparisons]

Soil condition	Nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
	Pounds [1]	*Pounds* [1]	*Pounds* [1]	*Pounds* [1]
Virgin	2,476	59,000	756	120
Cropped	1,746	36,200	685	116
Loss through cultivation	730	22,800	71	4

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

The average loss of total nitrogen as a result of cultivation has been 30 percent of the nitrogen in the uncultivated land. The total loss of organic matter has been approximately 40 percent of the total organic matter in the virgin soils. The total phosphorus content in these soils also has decreased, but the reduction is less than that of nitrogen and organic matter. No appreciable change in readily available phosphorus has taken place. When organic matter decays, phosphorus in the organic material is changed to an inorganic form. If the phosphorus is not absorbed by plant roots, it will increase the quantity of readily available phosphorus in the soil. Apparently the quantity of readily available phosphorus in the cultivated soils has remained comparatively constant.

A permanent agriculture cannot be maintained unless nutrients which are removed from the soil by crops are returned, either by the growing of legumes to increase the nitrogen content of the soil or by the application of commercial fertilizers containing nitrogen, phosphorus, potash, and other plant nutrients. The first important limiting factor in plant development on the average soil of this county is the supply of available nitrogen. Sufficient rainfall occurs during the average season to insure a good growth of winter legumes; consequently cropping systems can be used which will add nitrogen to the soil. As the nitrogen content of the cultivated soil decreases, a point eventually will be reached where the total production of small-grain or row crops will be less when planted on the land every year than the yields obtained in a rotation in which one season is used for the production of a legume in order to increase the nitrogen content of the soil. An experiment conducted on the farm of A. E. Ford, near Carrier, on Grant very fine sandy loam, indicates the possibility of maintaining wheat yields by means of a cropping system in which winter legumes are grown. In the fall of 1928 Austrian Winter peas were planted on duplicate plots adjacent to plots that were planted

in wheat to be turned under as a green-manure crop. No income was obtained from these plots in 1929. The lowest yield of wheat was during the first season, but the total yield of wheat from four crops of wheat produced on the land where Austrian Winter peas were plowed under as a green-manure crop was 25 bushels greater than the total yield from five crops produced on the land where no green-manure crop was grown. No additional increase in yield was obtained from the land where one crop of wheat was used as green manure. The results of this experiment are given in table 8.

TABLE 8.—*A comparison of the effects of Austrian Winter peas and winter wheat (both used as green manure) on wheat yields*[1]

Treatment	Acre yield of wheat in—					Total
	1929	1930	1931	1932	1933	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Austrian Winter peas	(2)	42.17	35.00	24.5	27.0	128.67
Wheat	(2)	32.26	28.03	19.0	22.1	101.39
None	13.45	18.50	28.11	18.9	24.3	103.26

[1] Experiment made on the farm of A. E. Ford, near Carrier, Okla.
[2] Plowed under May 27, 1929, and summer fallowed.

The Austrian Winter peas used in this experiment were well inoculated, and soil moisture was favorable for the utilization of the available nitrogen during the experiment. The total nitrogen content of the soil on which this experiment was made was 1,400 pounds an acre of surface soil 6⅔ inches deep. When dry weather occurs, winter legumes may not make much growth, and very few nodules can be found on the roots although the seed is inoculated with good strains of legume bacteria. Wheat may produce an abundance of straw following the growth of winter legumes, but grain yields may be reduced if drought occurs a few weeks before harvest. These are some of the problems that require more extensive study, but proper spacing of the wheat plants and delayed planting are important factors in the proper utilization of available nitrogen which accumulates in the soil after a legume crop is grown.

The residual effect of alfalfa can be noticed on the growth of wheat for several years. The Reinach soils are good soils for alfalfa, and wheat can be grown with alfalfa in a cropping system on this land. As a rule alfalfa is not grown for the specific purpose of improving the nitrogen content of the soil but to provide hay which will be fed to livestock or sold as a cash crop. When the yields of alfalfa decline and the land is plowed and planted to wheat, frequently crop yields are poor the first year, especially when the summer rainfall is not sufficient to increase the moisture content of the subsoil. Alfalfa increases the quantity of available nitrogen in the soil, but it also removes large quantities of subsoil moisture. The stimulating effect of available nitrogen on the growth of wheat growing on a soil which has a dry subsoil following the growth of alfalfa, will cause a decrease in the yield of the first crop of wheat unless rainfall is very favorable for plant development. Thick spacing of plants and early seeding should be avoided. Spacing the wheat in rows approxi-

mately 14 inches apart, in order to reduce the total number of plants per unit area, and late planting, in order to conserve soil moisture during the fall and winter, will eliminate to a very great extent the harmful effect which occurs when a vigorous growth of vegetation is produced on a soil containing a limited supply of water. Severe drought occurring a few weeks before the wheat matures reduces the yield; consequently the use of legumes for soil improvement under average soil conditions on such soils cannot be recommended unless the average yield of wheat is less than 15 bushels per acre.

A high percentage of the wheat produced in Garfield County is harvested with a combined harvester and thresher. When soil moisture conditions are favorable, the land should be plowed or cultivated by listing and disking as soon as the crop is harvested, in order to provide more favorable conditions for the absorption of water, to destroy weeds that may be present in the stubble, and to cover the straw that may have a bad effect on the succeeding crop if it does not decay sufficiently before the following crop is planted. A study of various methods that may be used in order to prepare a seedbed for winter wheat was conducted for 6 years on the farm of A. E. Ford. Each method of tillage was repeated three times. The area planted was divided into two parts. One half was plowed, listed, or disked during July and the other half early in September. The plots were one-twentieth of an acre in size. The average yields of wheat obtained from the different methods of tillage were as follows:

Method of tillage	*Average acre yield, bushels* [1]
Plowed early, straw burned early	[2] 18.4
Plowed early, straw turned under	17.7
Listed early, straw turned under	12.8
One-way disked early, straw turned under	12.8
Plowed late, straw burned early	14.7
Plowed late, straw turned under	14.7
Listed late, straw turned under	8.3
One-way disked, straw turned under	8.9

[1] Average of six crops 1928–33. All treatments in triplicate.
[2] Increased yield probably not significant. Straw yields were low for 3 of the 6 years.

Early preparation of the seedbed was an important factor in increasing the production of wheat on this land. Plowing was slightly superior to listing or the use of a one-way disk. Although the experiment was conducted for only 6 years, plots on which the straw was burned produced a slightly larger average yield than plots on which the straw was plowed under. This difference was not pronounced on two of the three pairs of plots which were available for comparison. The effect of straw on subsequent yields of wheat depends on the quantity of straw to be plowed under and the rate of decay. A large quantity of straw may prevent satisfactory contact between the plowed layer and the subsoil, if the land is not disked before it is plowed and dry weather occurs during the summer. When the straw is covered early in the season by plowing or other methods of tillage and moisture conditions are favorable, it will decay sufficiently to eliminate the harmful effect that frequently occurs when any type of organic material low in nitrogen and high in organic carbon is plowed into the soil only a short time before a crop

is planted. Burning destroys organic matter which is needed to improve the physical condition of fine-textured soils and to keep sandy soils from blowing. Nitrogen is lost from the straw through burning, and it can only be returned to the soil by bacteria occurring in the nodules on the roots of legumes, by vigorous strains of nonsymbiotic organisms which are present in soils containing a good supply of lime and other plant nutrients, or by the addition of nitrogenous fertilizers. The problem of maintaining soil fertility may not be important on some soils at present, but eventually it will appear on every farm where wheat is grown continuously. Conservation of organic matter by proper tillage methods and the use of leguminous crops are important factors in any system of soil improvement. Soil productivity can be maintained more economically by a diversified system of farming than by growing a cash crop, such as wheat. Where considerable areas of soil too rough to cultivate occur on a farm, a livestock system of farming is essential to proper land utilization. Under average conditions, the type of farming is regulated to a very great extent by the character of the soil.

The potential fertility of the different soil types varies greatly. Soil samples obtained from different soils were collected and analyzed. The results of these analyses are given in table 9. Since the samples were obtained from virgin areas, they are higher in total nitrogen and organic matter than similar soils now in cultivation. The data given in table 7 show that cultivation has been responsible for a marked decrease in the content of total nitrogen and organic matter.

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

SOILS OF THE UPLANDS

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Per cent*	*Per cent*	*Per cent*	*Parts per million*
Carwile loam:							
3836	NW¼ sec. 29, T. 23 N., R. 6 W.	0–6	7.0	0.136	2.68	0.032	24
3837		6–8	6.6	.090	1.79	.029	20
3838		8–13	6.5	.138	1.44	.032	20
3839		13–19	7.0	.043	.58	.026	16
3840		19–24	8.3	.025	.85	.035	16
3841		24–50	8.4	.018	.18	.041	16
Enterprise fine sand, dune phase:							
3767	NW¼ sec. 29, T. 20 N., R. 8 W.	0–4	7.5	.034	1.00	.016	32
3768		4–12	7.2	.022	.39	.031	24
3769		12–30	7.4	.002	.06	.029	12
3770		30+	7.3	.010	.09	.015	12
Renfrow clay loam:							
3761	SE¼ sec. 24, T. 24 N., R. 6 W.	0–5	8.4	.136	2.45	.035	84
3762		5–17	9.0	.110	1.33	.034	108
3763		17–22	9.0	.076	.94	.029	80
3764		22+	8.7	.039	.75	.031	28
Renfrow silt loam:							
3829	SE¼ sec. 18, T. 20 N., R. 3 W.	0–5	6.8	.134	3.37	.051	16
3830		5–7	6.4	.118	2.68	.042	12
3831		7–13	6.1	.102	2.09	.045	8
3832		13–30	6.9	.075	1.42	.035	20
3833		30+	7.5	.034	-------	.020	-------
Grant very fine sandy loam:							
3731	NW¼ sec. 21, T. 21 N., R. 7 W.	0–6	7.2	.128	2.56	.032	48
3732		6–10	7.2	.092	1.95	.047	40
3733		10–20	7.1	.072	1.56	.031	38
3734		20–40	7.0	.052	1.00	.062	56
3735		40–50	7.4	.050	.75	.062	60

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

SOILS OF THE UPLANDS—Continued

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Per cent*	*Per cent*	*Per cent*	*Parts per million*
Kirkland silt loam:							
3721	SE¼ sec. 26, T. 23 N., R. 4 W.	0–2	6.6	0.140	3.51	0.034	22
3722		2–6	6.6	.118	2.12	.041	14
3723		6–16	6.6	.084	2.00	.045	8
3724		16–19	6.9	.078	1.73	.040	8
3725		19–25	7.1	.058	1.14	.036	12
3726		25–36	7.9	.042	.78	.036	20
3727		36–46	8.5	.030	.50	.030	24
Nash very fine sandy loam:							
3859	NW¼ sec. 11, T. 24 N., R. 8 W.	0–6	7.6	.138	3.37	.071	136
3860		6–15	8.2	.084	1.12	.071	112
3861		15–23	8.5	.062	1.05	.045	152
3862		23–30	8.5	.023	.35	.062	128
Oswego silt loam:							
3773	SE¼ sec. 21, T. 23 N., R. 5 W.	0–2	6.5	.152	4.53	.030	48
3774		2–5	6.7	.092	2.06	.020	20
3775		5–9	6.8	.086	1.89	.028	16
3776		9–16	7.1	.076	1.61	.021	8
3777		16–30	7.7	.060	1.11	.019	32
3778		30–37	8.5	.052	.97	.027	64
3779		37–42	8.7	.036	.94	.020	80
3780		42–50	8.6	.032	.44	.027	60
Pond Creek silt loam:							
3814	NW¼ sec. 26, T. 22 N., R. 7 W.	0–3	6.5	.200	4.73	.055	56
3815		3–6	6.8	.120	3.00	.042	68
3816		6–14	7.1	.092	2.06	.043	28
3817		14–25	6.9	.080	1.39	.056	24
3818		25–42	7.3	.050	.89	.056	60
3819		42+	8.7	.046	.67	.038	96
Pratt loamy fine sand:							
3845	SW¼ sec. 19, T. 20 N., R. 8 W.	0–5	7.3	.054	1.10	.021	24
3846		5–17	8.4	.028	.18	.016	8
3847		17–30	7.1	.038	1.07	.012	8
3848		30–54	6.1	.015	.03	.031	4
Carwile fine sandy loam:							
3873	SW¼ sec. 35, T. 23 N., R. 7 W.	0–6	6.4	.112	3.35	.054	28
3874		6–13	6.6	.094	1.77	.042	16
3875		13–26	6.3	.056	.82	.029	16
3876		26–37	6.6	.027	.27	.036	16
3877		37–39	6.7	.058	.50	.036	14
3878		39–45	6.7	.047	.47	.047	12
Renfrow silt loam:							
3822	SW¼ sec. 32, T. 21 N., R. 6 W.	0–6	7.4	.160	3.62	.062	72
3823		6–10	7.0	.140	2.28	.059	80
3824		10–22	7.1	.090	1.75	.048	44
3825		22–30	7.7	.068	1.14	.046	64
3826		30+	8.1	.063	.55	.049	168
Vernon clay loam:							
3868	NE¼ sec. 26, T. 22 N., R. 5 W.	0–6	8.1	.133	2.50	.044	44
3869		6–12	8.7	.065	1.02	.062	64
3870		12+	8.6	.045	.52	.050	92
Vernon very fine sandy loam:							
3739	NE¼ sec. 17, T. 20 N., R. 3 W.	0–6	7.0	.124	3.65	.055	12
3740		6–11	6.9	.097	3.48	.038	8
3741		11–18	7.1	.061	2.25	.032	6
3742		18–30	6.8	0.28	1.33	.051	6
3743		30+	7.0	.027	.56	.081	10

SOILS OF THE TERRACES AND BOTTOM LANDS

Drummond clay:							
3800	NE¼ sec. 9, T. 21 N., R. 8 W.	0–5	8.0	0.174	3.92	0.081	----
3801		5–10	8.6	.102	1.92	.071	136
3802		10–21	8.6	.058	.97	.048	152
3803		21–42	8.0	.075	1.44	.065	144
3804		42–55	8.1	.076	1.56	.068	----
3805		55–66	8.1	.066	1.14	.068	100

TABLE 9.—*Chemical composition of soils in Garfield County, Okla.*—Continued
SOILS OF THE TERRACES AND BOTTOM LANDS—Continued

Soil type and sample No.	Location	Depth	pH	Total nitrogen	Organic matter	Total phosphorus	Readily available phosphorus
		Inches		*Per cent*	*Per cent*	*Per cent*	*Parts per million*
Drummond very fine sandy loam:							
3790	SW¼ sec. 34, T. 21 N., R. 6 W.	0 – 3½	7.1	.096	2.67	.075	84
3791		3½– 5	8.4	.061	2.91	.058	80
3792		5 – 7	8.7	.090	1.67	.063	72
3793		7 –13	8.7	.055	1.06	.066	48
3794		13 –24	8.9	.015	.44	.078	88
3795		24 –40	8.7	.024	.36	.047	96
3796		40 –54	8.9	.018	.40	.065	104
Drummond very fine sandy loam:							
3752	NW¼ sec. 17, T. 21 N., R. 8 W.	0 – 2	8.9	.098	5.00	.056	112
3753		2 – 5	9.3	.062	1.39	.034	96
3754		5 – 8	9.4	.053	.55	.029	96
3755		8 –14	9.3	.014	.39	.025	96
3756		14 –30	9.1	.018	.33	.036	88
3757		30 –42	8.8	.021	.28	.052	84
3758		42+	8.5	.067	.19	.029	88
Lincoln loamy fine sand:							
3808	SE¼ sec. 7, T. 22 N., R. 7 W.	0 – 5	7.3	.050	1.17	.029	28
3809		5 –12	7.5	.020	.28	.026	16
3810		12 –54	7.7	.020	.28	.032	12
Reinach loamy fine sand:							
3746	SE¼ sec. 11, T. 24 N., R. 8 W.	0 – 6	6.7	.058	3.28	.024	60
3747		6 –16	6.5	.046	1.61	.035	52
3748		16 –30	7.3	.030	.56	.037	24
3749		30+	6.8	.058	1.30	.053	64
Reinach silty clay loam:							
3864	SW¼ sec. 34, T. 24 N., R. 4 W.	0 – 3	7.9	.128	2.00	.034	60
3865		3 – 9	7.8	.125	2.82	.041	56
3866		9 –20	8.4	.066	1.25	.048	152
3867		20+	8.1	.078	.65	.037	40
Reinach very fine sandy loam:							
3784	SW¼ sec. 8, T. 22 N., R. 4 W.	0 –12	6.1	.100	2.42	.043	80
3785		12 –30	6.7	.060	1.23	.073	64
3786		30 –42	7.3	.057	1.56	.075	32
3787		42+	8.3	.020	.36	.067	92
Yahola very fine sandy loam:							
3716	NW¼ sec. 4, T. 23 N., R. 4 W.	0 –18	6.8	.068	1.36	.041	16
3717		18 –36	7.1	.068	1.31	.032	42
3718		36+	7.6	.050	.92	.030	14

Potential fertility in Garfield County is rather closely associated with soil texture. The sandier soils normally are lower in total and available plant nutrients than are the fine-textured soils. The rainfall has not been sufficient to remove a very high percentage of the basic material from these soils; consequently, soil acidity, if present, generally is confined to the surface layers. In many places the subsoils contain some lime, but samples of surface soil from cultivated areas collected from different sections of the county indicate that lime should be used in many instances in order to improve the growth of leguminous crops such as sweetclover and alfalfa. Although the total content of phosphorus in the soils of this county is comparatively low, the readily available phosphorus is sufficient for the production of good crops, except in the very sandy areas. Normally, the soils of the bottom lands are higher in readily available phosphorus than are the upland soils. The principal limiting factor in crop production on a high percentage of the soils is lack of available nitrogen, and under present conditions it seems that the best method of returning nitrogen to the soil will be by means of well-inoculated leguminous crops. On many soils it may be necessary to apply lime

in order to increase the growth of such crops as Austrian Winter peas, hairy vetch, sweetclover, and alfalfa. Very few field demonstrations have been conducted in this county to determine the effect of lime on the growth of crops like sweetclover; however, enough information is available to show that the response from the use of lime is pronounced, especially on the Kirkland and Renfrow soils occurring in the eastern part and some of the Enterprise soils northwest of Enid and west of Bison.

A study of the readily available phosphorus in 168 samples of surface soil, which were obtained from different parts of the county, indicates that a deficiency of phosphorus is not an important factor in crop production at present. Ordinarily, soils which have a medium content of readily available phosphorus do not respond to phosphorus fertilization. Only 7 of the samples analyzed were very low in readily available phosphorus, 19 were low, 19 contained a medium amount, 82 were high, and 41 were very high. Most of the samples that were low in readily available phosphorus were obtained from the Renfrow, Enterprise, and Pratt soils. The soils in the eastern part of the county tend to be lower in readily available phosphorus than the soils in the central and western parts. The soils developed on sandstone parent material generally are lower in readily available phosphorus than the soils developing on weathered shale.

Although many soils in the county are not acid, the analyses of 246 samples of surface soil indicate that lime is an important factor in the development of a more permanent type of agriculture on certain soils. Of the samples analyzed, 66 were basic in reaction and contained a good supply of lime, 41 were neutral and did not respond to applications of limestone for lime-loving crops, 55 were slightly acid, 26 were slightly acid+, 43 were medium acid, and 15 were strongly acid. When agricultural limestone is applied to a soil, a maximum effect on crop production does not appear until this material is thoroughly mixed with the soil. To accomplish this, generally two or three cultivations are necessary. Lime has a direct and an indirect effect on plant development, and its greatest benefit generally is derived from an increase in the production of leguminous crops, which results in a greater fixation of nitrogen in the soil. In very acid soils limestone supplies calcium as a plant nutrient and provides a more favorable reaction for bacterial development. As a result of increased bacterial activity, plant nutrients, such as nitrogen, phosphorus, and sulphur, which are combined with organic matter, are liberated, and consequently lime may have a very important indirect effect on crop production under certain conditions.

Although the normal rainfall in this county is sufficient to produce good crops, the distribution frequently is poor. Because of a gently rolling relief and the absence of gully erosion, very little attention has been given to the conservation of water on the majority of farms. When small grain is grown in a cropping system the surface soil is protected from the destructive effect of run-off water except during the summer and early fall. Torrential rains frequently occur during this period and considerable quantities of water and soil are lost as a result of run-off. In many instances moisture may not leave the field but is concentrated in depressions. Experimental

evidence concerning the value of tillage implements, such as a basin lister which will hold the water where it falls, is lacking. There is every reason to believe, however, that retention and uniform distribution of water over a field are important factors in successful crop development. About 500 pounds of water are required to produce 1 pound of dry matter in the form of wheat straw and grain. On rolling land the conservation of water is important, and on comparatively level land less damage will take place in depressions if water can be retained on the adjacent slopes. The Oswego soils are poorly drained, and, during periods of abundant rainfall, water accumulates on these areas from higher land. If terrace ridges are constructed on the slopes adjacent to the Oswego soils, water can be diverted from the lower lying areas. Oswego soils can also be improved by surface drainage to eliminate excessive quantities of water during periods of abundant rainfall.

MORPHOLOGY AND GENESIS OF SOILS

Garfield County lies in the transitional area between the Pedocals and Pedalfers. The heavy-textured soils have a fairly definite, though very lightly developed, zone of calcium carbonate accumulation in places, but the medium- and light-textured soils generally do not have this feature developed. The climate is subhumid, with a mean annual rainfall of 30.66 inches and a mean annual temperature of 59.3° F. The native vegetation on the medium- and heavy-textured soils is of the prairie type and is dominated by bluestems. The native vegetation on the lighter textured soils is dominantly blackjack oak with a scattered growth of bunch grasses. The normal soils of the county have developed under prairie types of vegetation and have brown or dark-brown surface soils which reach an average depth of 17 inches. The subsoils are influenced by the character of the parent material. The surface soil generally is friable very fine sandy loam of neutral or slightly acid reaction. The upper part is faintly laminated, and the lower part is prismatic.

Intrazonal and azonal soils deviate from the normal profile as a result of variations in relief, with its consequent influence on the moisture supply and degree of erosion. Soils occurring on flatter areas have no run-off and, therefore, have a moisture content in excess of the normal amount. This increased moisture supply has resulted in a darker colored surface soil, except in places where the heavy texture of the parent materials and consequent restricted drainage have developed a gray or grayish-brown color in the surface soil. Soils occurring on more sloping areas have a lighter colored and thinner zone of organic accumulation in the surface soil. These soils are in general brown or reddish brown. The parent material of most soils in this county is red, and this color is dominant in the more youthful upland soils.

Other deviations from the normal soil profile in intrazonal soils are the result of differences in parent materials and salt content. Soils developed from sandy parent material in this section are more thoroughly leached than the normal soils and support a forest type of vegetation. These soils have a slightly podzolized profile. The surface soil is grayish brown and becomes slightly lighter colored with depth. The subsoil is yellowish brown or pale yellowish brown.

The salty soils are very mixed in character and have profiles ranging from true Solonchak through true Solonetz and including Soloth.

The soils of this county have developed from red shales and red sandstones of Permian age and from the sands and clays of Quaternary and possibly Tertiary age. The Permian rocks in this section of the country have been classified by geologists as the upper and lower Enid formations. The upper Enid formation consists of sandy shale or shaly sandstones occurring in the western one-third of the county. The lower Enid formation occupies the eastern two-thirds and consists of heavy red shales and some consolidated sandstone. The Quaternary formation underlies the extreme southwestern part and areas northwest of Enid and northwest of Carrier. It is possible that some of the materials here classified as Quaternary should be called Tertiary. Table 10 describes the soils in relation to the parent materials and relief.

TABLE 10.—*Soil series of Garfield County, Okla., in relation to parent materials and relief*

Parent material	Flat uplands	Undulating uplands	Rolling uplands	Hilly uplands	Stream terraces	Recent alluvium
Red sandy shales	Pond Creek	Grant	Nash Vernon	Rough broken land (Vernon soil material)	Reinach Drummond	Yahola
Red shales	Oswego	Kirkland	Renfrow	Vernon Rough broken land (Vernon soil material)	Reinach	Do.
Tertiary and Quaternary sands and clays	Carwile	Pratt	Pratt Enterprise	Enterprise		Lincoln

A natural sequence of soil types has developed on the upper Enid formation as a result of differences in relief. This sequence, beginning with the most mature type, is as follows: Pond Creek silt loam, Grant very fine sandy loam, Nash very fine sandy loam, Vernon very fine sandy loam, and rough broken land (Vernon soil material). Pond Creek silt loam occurs in flat upland areas where drainage is slightly restricted. Following is a description of a typical profile of this soil observed southwest of Enid one-fourth mile south of Sunny Slope School:

1. 0 to 3 inches, very dark brown friable very fine sandy loam or silt loam, matted with grass roots. The material is indistinctly laminated and breaks into soft aggregates one-sixteenth to one-eighth inch in diameter. The reaction is very slightly acid.
2. 3 to 6 inches, very dark brown silt loam which breaks into prisms 3 or 4 inches in diameter. These prisms break horizontally, forming plates one-fourth to one-half inch thick, which, in turn, break into soft aggregates similar to those in the surface horizon. The reaction is the same as that in the layer above.
3. 6 to 14 inches, dark-brown or very dark brown silt loam which breaks into elongated prisms 3 or 4 inches in diameter. In the upper part of this horizon the prisms break horizontally, forming plates one-fourth to 1 inch thick, which, in turn, break into aggregates one-sixteenth to one-eighth inch in diameter. The prisms are easily broken when slightly moist but hard to break when dry. The material along all cleavage planes is much darker colored than that of the crushed material. The material in this layer reacts in the same way as that in the surface horizon.

4. 14 to 25 inches, dark-brown or brown silty clay loam which breaks into irregular prisms 2 or 3 inches in diameter. There is no horizontal cleavage. The prisms break down into hard aggregates one-eighth to one-fourth inch in diameter. When dry the prisms are broken with difficulty between the thumb and fingers, and the crushed material is brown. A few worm casts are present. The reaction of this layer, like that of the overlying layers, is almost neutral.
5. 25 to 42 inches, dark-brown cubical or prismatic heavy clay loam. The cubes are sharp-angled and coated with dark organic matter. Cut surfaces show some rusty-brown mottlings. The cubes or prisms are from 1 inch to 1½ inches in diameter and are broken with great difficulty between the thumb and fingers. The surfaces of the cubes are not shiny. No worm casts are present. This material is slightly acid in reaction.
6. 42 to 55 inches, grayish-brown clay loam mottled with rusty brown and light gray. The gray mottlings are calcareous. This is a zone of lime accumulation, and the reaction is neutral. The material grades into weathered red sandy shale or shaly sandstone of the Permian Red Beds.

Associated with Pond Creek silt loam but occurring on slightly undulating relief where surface drainage is not restricted is what is considered the normal soil of this general region—Grant very fine sandy loam. A description of a typical profile, observed 1 mile east and three-fourths of a mile north of Morning Star School, follows:

1. 0 to 6 inches, brown faintly laminated slightly acid very fine sandy loam. The laminations are fragile and easily broken into soft aggregates one-eighth to one-sixteenth inch in diameter. The material does not appear lighter when crushed.
2. 6 to 10 inches, brown heavy very fine sandy loam which breaks into large blocks or prisms from 4 to 8 inches in diameter, with horizontal or oblique breakage in places. Most of the prisms are five-sided and are easily broken down into soft aggregates similar to those in the surface horizon. The material is slightly lighter colored when crushed. It, also, is slightly acid.
3. 10 to 20 inches, brown silty clay loam with a structure similar to that of the horizon above. Some definite cleavage lines are thinly coated with very fine sand which appears to have fallen down the cracks. The prisms break into aggregates one-sixteenth to one-fourth inch in diameter. The crushed material is brown. Insect casts are numerous. The reaction is moderately acid.
4. 20 to 40 inches, reddish-brown fairly compact moderately acid silty clay loam which breaks out in irregular prisms with no horizontal breakage. The prisms are broken with difficulty between the thumb and fingers when the soil is dry. The crushed material is reddish brown or light reddish brown. Insect casts are numerous. This material also is moderately acid in reaction.
5. 40 to 50 inches, reddish-brown moderately acid clay loam which is slightly less compact than the material in the layer above. There is no indication of prismatic structure. The crushed material is reddish brown.
6. 50 to 65 inches, reddish-brown heavy clay loam which grades into red sandy shales or sandstones of Permian age.

In places, a zone of lime accumulation is present in the subsoil below a depth of about 50 inches.

Nash very fine sandy loam is associated with Grant very fine sandy loam, but it occurs on slightly steeper slopes and low hills or knobs. This soil is more shallow and slightly more red in the surface layer than is Grant very fine sandy loam. Calcareous sandy shale is reached at a depth of 3 feet or less in this soil. Vernon very fine sandy loam occupies sloping or steeply sloping areas. The surface soil to a depth of 6 inches is distinctly reddish brown, and the subsoil is brownish red. The broken, hilly, and gullied areas are correlated as rough broken land (Vernon soil material).

Soil types of another natural succession have developed from heavy red shales of the lower Enid formation of the Permian Red Beds. These soils, beginning with the more mature type, are Oswego silt loam, Kirkland silt loam, Renfrow silt loam, Vernon clay loam, and rough broken land (Vernon soil material). Oswego silt loam is developed on flats where surface drainage is restricted. Following is a description of a typical profile of this soil, a sample of which was taken 1 mile north of Breckinridge, in the SE ¼ sec. 21, T. 23 N., R. 5 W.:

1. 0 to 2 inches, grayish-brown highly laminated silt loam. The laminations are one thirty-second to one-eighth of an inch in thickness and break down into flattened aggregates. The chemical reaction is decidedly acid.
2. 2 to 5 inches, grayish-brown silt loam which breaks into plates one-fourth to one-half inch thick. These plates break readily into soft aggregates similar in size to those in the surface horizon, but they are not flattened. Close examination reveals faint mottlings of rusty brown. The material in this layer also is decidedly acid in reaction.
3. 5 to 9 inches, grayish-brown silty clay loam with no definite structure. The material breaks into soft irregular aggregates one-eighth to one-fourth inch in diameter. It, also, reacts decidedly acid.
4. 9 to 16 inches, light grayish-brown or gray clay loam which breaks into irregular clods one-fourth to one-half inch in diameter. The clods are grayish brown or brown on the interior and are coated with light-gray siliceous material. This is a well-defined gray layer. The material is not nearly so friable nor so acid as that in the surface horizons. The change to the underlying claypan is abrupt.
5. 16 to 30 inches, very dark brown or nearly black heavy compact clay. This is a claypan that is almost massive in structure. It cracks vertically into large irregular square-topped prisms from 6 to 8 inches in diameter. Gray material follows down the cracks in some places, giving a gray coating to the prisms, near the top. The large prisms, in turn, break down into irregular clods from 1 to 2 inches in diameter. Roots are very numerous, but insect casts are absent. The reaction is very slightly acid.
6. 30 to 37 inches, dark-brown clay containing numerous white or gray accretions of lime. The fine earth is noncalcareous. The material in this layer is neutral in reaction. There are no cleavage lines.
7. 37 to 42 inches, brown or dark-brown clay. Numerous white or gray mottlings of carbonate of lime are present, and this is the zone of greatest lime accumulation. The fine earth is noncalcareous. As in the layer above, the reaction is neutral.
8. 42 to 50 inches, brown calcareous clay which appears to be slightly lighter textured than that in the above horizon. A few mottlings of lime occur. The reaction of this material is neutral.
9. 50 to 65 inches, yellowish-brown clay mottled with rusty brown, brown, and black. This is only slightly altered shale which has lost the original red color owing to poor drainage. A few lime concretions are present. The material in this layer has a neutral reaction.

This is the most typical claypan soil in the county. It possibly was subjected to influences of sodium during the process of soil development, but now only small quantities of exchangeable sodium seem to be present in the profile.

Kirkland silt loam is associated with Oswego silt loam but has more rolling or undulating relief and better drainage than that soil. Following is a description of a typical profile of Kirkland silt loam observed three-fourths mile west of Garber, in the SW¼ sec. 26, T. 23 N., R. 4 W.:

1. 0 to 2 inches, brown loose friable silt loam. The apparent absence of laminations indicates that this is wind-blown material.
2. 2 to 6 inches, dark-brown moderately acid silt loam which breaks into irregular prisms and plates. The horizontal cleavage is more def-

inite than the vertical cleavage. The prisms are 4 or 5 inches in diameter, and the plates are one-fourth to one-half inch thick. They are easily reduced to irregular aggregates one-sixteenth to one-eighth inch in diameter.

3. 6 to 16 inches, dark-brown moderately acid silty clay loam which breaks into five-sided prisms from 4 to 6 inches in diameter. In a few places these form blocks or plates 2 or 3 inches thick. Insect casts are numerous. The blocks readily break down into aggregates one-eighth to one-fourth inch in diameter.
4. 16 to 18 inches, brown or grayish-brown clay loam which breaks into irregular clods one-eighth to one-half inch in diameter. The clods are brown on the interior and are coated on the outsides with gray siliceous material. No prismatic or platy breakage is evident. This is an incipient gray layer. The material is slightly less acid than that in the layers above. It rests on claypan without any transitional zone.
5. 18 to 25 inches, chocolate brown or dark-brown dense clay or claypan. This breaks into roughly cubical clods from 1 to 2 inches in diameter, which cannot be broken with the bare hands when the soil is dry. No insect casts are present. The material reacts slightly acid.
6. 25 to 36 inches, dark-brown or brown clay which is less compact than that in the overlying layer. There are no cleavage planes. The material in this layer is noncalcareous and the reaction is almost neutral.
7. 36 to 46 inches, brown clay containing white lime accretions and black manganese or iron accretions. The lime spots are calcareous, but the fine earth is noncalcareous. The reaction is neutral.
8. 46 to 60 inches, brownish-red and brown mottled clay which effervesces slightly with hydrochloric acid. Black concretions of iron or manganese and concretions of lime are few.

Associated with Kirkland silt loam but characterized by more rolling relief is a brown or reddish-brown soil which has no development of a claypan. This is classified as Renfrow silt loam. The reddish-brown heavy soil in this sequence of soils is classified as Vernon clay loam the relief of which is rolling or strongly rolling. In the more broken, hilly, and gullied sections the soil is mapped as rough broken land (Vernon soil material).

Soils of the Drummond series are salty soils that occur on old stream or lake terraces and in some upland areas. These soils are extremely irregular in development and range from Solonchak to Solonetz and solodized Solonetz. The heavier textured member is classified as Drummond clay. The Solonetz has not developed structure so well in this soil as in Drummond very fine sandy loam. A sample of Drummond very fine sandy loam taken 2 miles east and 1 mile north of White School near the southwest corner of sec. 34, T. 21 N., R. 6 W., has the following typical profile:

1. 0 to 3 inches, grayish-brown very friable loose very fine sandy loam containing a few reddish-brown spots. No laminations are apparent. The reaction is strongly acid.
2. 3 to 5 inches, grayish-brown or light grayish-brown very fine sandy loam, without laminations. The material reacts only very slightly acid.
3. 5 to 7 inches, brown columnar clay loam. The columns are about 2 inches in length, range from ½ to 1 inch in diameter, and are five- or six-sided. The tops of the columns are rounded and are covered with a very definite gray coating. The columns become irregular and indefinite with depth. They are very hard when dry. The reaction is neutral.
4. 7 to 13 inches, reddish-brown heavy clay loam which breaks into blocks or irregular prisms three-fourths to 1 inch in diameter. The material becomes slightly lighter colored on crushing.
5. 13 to 24 inches, reddish-brown clay loam containing white lime and gypsum in mycelial form lining old root channels. The fine earth and mycelia are both calcareous. There is no prismatic structure. The soil material is lighter colored when crushed.

6. 24 to 40 inches, grayish-brown calcareous clay loam mottled with reddish brown.
7. 40 to 54 inches, reddish-brown clay loam containing a few gray mottlings. The fine earth is noncalcareous, but a few accretions of lime are present.

The soils developed on the heavier Quaternary deposits are correlated with the Carwile series. These soils are subjected to a limited degree of Rendzina influence. The parent materials evidently contained a high percentage of lime. In places, these soils have a very distinct zone of lime accumulation at a comparatively slight depth. Soils developed on the Quaternary sandy formations are grayish-brown slightly podzolized forested soils and are correlated with the Pratt and Enterprise series.

Mechanical analyses of several soils are given in table 11.

TABLE 11.—*Mechanical analyses of several soils in Garfield County, Okla.*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Pond Creek silt loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
452314	0- 3	0.4	0.7	0.6	2.1	11.5	66.8	17.9
452315	3- 6	.2	.5	.5	1.5	13.1	65.2	19.1
452316	6-14	.2	.4	.5	1.4	14.4	59.5	23.6
452317	14-25	.1	.4	.3	.9	10.8	59.1	28.4
452318	25-37+	.1	.8	.6	1.2	7.4	50.3	39.6
452319	42-55+	.5	1.3	.9	1.6	7.3	35.2	53.3
Reinach silty clay loam:								
452380	0- 3	.1	.2	.3	1.7	21.7	45.0	31.0
452381	3- 9	.1	.1	.2	1.4	32.0	46.8	19.3
452382	9-20	.2	.5	.4	1.4	6.4	39.3	51.9
452383	20-42+	.1	.2	.2	.8	6.4	52.2	40.1
Kirkland silt loam:								
452368	0- 2	.2	.6	.6	1.8	11.5	66.8	18.6
452369	2- 6	.1	.7	.7	1.9	10.9	64.5	21.3
452370	6-16	.2	.7	.7	1.6	8.3	64.2	24.3
452371	16-18	.2	.7	.7	1.3	7.8	56.4	32.8
452372	18-25	.2	.7	.7	1.3	4.3	46.4	46.3
452373	25-36	.1	.8	.8	1.5	4.9	47.8	44.2
452374	36-46	.5	1.1	.9	1.6	4.5	46.3	45.1
452375	46-60+	.8	1.9	1.2	1.7	5.5	43.3	45.6
Oswego silt loam:								
452349	0- 2	.2	.4	.5	1.6	10.1	68.5	18.7
452350	2- 5	.1	.4	.5	1.4	9.7	68.2	19.8
452351	5- 9	.0	.5	.5	1.4	9.6	65.5	22.5
452352	9-16	.1	.3	.5	1.4	6.6	59.6	31.4
452353	16-30	.1	.3	.5	1.3	4.7	44.6	48.4
452354	30-37	.2	.3	.5	1.2	3.4	48.2	46.2
452355	37-42	.9	1.0	.7	1.4	3.7	50.2	42.0
452356	42-50	.6	.9	1.0	2.2	6.6	46.2	42.5
452357	50-66+	.3	1.2	1.2	2.7	8.7	45.7	40.2
Carwile loam:								
452361	0- 6	.6	4.1	6.5	14.9	20.0	33.9	19.9
452362	6- 8	1.3	4.5	6.3	14.1	20.0	31.2	22.6
452363	8-13	1.5	3.9	5.9	13.9	19.5	30.0	25.2
452364	13-19	.7	3.5	4.9	12.9	20.2	31.3	26.5
452365	19-25	.9	5.2	7.8	16.3	17.9	25.3	26.5
452366	25-50	.6	4.2	5.6	11.3	18.6	28.5	31.2
452367	50-60+	.6	4.3	5.2	8.0	15.7	30.0	36.1
Renfrow silt loam:								
452326	0- 6	.3	.3	.3	1.5	9.9	61.0	26.7
452327	6-10	.1	.3	.1	.9	9.5	50.5	38.7
452328	10-22	.1	.2	.2	.7	5.4	37.0	56.5
452329	22-30	.1	.1	.2	.7	4.6	33.5	60.8
452330	30-36+	.0	.1	.4	2.6	4.5	45.7	46.6

SUMMARY

Garfield County is in the northwestern part of Oklahoma. It is situated in the zone of transition from the humid prairies to the subhumid plains. The native vegetation was dominantly bunchgrasses,

among which bluestem and tall bluestem were the most important. In the less disturbed areas these grasses remain prominent.

The county includes two fairly smooth or gently undulating plains which slope to the east and southeast at the rate of approximately 6 feet to a mile. The uplands are not thoroughly dissected but are well drained in most places. Less than 6 percent of the land may be classed as strictly nonarable because of broken relief.

Climatic conditions have restricted the choice of crops in this section to those that can withstand periods of drought. Winter wheat and spring-sown oats are the important cash crops. Minor crops are grain sorghums, sorgo, alfalfa, and Sudan grass.

Most of the soils are medium in texture and are comparatively fertile. As they have developed under a grass cover, under conditions of low rainfall, they are not highly leached. The soils in most places are neutral or slightly acid in reaction. The upper horizons, to a depth ranging from 6 to 20 inches, are generally brown, dark brown, or grayish brown and largely of very fine sandy loam and silt loam textures. The subsoils are heavier than the surface soils, in many places claypanlike, and are brown, dark brown, or reddish brown. Most of the soils have developed from shales and sandstones of Permian age, but some have developed from sandy deposits of Quaternary age.

Most of the soils are fertile and well suited to the production of the dominant crops grown in this section. According to classifications made on the basis of this survey approximately 66 percent of the land is comparatively highly productive smooth land, 24 percent arable but moderately productive, 4 percent poor arable land, and the remaining 6 percent nonarable. A total of 22 soil types and phases and 1 miscellaneous land type are mapped, studied, and classified. They are divided into eight groups, according to the characteristics of the soils and their productive capacity and suitability for crops, as follows: (1) Brown Prairie soils with friable subsoils, (2) brown Prairie soils with dense heavy subsoils, (3) reddish-brown Prairie soils with friable subsoils, (4) red Prairie soils with both heavy and friable subsoils, (5) grayish-brown sandy soils with very friable subsoils, (6) brown soils with saline subsoils, (7) alluvial soils, and (8) miscellaneous nonarable land.

The brown Prairie soils with friable subsoils are the most productive soils. The members of this group are Pond Creek silt loam, Grant very fine sandy loam, Reinach very fine sandy loam, and Reinach silty clay loam. These soils are well suited to all the crops commonly grown in this section. They have smooth relief and, therefore, are not subject to excessive losses of soil or water by erosion and run-off of rain water.

The brown Prairie soils with dense heavy subsoils are also very productive. The tough heavy subsoils common to the soils of this group make these soils particularly adaptable to the production of wheat. This is the most extentive group of soils in the county. It includes Kirkland silt loam, Oswego silt loam, Carwile loam, and Carwile fine sandy loam. The relief is smooth, and the soils are not appreciably affected by erosion and run-off.

The group of reddish-brown Prairie soils with friable subsoils include some of the less valuable agricultural soils. No claypans

are present in the subsoils. These soils produce fair yields of wheat but are somewhat better adapted to the production of sorghums, Sudan grass, and oats. Renfrow silt loam, Renfrow clay loam, and Nash very fine sandy loam are classed with this group. They occur on rolling terrain and are, therefore, subject to losses of water and surface soil through run-off and erosion. Terracing and strip cropping have proved to be valuable in the protection of these soils.

The group of red Prairie soils with both heavy and friable subsoils include other less valuable agricultural soils. They are red or reddish brown and are rather shallow. They occupy rolling areas along stream valleys. The group comprises Vernon very fine sandy loam and Vernon clay loam. Fair yields of oats, wheat, and grain sorghums are produced under favorable conditions, but the soils are better suited to pasture. Run-off is rapid, causing severe erosion and loss of soil moisture.

The less valuable sandy soils are included in the group of grayish-brown sandy soils with friable subsoils. Owing to their very light textures, yields of wheat are poor. These soils are better adapted to cowpeas, peanuts, and watermelons than to wheat, and they produce fair crops of sorghums and Sudan grass. Pratt loamy fine sand, Pratt loamy fine sand, dune phase, Pratt fine sandy loam, and Reinach loamy fine sand are members of this group. These soils occur in flat or hummocky and undulating areas. Water penetrates rapidly, and there is little or no run-off or water erosion. Occasionally, however, the soils are subject to some wind erosion.

The brown soils with saline subsoils—Drummond clay and Drummond very fine sandy loam—have low agricultural value. They are shallow and eroded, and the concentration of soluble salts in the subsoils is sufficient, in many places, to inhibit the growth of plants. The few cultivated areas do not produce good yields of crops. These soils appear to be suited only for pasture or for the growing of salt-resistant crops.

The alluvial soils—Lincoln loamy fine sand and Yahola very fine sandy loam—consist of narrow strips of bottom land along the streams. In places the areas are too narrow or too closely cut by drainage channels to be farmed. Some steep banks and small gullies, as well as flat areas subject to overflow, also are included.

Miscellaneous nonarable land is rough and broken or otherwise physically unsuited to cultivation. This land is indicated on the map as rough broken land (Vernon soil material) and Enterprise fine sand, dune phase.

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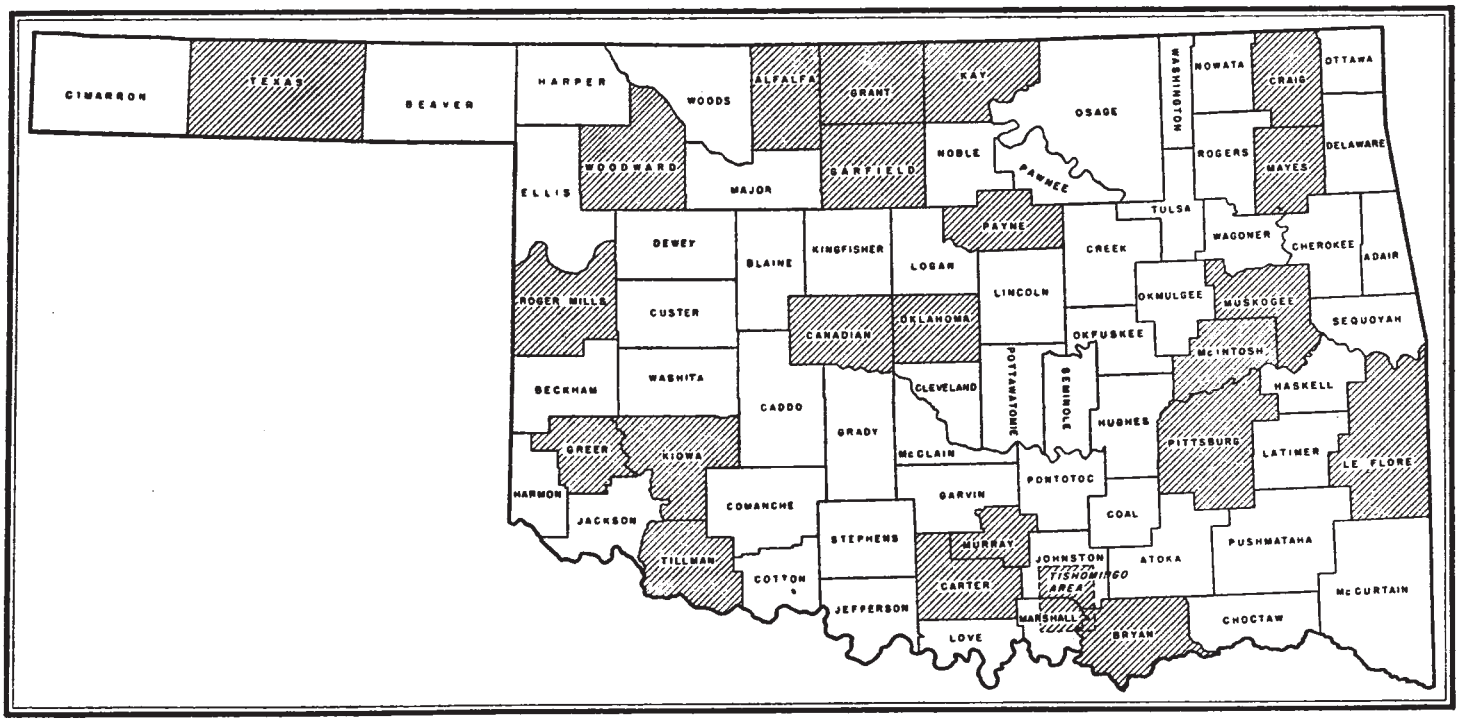

Areas surveyed in Oklahoma shown by shading. Detailed surveys shown by northeast-southwest hatching.

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