

SOIL SURVEY OF PAWNEE COUNTY, NEBRASKA.

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DESCRIPTION OF THE AREA.

Pawnee County is situated in the southeastern part of Nebraska, adjoining the State of Kansas. It lies about 40 miles southeast of Lincoln, and its eastern boundary is 30 miles west of the Missouri River. The county is rectangular in outline, being 24 miles long east and west and 18 miles wide. It has an area of 431 square miles, or 275,840 acres.

Pawnee County lies in the glaciated part of the Great Plains province. From a physiographic standpoint, the area included within the county is essentially a plain sloping gradually toward the southeast. The original constructional surface has been modified by stream erosion, giving rise to such topographic features as flat divides, rolling slopes, broken areas of terrace, and continuous strips of alluvial flood plain.

The uplands consist of small remnants of the original loess plain and extensive areas of eroded slope land. The loess plain occupies only the higher divides and constitutes some of the highest land in the county. The surface is flat to slightly undulating, modified in places by a few shallow swales and occasional stream valleys. The valleys are shallow, though sharply cut except near the margin of the loess plain areas, where they become broader and their slopes more gradual. The remnants of the loess plain are small and in places rather irregular in outline, owing to the headward erosion of numerous small branches. The most extensive areas are in the vicinity of Lewiston in the northwestern part and on the north side of Mission Creek in the southwestern part of the county. A few small, isolated areas in the southern part of the county have escaped destructive erosion; these are narrow, flat-topped divides varying in width from a few rods to about one-half mile. The total area of loess plain in Pawnee County probably does not exceed 5 square miles.

The eroded slope land includes all the remainder of the county except the alluvial terraces and flood plains along the streams. It comprises a succession of ridges and valleys. Over most of the county the major slopes are moderate and the ridges well rounded. The smaller drainage ways are generally shallow, though in places they are sharply cut and have short, steep grades. The slopes along the larger creeks are often abrupt immediately bordering the flood plains, but become gradual toward the crests of the divides, which lie from 100 to 150 feet above the stream channels. Along the North Fork of the Nemaha River dissection is much deeper and the slopes comparatively steep.

Throughout the southern quarter of the county the bedrock lies at a relatively high level and is exposed along the edges of the valleys, producing a number of steep to almost precipitous slopes. In most

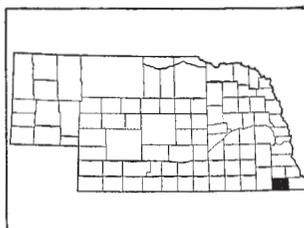


FIG. 39.—Sketch map showing location of the Pawnee County area, Nebraska.

places, however, the relief is moderate back of the valley edges. The slopes on the north side of West Branch, Johnson Creek, and the South Fork of the Nemaha River are usually long and gradual, while those on the south side are very steep and often deeply gullied, comprising the roughest topography in the county. In the southwestern part of the county, within the Mission Creek drainage basin, the divides are unusually broad and high, almost attaining the level of the original loess plain. The upper valley slopes are gradual, becoming steeper as they approach the flood plains. Throughout the areas of eroded slope lands there are flats that have a topography similar to the loess plains, but at a much lower elevation.

The alluvial terraces in the county are of very small extent and chiefly in the southeastern part, along Turkey Creek, Johnson Creek, West Branch, and Lores Branch. They lie from 8 to 12 feet above the present flood plains of the streams. The terraces are flat, bench-like and uneroded. The slope to the bottom land is usually marked by a short, steep grade, while that to the upland is comparatively long and gradual.

Pawnee County includes considerable bottom land. The largest area lies along the North Fork of the Nemaha River in the northeastern part and varies in width from one-half mile to about one and one-half miles. Another large body which lies along the South Fork of the Nemaha River in the southeastern part of the county is about 3 miles long and has an average width of three-fourths mile. A long though comparatively narrow strip extends across the central part of the county, bordering the channel of Turkey Creek. Small, narrow areas extend up the larger tributaries of this stream and along Mission, Plum, and Wolf Creeks, in the western part of the county. The surface of the bottom land is generally flat, though modified locally by slight depressions and overflow channels. It lies from 4 to 10 feet above the streams.

The average elevation of the loess plain is about 1,300 feet and that of the eroded slope land probably 1,200 feet above sea level. The bottom lands range in elevation from about 800 to approximately 1,050 feet. The elevations¹ of the various towns are: Table Rock, 1,023; DuBois, 1,084; Pawnee City, 1,210; Steinauer, 1,219; Lewiston, 1,475; Violet, 1,254; Burchard, 1,366; Armour, near the Chicago, Burlington & Quincy depot, 1,314; Tate, 841; and Bookwalter, 919 feet above sea level. The general slope of the county is to the southeast, with the exception of most of the western edge, which slopes southwest.

The county has a large number of major and minor streams, each fed by many tributaries, so that every section of land is reached. The North Fork of the Nemaha River, the largest stream, flows southeastward across the northeast corner of the county and drains the east-central and northeastern parts. The channel varies in width from 2 to 4 rods and has an average depth of about 5 feet. Taylor Branch and Clear Creek are the largest tributaries. The South Fork of the Nemaha River, which flows northeast across the southeast corner of the county, is somewhat narrower than the North Fork. Lores Branch and Nigger Branch, its largest tributaries, flow southeast and drain most of the southeastern part of the county.

¹Nebraska Blue Book, 1915.

The extreme northwestern part and the central part of the county from north to south are drained by Turkey Creek and its western tributaries, which include Rock Creek, Balls Branch, West Branch, and Johnson Creek. The western and southwestern parts are drained southwestward into the Big Blue River in Gage County, through Wolf, Plum, and Mission Creeks.

All of the loess plain, eroded slope, and terrace land of the county is well drained. Parts of the flood plains along the larger creeks and along the South Fork of the Nemaha River are subject to inundation during seasons of excessive rainfall. The channel of the North Fork of the Nemaha River has been artificially straightened so that there is at present little danger from overflow. Most of the creeks and smaller drainage ways are deepening their channels, especially in their upper courses. The rivers, however, are approaching base level and in many places are building up their flood plains.

Pawnee County was defined by an act of the first Territorial legislature in 1855. Before that it was included with Richardson County. When first organized the county was 24 miles square. A tier of townships along the northern boundary was later added to Johnson County, leaving Pawnee County with its present boundaries. The first settlers came from Ohio and located along the South Fork of the Nemaha River in the extreme southeastern part of the county. Later settlers came from Missouri, Indiana, and Illinois and spread over the entire area. According to the the 1920 census, the population of the county is 9,578, all being classed as rural, as there are no cities having 2,500 or more inhabitants. In 1920 there were 22.2 persons per square mile. With the exception of a greater density of settlement in the vicinity of the larger towns, the population is evenly distributed.

Pawnee City, the county seat and largest town, is located in the east-central part of the county. It has a population of 1,596, and is a distributing center for farming implements and supplies. Table Rock, in the northeastern part, with a population of 750, is one of the largest brick-producing centers in the State. Steinauer in the north-central part of the county, Lewiston in the northwestern part, Burchard and Armour in the west-central part, and DuBois in the southeastern part furnish local markets and shipping centers for the sections of the county in which they are situated. Tate, Bookwalter, Mayberry, and Violet are small villages along the railroads, in the western and central parts of the county.

The transportation facilities of Pawnee County are good, no point being more than 9 miles from a railroad. The main line of the Chicago, Burlington & Quincy Railroad, from St. Joseph to Denver, crosses the central part of the county from east to west, passing through Table Rock, Pawnee City, Burchard, Armour, and Violet. A branch line extends northeast from Table Rock to Lincoln. A branch of the Chicago, Rock Island & Pacific Railway from Horton, Kans., to Jansen, Nebr., crosses the county from southeast to northwest, connecting DuBois, Pawnee City, Steinauer, Mayberry, and Lewiston. The Kansas City Northwestern Railroad from Kansas City, Mo., to Virginia, Nebr., traverses the western part of the county, passing through Bookwalter, Armour, and Tate, but operation of this line has been discontinued in recent years.

Most of the wagon roads follow section lines, regardless of topography. All the roads are of earth. The more important highways are well graded and are dragged as soon as the ground permits after each rain. Little attention is given to the minor roads. The bridges along the main highways are prominent features of the county. Most of the larger bridges are substantial steel structures, and the culverts are reinforced concrete. All parts of the county have rural mail delivery and telephone service.

The direct connections with St. Joseph, Kansas City, and Lincoln furnish the county with good outside markets. In Lincoln there is a steady demand for most of the dairy products. The surplus livestock and grain are shipped to St. Joseph and Kansas City.

CLIMATE.

The climate of Pawnee County is typical of southeastern Nebraska and is well suited to grain farming and stock raising. The low temperatures sometimes occurring in winter usually are not destructive to winter-grown crops, owing to the protection of snow. There is not sufficient variation in topography to cause any appreciable differences in climate within the county.

The table below, compiled from the records of the Weather Bureau station at Pawnee City, gives the normal monthly, seasonal, and annual temperature and precipitation:

Normal monthly, seasonal, and annual temperature and precipitation at Pawnee City.

[Elevation, 1,175 feet.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	° F.	° F.	° F.	Inches.	Inches.	Inches.
December	28.1	70	-24	1.03	0.70	1.25
January	24.6	65	-29	.77	.15	1.75
February	28.0	75	-20	1.12	.90	3.67
Winter	26.9	75	-29	2.92	1.75	6.67
March	41.0	94	-20	1.19	2.52	1.67
April	51.7	96	18	2.77	2.25	2.24
May	61.5	100	25	5.09	1.22	7.55
Spring	51.4	100	-20	9.05	5.99	11.46
June	71.5	106	39	4.73	4.60	7.92
July	76.4	111	41	3.69	.40	6.56
August	75.5	110	38	3.80	1.84	5.01
Summer	74.5	111	38	12.22	6.84	19.49
September	67.4	105	25	3.88	6.50	4.71
October	54.5	92	13	2.51	2.15	1.34
November	42.1	83	2	1.63	T.	2.02
Fall	54.7	105	2	8.02	8.65	8.07
Year	51.9	111	-29	32.21	23.23	45.69

The mean annual precipitation is 32.21 inches, of which about 75 per cent occurs during the growing season, from April to September, inclusive. About 42 per cent falls during May, June, and July, with

the maximum in May. December, January, and February are the driest months, with a total precipitation of 2.92 inches. The precipitation for the driest year on record was 23.23 inches and that for the wettest year 45.69 inches.

The summer rainfall usually occurs as heavy thundershowers of short duration. A considerable amount of the rainfall in May, June, and July occurs in quantities of 1 inch or more in 24 hours. The rainfall in May and June is usually well distributed, and droughts are practically unknown in these months. In July the distribution is not so favorable, though on the average rain falls at least once every five days during May, June, and July. In August and September the precipitation is lighter, and occasional short droughts occur, causing reduced grain yields. Crop failures are practically unknown, however, as the soils are retentive of moisture. The average annual snowfall is about 20 inches.

The mean annual temperature is 51.9° F. January is the coldest month, with a mean of 24.6° F., and July is the warmest, with a mean of 76.4° F. The lowest temperature recorded is -29° F., in January, and the highest 111° F., in July.

The average date of the last killing frost in the spring is April 27 and of the first in the fall October 7. This gives an average growing season of 163 days, which is ample for the maturing of all farm crops common to the region. In the 20 years, 1895 to 1914, there were 4 seasons in which the last killing frost was 10 or more days later in the spring and the earliest 10 or more days earlier in the fall than the average. Killing frost has been recorded as late as May 14 and as early as September 20.

The winds are prevailingly from the northwest, except during June, July, and August, when they are mainly from the south and southeast. The average wind velocity at Lincoln, about 50 miles northeast of Pawnee County, is 11 miles an hour. A velocity of 70 to 80 miles has been recorded for short periods during severe storms. Tornadoes are rare.

The relative humidity is quite regularly near 70 per cent. About half the days are clear and sunshiny, the remainder being cloudy or partly cloudy.

AGRICULTURE.

The first settlers in Pawnee County established claims along the larger streams, where there was an abundance of wood for fuel. The first crops consisted largely of small patches of corn and wheat, which, with game and pork, constituted the chief foods. As homesteads were permanently located and conditions became more stable, the farmers began to break the prairie land for the more extensive production of corn and wheat, with some oats for stock feed and garden vegetables for home consumption. The early agricultural development was slow. The farming methods were crude and wasteful. Seed selection, crop rotation, and fertilization were not practiced, and the prices of crops were very low on account of the absence of transportation facilities.

The census reports the value per farm of all farm property, including land, buildings, implements, and domestic animals, at \$3,057 in 1880, \$5,805.50 in 1890, \$5,310 in 1900, \$15,806 in 1910, and \$29,302 in 1920. The number of farms in the county increased from 1,033

in 1880 to 1,649 in 1900, and later decreased to 1,339 in 1920. The average size of the farms varied from 173 acres in 1880 to 161 acres in 1900 and 184.8 acres in 1920. The proportion of the entire county in farms increased from 49.1 per cent in 1880 to 89.7 per cent in 1920. The percentage of farms operated by owners gradually decreased from 68.4 per cent in 1880 to 57 per cent in 1920, showing that more farms are being rented each year.

The following table, compiled from the reports of the Bureau of the Census for 1880, 1890, 1900, 1910, and 1920, shows the trend of agriculture in Pawnee County during the last 40 years:

Acraege and production of principal crops, 1879, 1889, 1899, 1909, and 1919.

Crop.	1879		1889		1899	
	Area.	Production.	Area.	Production.	Area.	Production.
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>
Corn	38,572	1,516,879	72,266	3,315,708	107,685	3,822,590
Oats	5,628	118,331	18,756	689,760	23,811	688,800
Wheat	9,779	62,422	1,112	18,380	8,172	67,680
Rye	521	6,403	282	4,576	142	1,720
Barley	510	3,873	8	125	37	750
Flax seed		465	5,413	38,317		
Potatoes		22,467	942	77,026	712	62,283
Hay and forage	17,578	<i>Tons.</i> 26,250	41,527	<i>Tons.</i> 52,656	27,204	<i>Tons.</i> 37,973
Apples	<i>Trees.</i>	<i>Bushels.</i>	<i>Trees.</i>	<i>Bushels.</i>	<i>Trees.</i>	<i>Bushels.</i>
Peaches and nectarines			61,167	55,145	113,960	29,569
			9,054	324	44,115	947

Crop.	1909		1919	
	Area.	Production.	Area.	Production.
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>
Corn	81,920	1,791,406	60,818	952,299
Oats	20,861	542,483	16,404	360,510
Wheat	19,452	363,061	38,798	542,991
Rye	32	511	433	3,771
Barley	7	140	213	3,276
Flax seed				
Potatoes	641	61,736	427	18,882
Hay and forage	30,925	<i>Tons.</i> 45,294	35,405	<i>Tons.</i> 55,225
Apples	<i>Trees.</i>	<i>Bushels.</i>	<i>Trees.</i>	<i>Bushels.</i>
Peaches and nectarines	86,009	36,158	13,168	12,969
	53,636	2,559	8,376	110

The present agriculture of the county consists mainly of grain production, in conjunction with livestock raising and dairying. Corn, wheat, oats, alfalfa, wild hay, and clover and timothy mixed are the principal crops, ranking in acreage in the order named.

Corn is by far the most important crop, and on farms where little feeding is done it is the leading cash crop. The average yield as reported by the last five censuses ranged from 16 to 46 bushels per acre. The State board of agriculture reports 69,962 acres, or a little over one-fourth of the entire county, devoted to corn in 1920, with an average yield of 38 bushels per acre. Corn is grown on practically all the soils of the county. The highest yields, however, are obtained

upon the well-drained bottom lands, where the most favorable moisture conditions exist. Most of the corn is husked from the standing stalks, and cattle and horses are allowed to run in the fields during the winter. Many farmers fence off a few acres of unhusked corn for hog range. On farms equipped with silos, of which there are 41 in the county, from 15 to 20 acres of corn are cut each year for ensilage. On tenant farms most of the corn is sold, but on farms operated by owners the crop is largely fed to hogs, cattle, and horses. The less progressive farmers grow corn on the same land for five or six consecutive years. Much better yields are obtained where it is grown in rotation with small grain and alfalfa. The improvement of seed corn is receiving more attention over the county as a whole, but seed selection is not generally practiced. The leading varieties are Reid Yellow Dent and Iowa Silvermine.

Wheat ranks second in acreage in Pawnee County. The Nebraska State Board of Agriculture reports that of the 22,786 acres of wheat in 1920 all but 78 acres was winter wheat, with an average yield of 17 bushels per acre. Turkey, a hardy winter variety, is grown almost exclusively. This variety is seldom subject to winterkilling and usually matures before the advent of dry weather and hot winds in the summer. The crop is cut with a binder and shocked or stacked in the field for threshing. The grain is sold to local elevators, from which it is later shipped to Kansas City. A small proportion of the crop is annually stored in farm elevators or granaries and held for higher prices. The straw is left in the field, and stock is allowed to feed from the stacks.

Oats rank next to wheat in acreage. The average yield was 22 bushels per acre in 1919 and 39 bushels in 1920. Kherson and Red Rustproof are the principal varieties. The crop is usually cut with a binder and is threshed from shocks or stacks. The grain is used mainly as feed for horses and other stock, although some is sold. The straw is usually left in the field, where stock has access to the stacks; a little of the straw is baled and shipped. Some of the seed is obtained from other sections, but more commonly a sufficient amount of the previous crop is cleaned for the next seeding. Although oats are grown upon nearly all the soils of the county, they do best on the silt loams.

According to the census, alfalfa was grown in 1919 on 14,439 acres, with a total yield of 26,378 tons of hay, which is nearly four-fifths of the total tonnage of tame hay. In 1909 alfalfa occupied 3,935 acres. The crop is used as feed for hogs and cattle. Hogs are often pastured on green alfalfa during the summer season, but as a rule cattle are not allowed to graze alfalfa on account of the danger of bloating. Three cuttings are usually obtained, and in exceptional years a fourth crop is cut. The hay is stacked in the fields and hauled to the feed lots as needed. A small part is baled for shipment. Alfalfa is an excellent crop for building up depleted soils and for preventing erosion on hillsides. However, it is not in favor for short rotations, as most farmers prefer to leave the stand for several seasons before changing to other crops.

Until recently clover and timothy mixed constituted the most important tame hay, being grown in 1909 on 6,044 acres. In 1919 the mixed crop occupied 1,894 acres, timothy alone 2,672 acres, and clover alone 332 acres. Clover and timothy hay is fed largely to

cattle and horses and is especially esteemed for work animals. It is grown chiefly on the bottom lands, where there is an abundance of soil moisture. As a rule, the first crop from a mixed seeding is almost pure clover, the second about an equal mixture of clover and timothy, and the third almost pure timothy.

Wild hay is still an important crop in Pawnee County. It was cut on 12,003 acres in 1919 and yielded 13,942 tons. The crop is grown in the more hilly parts of the upland and upon the poorly drained portions of the flood plains. The yield of upland hay is about half as much as that of bottom-land hay, but it is of much better quality and higher feeding value. The hay is usually stacked in the field and hauled to the feed lots as needed. A little is baled and shipped to Kansas City.

Barley, rye, sorghum, and potatoes constitute the less important crops. Barley was grown on 213 acres in 1919, rye on 433 acres, sorghum on 523 acres, and potatoes on 427 acres. Barley and rye are grown chiefly for the grain, though some rye is planted for late fall pasture. Sorghum is grown chiefly for winter roughage; the average yield is 3 tons per acre. Potatoes are grown only for home consumption, and the supply does not equal the demand, so that large quantities are shipped in from outside markets.

Most of the farms have small orchards of apple, peach, plum, and pear trees. The trees bear well when properly cared for, but owing to inadequate pruning and spraying most orchards are gradually dying out. Grapes and plums are the most important of the wild fruits. They grow chiefly along the larger streams throughout the county.

The cattle in Pawnee County are mostly grade stock, although many herds are headed by a purebred bull. Some herds are mainly of Shorthorn and Hereford breeding. There are 86,675 acres of pasture land in the county, and many farmers purchase cattle for summer grazing. On several farms one or two carloads are fattened each year and shipped to the Kansas City and St. Joseph markets. The census reports 25,275 cattle in the county on January 1, 1920.

Dairying receives little attention, and there are no farms devoted entirely to dairying. Many farmers, however, milk from 3 to 10 cows, chiefly of the beef breeds, and sell their surplus cream or butter in the surrounding towns. Part of the cream is shipped to St. Joseph or Lincoln.

Hog raising is one of the most important livestock industries. Nearly every farmer fattens from 25 to 30 hogs each year and some as many as 100. Not nearly so many hogs or other animals are raised on tenant farms as on farms operated by owners. Poland-China, Duroc-Jersey, and Berkshire are the leading breeds. Most of the hogs are grade stock, though there are a few registered herds. Pork production is profitable. In past years profits were often considerably reduced by the prevalence of hog cholera, but vaccination and better sanitary conditions have greatly reduced the ravages of this disease. Most of the hogs are marketed in St. Joseph and Kansas City. Nearly every farmer butchers enough hogs to supply the home with meat the year round. The census reported 36,008 hogs in Pawnee County in January, 1920.

There are only a few flocks of sheep in the county. Some farmers ship in a carload or two for winter feeding. It would appear that this practice could be profitably extended, as the animals can be run in the cornfields in the fall and expense for feed kept at a minimum.

According to the census, there were 8,795 horses and 952 mules in the county in January, 1920. Nearly every farmer raises one or two colts each year, and in this way supplies his own work stock and occasionally has a team to sell. The Percheron is the principal breed. Nearly all the stallions are purebred, but the mares are usually grades. A few mules are also raised.

The census reported 145,604 chickens in the county in 1920. A few ducks, turkeys, geese, and guinea fowls are raised on many farms. Plymouth Rock, Leghorn, and Rhode Island Red are the principal breeds of chickens. The surplus poultry products are sold in the local markets.

Increased attention is being given to the adaptation of crops to different soils. It is generally recognized that the Carrington and Pawnee silt loams are well suited to corn, wheat, and oats, and that alfalfa and grass do well on the steep slopes of the Shelby loam. The Wabash soils are considered as well adapted to corn and alfalfa and less well suited to the small grains. The Rough stony land is used only for grazing.

Systematic crop rotations are followed by a few progressive farmers. The usual plan is to grow corn 2 or 3 years, oats 1 year, and wheat 2 to 3 years, when the field generally is returned to corn. Frequently either corn or wheat is grown continuously on the same land 5 or more years. When these crops are grown year after year the yields noticeably decrease. Alfalfa is sometimes seeded on stubble ground and allowed to remain 6 or 7 years. A rotation which appears to have merit consists of 2 years of corn, 1 year of oats, and 2 years of wheat, followed occasionally by alfalfa.

Stubble and sod land is plowed in the fall if time permits. When corn follows wheat or a hay crop, it is either listed or checkrowed on land that has been plowed and disked. If the land is plowed in the spring, the corn is more often listed. When corn follows corn, the stalk land is disked two or three times before the seed is listed. Many farmers cut the stalks with a stalk cutter before diskings. Corn is usually cultivated three or four times. In some cases the corn land is harrowed once or twice before the young plants are large enough to cultivate, in order to keep down the weeds. When oats follow corn, the land is disked several times, then harrowed, and the seed sown with a press drill. Land for wheat is often plowed immediately after the preceding crop has been removed. Alfalfa is usually planted in the early fall, on a well-prepared, mellow seed bed. Sometimes a nurse crop of oats or wheat is grown with the alfalfa. As a rule the plowing is shallow, ranging from 4 to 6 inches deep. Deeper plowing results in larger yields.

Green crops are seldom turned under, and no commercial fertilizer is used. Considerable barnyard manure is applied to the land. It is usually hauled from the feed lots during the late fall or early spring and spread upon the land to be used for corn or wheat.

The farms are usually well improved. The buildings are kept in good repair and most of them are well painted. The farms are fenced and cross fenced, mostly with barbed wire, though woven-wire fencing is commonly used around hog lots. Modern labor-saving machinery is in general use. Most farms are equipped with mowers, rakes, binders, harrows, disks, grain drills, riding cultivators, and plows,

while a few have in addition corn binders and tractors. There is a general effort to economize on manual labor by the increased use of machinery. Automobiles are used on nearly all farms.

Farm laborers are difficult to obtain. They are chiefly native whites. Wages² range from \$50 to \$60 a month with board and room. Day labor commands \$3 to \$4 a day. Harvest hands have been paid as high as \$6 a day with board. Corn shuckers receive 8 or 9 cents a bushel. Many farmers hire labor by the year in order to have sufficient help at critical periods.

According to the census, 89.7 per cent of the entire county was included in 1,339 farms in 1920, and 82.2 per cent of the land in farms was classed as improved. The farms vary considerably in size. Most of them, however, contain about 160 acres. There are a few as small as 80 acres and several ranging from 320 to more than 1,000 acres.

In 1920, 763 farms were operated by owners, 17 by managers, and 559 by tenants. On the tenant farms the cash and share systems of land rental are about equally divided. The farms are seldom leased for longer than one year. Cash rent ranges from \$6 to \$10 an acre. Under the share system the tenant furnishes all labor, seed, and machinery and receives from two-fifths to one-half of the crop. On a few farms a combination system is used, the wheat land being rented on the share system and the remainder of the farm for cash. In any share system of renting the tenant is required to deliver the grain to the elevator.

The price of farm land in Pawnee County ranges from \$125 to \$250 an acre, depending upon the character of the soil, the improvements, and the location.

SOILS.

The soils of Pawnee County have been differentiated into a number of series and types on the basis of their most obvious physical characteristics and their chemical constituents, so far as these could be readily ascertained in the field. The characteristics of the soils of any region are the result of two factors: (1) The character of the parent material, and (2) the processes of soil formation, including weathering, leaching, aeration, and oxidation, to which the soils have been subjected during their development. The soil-forming processes, which are controlled to a large extent by climatic conditions, are believed to have been of greater influence in fixing the present character of the soils in this area than the composition of the parent rock.

The broadest and most striking characteristic of the soils of this area is the dark color imparted by the large quantities of black organic matter which they contain. The county lies in a region where topography, moisture supply, and temperature have favored a prairie vegetation consisting of a heavy growth of grasses, and from the decay of this vegetation the surface soils derive their black organic constituent.

Another feature of these soils is the comparative uniformity of their chemical composition, which has been brought about by a long period of weathering. It is almost certain that the parent soil

² The wages given are those that prevailed in 1920, when the field work of this survey was being done. At that time wages were abnormally high.

materials varied widely in composition, particularly in their content of lime carbonate, but leaching has largely removed the lime carbonate as well as the other carbonates and more soluble constituents to a depth of more than 3 feet.

The dark-colored soils that have been weathered in their present positions for long periods of time fall into two groups.

The soils of one of these groups, of which the Carrington series is representative, were developed under conditions of good soil and subsoil drainage. The typical profile has a surface horizon of dark-brown color and a friable granular structure. This is underlain by a brown, granular, heavy silt loam, which passes at a depth of about 24 inches into yellowish-brown clay loam. The carbonates have been largely removed to depths of more than 3 feet. With this group belong the soils of the Carrington and the Shelby series of the upland and the Waukesha series of the well-drained terraces.

The second group has dark-brown, friable, granular surface soils, not differing essentially from those of the Carrington group, but the upper subsoil is a very dark brown or dark-gray compact silty clay loam or clay. The lower subsoil varies somewhat in color, but less in texture and structure. It is a grayish-brown or gray and brown, mottled, tough, compact clay. The mottled color and compact structure are due to weathering for a long period under conditions of imperfect drainage. The carbonates have been removed to depths of more than 3 feet. This group includes the Grundy series, developed upon loess, and the Pawnee, developed upon drift.

Besides these two groups, there are two series of soils of more recent formation which may be regarded as immature. The Sogn series includes thin layers of soil formed upon limestone. The Wabash soils are composed of recent-alluvial deposits on the first bottoms.

The principal characteristics mentioned above are those imparted to the soil by the great soil-forming processes, such as leaching, oxidation, and the accumulation of organic matter, and no account has been taken of the characteristics due to the composition and the processes of accumulation of the material from which the soils have been developed. In the following pages, the classification of soils into series includes a consideration of the parent materials.

Practically all the soils of Pawnee County are derived from transported material, except those of the Sogn series and small areas of rock outcrop. The upland was originally covered with a thick mantle of silty material commonly called loess, but through erosion the deposit has been practically worn away, leaving only a few remnants of the original constructional surface. The most typical remnants are in the vicinity of Lewiston and along the north side of Mission Creek. Smaller areas occur scattered throughout the upland.

The loess in its original unweathered condition consists of loosely consolidated material ranging in texture from silt loam to heavy silt loam. It varies in color from brownish yellow to yellow, light gray, or almost white. The material has a moderate lime content, and the presence of iron is indicated in places by rusty streaks and blotches. Since its deposition the surface material has undergone marked changes in color, structure, and composition caused principally by weathering, the accumulation of organic matter in the soil, the concentration of clay in the subsoil, and the partial removal of lime from the soil and upper subsoil. These changes have resulted in the for-

mation of a dark-brown or black silty surface soil with a brown, heavy, compact subsoil. In Pawnee County the soil derived from loess by these processes is mapped as the Grundy silt loam.

Below the loess mantle lies the Kansan drift sheet. The material comprising this sheet is a loosely consolidated mass of rock, gravel, sand, and clay, which was carried down and deposited from regions to the north during the last glacial advance into Nebraska. Subsequent to its deposition the surface of the drift sheet has become thoroughly oxidized and the coarser materials have been reduced through disintegration and decomposition. This surface layer has been classed by the State geologists as the weathered phase of the Kansan drift. It is the most extensive soil-forming formation in Pawnee County and occurs throughout the area, giving rise to the Carrington loam and silt loam and in a large manner to the Pawnee loam, silt loam, and silty clay loam.

Although the loess and the weathered phase of the Kansan drift are similar in character, there are a few distinctions which may be recognized. The weathered phase of the drift consists of brownish-yellow or yellow to grayish-yellow or light-gray loesslike deposits with numerous lime concretions and reddish iron stains. It has a vertical structure and is practically stone free, although it contains a very small quantity of large sand grains and small cobblestones. This material differs from the true loess in that it contains a little more clay, has a pronounced vertical structure, and contains some sand and pebbles. There is no definite line between the loess and the weathered phase of the Kansan drift, but they grade imperceptibly into each other.

The Kansan drift proper underlies the weathered phase of the Kansan drift. It is exposed in many places where erosion has removed the overlying layer. In these places the exposed material has developed an upper oxidized zone varying in color from yellowish brown or brown to reddish brown. Below the oxidized layer the drift changes to light gray or pale yellow with numerous iron stains, and lime occurs in the form of concretions, seams, or pockets. On slopes and hill crests subject to considerable erosion the Kansan drift proper has given rise to the Shelby loam, which is closely associated with the Carrington soils.

Below the Kansan drift lies a layer of stratified sand and gravel, with a few boulders, known as the Aftonian sand sheet. Outcrops of this material occur in a few places along the North Fork of the Nemaha River, in the northeastern part of the county. The material has not given rise to any large areas of soils, but has caused local sandy spots in the drift soils.

The lowest drift sheet, the Nebraskan, was deposited during the first advance of the ice sheet into Nebraska. It is not well defined in Pawnee County and the exact extent of its occurrence is not definitely known. It is not believed to have contributed to the soils of the area.

The loess and drift deposits are underlain by a very uneven surface of bedrock belonging to the Pennsylvanian division of the Carboniferous age. The upper layers of the bedrock belong to the Nemaha formation and consist of alternating beds of limestone and shale. These rocks slope upward about 400 feet from the vicinity of Humboldt in Richardson County to Table Rock in Pawnee County.

Between Table Rock and Pawnee City they remain nearly horizontal. From Pawnee City the rocks dip westward toward the Big Blue River in Gage County. In many places throughout the southern third and the eastern part of the county the streams have cut through the loess and drift deposits, either exposing small areas of bedrock or leaving them covered with a thin veneer of soil. Where the rocks are exposed the bodies are indicated on the soil map by rock-outcrop symbols and where they lie within a few inches of the surface they are included with Rough stony land.

In a few places where recent erosion has not been severe the limestones have weathered into a fine-textured residual soil which has been classed with the Sogn series. The nearness of the lime rock to the surface has undoubtedly influenced the character of the drift soils to a considerable extent throughout the southeastern third of the county.

The alluvial soils of Pawnee County include both terraces and flood-plain deposits. The terraces are inextensive. The largest developments are along Turkey Creek and its tributaries. The surface material on these terraces consists largely of silt, known in Nebraska as valley loess, which was deposited at a time when the streams were flowing at a higher level than at present. The deposits were derived largely from the plains loess and from finely divided drift débris. Subsequent weathering and the accumulation of organic matter has produced the present soils, which are classified with the Waukesha series.

The flood plains or first bottoms are rather extensive in Pawnee County. The largest areas occur along the North Fork of the Nemaha River, the South Fork of the Nemaha River, and Turkey Creek. Smaller developments extend up the larger tributaries of these streams. The flood plains were formed by the entrenchment of streams below the terrace levels and the subsequent deposition of sediment along their channels. The soils are very uniform and fine in texture. They are mainly of silt loam or very fine sandy loam texture, and are formed of materials washed down from the finer textured upland soils. They are of recent origin and in a few places they are subject to overflow, but generally they lie several feet above the stream channels and are flooded only during seasons of abnormal rainfall. The flood-plain soils are correlated with the Wabash series.

In the classification adopted by the Bureau of Soils, the soils are grouped into series on the basis of similarity in color, structure, and minor details of the soil profile, and on the basis of the source, character, and processes of accumulation of the material from which the soils have been developed. Each series is divided into types on the basis of difference in texture, which depends upon the proportions of sand, silt, and clay. The type is the unit of mapping.

The surface soils of the Grundy series are dark brown to black. The subsoil consists of three layers. The upper or subsurface layer is brown or light brown to grayish in color and a little heavier than the soil. The second layer is a heavy, dark-brown to dark-drab and brown, mottled clay, rather plastic when wet and hard when dry. The lower subsoil is a little lighter in color and less tough than the intermediate layer. The topography is usually flat. The material is derived from silty deposits of glacial age, usually defined as loess.

The Carrington series has dark-brown and occasionally black surface soils, underlain by a brown silty clay subsoil, which is moderately friable and practically free from any compaction in the upper part. The topography is gently undulating to rolling, although some areas are nearly flat. The soils are derived from glacial deposits and carry a moderate to low content of lime.

The surface soils of the Pawnee series are dark brown to almost black and range in depth from 6 to 12 inches. The subsoil has two distinct layers. The upper, which extends to an average depth of about 20 inches, is a dark grayish brown heavy clay; in places this is almost black and darker than the surface soil. The lower part is a grayish-brown or yellowish-brown, tough, compact clay, which normally extends to more than 36 inches. The soil is for the most part noncalcareous within the 3-foot section, but may contain fragments of limestone or lime concretions that effervesce with acid. Reddish-brown iron stains and iron concretions are often found in the lower subsoil. The topography ranges from almost flat to rolling. The soils have been derived from the weathered phase of the Kansan drift sheet. They differ from those of the Grundy series in the lighter color and heavier nature of the lower subsoil, the generally more rolling topography, and the scattering pebbles in the soil and subsoil.

The surface soils of the Shelby series are predominately dark brown. The subsoil is composed of yellow, reddish-yellow, or light-brown, tenacious sandy clay, which contains numerous iron pipes, and nodular masses and streaks of calcareous material. These soils are derived from the Kansan drift proper and occupy steep stream slopes and narrow divides. They are subject to severe erosion.

The surface soils of the Sogn series are dark gray to dark brown and are underlain by a light-gray to mottled yellow and gray subsoil of moderately compact silt to silty clay loam. The series occupies gently sloping to steeply sloping hillsides and low rounded divides. The surface in general is gently rolling. The soils are of residual origin and are derived from calcareous shale associated with thick interbedded layers of limestone. The surface material, except where erosion has been severe, is rich in organic matter. The subsoil is highly calcareous. Drainage is well established and in many places excessive.

The surface soils of the Waukesha series are dark brown to black and underlain by a grayish-yellow to yellow subsoil. They are derived from water-assorted glacial material deposited in broad filled-in valleys or on outwash plains and terraces. The deposits are classed as valley loess by the geologists of the Nebraska Soil Survey. The topography is mainly flat to gently undulating and drainage is good.

The Wabash series includes soils which are prevailingly dark brown to black and contain a high percentage of organic matter. The subsoil ranges in color from dark brown to brownish gray or gray and is usually heavier and more compact than the surface layer. The types are developed in the first bottoms of streams. The material is derived mainly from the loessial and associated soils of the regions. The Wabash soils have a flat topography, but are generally fairly well drained, considering their low position. During periods of high water they are subject to overflow in places.

The following table shows the actual and relative extent of the soil types mapped in this county:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Carrington silt loam.....	93,056	33.7	Pawnee silty clay loam.....	4,928	1.8
Carrington loam.....	78,144	28.3	Wabash very fine sandy loam.....	3,264	1.2
Wabash silt loam.....	35,456	12.9	Pawnee loam.....	2,112	.8
Pawnee silt loam.....	30,592	11.1	Waukesha silt loam.....	1,728	.6
Shelby loam.....	14,272	5.2	Sogn silt loam.....	384	.1
Rough stony land.....	6,528	2.4			
Grundy silt loam.....	5,376	1.9	Total.....	275,840

GRUNDY SILT LOAM.

The surface soil of the Grundy silt loam is a dark-brown to almost black heavy silt loam, 12 to 15 inches deep. It is high in silt particles, contains a small proportion of clay, and very little sand of any grade. The surface material passes rather abruptly into an upper subsoil of decidedly compact, stiff, plastic clay of very dark gray color, locally mottled with brown or yellowish brown. When moist this material appears almost black. Below 24 to 30 inches the subsoil becomes gradually lighter in both color and texture, though as a rule it remains rather heavy and compact. In a few places the material below 30 inches changes into a yellowish-gray or pale-yellow silty clay loam, which is fairly friable, often has a flaky or columnar structure, and is much more open than the upper subsoil. In these areas the lower stratum is usually somewhat calcareous, the lime being present in the form of concretions, and brownish iron stains occur here and there. Below the 3-foot section, as seen in deep road cuts, the material usually changes to the light-gray silt or silt loam of the original loess deposit.

The Grundy silt loam is of small extent in Pawnee County, its total area being about 8 square miles. The largest area lies on the north side of Mission Creek in the southwestern part of the county. A smaller area lies in the vicinity of Lewiston in the northwestern part. Other bodies of minor importance occur as isolated areas throughout the upland of the county.

The type has been derived by weathering from the original loessial deposit which once covered the entire upland, and was developed under conditions of more or less restricted drainage. The accumulation of organic matter in the surface layer of this deposit through the growth and decay of plant life, the concentration of clay just below the surface through the downward leaching of the finer soil particles, and the partial removal of lime from the upper 2 feet, have given the soil its present characteristics.

The Grundy silt loam has a flat to slightly undulating plainlike topography. It covers the original constructional surface of the county and as a rule occupies the highest positions. Drainage channels are not well developed and consist of slight sags or broad shallow draws. The surface drainage is adequate in all except very wet seasons, when it is in places not sufficient for maximum crop production. The internal drainage is poor on account of the compact upper subsoil. The soil does not withstand prolonged droughts as well as types with more open porous subsoils, as during periods of high tem-

peratures and hot winds the compact subsoil retards the upward capillary movement of water, and consequently crop yields are sometimes reduced.

Owing to its small extent, the type is of little agricultural importance in this county. It is, however, one of the strongest upland soils of the Great Plains region, and where it is more extensive it is highly esteemed as a general farming soil. Practically all of the type in Pawnee County is under cultivation and is used for the production of corn, oats, wheat, and alfalfa. High average yields are common, those for corn being 30 to 40 bushels per acre, and in favorable years with proper cultivation 60 bushels have been obtained. Oats yield 20 to 30 bushels per acre. This crop is grown extensively and usually does well if it matures before the dry weather occurs. The average yield of wheat is about 20 bushels per acre. Wheat seldom fails to give good returns, as it matures before the dry season. Alfalfa is the principal hay crop. Usually three and sometimes four cuttings are made, with a total yield of $2\frac{3}{4}$ to 4 tons per acre. The farmers on this type are generally prosperous.

Owing to its smooth surface and friable, silty, stone-free character, the soil is easily handled and can be worked under a rather wide range of moisture conditions. It has a tendency to clod when plowed while wet, but the lumps are easily reduced. The type is naturally very productive and responds readily to good farming methods. Little barnyard manure is applied and no commercial fertilizer is used.

The selling price of the Grundy silt loam ranges from \$125 to \$250 an acre, depending largely upon improvements and location.

In fields which have been devoted to the same crop for several years the soil has deteriorated in productiveness. Deeper plowing results in increased yields and is needed on most farms. In general more thorough cultivation would be beneficial. As the soil contains much organic matter, it is not necessary to alternate the cereal crops with legumes more often than once in four or five years.

CARRINGTON LOAM.

The surface soil of the Carrington loam consists of a dark-brown to dark grayish brown, mellow, fine-textured loam, 8 to 12 inches deep. It is relatively high in silt and clay, but contains enough of the finer and coarser grades of sand to give it a loamy character. The upper subsoil is a rather compact silty clay containing a small proportion of very fine sand. It ranges in color from a light brown or yellowish brown to reddish brown and in a few places has a decided chocolate-brown color. Below an average depth of about 20 inches the material becomes gradually lighter in color and more friable, and at 30 inches is usually a gray to light-gray silty clay or silty clay loam stained more or less with brown iron oxides. Occasional small pebbles and cobblestones occur on the surface, but are seldom encountered in the subsoil. The depth and color of the soil varies with its topographic position. On the more level areas, where conditions have favored undisturbed weathering and accumulation of organic matter, the soil is very dark brown in color and in places 12 to 14 inches deep. On the steeper slopes the weathered surface material has been considerably thinned and the organic matter largely removed by erosion, so that the soil is of a lighter shade and shallower depth. The transition from the soil to upper subsoil is gradual in both color and texture.

The upper subsoil is hard, breaks down into granules when dry, and is only slightly plastic when wet. Occasional lime concretions are encountered below 30 inches, but as a rule the material gives no lime reaction with dilute hydrochloric acid throughout the 3-foot section.

In the southern part of the county erosion has in places removed both the soil and subsoil, exposing small areas of bedrock. Such places are indicated on the soil map by rock-outcrop symbols.

Along intermittent streams this type includes many narrow strips of colluvial material which are too small to be shown separately on a map of the scale used in this survey. The material is usually a black silt loam with little change in color or texture within the 3-foot section. If these bodies were of sufficient size, they would have been mapped as Judson silt loam.

The Carrington loam differs from the Pawnee loam in the darker color and less compact nature of its subsoil. The Pawnee loam seldom has the reddish tinge so characteristic of the Carrington loam. The two soils, however, grade into each other and in many places it was necessary to draw arbitrary lines separating them.

The Carrington loam is the second most extensive type in the county, ranking next to the Carrington silt loam in acreage. The type occurs throughout the uplands in all parts of the county. It generally occupies the sloping areas between the higher lying divides of Carrington silt loam and the bottom lands. The soil has been derived from the weathered phase of the Kansan drift sheet. It has been subjected to more severe erosion than the Carrington silt loam, and its coarser texture is due in part to the removal of the finer soil particles by surface wash and in part to a less advanced stage of weathering.

The topography ranges from rolling to hilly. The greater part of the type occupies the strongly rolling slopes along drainage ways. Where the Shelby loam is extensively developed on the lower slopes, the Carrington loam usually occupies the upper slopes or gently arched divides.

Drainage is everywhere thorough, and in many places excessive. Erosion has become a serious factor on the steeper slopes, and in a few places the lower lying areas of Shelby loam are gradually increasing in size at the expense of the Carrington loam.

Owing to its large extent, the Carrington loam is one of the most important agricultural soils of Pawnee County. It is not so productive as the Carrington silt loam, but when carefully managed it compares favorably with that type in crop yields. About 70 per cent of it is under cultivation, and the rest, including the rougher areas, is used for grazing and hay production.

The most important crops are corn, oats, wheat, and alfalfa, ranking in acreage in the order named. About 60 per cent of the cultivated land is devoted to corn. Iowa Silvermine and Reid Yellow Dent are the leading varieties. In average years corn yields from 30 to 40 bushels per acre. Most of the crop is fed on the farms where produced, though a considerable amount is sold locally to feeders. Oats are grown on nearly every farm and often constitute the crop between corn and other small grains or alfalfa in the crop rotations. The average yield of oats ranges from 30 to 40 bushels per acre, depending upon the season. In exceptionally wet years the yield is often mate-

rially reduced by rust. The grain is used as feed for work stock, very little being shipped out of the county. Wheat does well on this soil. It has been grown on a greatly increased acreage during the last few years. Yields range from 15 to 25 bushels per acre. Winter wheat is grown chiefly, as it can be sown in the fall at a time when farm work is slack, and it usually matures before the hot dry weather of summer. The yields also fluctuate less and are somewhat greater than those of spring wheat. Practically all of the wheat is sold direct from the thresher. Alfalfa is an important crop on the Carrington loam and is grown more or less on nearly every farm. The crop is usually cut three times, and occasionally a fourth cutting is obtained. Yields range from 3 to 3½ tons per acre. Most of the hay is fed to beef and dairy animals, though a small part is baled for shipment. Alfalfa is excellent for building up depleted soils and is valuable in crop rotations, but it is not in favor for short rotations, as most farmers prefer to leave the stand six or seven years before changing to other crops.

Every farmer raises a few hogs, and many fatten from 50 to 150 head for market each year. Cattle raising is not practiced extensively, although some cattle are fattened annually. A few farmers ship in from one-half to 2 carloads of feeders, fatten them on corn, ensilage, and alfalfa, and return them to the St. Joseph or Kansas City market.

The Carrington loam is one of the easiest types in the county to handle. It can be cultivated under a wide range of moisture conditions. When plowed wet there is a slight tendency to clod, but the lumps are easily reduced and an effective mulch can be maintained with a minimum of cultivation. Manure is applied when available, but the supply is usually inadequate for best results.

Land of the Carrington loam is valued at \$150 to \$250 an acre, depending upon improvements, topography, and location.

The soil in places has been farmed for long periods without rotation of crops or turning under green-manure crops, and the supply of organic matter has been reduced, resulting in decreased yields even in years of favorable moisture conditions. A more systematic crop rotation should be devised and followed. The more progressive farmers plant alfalfa at least every 5 years and so rotate their crops that no field is planted to the same grain more than 2 years in succession. A rotation which appears to have merit consists of corn 2 years, oats 1 year, wheat 1 or 2 years, and alfalfa 3 to 5 years, returning to corn.

CARRINGTON SILT LOAM.

The surface soil of the Carrington silt loam consists of a dark-brown heavy silt loam, 8 to 15 inches deep, with an average depth of 12 inches. It is deepest on the flatter areas, where erosion has been least active. The soil is rich in organic matter and rather friable, considering its heavy texture. The upper subsoil consists of a reddish-brown to brown fairly compact silty clay containing considerable very fine sand. Below an average depth of 30 inches the subsoil becomes lighter in color and more friable, changing to a yellowish gray, or, in a few places, yellow faintly mottled with gray. The color becomes lighter with depth, and below the 3-foot section the substratum is usually light gray, stained more or less with brown iron oxides. The change in color from soil to subsoil is rather gradual. The soil

does not stand up in vertical banks as do the loess soils. Lime concretions occur in the substratum, but rarely within 3 feet of the surface. Occasional pebbles lie on the surface.

In the southern part of the county, in the vicinity of the Pennsylvanian beds, a soil with a reddish subsoil is encountered. This color, however, is an original material color rather than one of oxidation, and is therefore regarded as unimportant as far as the soil weathering is concerned. The soil of this variation is a dark-brown heavy silt loam, 6 to 8 inches deep, underlain by a light chocolate brown heavy silty clay, which at 20 to 24 inches passes into a rather bright reddish brown material. In a few places erosion has removed the soil and upper subsoil, exposing the reddish layer. Locally the bedrock is exposed, producing a rough stony variation of the Carrington silt loam.

In a few places throughout the type, material washed from the higher lying land has accumulated at the foot of slopes, and the resultant soil in these areas is a dark-brown to black heavy silt loam 20 to 40 inches deep. These areas, however, are too small to warrant separate mapping.

The Carrington silt loam may be readily distinguished from the Grundy silt loam by its lighter colored surface soil, a less abrupt change from soil to subsoil, and a less compact, tough, and heavy subsoil. The type occupies the slope land, or a destructional topography, whereas the Grundy silt loam occupies a high, almost flat, constructional surface. The Carrington silt loam contains a few pebbles, while the Grundy silt loam has practically none. The Carrington silt loam differs from the Pawnee silt loam chiefly in the character of its subsoil. The Pawnee type has a much lighter colored, heavier, and more compact subsoil and also lacks the reddish tinge so well developed in the Carrington silt loam. The two types merge gradually and in places the lines separating them are arbitrarily drawn.

The Carrington silt loam is the most extensive type in the county, occupying one-third of the area surveyed. It occurs in all parts, but is least extensive in the southern part. The soil has been derived from the weathered phase of the Kansan drift.

The type has a gently rolling to hilly topography. It is closely associated with the Carrington loam and Shelby loam and commonly occupies the more gently rolling slopes and broader rolling divides. In the southern part of the county, in the vicinity of the Pennsylvanian beds, the type is more steeply rolling and hilly. Drainage is everywhere good and in many places excessive, and on the steeper slopes erosion has become serious. With proper tillage and crop rotation this soil, owing to its rather high organic content, is very retentive of moisture.

The Carrington silt loam is the most important farming soil in Pawnee County. It is naturally strong and fertile and well adapted to all crops common to the region. About 90 per cent of it is under cultivation; most of the rest, which occupies only the rougher land, is in permanent pasture. Corn, the crop most extensively grown, yields from 30 to 60 bushels per acre, with an average of about 35 bushels. Oats rank second in acreage, and yield an average of about 30 bushels per acre. This crop is not so profitable as corn or wheat, but is used in rotation as an intermediate crop between corn and some other small grain or alfalfa. Wheat does well, and in dry

years is the most certain crop. Winter wheat is grown chiefly, and Turkey is the principal variety. In normal seasons it yields 25 bushels per acre. The acreage of alfalfa is increasing each year and at present is almost equal to that devoted to wheat. Ordinarily three cuttings a season are obtained, with a total yield of $3\frac{1}{2}$ to 4 tons per acre. In favorable seasons clover and timothy do well, yielding from $1\frac{1}{2}$ to 2 tons per acre. Many farmers grow small quantities of rye, barley, and millet for feed, and nearly every farm has from one-tenth to one-half acre of potatoes.

Most of the corn is fed on the farms where produced or is sold locally to cattle feeders. The oats are fed chiefly to work stock. Wheat is hauled from the threshing machine to local elevators and later shipped to outside markets. Most of the alfalfa is fed to cattle, a small quantity being baled for shipment.

Stock raising is not practiced extensively, though every farmer has a few milk cows, and some farmers fatten from one-half to 2 carloads of beef cattle each year. Hogs are raised on every farm; they are fattened on corn and alfalfa and shipped to St. Joseph or Kansas City.

The Carrington silt loam is somewhat more difficult to handle than the Grundy silt loam. If plowed when wet it bakes and forms clods that are rather difficult to reduce. In dry weather small seams and cracks form on the surface of this type, but not to a sufficient extent to cause serious loss of moisture by evaporation. Where the land is disked before listing for corn it withstands drought well.

Barnyard manure is the only fertilizer used, but the supply is seldom adequate.

The value of farm land on the Carrington silt loam ranges from \$175 to \$250 an acre, depending largely on improvements and location.

Owing to the strong fertile nature of this soil, the farmers have not realized the necessity of careful management in order to maintain its present high productiveness. Systematic crop rotation is not practiced, although many farmers have an indefinite system, subject to numerous substitutions. Leguminous crops and especially alfalfa should be grown after every four years of other crops, or the soil will gradually become less productive. A good rotation which is followed by the more progressive farmers in this and other counties includes corn 1 or 2 years, wheat 2 years, and alfalfa 4 to 6 years, returning to corn.

PAWNEE LOAM.

The surface soil of the Pawnee loam consists of a loose, friable, dark-brown to dark grayish brown loam 6 to 10 inches deep. It contains a relatively high proportion of the various grades of sand, numerous small pebbles, and sufficient silt and clay to give it a loamy texture. The immediate surface is rich in organic matter and has a decidedly darker color than the lower portion. The upper subsoil is a slightly compact brown silty clay loam or heavy loam containing some coarse sand and a very little fine gravel. Below a depth of 18 inches the material gradually becomes heavier and more compact, until at about 2 feet the subsoil consists of heavy, almost impervious, gritty clay predominantly brown in color, faintly mottled with gray. The content of gravel and coarse sand decreases with depth, though a few gravel fragments are encountered throughout the 3-foot section.

In a few places on the flatter areas of this type, where the accumulation of organic matter has been especially favored, the surface soil consists of a very dark brown to almost black loam, 8 to 12 inches deep, underlain by a heavy, black, sandy clay having an average thickness of 10 inches. Below this a mottled gray and brown compact clay is encountered. On the steeper slopes in the region occupied by the Pennsylvanian limestone the subsoil below 24 inches is variable, as shown in the road cuts in the southern part of the county. The material in places is a gray, highly calcareous, moderately compact clay containing a small quantity of medium sand and scattering gravel. Locally it is spotted with numerous iron concretions and reddish-brown iron stains. Elsewhere along the same slopes the material is a yellowish-brown to reddish-brown very compact gritty clay, which gives no lime reaction to dilute hydrochloric acid. These two variations in the subsoil occur at irregular intervals along the slopes. Where the areas having a bright-colored, highly calcareous subsoil were of sufficient size to warrant mapping, they were included with the Sogn series. The Pawnee loam as mapped also includes narrow strips of colluvial material from 50 to 100 feet wide along the intermittent streams.

The type is confined to the south-central part of the county. The largest development, comprising an area of about $2\frac{1}{2}$ square miles, lies on the south side of West Branch. The other bodies are few and scattered, seldom exceeding 160 acres in size. The soil has been derived largely from the weathered phase of the Kansan drift sheet, but has been considerably modified by wash from the higher lying loessial areas.

The topography is undulating to rolling. The greater part of the type occupies fairly steep though comparatively smooth slopes. Drainage is everywhere good, and in many places excessive, owing to the steep gradients.

Because of its small extent in the county, the type is of little agricultural importance. The more gradual slopes are well adapted to general farming, and all crops common to the region can be successfully grown. About 50 per cent of the type is under cultivation, and the remainder, including the steeper slopes and small badly eroded areas around the heads of streams, is used for pasture land. The grasses on this soil will support 100 to 110 cattle per quarter section during the grazing season. Corn, wheat, oats, and alfalfa are the principal crops, ranking in acreage in the order named. The yields compare favorably with those obtained upon the Carrington loam, which this type closely resembles.

Listed corn sometimes suffers from washing, especially on the steeper grades, and many farmers plan their fields so that the corn furrows run parallel to the upper and lower edges of the slopes. The soil is easy to handle and can be cultivated under a wide range of moisture conditions. It has a tendency to clod when plowed while wet, but the lumps are easily reduced. Barnyard manure is applied when available, but the supply is usually inadequate, and the fertility of the soil is gradually becoming depleted through improper management.

The Pawnee loam ranges in price from \$125 to \$200 an acre, depending upon topography, improvements, and location with respect to markets.

The greatest need of this soil is the addition of organic matter. In the absence of an adequate supply of manure, it is advisable to grow leguminous crops such as alfalfa and clover in rotations. Alfalfa does well and its use should be extended, as it not only adds organic matter to the soil but prevents erosion.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the type:

Mechanical analyses of Pawnee loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
373514....	Soil, 0 to 6 inches....	1.8	4.2	3.6	13.2	19.0	40.2	18.0
373515....	Subsoil, 6 to 35 inches.....	2.4	4.4	3.3	11.3	14.2	36.3	28.1

PAWNEE SILT LOAM.

The surface soil of the Pawnee silt loam consists of a very dark grayish brown to black heavy silt loam 6 to 8 inches deep. This is underlain by a dark-brown, heavy, plastic silty clay loam, which continues to an average depth of 20 inches. The lower subsoil begins rather abruptly and is a grayish-brown or yellowish-brown tough clay loam, or silty clay loam, which usually extends below the 3-foot section. Locally this material contains numerous particles of brown and black ferrous oxides, which give the subsoil a decidedly mottled gray and brown appearance. The surface contains a few scattering gravel fragments, and a few pebbles were noticed throughout the subsoil where exposed in road cuts and stream banks. In many places around the borders of the type, where the relief is rather abrupt, as upon the shoulders and upper slopes of hills, outcrops of Pennsylvanian limestone and coarse glacial till are encountered.

The Pawnee silt loam as mapped in this county includes many minor variations both within the type and near the margins where it merges with other soils. In a few places along the steeper and more gullied slopes in the vicinity of the limestone beds the soil has a reddish subsoil. The soil of this variation consists of 10 to 15 inches of dark-brown heavy silt loam, underlain by a chocolate-brown heavy silty clay, which at 20 to 30 inches passes into a bright reddish brown, heavy, plastic clay.

Locally the subsoil below 24 inches contains scattering globular specks of lime. The lime does not appear to be diffused throughout the subsoil, however, as the material will effervesce with dilute hydrochloric acid only in the immediate vicinity of these concretions.

In a few places, seldom more than 1 acre in extent and occurring only on the steeper slopes where the deeper drift is exposed, the lower subsoil is a light-gray mottled with brown, moderately compact silty clay. In these places the lime seems to be diffused throughout the subsoil, making it highly calcareous.

Near the southern boundary in the southeastern part of the county the subsoil below 30 inches consists of an olive-gray, heavy plastic clay.

Around the margins of the type, where it merges into the Grundy and Carrington soils, the transition is very gradual and in many places almost imperceptible, and in places the boundary lines were arbitrarily placed. The typical material differs from the Grundy silt loam in the lighter color of its subsoil and from the Carrington silt loam in its darker and deeper surface soil and lighter colored but heavier and more compact subsoil.

In a few places the surface approaches a silty clay loam in texture. Where these areas were of sufficient size to warrant mapping they were included with the Pawnee silty clay loam.

Small narrow strips of colluvial material along the intermittent streams throughout this type were included with the Pawnee silt loam. These strips consist of black silt loam extending to a depth of more than 3 feet without perceptible change in color or texture. If they were of sufficient width to warrant mapping they would be classed with the Judson silt loam.

The Pawnee silt loam is extensive in Pawnee County. It occurs chiefly in the southwestern part, where it is the dominant soil in the Mission Creek drainage area. A large body lies in the southeastern part between DuBois and Pawnee City. Smaller areas are scattered throughout the southern third of the county. The type as a rule occupies high, relatively broad divides and long, gradual slopes. It has been derived chiefly from the weathered phase of the Kansan drift sheet, but the addition of limy material from the underlying bed-rock has undoubtedly influenced the character of the soil and subsoil.

The topography is gently undulating to rolling. Both surface and internal drainage are everywhere good, though seldom excessive.

The Pawnee silt loam is an important agricultural type in this county. It is a strong fertile soil and well adapted to all crops common to the region. About one-half is under cultivation and the rest is used for pasture and hay land. The native vegetation consists largely of big bluestem, little bluestem, grama grass, and buffalo grass. Most of the cultivated land is used for corn, wheat, oats, and alfalfa. Small patches of barley, rye, and millet are grown for feed and roughage. Cattle raising is not practiced extensively, although all farms support a few beef animals and milk cows. Some farmers fatten a few cattle for market each winter; most of the beef cattle, however, are sold as stockers and feeders after coming off summer range. The principal breeds are grade Herefords and Shorthorns. Hogs are raised on every farm, and a few farmers have large herds. All livestock intended for market is shipped to St. Joseph or Kansas City.

Crop yields vary widely from year to year, depending upon the rainfall. Good yields are obtained in normal years, and during dry seasons the yields are probably higher than the average for eastern Nebraska on account of the high water-retaining power of the soil. The average yield of corn is about 40 bushels per acre, though 60 to 65 bushel yields have been obtained on well-managed fields. Wheat yields 20 to 25 bushels and occasionally 30 bushels. The average yield of oats is about 35 bushels. This crop is grown for feed on nearly every farm and is used as a step in crop rotation between corn and wheat. Alfalfa yields $3\frac{1}{2}$ to 4 tons per acre from three cuttings. The crop is very beneficial to the soil and often used in the rotation.

The changing of crops is not systematically practiced, although the more progressive farmers have developed indefinite rotations subject to numerous variations. A rotation in common use consists of corn 2 years, oats 1 year, wheat 2 years, and alfalfa 4 to 7 years.

The most improved modern machinery is used. Four-horse teams are in common use for plowing, seeding, and cultivating. Tractors are used on many farms. Most of the corn is listed in, and the rest is planted in checkrows. When corn follows corn or wheat, the land is disked 3 or 4 times and the seed then planted with a lister. When a corn planter is used, the land must be plowed and thoroughly harrowed before planting. Wheat is sown with a press drill on well-prepared corn or stubble ground. Alfalfa is sown broadcast on a fairly compact, mellow seed bed. Barnyard manure is applied when available, generally on land to be used for corn or wheat.

Land of the Pawnee silt loam sells for \$175 to \$225 an acre, varying with the topography, location with respect to markets, and improvements.

The results of mechanical analyses of samples of the soil, subsurface, and subsoil of the type are given in the following table:

Mechanical analyses of Pawnee silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
373417....	Soil, 0 to 14 inches..	1.0	5.8	4.4	11.1	20.6	41.4	15.5
373418....	Subsurface, 15 to 32 inches.....	1.8	9.7	5.8	14.4	14.8	34.0	19.6
373419....	Subsoil, 33 to 40 inches.....	2.6	18.5	10.0	17.9	14.7	18.2	18.1

PAWNEE SILTY CLAY LOAM.

The surface soil of the Pawnee silty clay loam is a black heavy silty clay loam, 8 to 10 inches deep, underlain by 10 to 12 inches of black, heavy, tough clay. Below an average depth of 20 inches the subsoil gradually becomes lighter in color and at 24 inches is a mottled gray and brown almost impervious clay which differs very little from the lower subsoil of the Pawnee silt loam. The type contains only a few scattering pebbles and small boulders to prove the glacial origin of the parent material upon which the soil was developed. Iron concretions and stains are usually found below the 2-foot depth. The surface soil is rich in organic matter, as the color indicates.

In a few spots minute lime globules were encountered in the lower subsoil, but these have not made the material calcareous, except that part of the subsoil with which they are in actual contact. In a few places, usually where the soil overlies weathered limestone, the subsoil is mottled with bright-red splotches and streaks. In other localities, where the material is well oxidized, neither reddish nor brown stains are present, and the lower subsoil is a heavy gray clay. In these places the soil profile resembles that of the Grundy soils, and it is possible that small bodies of Grundy silty clay loam are included with the type. Where gravel or small boulders could be found, however, the soil was mapped with the Pawnee series. On the steeper slopes, where erosion has been most active, the surface soil has been entirely removed from small patches, exposing the

heavy black clay of the upper subsoil. Along intermittent streams the type includes small, narrow strips of colluvial material, which is usually a black silt loam or silty clay loam with no change in color or texture within the 3-foot section. This colluvial soil merges gradually with the main type. These variations are all of such small extent and minor importance that they do not warrant mapping and are therefore included with the type.

The Pawnee silty clay loam occupies positions as high as any of the Pawnee soils, and in many places lies almost at the same level as the Grundy silt loam. The largest area occupies the high divide between Turkey Creek, Lores Branch, and Nigger Branch in the southeastern part of the county. A smaller area occurs on the long narrow divide between West Branch and Johnson Creek in the south-central part. The soil has been derived largely from the weathered phase of the Kansan drift sheet, although undoubtedly considerably modified by wash from the higher lying loessial deposits. The heavy compact subsoil is due to a downward leaching and concentration of the finer soil particles. The topography ranges from almost flat to slightly rolling, but the greater part of the type has a gently undulating surface. Drainage is good though not excessive.

The total area of the Pawnee silty clay loam is not large, and therefore the type is not important agriculturally. It is, however, a very strong fertile soil and ranks well with the Grundy silt loam in crop production. About 90 per cent of the type is under cultivation and the remainder is used for pasture land. All crops common to the region can be successfully grown. The soil can not be handled under so wide a range of moisture conditions as the lighter textured types. It has a decided tendency to clod if plowed when wet, and the lumps are reduced with difficulty. It is almost impossible to plow the soil when extremely dry. When cultivated under the proper moisture conditions the soil assumes a loose, mellow structure very similar to that of a loam or heavy silt loam. It is very high in moisture-retaining capacity and withstands droughts better than most of the upland types. Care must be taken, however, to keep the surface soil well pulverized, as it sometimes cracks badly when extremely dry and injures the roots of growing plants. Barnyard manure is applied when available, but the type receives little fertilization, as the poorer soils receive most of the manure.

Land of the Pawnee silty clay loam sells for \$175 to \$250 an acre, the price varying with the improvements, topography, and location with respect to roads and markets.

The type is naturally fertile, and every possible means should be used to maintain its present producing power. In the absence of an adequate supply of manure, the productiveness of the type can be maintained by growing a leguminous crop, such as alfalfa or clover, at least once in every four years.

SHELBY LOAM.

The soil of the Shelby loam to a depth of 6 to 10 inches is a brown to dark grayish brown loam to sandy loam, fairly high in organic matter. It contains considerable silt, a large proportion of the several grades of sand, and a few boulders. This is underlain by a brownish-yellow or reddish-brown moderately compact clay loam containing considerable coarse sand and fine gravel. Below an average

depth of 18 inches the material becomes gradually lighter in texture and at 24 inches usually consists of a mass of sand and gravel cemented together by a reddish-brown gritty clay. The color of the subsoil usually changes to a yellow or light yellowish brown at about 30 inches. The subsoil is usually not highly calcareous in this county, though small lime concretions occur here and there below 24 inches.

While the above description applies to the greater part of the type as mapped in Pawnee County, there are numerous variations. In a few places along the North Fork of the Nemaha River the surface soil has become so mixed with sands from the Aftonian formation that it has the texture of a sandy loam to loamy sand. The subsoil in these localities contains a smaller proportion of clay and more sand than the typical. In a few spots the subsoil has a decidedly reddish shade which is due to the color of the original material and not to oxidation. Locally the gravel and small bowlders are very thickly scattered throughout the subsoil. All these variations are so small and scattered that it was impracticable to show them on the soil map.

The Shelby loam is not extensive in Pawnee County. It occurs in scattered patches chiefly along the valley slopes in the northern two-thirds of the area. One of the largest areas lies east and north of Steinauer. Smaller areas lie along the western county line and on the slopes bordering the North Fork of the Nemaha River, Turkey Creek, Balls Branch, West Branch, and Johnson Creek. The type usually occurs upon steep slopes of drainage ways between the Carrington loam and silt loam on the higher land and the Wabash silt loam on the bottom land, though it also occupies a few low knolls and sharp crests of hills. The material has been derived from the Kansan drift proper, consequently it has a coarser texture than the soils derived from the highly decomposed, weathered phase of the Kansan drift. The larger content of bowlders and pebbles throughout the soil and subsoil distinguish it from the Carrington loam.

Drainage is everywhere thorough and in many places excessive, and erosion is a serious factor on the steeper slopes. The type is not so drought-resistant as the Carrington loam or silt loam. The subsoil, however, retains moisture remarkably well on account of its high clay content, and crops suffer only in seasons of prolonged drought.

Owing to its small area and unfavorable topography, the Shelby loam is not used extensively as a farming soil. Only about 40 per cent is under cultivation and the remainder is used for pasture and hay land. Corn, oats, wheat, and alfalfa are the chief crops on the cultivated areas. Corn occupies the largest acreage; it yields from 20 to 35 bushels per acre in average years, and on well-managed fields 50 bushels are commonly obtained. Oats yields 25 to 40 bushels, with an average of about 30 bushels per acre. The average yield of wheat is about 18 bushels; alfalfa produces 2 to 3 tons of hay per season and is usually cut three times. The wild grasses on the type will support about 80 head of cattle per quarter section, or, when cut for hay, will yield from one-half to three-fourths ton per acre.

Most of the corn, oats, alfalfa, and wild hay is fed to stock on the farms where produced. A small part of the alfalfa is baled for shipment to eastern markets. Wheat is the leading cash crop and is hauled to the elevators direct from the threshing machine. Hogs are raised on nearly every farm. They are fattened on corn and alfalfa and shipped to the St. Joseph and Kansas City markets. Cattle

raising is not practiced extensively, although a few winter feeding yards are located on this type. All of the land not suited to grain or hay production is used for pasture, and many farmers annually ship in from 1 to 2 carloads of cattle for summer grazing.

The soil of the Shelby loam is easy to handle and can be kept in good tilth with a minimum of labor. It can be cultivated under a wider range of moisture conditions than either the Carrington loam or silt loam on account of a larger sand content in the surface soil. The chief disadvantage of this type for farming is its steeply sloping topography and excessive drainage.

No definite crop rotation is practiced. The soil receives the greater part of the manure produced on the farm, but the supply is usually inadequate for best results.

Land of the Shelby loam sells for \$150 to \$200 an acre, the improvements, topography, and location with respect to markets being the determining factors.

Considerable care is necessary to prevent gullying. The steep areas should remain in permanent pasture or cover crops as much of the time as possible. Corn rows should be parallel with the upper and lower edges of the slopes, in order to check the destructive effects of erosion. The content of organic matter could be maintained and increased by turning under green crops and by growing legumes such as alfalfa or clover.

SOGN SILT LOAM.

The Sogn silt loam consists of 6 to 10 inches of dark-brown or dark-gray heavy silt loam, underlain by a light-gray moderately compact silty clay loam containing a few yellowish-brown iron stains. The surface soil varies slightly in depth and color with its topographic position. On the more gradual slopes, where conditions have favored the accumulation of organic matter, the material is dark brown in color and in places extends to a depth of 10 inches. On the steeper slopes erosion has removed the surface soil over small patches and exposed the light-gray subsoil. Near areas of soils having a coarse sandy or loamy texture the surface material of this type contains a relatively large proportion of sand and in places approaches a loam in texture. Over the most of the area of its occurrence, however, it is a smooth heavy silt loam. Some gravel is scattered over the surface of the type, but it seldom extends below the 10-inch depth. The soil is developed only over beds of the Pennsylvanian limestone, and exposures of the unweathered rock are usually found at some point within the boundaries of each area of this type. In many places the subsoil consists of partly decomposed limestone and contains numerous small fragments of the parent rock, and in a few places the limestone is encountered within the 3-foot depth. The surface soil often gives a slight lime reaction and the subsoil is composed largely of lime.

In a few small areas lying within the borders of this type the subsoil material appears to consist largely of a gray shale which is not yet completely decomposed and disintegrated, as it still retains its laminated structure. In such areas no lime reaction is obtained within the 3-foot section.

The type occurs in a few isolated areas chiefly along Lores Branch and Nigger Branch in the southeastern part of the county. The bodies occupy gradual to steep slopes, and erosion is a serious factor

over most of the type. The soil is of residual origin, having been derived through the weathering of the underlying limestone and shales of Pennsylvanian age. Wash from the higher lying drift soils has in places considerably modified the surface of the type.

Owing to its small extent and unfavorable topography the type is not used for crop production, but is all devoted to pasture. The native grasses consist of big bluestem, little bluestem, grama grass, buffalo grass, and some bunch grass. The grasses on each 2 or 3 acres of this type will support a horse or cow during the summer grazing season. The type has a general tendency to lower the value of the farms on which it occurs.

The Sogn silt loam is well adapted to the production of alfalfa on account of its high lime content, and the growing of this crop would not only greatly increase the producing capacity of the soil but would also tend to check erosion.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the type:

Mechanical analyses of Sogn silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
373516....	Soil, 0 to 10 inches...	0.4	4.8	4.9	11.7	10.6	45.6	22.0
373517....	Subsoil, 10 to 36 inches.....	.6	5.0	4.2	11.4	3.4	33.1	42.3

WAUKESHA SILT LOAM.

The surface soil of the Waukesha silt loam is a brown to dark-brown silt loam 10 to 15 inches deep. It is high in organic matter and has a smooth velvety feel. The subsoil is a brown compact silty clay loam to silty clay to a depth of about 28 inches, where it gradually becomes lighter in both color and texture, and below an average depth of 32 inches is a yellowish-gray or gray friable silt loam. The lower subsoil locally contains light-gray mottlings and reddish iron stains. Scattering lime concretions are present here and there in the last 6 inches of the subsoil and become rather numerous in the substratum.

On the marginal areas adjoining the upland the surface soil is 18 to 20 inches thick in places owing to the addition of material washed from the higher lying types. In a few places where the type is adjacent to bodies of Shelby or Carrington loam the surface material contains considerable sand and ranges in texture from loam to very fine sandy loam, but these variations were not of sufficient size to warrant mapping.

The Waukesha silt loam has a total area in Pawnee County of less than 3 square miles. It occupies scattering small patches on terraces in the southern and southeastern parts of the county, mainly along Turkey Creek, Johnson Creek, West Branch, and Lores Branch. The type is derived from material carried down and deposited by the streams when they were flowing at a higher level than at present.

The topography of the terraces is flat, sloping gently down the valley and toward the stream. The surface lies from 10 to 15 feet above

the first bottoms. The transition to the flood plains is marked by a rather steep slope, while the grade to the uplands is gradual. All of the type has thorough though not excessive drainage.

Owing to its small extent the Waukesha silt loam is of little agricultural importance in this county. It is, however, one of the strongest and most fertile soils of the region, and in other counties where it is more extensive it is a very valuable general farming soil. Practically all of the type is under cultivation, and all crops common to the region are successfully grown. Corn leads in acreage, followed by oats, wheat, and alfalfa. The average yield of corn is about 35 bushels per acre, oats 35 bushels, wheat 25 bushels, and alfalfa 3 to 3½ tons from three cuttings. Occasionally a fourth crop of alfalfa is obtained.

The methods followed in handling the soil are about the same as on the better upland types, except that manure is seldom applied to the land. The soil needs little fertilizer of any kind as it annually receives a thin veneer of surface wash from the higher levels. The type withstands prolonged drought better than any of the upland soils, chiefly on account of its more favorable situation with respect to the underlying water table.

No farm in this county is located entirely on the Waukesha silt loam, and for this reason it is difficult to obtain land values for the type. In other counties it sells for \$250 to \$300 an acre.

WABASH VERY FINE SANDY LOAM.

The surface soil of the Wabash very fine sandy loam is a dark-brown to dark grayish brown, loose and friable very fine sandy loam, rich in organic matter, with an average depth of about 8 inches. The subsoil is a moderately compact, heavy silt loam which contains a small proportion of very fine sand and has a granular structure. It differs little in color from the surface soil, except that faint brown mottlings usually occur below 24 inches. A few lime concretions are encountered in the lower subsoil and are abundant in the substratum. The change from soil to subsoil is very gradual in all characteristics.

In a few places the surface soil approaches a silt loam in texture. These spots, however, are of such small extent that they can not be satisfactorily shown on a map of the scale used in the survey and are therefore included with the very fine sandy loam.

The Wabash very fine sandy loam is of small extent in Pawnee County, its total area being about 5 square miles. It occurs as narrow elongated bodies, varying in width from a few rods to about one-half mile along stream channels. The largest development is along Balls Branch, north and west of Violet. A smaller body lies southeast of Steinauer along Turkey Creek. The type occupies flat bottoms or flood plains. It is composed of sediments carried down and deposited along the stream channels during periods of high water.

The surface is generally flat with a gentle slope down the valley. It lies from 3 to 4 feet above the normal flow of the streams. Drainage is good, except during periods of high rainfall, when most of the type is subject to inundation. The water does not stand on the surface longer than a few hours and seldom injures growing crops.

The Wabash very fine sandy loam is one of the strongest and most fertile soils of the region and compares very favorably with the Wabash silt loam for general farming. About half of it is under cultivation and the rest is used for pasture and wood lots. The native vegetation consists of a luxuriant growth of prairie grasses, with marginal strips of timber along the stream channels. The tree growth is oak, elm, ash, boxelder, cottonwood, hackberry, and scattering trees of basswood, hickory, and walnut. Corn, oats, wheat, and alfalfa are the principal crops on the cultivated areas, but small patches of timothy, clover, potatoes, and garden vegetables are grown on many farms. The yields of all crops compare favorably with those obtained on the Wabash silt loam. The soil is handled in the same manner as the better upland types. Barnyard manure is seldom applied to the land, as the surface wash from the adjoining uplands tends to maintain its high fertility.

No farm is located entirely on the Wabash very fine sandy loam and consequently it is difficult to determine land values. The land sells for \$200 to \$275 an acre, depending upon improvements. On farms where it occurs it has a tendency to increase the general value of the land.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam is a dark-brown to black, friable silt loam, 10 to 18 inches deep. It is rich in organic matter, as the color indicates. The subsoil is a black silty clay loam of more compact structure than the surface soil. When wet the subsoil is rather plastic and sticky, though the plasticity is not a marked characteristic, and when dry it breaks down into granules. Faint brown mottlings are encountered locally below 30 inches. In poorly drained areas light-gray mottlings are common in the lower part of the subsoil. Ditches on this type show that between the depths of 4 and 5 feet the substratum passes into a light-gray silt loam streaked and blotched with reddish iron stains, and containing some lime concretions.

In the narrower stream valleys, and in a few places on the wider bottoms, the soil section shows little or no change in color or texture to a depth of 3 feet or more, except that below 24 inches the material becomes slightly more compact. The soil in these localities consists of a smooth dark-brown silt loam underlain by a dark-brown more compact silt loam.

The type is the most extensive alluvial soil in the county and is next to the Carrington types in total area. It occurs in long narrow strips occupying the first bottoms or flood plains of the larger streams. One of the largest developments is along the North Fork of the Nemaha River in the northeastern part of the county. Typical bodies lie along the South Fork of the Nemaha River and along Turkey, Johnson, Plum, Mission, and Wolf Creeks. The areas vary in width from a few rods to about 1 mile, the widest developments being along the larger streams. The soil material consists of sediments carried down by the streams from adjoining uplands and from more distant regions to the north and west and deposited along the channels.

The surface of the type lies from 4 to 6 feet above the normal flow of the streams. It is generally flat with only slight topographic relief where old cut-offs occur. Originally the drainage of this type was poor, especially along the North Fork of the Nemaha River, but by

clearing and straightening the channels the conditions have been much improved. Most of the type even at present is subject to overflow for short periods in the spring, and in a few places the soil is too wet for crop production.

The Wabash silt loam is an important farming soil. It is very strong and fertile and withstands drought better than any other type in the county. About 85 per cent of it is under cultivation, and the remainder, including the poorly drained areas, is in pasture land and wood lots. Originally the greater part of the type was covered with a luxuriant growth of prairie grasses, with narrow strips of timber along the stream channels. Much of the timber still remains, though large quantities have been cut for fuel and building purposes. The present tree growth consists of oak, elm, ash, cottonwood, hackberry, boxelder, and occasional trees of basswood and walnut. Corn, oats, wheat, and alfalfa are the leading cultivated crops. The livestock industry is as well developed on this type as on any other soil in the county. It consists largely of hog raising and the winter fattening of steers. Many feeding yards are located on the Wabash silt loam on account of the convenient water supply and the protection afforded stock during severe weather.

The type is considered the best land in the county, and crop yields are usually 10 to 30 per cent higher than on the upland soils. Corn is the dominant crop. It yields from 40 to 50 bushels per acre in average years, and on well-managed fields 70 to 80 bushels are often obtained. The average yield of wheat ranges from 25 to 30 bushels. During wet seasons wheat sometimes lodges and the yield is materially reduced. Kherson oats, a short, stiff-stemmed variety, do well on this type, yielding 35 to 50 bushels per acre. The long-strawed oats are likely to lodge. During seasons of excessive rainfall both oats and wheat are sometimes injured by rust. Alfalfa does well on all but the more poorly drained parts of the type, and during normal years three or four cuttings are obtained with a total yield of 4 to 5 tons per acre. The legume makes a more luxuriant growth on this type than on any other soil in the county. The native grasses on each acre of the soil will support a cow or horse during the summer grazing season, or when cut for hay will yield from 1 ton to 1½ tons. Timothy and clover do well in wet seasons, yielding from 1½ to 3 tons of hay per acre. Potatoes and other garden vegetables are planted in sufficient quantities for home use.

Crop rotation is given little attention. The soil is easy to handle and can be cultivated under a rather wide range of moisture conditions. Clods are formed if plowed when wet, but the lumps are easily reduced. Manure is not used so much as on the upland soils, as with proper management it is not needed. The addition of silt washed down from the adjoining uplands tends to maintain the soil in a productive condition.

The price of land of the Wabash silt loam type ranges from \$200 to \$300 an acre, depending upon its drainage, location, and improvements.

ROUGH STONY LAND.

Rough stony land includes slopes that are too steep and rocky for cultivation. The soil is very shallow, seldom being deeper than 6 or 8 inches, and over considerable areas the bedrock is exposed.

The thin veneer of soil consists of dark-gray to black silt loam underlain by rotten limestones and shales of the Pennsylvanian formation. These decomposed rocks are generally of a light color, ranging from gray to almost white, but in a few places they have a decidedly reddish tint. Locally the soil contains considerable sand and carries numerous boulders and much gravel scattered over the surface. Exposures of the bedrock are represented on the soil map by rock-outcrop symbols.

The material comprising the Rough stony land has been derived largely from the underlying bedrock. The downward creep and wash of the coarser materials from the higher lying glacial drift sheets have also contributed to its formation.

The Rough stony land occurs chiefly as long narrow areas along the deeper valleys throughout the east-central and southern parts of the county. The largest areas lie along the North Fork of the Nemaha River southeast of Table Rock. Smaller areas lie along West Branch, Johnson Creek, and Lores Branch in the southern part.

The topography is extremely rough and broken and is marked by an intricate drainage system. Immediately bordering the bottom lands the slopes are often precipitous. The areas mapped include rock bluffs along streams and occasional low knobs in the higher lying land.

A fairly good stand of prairie grasses is supported where the soil material has not been entirely removed. Along the bluffs bordering the first bottoms scrub bur oak with scattering trees of ash and elm constitute the chief vegetation.

The land is used almost exclusively for grazing. A few farmers have established quarries in the Pennsylvanian limestone, from which they derive a large part of their building material. Rough stony land seldom changes hands, but would probably sell for \$20 to \$40 an acre, depending upon its value as grazing land.

SUMMARY.

Pawnee County is located in southeastern Nebraska, about 40 miles southeast of Lincoln. It is rectangular in outline and comprises an area of 431 square miles, or 275,840 acres.

From a physiographic standpoint the land included within the county is essentially a plain sloping gradually toward the southeast. It includes areas of almost flat to rolling upland, large areas of eroded, rolling to hilly slope land, and narrow strips of flat alluvial land.

The average elevation of the upland is about 1,300 feet above sea level, that of the eroded slope land probably 1,200 feet, and the alluvial land 800 to 1,050 feet.

Drainage as a whole is thorough though not excessive. Small parts of the river flood plains have inadequate drainage, and local patches of the slope lands are excessively drained because of the steep grades.

The boundaries of Pawnee County were defined by an act of the first Territorial legislature in 1855. The first settlers were from Ohio and located along the South Fork of the Nemaha River. Later settlers came from Indiana, Missouri, and Illinois and spread over the entire county.

According to the 1920 census the population of Pawnee County is 9,578, all of which is classed as rural. Pawnee City, the county seat and largest town is located in the east-central part of the county.

The county has good transportation facilities. It is well supplied with railroads, and graded wagon roads follow most section lines. All communities enjoy the advantage of rural mail delivery and telephone service. The chief markets for grain and livestock are St. Joseph and Kansas City. A large part of the dairy products is shipped to Lincoln.

The climate of Pawnee County is well suited to grain farming and stock raising. The mean annual temperature is 51.9° F. and the mean precipitation is 32.21 inches.

The agriculture consists mainly of grain farming and stock raising. Corn is the leading crop, followed by wheat, oats, alfalfa, wild hay, and clover and timothy. Potatoes and garden vegetables are grown for home use. Apples, pears, peaches, and cherries are produced on many farms, though the supply of fruits is inadequate. The raising of hogs and beef cattle comprise the chief livestock industries. The animals are fattened on corn and alfalfa and shipped to outside markets.

Systematic crop rotation is not practiced, although several indefinite systems, subject to numerous variations, have been worked out. Green crops are seldom turned under, and no commercial fertilizer is used. Barnyard manure is applied to the land when available.

As a rule the farms are well improved, and modern labor-saving machinery is in general use. Farm labor is difficult to obtain.

Excluding Rough stony land 11 soil types, representing 7 soil series, are mapped in Pawnee County. They are classed in four groups: Soils derived from loess or the silty upland material, soils derived from glacial drift, residual or partly residual soils, and alluvial soils.

The Grundy silt loam is of small extent in this county. It is one of the strongest upland types of the region and it is well adapted to all crops common to the region, but corn, wheat, oats, and alfalfa do exceptionally well. The type is derived from silty loessial material of glacial age.

The Carrington silt loam is the most extensive soil type in the county. It is a strong, fertile soil, has good drainage, and is well adapted to all crops common to the region. The soil has been derived from the weathered phase of the Kansan drift sheet. The Carrington loam is nearly as extensive as the silt loam. It is slightly more mellow and not quite so productive.

The Pawnee silt loam is rather extensive and is well adapted to general farming. The type occurs chiefly in the southern one-third of the county, in the region underlain by the Pennsylvanian limestone. It has a gently undulating to rolling topography and good drainage. The Pawnee loam and silty clay loam are inextensive. These soils have been derived largely from the weathered phase of the Kansan drift sheet, although the underlying limestone has undoubtedly modified their character to some extent.

The Shelby loam is of small extent in Pawnee County. It has been derived from the Kansan drift proper and contains considerable quantities of sand, gravel, and small boulders in the subsoil. The

type occupies steep slopes and drainage is in many places excessive. Only about 20 per cent of it is under cultivation, the rest being used as pasture and hay land.

The Sogn silt loam is of little agricultural importance in Pawnee County, on account of its small extent and unfavorable topography. It represents residual material from the underlying limestone bedrock of the region.

The Waukesha silt loam is the only terrace or bench-land soil in this county. It is of small extent and for this reason is of little agricultural importance. The type is very strong and fertile, however, and where it occurs in large bodies it is classed as one of the best farming soils.

The Wabash silt loam occupies the first bottoms or flood plains along the rivers and larger creeks. As a rule it is well drained, considering its low position, and about 85 per cent of it is under cultivation. The type is probably the strongest soil of the county and withstands continued cropping without fertilization remarkably well. Surface wash from the adjoining uplands tends to maintain its fertility. The Wabash very fine sandy loam compares favorably with the silt loam in value, but occupies a small total area.

Rough stony land includes areas of badly dissected topography where erosion has removed much of the soil material and in places exposed the underlying bedrock of the Pennsylvanian limestones. The areas of Rough stony land are used chiefly for pasture.

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