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Soil Survey

of

Pierce County, Nebraska

By

A. W. GOKE

U. S. Department of Agriculture, in Charge

and

W. H. BUCKHANNAN

Nebraska Soil Survey

Bureau of Chemistry and Soils

In cooperation with the

University of Nebraska State Soil Survey Department

of the Conservation and Survey Division

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SOIL SURVEY OF PIERCE COUNTY, NEBRASKA

By A. W. GOKE, U. S. Department of Agriculture, in Charge, and W. H. BUCKHANNAN, Nebraska Soil Survey

COUNTY SURVEYED

Pierce County is in northeastern Nebraska. (Fig. 1.) Its geographical center is about 70 miles west of Sioux City, Iowa, and 45 miles south of Yankton, S. Dak. The county is almost square and comprises an area of 570 square miles, or 364,800 acres.

The county is part of a broad plain that slopes slightly toward the southeast, with minor relief produced by stream erosion and wind action. The most pronounced relief is along the valleys of North Fork Elkhorn River and some of its tributaries. This river crosses the central part of the county in a southeasterly direction and receives the drainage from nearly all parts of the county. It has developed an alluvial flood plain lying from 50 to 75 feet below the general surface level of the surrounding country.

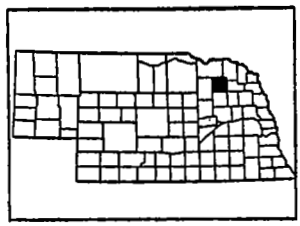

FIGURE 1.—Sketch map showing location of Pierce County, Nebraska

The tributaries of North Fork Elkhorn River have not developed so strong relief in the southwestern two-thirds of the county, which is covered by sandy material, as in the northeastern one-third, where a deposit of silty material ranging up to several feet in thickness overlies a formation of alternating layers of sand, gravel, and heavy clay. The underlying layers outcrop along the lower parts of steep slopes and in places on the crests of very low ridges.

In the sandier parts of the county the surface layer prevents erosion by absorbing the water from rainfall and melting snows, consequently drainage channels to the tributaries of North Fork Elkhorn River are not everywhere established. The uplands in Blaine and Mills Precincts have no drainage tributaries to Willow Creek. Any changes, therefore, that have been made on the original surface in the sandy area of the county are owing entirely to wind erosion, which has formed numerous broad gently sloping ridges with intervening flats and depressions and on higher knolls or ridges has pitted the surface with blow-outs and drifting sand.

In the areas covered with silty material stream erosion is active as the silty material is easily removed by stream dissection, and only a few broad divides remain to mark the original level of the land. The surface of the flood plains is comparatively smooth and flat and is broken by narrow strips of alluvial land along the larger tribu-

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taries of North Fork Elkhorn River. The valley slopes are gently to steeply rolling. The silty areas are sufficiently dissected with drainage ways to carry off all surplus surface moisture.

Alluvial lands occur along all the streams and larger drainage ways of the county. Along the larger streams they consist of terraces and flood plains. The terraces are flat and lie from 8 to 10 feet above the level of the flood plain, toward which there is a gradual slope. The stream channels in some of the larger valleys in the northeastern part of the county are deeply dissected, and the alluvial land may be entirely either a terrace or a flood plain. Drainage is good, but the valleys are subject to overflow after very heavy rains.

The flood plains along the North Fork Elkhorn River, Dry Creek, and Willow Creek are the most extensive. They range from 1 to 2 miles in width and lie from 3 to 5 feet above the stream channel. The surface of the flood plains is comparatively smooth and flat and in many places the land is poorly drained, especially in valleys that extend to the western part of the county and at the heads of some of the small drainage ways in the northeastern part near McLean.

Drainage in all of the upland areas is good, except in a few depressions in the northern part of the county. The heavier lands have sufficient surface slope to allow excess moisture to escape, and there are enough drainage ways to remove the surface water.

The highest elevation is in the northern part of the county and the lowest in the southern part. According to the records of the United States Geological Survey the elevations along Dry Creek and North Fork Elkhorn River Valleys are as follows: at Plainview, 1,683 feet above sea level; at Foster, 1,642 feet; at Pierce, 1,583 feet; and at Hadar, 1,557 feet.

The boundaries of Pierce County were created in 1859, and Pierce, located near the geographical center of the county, was selected as the county seat.

The first permanent settlement of importance was made in 1866 along the North Fork Elkhorn River Valley in the vicinity of Hadar. The first settlers were mostly people of German descent who came from the State of Wisconsin. At present most of the inhabitants are American born, of either German, Bohemian, Scandinavian, or English extraction.

Before settlement most of the land was owned by nonresident land speculators and was purchased by the settlers at prices ranging from $2 to $4 an acre.

According to preliminary returns from the census of 1930[1] the total population of the county is 11,080. Of this number 1,271 live in Pierce, 1,216 in Plainview, 750 in Osmond, 141 in Hadar, and 122 in Foster. The distribution of the population in the rural districts varies, the southwestern part of the county being most sparsely settled.

Rural mail routes are in easy reach of every farm. Good schools are numerous, and the school term is nine months. The roads, which

[1] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

follow section lines and extend to all parts of the county, are kept in good condition and are passable during most of the year. Practically every farmhouse has a telephone. Water of excellent quality is obtained, mostly from tubular wells that range from 100 to 200 feet in depth.

The county is provided with good transportation facilities for the shipping of farm products to distant markets. Branches of the main railroad lines that cross the State reach the principal trading centers of the county. The main highways are within easy reach of most farms and facilitate the use of trucks for hauling farm products to distant markets.

CLIMATE

The climate of Pierce County, which is typical of that of northeastern Nebraska, is favorable for general farming. The winters are cold and the summers are rather warm. The average temperature for the winter at Norfolk, in the adjoining county (Madison), is 21.7° F. and for the summer is 71.8°. Spring is usually cool, with considerable precipitation. The fall season is long, with moderate temperature and occasional periods of rainy weather. The difference in surface relief is not sufficient to cause appreciable differences in climate within the county.

The average date of the last killing frost is May 5 and of the earliest is October 2. This gives an average frost-free season of 150 days, which is sufficient for the proper growth and maturity of crops.

The mean annual rainfall is 27.94 inches, of which nearly half falls during the summer months. During this season short periods with very little rainfall occur, especially during the latter part of August when the corn crop is in the tasseling stage.

Snowfall is perhaps slightly greater in this part of the State than in any other part, although open winters frequently prevail and snow lies on the ground for only short periods. The average annual snowfall is 29 inches.

In early spring and late fall there is usually considerable wind, prevailingly from the northwest. During the middle part of the growing season the direction of the wind is more variable, although in exceedingly dry periods in the summer it blows from a southerly direction and brings considerable heat. The drying effects of the warm south winds do not seem to be so severe as in the more southerly counties of the State.

The weather is clear during the greater part of the year, and the number of sunshiny days is ample for the growing of crops and for the usual field duties that must be attended to on the farm. Cloudy periods are short and occur mostly during rainy spells in the fall or early spring.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation at Norfolk, Madison County, and may be considered fairly typical of climatic conditions in Pierce County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Norfolk, Madison County, Nebr.*

[Elevation, 1,532 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1909)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	23.8	72	−29	0.85	1.00	(1)	5.4
January	19.5	64	−39	.51	.20	0.94	5.1
February	21.8	72	−35	.83	(1)	.72	6.8
Winter	21.7	72	−39	2.19	1.20	1.66	17.3
March	34.0	92	−15	1.10	.49	.88	5.3
April	48.0	102	10	2.80	2.59	3.83	2.1
May	59.4	101	21	4.00	1.80	9.88	.5
Spring	47.1	102	−15	7.90	4.38	14.59	7.9
June	68.9	103	35	4.81	2.74	4.48	0
July	74.2	108	37	3.98	1.82	4.31	0
August	72.3	106	37	3.62	1.68	3.28	0
Summer	71.8	108	35	12.41	6.24	12.02	0
September	63.5	106	20	2.98	.49	6.14	0
October	50.8	92	8	1.56	1.49	.82	.9
November	35.7	83	−12	.90	(1)	2.45	2.9
Fall	50.0	106	−12	5.44	1.98	9.41	3.8
Year	47.7	108	−39	27.94	13.80	37.68	29.0

[1] Trace.

AGRICULTURE

According to preliminary figures for the census of 1930, 92.8 per cent of the area of Pierce County is in farms. The average size of farms is 213.9 acres. As there is a variation in soils, relief, and drainage over the county, the size of farms differs in various parts of the county. The average number of farms as indicated by the number of farmhouses shown on the accompanying soil map, is 1.7 to the section in the southwestern part of the county, 3 to the section in the western and northern parts, and 2.7 to the section in the northeastern part.

The farm buildings on the average farm include a residence for the family, horse barn, poultry house, and a few minor buildings. Modern farm implements are used in the cultivation and gathering of the crops. Most of the implements are drawn with horse power, but a few farmers use tractors to draw harvesting machinery. In general, less machinery is required on the farms in Pierce County than in other agricultural sections of the State where more small grain is raised. According to the 1925 census the average total value of all farm property for each farm in that year was $22,340, and of this amount 70.6 per cent represented the value of land, 15.8 per cent the value of buildings, 3.7 per cent the value of implements, and 9.9 per cent the value of domestic animals.

The average assessed value of farm land in 1930 was $91.18 an acre. However, the selling price of land varies in different parts of

the county. The highest-priced land is that along the valley bottoms between Pierce and Hadar and in the level sections including the heavier soil types in the northern part of the county; the lowest-priced land is in the southwestern part where the soils are sandy; and the medium-priced land is on the heavier sandy upland soils between Dry and Willow Creeks.

In 1930, 45.1 per cent of the farms were operated by owners, 53.7 per cent by tenants, and 1.2 per cent by managers. About 40 per cent of the tenants (a rough estimate from local information) are relatives of the owners.

The average expenditure for labor in 1924, on the 887 farms reporting, was $264.85 a farm; for feed, on the 1,123 farms reporting its purchase, $424.63 a farm; and for fertilizer, on 12 farms reporting its use, $157.50 a farm.

The domestic animals on most farms include horses, mules, beef or dairy cattle, swine, and chickens. In 1930 there were 9,560 horses in the county, 877 mules, 38,525 cattle (8,831 of which were dairy cattle), 42,556 hogs, and 181,001 chickens.

Most of the horses and mules are raised on the farms. The horses are mainly of the Percheron and Belgian breeds. On most farms three or four teams of horses or mules are kept for use in farming operations.

Hereford and Shorthorn are the popular breeds of cattle. Many of the larger herds are of good breeding through the use of purebred sires. On the smaller farms cattle of these breeds are used for dairy purposes as well as for beef production. However, where the dairy industry is extensively developed, Holstein and Guernsey are the favorite breeds. Most farmers keep from four to six cows which supply enough dairy products for home use and a surplus for trade in exchange for groceries. The value of dairy products, excluding those used at home, was $230,657 in 1924.

A few sheep and goats are raised. Some farmers purchase sheep from commission firms and pasture the flock on rape and in cornfields. Later, after a short feeding period, the sheep are shipped to market.

Hog raising is the most important branch of livestock farming in Pierce County. Almost every farmer raises a few hogs that are fed for market, and the average herd is between 10 and 20 hogs. The leading breeds are Duroc-Jersey and Poland China.

Cattle and hogs are fed for market on a more extensive scale on farms located in the valleys adjacent to large tracts of hay land. The hay land provides an abundance of coarse feed for cattle, and the corn is obtained from surrounding upland areas. Most of the cattle are of a type which fattens well in the production of baby beef. Hogs are fed for the market in conjunction with cattle because it is considered economical to have hogs in feed lots with cattle. Most of the cattle used for these large feeding operations are raised in the large pastured areas in the sand hills of the county. The hogs are purchased from local farmers who have small herds to sell. This extensive livestock industry is followed mainly by farmers having large tracts of land of which a part is usable only for pasture or hay land. Most of the supplementary feed is purchased from local farmers.

The principal cereal crops are corn and oats, and rye, wheat, and barley are grown less extensively. The average yield of corn is between 20 and 30 bushels to the acre. On the sandier soils 20 bushels is the average yield, and on the bottom-land soils, 35 bushels. Both white and yellow dent varieties of corn are commonly grown, principally Iowa Goldmine and Iowa Silvermine.

Kherson is the principal strain of oats grown in the county. Oats are commonly grown in rotation with corn and are used chiefly as feed for livestock. A little of the crop is sold.

Rye is a more or less profitable small-grain crop on the sandy soils, being the best adapted of the winter grain crops to these soils.

Alfalfa and sweetclover are important crops, yielding from 2 to 3 tons of hay a season. The principal variety of alfalfa is the Grimm which seems to be the hardiest to survive the extremely cold winters. Sweetclover is grown mostly on the heavier soil types in the northeastern part of the county where the land is more or less subject to erosion. It is grown for hay or as a pasture crop, and after a few years is plowed under as a green-manure crop. Both yellow and white sweetclover are grown.

The natural prairie grasses grow chiefly in the low wet depressions in the uplands or along the valley bottoms. They yield from 1 to 2 tons of hay a season.

Garden vegetables are grown mostly for home use. A few farmers have orchards, including apple, cherry, and plum trees, and some strawberries are grown, but most of the fruit for home use is purchased on local markets.

Table 2 shows the acreage and production of selected crops, as reported by the censuses from 1900 to 1925, inclusive.

TABLE 2.—*Acreage and production of selected crops in Pierce County, Nebr., in stated years*

Crop	1899		1909		1919		1924	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Corn	81,324	2,395,040	107,231	3,592,535	97,530	3,253,841	115,174	2,423,013
Oats	25,417	756,570	59,103	1,337,171	61,954	1,608,467	59,223	1,592,608
Wheat	40,130	404,240	4,501	69,185	5,352	45,614	825	14,267
Rye	2,970	40,310	860	7,374	6,427	50,200	3,433	31,837
Barley	3,101	83,240	1,090	23,072	813	15,865	891	22,042
Potatoes	793	88,482	742	56,626	863	40,059	904	84,046
		Tons		*Tons*		*Tons*		*Tons*
Alfalfa	167	340	1,390	3,285	10,698	21,630	13,695	----------
Wild hay	26,474	32,845	26,077	36,270	21,280	24,011	23,743	----------

No definite scheme is followed in maintaining the productiveness of the cultivated land. The common practice includes some rotation of corn and oats, but this is followed merely for the convenience in handling the crops, the corn crop being more easily cultivated on land that had been previously devoted to oats. When corn is repeatedly planted on the same field large quantities of partly decayed cornstalks accumulate and are a hindrance to proper tillage. Some of the farm lands in the county have been planted to corn or seeded to oats ever since they were first placed under cultivation, and about two-thirds of the time they have been cropped chiefly with corn.

No systematic attempt is made to rotate alfalfa with other crops. Where alfalfa can be grown successfully it is usually left on the same land for five or six years, or as long as the crop maintains a good stand. In most places it is difficult to obtain a good stand of alfalfa, especially on land that has a slightly sandy surface soil, as the surface sand shifts readily and injures the small plants. Fields of alfalfa have been observed where the shifting sandy material has shredded the young alfalfa plants to such an extent that they were subsequently destroyed. A few farmers have achieved some success in overcoming this danger by spreading a thin coat of straw over the surface to prevent the sand from shifting. More success perhaps would follow for many years if the land suitable for growing alfalfa were left in this crop no longer than two or three years. If alfalfa is continually grown on the same land for a longer period, soil moisture will become exhausted to a great depth and alfalfa can not then be successfully grown. Records from the experiment station at Lincoln show that it will require many years before the supply of moisture that has been exhausted will be replenished by rainfall.[2]

The tillage methods used in planting and cultivating the land are practically the same in all parts of the county. The land is plowed or listed in preparation for planting corn, or it is thoroughly harrowed and disked before seeding to oats. Damage strikingly revealed on the surface of some fields makes it apparent that careful tillage methods must be practiced. The sandy soils drift badly during windstorms in early spring, as at that time the surface is bare and exposed to the full sweep of the wind. After crops have attained sufficient size to break the force of wind this wind erosion is subdued. Experience has proved that wind erosion can be reduced by keeping the sandy surface soil firm or compact. Where the land has been recently planted to corn by listing, it should be harrowed at frequent intervals, especially after rains. This compacts the surface soil and leaves the surface material in small clods so that it can not be readily dislodged by wind. Crops planted in rows running east and west are not so badly damaged by wind erosion as are the crops planted in rows running north and south. A common practice in cultivation, in order to prevent soil drifting in the field when corn is small, is to cultivate narrow strips 10 or 12 rows wide and leave alternate uncultivated strips, or to cultivate every other row of corn.

Erosion on the heavier soil types of the county is another agency which is destructive of soil fertility. It is most severe on the more rolling land, where the dark surface material has been removed and the yellow subsoil is exposed, giving rise to the local term "clay hills." Crops suffer quickly from very dry weather on this land and produce low yields. The material exposed on the surface contains more fine material which forms a hard surface and therefore is not so easily cultivated as soils that have maintained their original dark surface material. In addition the clay is easily puddled if cultivated when too wet. Land of such character should be terraced in order to retain the original surface material, or the fields should be cultivated along the contour of the slopes. A few farmers have

[2] KIESSELBACH, T. A., RUSSEL, J. C., and ANDERSON, A. THE SIGNIFICANCE OF SUBSOIL MOISTURE IN ALFALFA PRODUCTION. Jour. Amer. Soc. Agron. 21: 241–268, illus. 1929.

attempted to seed the land to sweetclover for a few years in order to stop soil erosion.

The practice of seeding or planting the principal crops at a definite time is followed by most farmers, though the tendency is to plant the crops as early as weather conditions allow. Oats are usually seeded during the middle of April, and when seeded at that time they are likely to produce a slightly larger yield than when seeded at a later date. Corn is planted during the middle of May. A few farmers have reported larger yields when the corn was planted slightly later.

SOILS AND CROPS

Pierce County is in a region where climate, soils, and economic conditions favor the utilization of the tillable land for the production of two principal crops—corn and oats. The county is too far north for the successful production of winter wheat and not far enough north for the production of spring wheat, even if these crops could compete with the combination of corn and oats. Some of the soils are ideal for corn production and the greater part of the land in cultivation is as well or better suited to corn than to any other crop. The large area of land suited only for pasture and hay land favors the livestock industry, and the predominant corn-oats grain crop fits perfectly into livestock farming. As indicated by the census figures, wheat has steadily declined in acreage, corn and oats have increased, and alfalfa has very greatly increased. The increasing production of feed crops indicates that the livestock industry is growing. At the present time, however, it is estimated that nearly half the grain produced is shipped out of the county.

According to the 1930 census, of the 92.8 per cent of the farmed land in Pierce County, 72.6 per cent is devoted to planted crops, including forage crops, and nearly all the rest is used for pasture and hay land. The principal crops, ranking by acreage, are corn, oats, alfalfa, rye, clover and timothy mixed, clover alone, potatoes, barley, and wheat. The acreages of corn and oats far exceed those of other crops; probably 50 per cent of the area in planted crops being devoted to corn and a large proportion to oats. Alfalfa occupies a large acreage of the cultivated land. Other crops are of minor importance. Prairie grasses were cut for hay on 21,280 acres in 1924.

The crops are not uniformly distributed, but the relative acreage of each varies rather widely in different sections of the county. Since climate and economic conditions operate alike over the entire county as factors of crop distribution, the differences in relative acreage in different parts can be attributed to variations in the character of the soil. The soils affect crop yields and as a result determine the type of agriculture practiced. This does not mean that a crop is confined to a particular soil or group of soils; it may be grown on all of them, but as a result of adaptability to a particular soil, it may be the dominant crop on that soil.

In the study of the soils with reference to characteristics, topographic features, and agricultural value, it is convenient to consider the soils of the uplands and terraces and the soils of the stream bottoms and depressions separately.

On the bases of soil characteristics and other features that affect agriculture, the upland and terrace soils may be subdivided into

three general groups—the loamy upland and terrace soils, the sandy loam upland and terrace soils, and the sandy upland soils. In addition to differences in texture, these soils differ in other characteristics that affect their agricultural value, such as surface features, drainage conditions, and the tendency to erode. Each of these groups is confined in a general way to a particular section of the county. The loamy soils occupy the northeastern one-third of the county; the sandy loam soils occur in a belt extending in a northwest-southeast direction across the central part; and the sands occupy the greater part of the southwestern corner.

Soils of the stream bottoms and soils of the depressions are derived from water-laid material. They occupy flat or nearly flat areas, and they are now or were formerly poorly drained.

In the following pages the various soils of Pierce County are described in detail and their crop adaptations are discussed. The soil map accompanying this report shows the distribution of the soils in the county, and Table 3 gives their acreage and proportionate extent.

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

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Moody very fine sandy loam	75,840	20.8	O'Neill loamy sand	13,056	3.6
Moody very fine sandy loam, deep phase	2,304	.6	O'Neill sandy loam	2,752	.8
Moody fine sandy loam	28,160	7.7	O'Neill fine sandy loam	832	.2
Moody fine sandy loam, deep phase	704	.2	Valentine sand	41,344	11.3
Moody silt loam	192	.1	Dune sand	9,088	2.5
Moody silt loam, deep phase	20,288	5.6	Lamoure silt loam	20,672	5.7
Shelby loam	8,320	2.3	Lamoure silty clay loam	768	.2
Shelby sandy loam	3,584	1.0	Lamoure very fine sandy loam	320	.1
Hall silt loam	13,696	3.7	Cass fine sandy loam	12,160	3.3
Waukesha silt loam	7,808	2.1	Wabash silt loam	8,768	2.4
Waukesha very fine sandy loam	10,048	2.8	Wabash clay loam	1,216	.3
Waukesha fine sandy loam	3,456	.9	Gannett loamy sand	5,760	1.6
Dickinson loamy sand	55,232	15.1	Scott silt loam	704	.2
Dickinson loamy sand, deep phase	2,752	.8	Muck	256	.1
Dickinson fine sandy loam	14,400	3.9	Total	364,800	------
Dickinson sandy loam	320	.1			

LOAMY UPLAND AND TERRACE SOILS

The loamy upland and terrace soils occupy the northeastern part of the county and cover about two-fifths of the total area. They occur on uplands that range in surface features from nearly level to rather sharply rolling, and on the higher river terraces. They have adequate drainage both on the surface and in the subsoil. This group includes the Moody and Shelby soils of the uplands and the Hall and Waukesha soils of the higher terraces.

The surface soils of these soils, except on eroded areas, are very dark grayish brown or almost black and range in texture from sandy loam to clay loam, the very fine sandy loams and silt loams predominating. The subsoils of the sandier soils are heavier than the surface soils, being as a rule more silty.

Owing to their high content of organic matter these soils have deeper and darker surface soils than the other soils in the county. This organic matter has many beneficial effects. It is the chief

source of soil nitrogen, a constituent now rapidly being depleted. The water-holding capacity of the surface soil is greatly improved by the organic matter. In the loams and silt loams, the organic matter aids in the development of a loose granular structure that allows easy penetration of soil water and plant roots. It helps in the maintenance of good tilth and retards erosion. In the sandier soils of this group, the content of organic matter is almost as high as in the heavier soils, but the granular structure is less distinct. Water penetrates the sandy soils, however, very readily, and in most places it is well retained.

All soils of this group contain lime carbonate in their subsoils, but the depth of its occurrence and its abundance may vary somewhat in the different soil types. As a rule, on the smooth upland areas leaching of lime carbonate has taken place to a depth of 3 or 4 feet. Soils on the more rolling areas have been eroded to such an extent that the lime is near the surface. On the deeper soils of the smooth upland, lime occurs at a rather uniform depth, and the upper layers of the subsoil are generally richer in lime than the layers above and below.

The main crops of the county are grown on all soils of this group, and only very slight differences in yields can be ascribed to soil differences. The relative crop value of the sandier and heavier soils varies from year to year depending on the amount of precipitation. The topographic features, particularly the slope of the land, have a greater influence on production than does soil texture. Rainfall runs off the steep slopes so rapidly that little water sinks into the ground for the use of crops. This condition prevails more generally on the Shelby soils and, in certain sections of the county, on the Moody soils.

Moody very fine sandy loam.—The most extensive and most important agricultural soil in the county is Moody very fine sandy loam. It occupies the larger divides having gently to sharply rolling surfaces and occurs more extensively in the eastern half of the county. The very dark grayish-brown surface soil common to the group has an average depth of about 6 inches in this soil. Below this is a dark-yellow friable silty very fine sandy loam or silt loam layer, the upper part of which is firm but not compact and does not interfere with the penetration of plant roots. The material is retentive of moisture but is not so impervious as to prevent the movement of water. Below a depth of 20 inches the subsoil becomes loose and in places is sandier. Lime concretions, which continue to a depth of 42 inches, are abundant in this material.

About 80 per cent of the land is in cultivation and the other 20 per cent is in pasture. This soil has a fairly wide range in crop adaptations. A large part of the corn produced in the county is grown on it, although it is not the most productive corn soil, giving slightly lower yields than Moody silt loam and the deep phases of the Moody soils, but owing to its extensive area it has a large total production.

This soil can be farmed under a wider range of moisture conditions without injuring the tilth than can Moody silt loam. In ordinary years it does not produce such high yields as the silt loam but in very dry years the yields are as high or even higher.

Moody very fine sandy loam, deep phase.—The deep phase of Moody very fine sandy loam is more productive than the typical soil. It occurs on smooth, more nearly level land where erosion has not been so active, and the dark-colored surface soil, having been left in an undisturbed condition, is thicker than on the rolling land. As a rule the subsoil is slightly more loamy and consequently more retentive of moisture. Corn and oats are the principal crops. Yields are slightly higher than on typical Moody very fine sandy loam, average yields of corn being from 2 to 5 bushels higher.

Moody fine sandy loam.—Moody fine sandy loam differs from Moody very fine sandy loam in that both the surface soil and subsoil are sandier, looser, and more friable. The soil does not produce such high average yields as either the very fine sandy loam or the silt loam, but in seasons of normal rainfall the difference in crop yields is very slight. The greater part of this soil is in the southwestern part of the county in a belt a few miles from and paralleling the Chicago & North Western Railway and bordering the sand-hill areas. Its total area is 44 square miles.

Moody fine sandy loam, deep phase.—The deep phase of Moody fine sandy loam is of little agricultural importance as it covers only 1.1 square miles. Like the corresponding deep phase of the other Moody soils, this soil has a smoother relief than the typical soil. The surface soil is deeper and the subsoil very slightly heavier and more retentive of moisture. The principal areas are in the northern part of the county in Thompson and Eastern Precincts.

Moody silt loam.—Moody silt loam occurs in a small area in the northeast corner of Dry Creek Precinct. The soil differs from its deep phase in that the surface soil is somewhat thinner and the relief is more rolling and more susceptible to washing and gullying. In dry years this soil has a slightly lower agricultural value than the deep phase, but in normal seasons or seasons of heavy rainfall there is little difference in crop yields between the two soils.

Moody silt loam, deep phase.—Moody silt loam, deep phase, is the most productive soil in this group. It differs from Moody very fine sandy loam and the deep phase of that soil in the texture of both surface soil and subsoil, as it contains a larger proportion of silt and clay. The dark-colored surface soil typical of this group is about 12 inches thick in this soil. It has good tilth under proper cultivation and forms a firm seed bed. The subsoil is yellowish-brown friable silt loam containing a slightly higher content of clay than the surface soil, and thus having a higher water-holding capacity. Below a depth of 24 inches is friable light-colored material. Lime, both in the form of concretions and as fine floury dust, occurs below a depth of 42 inches. Lime is one of the essential soil constituents for the successful production of alfalfa and clovers, and the friable subsoil allows normal root development, consequently the lime is available for plants.

This soil occurs in the northern half of the county, mainly in the northern tier of precincts. It occupies the broad interstream divides where the original surface is least dissected by drainage ways. The surface is smooth, level, or gently undulating and allows absorption of nearly all the rainfall. Owing to the excellent quality of the soil and its favorable topographic features, nearly 98 per cent of the total

acreage is cultivated. Yields for all the common crops average higher than on the more sandy soils of this series, and it is estimated that the yields of corn and oats will average about 2 bushels more to the acre than on typical Moody silt loam. The greater part of the acreage in alfalfa on the Moody soils is on Moody silt loam, deep phase.

Shelby loam.—Shelby loam occupies a rather large area in the central part of the belt of loamy upland soils. A part of this soil occurs on smooth areas of the interstream divides, but the greater part is rolling or hilly. The thickness of the dark-colored surface soil varies with the relief. On the nearly flat areas the surface soil is from 8 to 10 inches thick, but on slopes the thickness varies with the degree of steepness. On very steep slopes erosion has removed nearly all the dark surface soil, and in small areas it is entirely removed, the yellow subsoil material lying at the surface. The surface soil is not distinctly granular but is friable and easily worked. The subsoil is rather variable, in most places being yellow friable clay loam containing various quantities of gravel. Lime concretions are abundant at a depth of 40 or more inches, and in places heavy plastic clay occurs at a depth of 40 inches.

Owing to the sloping surface of the areas of Shelby loam, the soil is used mostly as pasture land, for which purpose it is well suited.

Shelby sandy loam.—Shelby sandy loam differs from Shelby loam mainly in containing a larger proportion of sand in its surface soil. In general it covers the more sharply rolling areas on high knobs and ridges. Much of the sand has apparently been blown on this soil from near-by sandy soils. Gravel are abundant throughout the soil and in many places are scattered over the surface.

The agricultural value of Shelby sandy loam is lower than that of Shelby loam. Only a small part of the land is cultivated, the remainder being used as pasture.

Hall silt loam.—Of the terrace soils, Hall silt loam is the most extensive and the most important agriculturally. The surface soil to an average depth of 12 inches is mellow silt loam. The color is fully as dark as in the soils of the Moody series on the uplands. The subsoil is grayish-brown more or less compact heavy silt loam or clay. It is more compact than the subsoils of the upland soils but is not so dense as to prevent the penetration of crop roots or the percolation of water. Below a depth of 30 inches the subsoil becomes more friable and lighter in color, and below a depth of 36 inches lime is abundant.

Hall silt loam produces as large yields of corn as any other soil of this group and is generally recognized as superior to the more sandy terrace soils and the sandy loam upland soils. In corn production it averages at least 2 bushels more to the acre than the sandy terrace soils and at least 5 bushels more than the sandy loam upland soils. Corresponding increases can be noted in the yields of oats. Alfalfa does as well as on any other soil. Some areas of Hall silt loam that are so cut by stream channels as to make farming difficult, are left in native hay which yields, perhaps, one-half ton to the acre higher than on the upland soils.

Waukesha silt loam.—Waukesha silt loam differs from Hall silt loam in two respects. The heavy and somewhat compact subsoil

characteristic of the Hall soils is not developed under the Waukesha soils, and lime has been thoroughly leached from Waukesha silt loam to a depth of many feet.

This soil covers a total area of 12.2 square miles. It occurs on terraces along some of the larger tributaries of North Fork Elkhorn River, the largest areas being northeast of Pierce along Yankton Slough and its tributaries. As a rule this soil occurs along the stream courses, reaching almost to the headwaters. Little difference in productiveness can be noted between Waukesha silt loam and Hall silt loam, yields of corn and oats, the principal crops, being practically the same on both soils. Only a small acreage is devoted to rye and barley. Theoretically, alfalfa should thrive better on the calcareous Hall silt loam, but neither soil is deficient in lime to a depth easily pentrated by alfalfa roots.

Waukesha very fine sandy loam.—Waukesha very fine sandy loam is very similar in appearance to Waukesha silt loam, but the character of the surface soil and subsoil is somewhat changed by the content of very fine sand. The surface soil is very dark grayish-brown sandy loam, and the subsoil is brown sticky fine sandy loam which is not so heavy as the subsoil of Waukesha silt loam. Waukesha very fine sandy loam covers a slightly larger area than Waukesha silt loam, but in agricultural importance it ranks slightly below that soil. The relative acreages of the different crops are very nearly the same as on the silt loam, and yields are only very slightly lower. Waukesha very fine sandy loam occurs in comparatively small areas in all parts of the county, occupying flat areas on the higher terraces at about the same elevations above the streams as Waukesha silt loam areas.

Waukesha fine sandy loam.—Waukesha fine sandy loam is similar in all respects to Waukesha very fine sandy loam except in the texture of its surface soil which contains a larger proportion of fine sandy loam in place of very fine sand. This soil occurs in a number of scattered areas, most of them on the edge of the North Fork Elkhorn River Valley within a few miles of Pierce. Crop yields and the agricultural possibilities of this soil are similar to those of Waukesha very fine sandy loam. Theoretically, this soil should be slightly inferior to the very fine sandy loam, but this difference is not noticeable in normal years.

SANDY LOAM UPLAND AND TERRACE SOILS

The sandy loam upland and terrace soils occur mainly in a belt about 12 miles wide which follows North Fork Elkhorn River and its larger nearly parallel tributaries. These soils have dark grayish-brown surface soils, mainly sandy loams. They are lighter in color than the surface soils of the loamy group, but are darker than those of the sandy group. The subsoils are, in most places, little if any heavier than the surface soils and are nowhere so heavy as the subsoils of the loamy upland soils. These soils occur on smooth and gently rolling areas.

The soils of this group, although they are not so productive as the loamy soils, produce good crops in most years. In very dry seasons most crops suffer less on the sandy loam soils than on the loamy soils, because the water falling during a light rain on the sandy loam soils sinks into the ground and is immediately available

for plants, whereas on the loamy soils a large percentage of moisture is lost through run-off.

The crops grown on these soils and the relative acreages in each crop differ somewhat from those of the heavier soils. Corn, on account of its ability to withstand drought on these soils, is the principal crop. A greater acreage of rye is sown than on the loamy soils. This crop makes better yields on the heavier soils, but on account of the comparatively low yields of oats during recent years farmers prefer to grow rye. Potatoes produce well, but at present they are grown only for local use. Wheat, alfalfa, and clover are not successfully grown on the sandy loam soils because of the loose shifting surface soil and low lime content of the subsoil.

Dickinson loamy sand.—Dickinson loamy sand is the most extensive soil in this group and ranks second in area among the soils of the county. The surface soil is dark grayish brown but is noticeably lighter in color than the surface soils of the heavier Moody soils. It contains a moderate amount of organic matter. The color gradually becomes lighter downward, and at a depth of 20 inches the soil material is light-yellow sand or in places brownish-red or yellowish-red incoherent sand which continues to a depth of many feet with no marked change in color.

This soil is porous and can absorb large quantities of water. Although it is not so retentive of moisture as the heavier soils, it endures short droughts much better. Neither surface soil nor subsoil contains lime in sufficient quantities to be detected by field tests. Principally on account of this lack of lime, the soil is not adapted to alfalfa and sweetclover. It is difficult to obtain a stand of these crops without liming, the yields are low, and the plants finally die. Where a good stand of alfalfa is obtained, the first cutting produces a large crop of hay, but later cuttings return a much smaller yield as the later growth is retarded by lack of moisture.

Dickinson loamy sand, deep phase.—The deep phase of Dickinson loamy sand differs from the typical soil in having a thicker dark-colored surface layer. In many places the organic matter reaches a depth of 30 inches. This deep soil occurs in depressions and on the parts of slopes where black soil material has washed down from the surrounding higher land. The agricultural value of this land is much higher than that of typical Dickinson loamy sand. The same crops are grown as on the typical soil, but yields are higher, corn averaging at least 5 bushels more to the acre. The total area of this soil is 4.3 square miles.

Dickinson fine sandy loam.—Dickinson fine sandy loam covers a total area of 22.5 square miles, the greater part of which occurs on the divide between Dry Creek and Breslau Creek. This soil differs from Dickinson loamy sand principally in having a slightly heavier surface soil and a considerably heavier subsoil. The dark-colored surface soil is loose fine sandy loam, and the subsoil is slightly heavier fine sandy loam which is friable and not so firm in position as the silty subsoils of the Moody soils. Below a depth of 24 inches is yellow loose sandy loam grading into loose fine sand similar to that in the lower part of the subsoil of Dickinson loamy sand.

The crops grown on the loamy sand are also grown on this soil, and yields are slightly higher on the fine sandy loam, owing to the better water-holding capacity of the subsoil.

Dickinson sandy loam.—Dickinson sandy loam is of slight agricultural importance as it occurs in only one area, comprising one-half square mile, on the northern border of the county northwest of Osmond. This soil differs from Dickinson fine sandy loam in that the surface soil is lighter in texture and contains less organic matter. It has a lower water-holding capacity and does not produce such high yields.

O'Neill loamy sand.—O'Neill loamy sand is similar in appearance to Dickinson loamy sand but it occurs on nearly flat terraces instead of on rolling upland slopes. The dark surface soil is rather deep, reaching a depth of about 24 inches before the influence of the black organic matter disappears. The surface soil is underlain by brown or reddish-brown sand which is underlain by loose yellow sand at a depth of 28 inches.

This soil covers a total area of 20.4 square miles. It occurs in a number of irregular-shaped areas scattered over the central valleys of the county. Its agricultural value is slightly higher than that of Dickinson loamy sand.

O'Neill sandy loam.—O'Neill sandy loam covers a total area of 4.3 square miles. Its largest development is on a nearly flat terrace south of Pierce, and smaller areas are in the vicinity of Plainview. The surface soil is very dark grayish-brown loamy sand 12 inches deep, underlain to a depth of 24 inches by brown or dark-brown loamy sand. Below this is brown or reddish-yellow sand mottled with gray. The lower part of the subsoil contains a small amount of lime. This is a productive soil from which good yields of corn and oats are obtained.

O'Neill fine sandy loam.—O'Neill fine sandy loam is of little importance in the agriculture of the county as it has a total area of only 1.3 square miles. It occurs in the vicinity of Plainview. This soil differs from O'Neill sandy loam only in having more coarse sandy material in the subsoil. Crop yields on both types of soil are about the same during normal years, but during extremely dry periods crops on this soil are among the first to show injury and the yields are often considerably reduced.

SANDY UPLAND SOILS

The sandy upland soils occupy about one-eighth of the total area of the county. They occur most extensively in the southwestern part. The agricultural value of these soils is lower than that of the sandy loam upland soils and the greater part of their area can be used only for pasture and grazing. This group includes two soil types, Valentine sand and dune sand, which differ from each other very slightly. Dune sand is loose wind-drifted sand and contains little organic matter. Valentine sand has been undisturbed a longer time than dune sand, the sand grains have broken down under weathering, and a small amount of organic matter has accumulated. These sands are either wind laid or the surfaces have been eroded and shaped by wind, and as a result, the greater part of the area of these soils has a dunelike relief. Both soils are excessively drained, as water sinks readily into the sand and moves down from the surface beyond the reach of plants. Where the surface is intact it is covered with a large variety of grasses, including bunch grass,

stipa, black grama, and a number of bush plants such as ragweed and wild rose. The grasses will support from 50 to 60 head of cattle to the square mile, depending on the rainfall for the season.

Valentine sand.—The surface soil of Valentine sand consists of loose incoherent grayish-brown sand from 10 to 14 inches deep. The upper 4-inch layer is generally darker than the lower part, owing to a small content of organic matter. The subsoil is loose incoherent sand to a depth of more than 3 feet. In most places it is gray, but it may be light brown or pale reddish brown. Both surface soil and subsoil are low in lime. The color and depth of the surface soil varies somewhat with the relief of the soil. In shallow depressions, conditions have been favorable for plant growth and decay, and the surface soil is somewhat darker and deeper than on the crests of the low rounded knolls and ridges, where the organic layer has been largely removed by the wind. This soil differs from dune sand, which it closely resembles, in its smoother surface and larger content of organic matter.

Valentine sand occupies an aggregate area of 64.6 square miles. It is of little value for crop production on account of its low content of organic matter and its low water-retaining capacity. Only a very small percentage of it is under cultivation. A few of the more favorably situated areas, particularly in the lower depressions where crops can obtain moisture through seepage, are used in the production of corn and alfalfa. Small grain is seldom grown because of the loose character of the seed bed and the danger of blowing. Yields of all crops are low except in the most favorable years.

Dune sand.—Dune sand consists of gray or grayish-brown incoherent fine or medium sand which continues downward to a depth of more than 3 feet with little change in texture. The surface soil contains some organic matter but not enough to prevent drifting by the wind when the covering of grasses is removed. The soil on the ridges is generally lighter in color than that in the hollows because of a lower content of organic matter. Neither surface soil nor subsoil contains lime. The topographic features of dune sand areas have been caused by wind, and the relief is sharply rolling, ridged, and dune shaped, the dunes ranging in height from 20 to 50 feet. A small part of the dune sand is at present subject to active wind drifting. There is little or no surface drainage from these areas, as the rainfall is absorbed by the sand.

Dune sand occurs in a number of areas distributed over the southwestern one-eighth of the county. The total area is 14.2 square miles.

Dune sand is of no value for farming. Small patches have been cultivated, but the soil is so susceptible to blowing that the removal of the natural vegetation ruins the land. Dune sand is used almost exclusively for pasture, and hay is cut in some valleys. The natural vegetation includes a great number of grasses of which bluestem, longleaf reed grass, and needle grass are the most common. These grasses afford good grazing during the spring and summer but are killed by frost. The better dune sand pastures will carry from 30 to 40 head of cattle to the section during the summer months. Hay yields from one-fourth to three-fourths ton to the acre, depending on the rainfall.

FIRST-BOTTOM SOILS

The first-bottom soils occur on the flood plains of all the streams of the county. The small branches and drainage ways have narrow bottoms, in places too small to indicate on the soil map. Along the larger streams the areas of bottom soils may attain a width of more than a mile. The largest bodies are along North Fork Elkhorn River and its large tributary, Dry Creek.

These soils are subject to frequent floodings, and in places they are in process of formation from the addition of sediments brought down the streams by flood waters. The character of the first-bottom soils depends largely on the composition of the upland soils from which sediments have been brought down. In the northern and central parts of the county, the bottom soils are the heavy soils of the Lamoure and the Wabash series. In the southwestern part of the county, where the upland soils are mainly sands, most of the bottom soil is Cass very fine sandy loam.

The first-bottom soils range widely in agricultural value from the almost worthless soils of the poorly drained areas to the rich soils of higher areas, where drainage is adequate in seasons of normal rainfall. In many places artificial drainage has been established.

Corn is grown on all soils having sufficient drainage to give promise of a crop in normal years, oats are grown to less extent, and nearly all the wheat produced in the county is grown on the heavier bottom soils. The poorly drained areas, particularly of the sandy soils, are used for hay land and pasture. Lime is abundant in the Lamoure soils and in places in Cass fine sandy loam. In the Wabash soils the lime occurs at a greater depth, but apparently it is nearly everywhere within reach of plant roots. Owing to the lime supply, alfalfa does well on the bottom soils where drainage is adequate to a depth of several feet.

Lamoure silt loam.—The most extensive bottom soil is Lamoure silt loam, which covers a total area of 32.3 square miles. The largest area is along Dry Creek, extending from the county line southeastward almost to Pierce, and the next largest is southeast of Pierce on North Fork Elkhorn River. The surface soil is very dark grayish-brown or almost black heavy silt loam from 12 to 14 inches deep, in places approaching silty clay loam in texture. It is high in organic matter and appears jet black when wet. The upper part of the subsoil is dark-gray heavy silt loam or silty clay loam, and the lower part, below a depth of 20 inches, is heavy, rather compact silty clay or clay which is light gray in color, mottled in places with dark-gray splotches and iron stains. The soil in most places is high in lime from the surface downward, and in all areas the light-colored subsoil is calcareous.

The surface is prevailingly flat, modified in places by shallow depressions, old cut-offs, and stream channels. The greater part of this soil lies only a few feet above the normal stream level and is subject to frequent overflow. Large areas remain in a marshy condition during the greater part of the year and are used only for hay and pasture. The common crops of the region are grown on the cultivated land, and yields vary widely, according to the rainfall. In favorable seasons the yield of corn on this soil is as high

as on any soil of the county, but the average yield for a number of years is lower than on the better upland soils. Nearly all the wheat produced in the county is grown on this soil, but the acreage seems to be decreasing. In normal years the yield of hay is slightly less on this soil than on the heavier bottom soils, but the average over a period of years is higher.

Lamoure silty clay loam.—Lamoure silty clay loam differs from Lamoure silt loam mainly in the heavier texture of its surface soil. The subsoil is as heavy as or heavier than the surface soil. Drainage is more deficient than in other Lamoure soils, and because of the slow drainage more than two-thirds of the land is in hay meadows which return from 1 to 1½ tons of good hay to the acre, and as pasture they are superior to the sand-hill areas. Yields of corn, oats, and other crops are about the same on this soil as on Lamoure silt loam. Some wheat is grown, but the acreage devoted to this crop is steadily decreasing.

Lamoure very fine sandy loam.—Lamoure very fine sandy loam is of little agricultural importance as it occupies only one-half square mile in the county. It occurs along small creeks in the northeastern part of Plum Grove Precinct. The topsoil is dark very fine sandy loam and is underlain at a depth ranging from 8 to 12 inches by lighter-colored material of similar texture. A grayish-brown clay loam layer may occur at a depth ranging from 14 to 18 inches below the surface, but where present it is thin and is underlain by sandy loam. This soil is better drained than the heavy Lamoure soils and is adapted to several different crops. A large part of its area is in corn and in normal seasons yields are as large as on any other soil in the county. A small part of the land is poorly drained and is used for pasture.

Cass fine sandy loam.—Cass fine sandy loam has a dark grayish-brown fine sandy loam surface soil from 8 to 12 inches deep. The upper part of the subsoil is grayish-brown loamy fine sand and is underlain at a depth of about 36 inches by coarse sand and, in places, by gravel. The surface soil is well supplied with organic matter and with sufficient lime to supply all crop needs.

This soil occurs within and on the borders of the sandy upland soils and is developed over sandy material brought down the streams by flood waters. The most extensive areas are along Willow Creek Valley. The areas along North Fork Elkhorn River have a finer-textured surface soil than areas of this soil in other parts of the county. These areas also have less efficient drainage, and the land is saturated during a large part of the year.

Cass fine sandy loam has a low agricultural value on account of its uncertain drainage conditions. More than half of the area of this soil is used for pasture and hay land. The yield of hay ranges from three-fourths to 1½ tons to the acre. Where drainage is good the yield of corn is about 40 bushels, of oats from 40 to 45 bushels, and of alfalfa from 2 to 3 tons to the acre.

Wabash silt loam.—Wabash silt loam is the principal bottom soil in the northeastern part of the county. The surface is very dark grayish-brown or almost black silt loam, and the upper part of the subsoil is black silty clay loam. Brown mottlings appear below a depth of 30 inches and the color becomes grayish brown. Below a

depth of 4 feet, the lower part of the subsoil is light-gray silty clay loam. This soil is very similar in appearance to Lamoure silt loam, and the separation of the two soils was made principally on the basis of lime content. Lamoure silt loam is high in lime in most places from the surface downward, but Wabash silt loam contains no appreciable quantity of lime to a depth of more than 3 feet. Below a depth ranging from 4 to 5 feet lime concretions are abundant and in most places the entire material at this depth is calcareous. This soil, therefore, is not lacking in lime available to deep-rooted plants such as alfalfa.

Wabash silt loam occurs on first bottoms, and the surface of most areas is flat, modified in places by old stream channels and shallow depressions. These bottoms are overflowed after heavy rains, but in most places the slope of the land is sufficient to carry off the surplus water within a short time.

This is a very productive soil and withstands drought as well as any other soil in the county. About 85 per cent of the land is under cultivation, and the remainder, including poorly drained areas, is in pastures and wood lots. The tree growth, which occurs near the stream channels, consists of elm, ash, cottonwood, hackberry, and boxelder.

On the cultivated areas, corn is the crop most extensively grown, and yields in favorable years are from 10 to 15 per cent higher than on the adjoining upland soils, but the average yield for a period of years is no higher. Oats rank next in importance but are likely to lodge in wet years. Alfalfa is very successfully grown on the better-drained areas, and during normal seasons three or four cuttings a year are obtained with a total yield of 4 or 5 tons of hay to the acre. Native grasses on the poorly drained areas furnish good grazing during the summer months or when cut for hay yield from 1 to 1¼ tons to the acre.

Wabash clay loam.—The surface soil of Wabash clay loam to a depth of 20 inches is very dark grayish-brown or black clay loam. The subsoil is brown, mottled with rust brown, clay loam which is hard when dry and plastic when wet. The movement of moisture through the soil is slow, and poor drainage results unless the surface water can be removed rapidly. The surface soil is sticky when wet, but if the land is plowed at the proper stage of moisture a good tilth can be obtained. Corn, oats, and alfalfa are the principal crops grown. Average yields are below those on Wabash silt loam. The only important area of this soil is just east of Pierce.

DEPRESSION SOILS

The depression soils include areas of reworked upland soils, which occupy depressions surrounded by better-drained upland soils, and muck which occupies the most poorly drained bottom lands.

Gannett loamy sand.—The surface soil of Gannett loamy sand to a depth of about 12 inches is dark-brown or black loamy sand composed of medium and very fine sand in which is incorporated a large proportion of well-decayed organic matter. The color and structure of the soil vary with the proportion of organic matter. In the poorly drained areas, where plant growth and decay have been favored, the surface soil is black, spongy, and light in weight,

and in a few places it is almost a muck. Beneath the surface soil and extending to a depth of about 20 inches is gray or light grayish-brown incoherent fine or medium sand which is low in organic matter and not porous and compressible like the material above. Rust-brown stains are a feature of this upper subsoil layer. Below this and continuing to a depth of several feet is bluish-gray or almost white sand. In places where drainage is exceptionally poor a thin layer of dark-gray sand occurs below a depth of 36 inches.

Gannett loamy sand occurs in poorly drained basins in the sand hills and sandy uplands. The largest areas are in the vicinity of Widhelm School in Blaine Precinct.

Scott silt loam.—The surface soil of Scott silt loam is dark grayish-brown heavy silt loam to a depth ranging from 7 to 12 inches. In places in the deeper areas the texture is silty clay loam or silty clay. The subsoil is black heavy clay to an average depth of 18 inches, below which the material becomes lighter in color. As a rule, lime is not abundant to a depth of several feet. This soil occurs in a number of comparatively small depressions, known as "buffalo wallows," on the smooth upland within areas of Moody soils. The total area of these basins is 1.1 square miles. Drainage is poor, and in the spring after heavy rains water stands on the surface for periods ranging from a few days to several weeks.

Owing to poor drainage, the land is not used for crop production, but most of it is used for grazing, and some wild hay is cut. The natural vegetation consists of sedges and other water-loving plants.

The greatest need of the soil is drainage. Where the depressions are deep, however, it is doubtful that the value of the reclaimed land would justify the cost of drainage.

Muck.—Muck occurs in a few small areas along Dry Creek Valley. This material has accumulated where extremely wet swampy conditions prevail, and it supports a luxuriant growth of grasses such as slough grasses, cattails, and other water-loving plants. To a depth of 12 inches muck consists of partly decayed plant remains and very little mineral soil material. Below a depth of 12 inches there is a smaller amount of undecayed plant remains and more mineral matter, and at a depth of 36 inches muck is underlain by a substratum of bluish-gray or white sand. On account of its poorly drained condition, no use is being made of muck at the present time.

SOILS AND THEIR INTERPRETATION

Three principal factors—the parent material, the soil-forming agencies that have acted on this material, and the length of time these agencies have acted—determine the development and distribution of soils in a given region.

Originally a loess deposit of silt covered all or nearly all of Pierce County, but erosion has removed most of this mantle, and the only extensive remnants are represented by areas of Moody silt loam in the northern part of the county. The sandy soils of the Moody series occur where the loess was covered to greater or less depth by very fine sand transported by wind action. Below the loess is a layer of sand the exact geological relation of which is not clearly understood. It is thought to be composed largely of debris carried down from regions to the north and west and is generally

regarded as being of early Pleistocene age. This sand plain has been exposed over the central and southwestern parts of the county. In its original condition it consisted of light-brown or yellowish-gray fine sand, which locally contained considerable fine gravel. Weathering and the accumulation of organic matter has given the surface soil a brown or dark-brown color. Wind has played an important part in the modification and transportation of this sand deposit, so that probably a very small proportion of the surface soil has remained undisturbed. In the southwestern corner of the county are extensive areas in which the wind has heaped the sand into dunes. Such areas have been classed as dune sand. In other areas, where the original surface soil has been less disturbed, slight weathering has taken place and some organic matter has accumulated, giving rise to soils classed with the Valentine series.

Pierce County lies in that belt of the United States where the influences of climate and vegetation on the soils is particularly evident. On the well-drained uplands, where the soil-forming processes have acted without interruption through long periods of time, soils have been produced having certain common characteristics. The most obvious and striking characteristics of the mature soils is the dark color of the surface soil. The available moisture supply of the region has not been sufficient to support a forest vegetation but has been favorable to the growth of short grasses. These grasses are the source of the organic matter which imparts the black color to the surface soils.

The second common characteristic of the mature soils is the accumulation of carbonates, principally lime carbonate, in the lower part of the subsoils. This high content of carbonate also has resulted from a low moisture supply. The carbonates are leached from the surface soil and the upper part of the subsoil, but are present in the lower part of the subsoil in such abundance as to indicate an accumulation. Other less noticeable characteristics, which are a direct result of the soil-forming processes, will be discussed in the profile descriptions in subsequent pages of this chapter.

The mature or well-developed soils of the county have been formed through the action of the soil-forming processes of the loess and drift deposits of the uplands and on the heavier materials of the terraces. The soils which have not developed the typical regional profile occur where the parent soil materials have not been exposed for a sufficient length of time for the development of a mature soil or where the surface soil has been removed by wind or water. The extremely youthful soils are the sand areas where the material has been stationary only a short time or is still drifting.

The well-developed upland soils are those of the Moody series on the loess-covered upland and of the Waukesha, Hall, and O'Neill series of the well-drained terraces.

Soils in which the characteristics of the regional profile have not been strongly impressed by climate are as follows: (1) Soils that may be regarded as immature because insufficient time has elapsed for their full development or, as in the sands, because the parent material has been resistant to the soil-forming processes; and (2) abnormal soils or soils developed under conditions of excessive moisture which inhibited the formation of the regional profile.

The following profile of Moody silt loam, deep phase, was observed in a cut in section 21, T. 28 N., R. 3 W.: The surface horizon, which is very dark grayish brown or black to a depth of 12 inches, consists of two layers, a dust mulch and a granular layer. The dust mulch varies from one-half to 1 inch in thickness and consists of partly decayed organic matter and loose structureless material composed of sand and silt. The granular layer, which consists of very fine sand or silt, breaks into small granular particles having more or less rounded corners. The particles are soft and are easily crushed into a soft velvety powder. Apparently there is a high content of organic matter throughout the material, as crushing the particles does not produce any change in color. This layer contains a large quantity of grass roots and a few insect casts.

The next lower horizon of the profile is the zone of maximum concentration of finer soil material. It consists of brown silty clay loam or clay loam in the upper part and more friable or almost structureless material in the lower part, which is the transitional layer to the next horizon below. The material in the upper part breaks into large angular particles that range from one-eighth to one-half inch in diameter. These particles are more difficult to crush than those in the dark-colored horizon, and crushing gives a much lighter color to the powdered material. This indicates that the organic material has not been thoroughly incorporated with the mineral constituents of the soil but exists as a film on the granules. In the lower part of the horizon the material is in the form of prismatic particles, ranging from one-half to 1 inch in diameter. These particles are easily crushed into a structureless mass.

This horizon is underlain at a depth of 42 inches by a yellow horizon consisting of loose and structureless very fine sandy loam or silty loam. Lime is more abundant in this horizon than in any other in the profile, either above or below. It occurs in the form of hard concretions and is also finely disseminated within the material. The lime concretions are most abundant between depths of 42 and 50 inches and below this depth a few are scattered through the material.

The pH value in the dark surface horizon is 6.7, in the brown horizon 7.0, and in the horizon of lime accumulation, 8.0.

Table 4 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of Moody silt loam.

TABLE 4.—*Mechanical analyses of Moody silt loam*[1]

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
376921	Surface soil, 0 to ¼ inch	0.3	0.5	0.8	2.5	9.8	49.9	36.1
376922	Subsurface soil, ¼ to 12 inches	.1	.4	.8	2.7	7.4	47.8	40.5
376923	Subsoil, 12 to 24 inches	.1	.2	.3	1.0	5.1	48.6	44.7
376924	Subsoil, 24 to 42 inches	.1	.2	.3	1.1	6.8	49.3	42.2
376925	Subsoil, 42 to 48 inches	.3	.2	.2	.6	8.1	53.7	36.9
376926	Subsoil, 48 to 108 inches	.0	.2	.3	1.0	22.0	46.5	30.1

[1] After treatment with hydrogen peroxide.

Hall silt loam is another soil developed under the fullest influence of climate and vegetation. It occurs on the terraces of the larger streams in the northeastern part of the county. Its profile is similar to the profile of Moody silt loam, deep phase, except in detail. The black surface horizon is more deeply developed, and the zone of lime accumulation occurs at a greater depth. Hall silt loam has a black surface horizon that reaches a depth of 18 inches. Beneath this is a brown horizon that merges into a yellow horizon of lime accumulation at a depth of 48 inches. The pH value in each of these horizons is as follows: Black horizon 6.5, brown horizon 6.5, and yellow horizon 7.0.

The soils of the Waukesha and O'Neill series differ in the lower horizons from the soils described above. The Waukesha soils have similar characteristics to the Hall soils, except that the Hall soils do not have a zone of lime accumulation below the brown horizon. The Waukesha soils have very dark grayish-brown or black surface soils underlain at a depth of about 8 inches by brown heavy silty clay loam which grades into loose friable structureless yellow silty material at a depth of about 24 inches. Below this and extending to a depth of 10 or more feet the material is uniform in character and does not contain lime concretions or effervesce with acid. This deficiency in lime is probably due to local conditions of underdrainage, by which the lime has been removed, or to the removal of the lime from the parent material during the time this material was in the process of accumulation on the terraces.

The O'Neill soils have very dark grayish-brown or black surface soils and somewhat heavier grayish-brown or brown upper subsoil layers. They differ from the Moody, Hall, and Waukesha soils in that they are underlain by material containing considerable sand, although the surface material has been covered with a silty deposit similar to that from which the other soils of this group have developed.

The most immature soils are the lighter-colored sands—Valentine sand and dune sand. The light color of these soils is due to the low content of organic matter. The sandy material is of recent deposition and, being composed of quartz, does not readily decompose through weathering. Organic matter released on or near the surface is rapidly oxidized in place instead of being incorporated and preserved with the fine mineral constituents of the soil.

Valentine sand is the more extensive of the light-colored sandy soils. The surface soil consists of loose incoherent grayish-brown sand from 10 to 14 inches deep. In most places the upper 4-inch layer is somewhat darker than the lower part, owing to a small amount of organic matter, but the organic-matter content is not sufficient to prevent the soil from drifting where the protective vegetation is removed. The subsoil is loose incoherent sand which generally extends to a depth of more than 3 feet and in places to a depth of 10 or more feet. Most of this sand is gray, although in local patches it has a light-brown or pale reddish-brown tint. Neither surface soil nor subsoil is calcareous. The soil material is largely composed of medium fine and very fine grades of sand which is mainly quartz.

Dune sand consists of wind-blown sand and belongs to no soil series. The sand is grayish brown or yellowish brown and is smooth and incoherent. It continues for great depths with very little change in texture or color. The areas of dune sand have a hilly or dunelike relief as a result of wind action.

A group of less immature soils are the dark-colored sandy loam soils. These soils are derived mainly from the same kind of parent material as the light-colored sands. The dark-colored sandy loams contain a greater amount of organic matter than the light-colored sands, because of their more stable surface soils. Dickinson loamy sand is typical of the dark-colored sandy loam soils. The upper 4 inches of the surface soil consists of dark-brown friable loamy sand containing large quantities of organic matter. Below this the soil, to a depth of 20 inches, is very dark brown and is slightly heavier in texture. The underlying material, to a depth of 10 feet and in places more, is loose incoherent fine or coarse sand containing some fine gravel. It is yellow or gray in color and uniform in character. None of the material in the entire soil profile will effervesce with acid. The pH value averages 6.5.

Other soil types included in this group are Dickinson sandy loam and soils of the O'Neill series, which are developed on the terraces. The O'Neill soils have essentially the same profile as Dickinson loamy sand, except that they have a slightly deeper dark surface horizon.

The immature or abnormal soils are those developed under conditions of more or less restricted drainage. They have dark-colored surface soils and mottled rust-brown and gray subsoils. The surface soils are slightly darker than those of any other soils in the county.

These soils are developed on the alluvial flood plains and in depressions on the uplands, where the surface is subject to inundation and poor drainage. A luxuriant growth of grasses covers these soils. Because the soils are excessively saturated with moisture, aeration is restricted and the decomposition of the organic material is slow. Consequently the accumulation of organic matter is more rapid than the decay, until finally a large quantity has accumulated and imparts a dark color to the surface soils. The mottled gray and rust-brown color in the subsoils is indicative of poor oxidation because of excessive moisture and lack of aeration for this process.

The soils included in this group are the Gannett and Scott soils of the upland depressions and the Lamoure, Cass, and Wabash soils and muck of the flood plains.

The surface soil of the Gannett soil is dark gray or black and contains much organic matter, in a few places almost enough to constitute muck. The subsurface layer in places is darker than the surface soil. The subsoil is light-brown or grayish-white sandy loam mottled with rust brown and gray. The soil is developed in pockets and swales throughout the more sandy parts of the county. Drainage is poor, and in the lower part of the depressions a marshy condition prevails during the greater part of the year.

The Scott soil is developed in depressions occurring within areas of the heavier soils of the county and differs from the Gannett soil in having a heavy claypan subsoil. The surface soil is very dark grayish brown or black and is underlain by a thin gray layer which passes into a heavy plastic claypan subsoil mottled with gray and

rust brown. Small iron pelletlike concretions ranging from one-eighth to one-sixteenth of an inch in diameter are abundant in the upper part of the subsoil.

The Lamoure soils have very black surface soils that merge, at a depth of about 12 inches, into ash-gray highly calcareous subsoils. The lower parts of the subsoils are mottled with rust brown and gray.

The Wabash soils differ from the Lamoure soils in having yellowish-brown or drab heavy clay subsoils which do not effervesce with acid.

The Cass soil differs from either the Lamoure or Wabash soils in that it is derived from more sandy alluvium and has a sandy porous subsoil. The surface soil is dark brown or black, and the subsoil is brownish gray or light gray.

Muck occurs in swampy areas in which a high content of organic matter and undecomposed plant remains have accumulated. The material is loose and fluffy to a depth ranging from 20 to 30 inches, and below this depth gray fine sandy loam, splotched with rust brown and yellow, occurs. The vegetation on these areas consists principally of slough grass and cattails.

SUMMARY

Pierce County is in northeastern Nebraska. It is part of a broad plain that slopes slightly toward the southeast, on which minor relief has been produced by stream erosion and wind action. North Fork Elkhorn River crosses the central part of the county in a southeasterly direction, and its tributaries extend to most parts of the county.

The census of 1930 gives the total population of the county as 11,080. The rural population is densest in the northern part.

The average annual rainfall is 27.94 inches. The climate is suitable for general farming.

Of the total area of the county, 92.8 per cent is in farms, the largest of which are in the southern and western parts of the county. Most of the farms are well equipped with buildings, modern implements, and livestock. About 45 per cent of the farms are operated by owners and the rest mainly by tenants.

The most extensively developed agricultural lands of the county are in two major soil belts that cross the county from northwest to southeast. One belt covers the northeastern one-third of the county and includes fine-textured soils commonly known as "yellow clay." The other belt extends across the central part of the county and is composed of sandy soils. The same crops predominate in both soil belts. Corn is the crop most extensively grown, and oats rank second in acreage. The yields of these crops in the northeastern belt are normally from 10 to 15 bushels more to the acre than in the central belt. In very dry seasons yields of corn in the northeastern belt are greatly reduced. The largest acreages of alfalfa and sweetclover are in the northeastern soil belt, and of rye and potatoes in the central soil belt. Alfalfa and sweetclover make the best yields on the soils in the northeastern belt, which are heavy in texture and contain plenty of lime.

The greater part of the uncultivated land of the county occurs in a belt of rolling light-colored sandy soils that covers the southwestern part, and on the poorly drained dark-colored alluvial lands along Willow and Dry Creeks. On the uplands the sandy land is used chiefly for pasture and on the alluvial lands for hay land. The upland pastures support from 50 to 60 head of cattle to the section during the summer season. The hay land in the bottoms produces from 1 to 1½ tons of hay to the acre. The bottoms produce large crops where drainage is good.

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[PUBLIC RESOLUTION—No. 9]

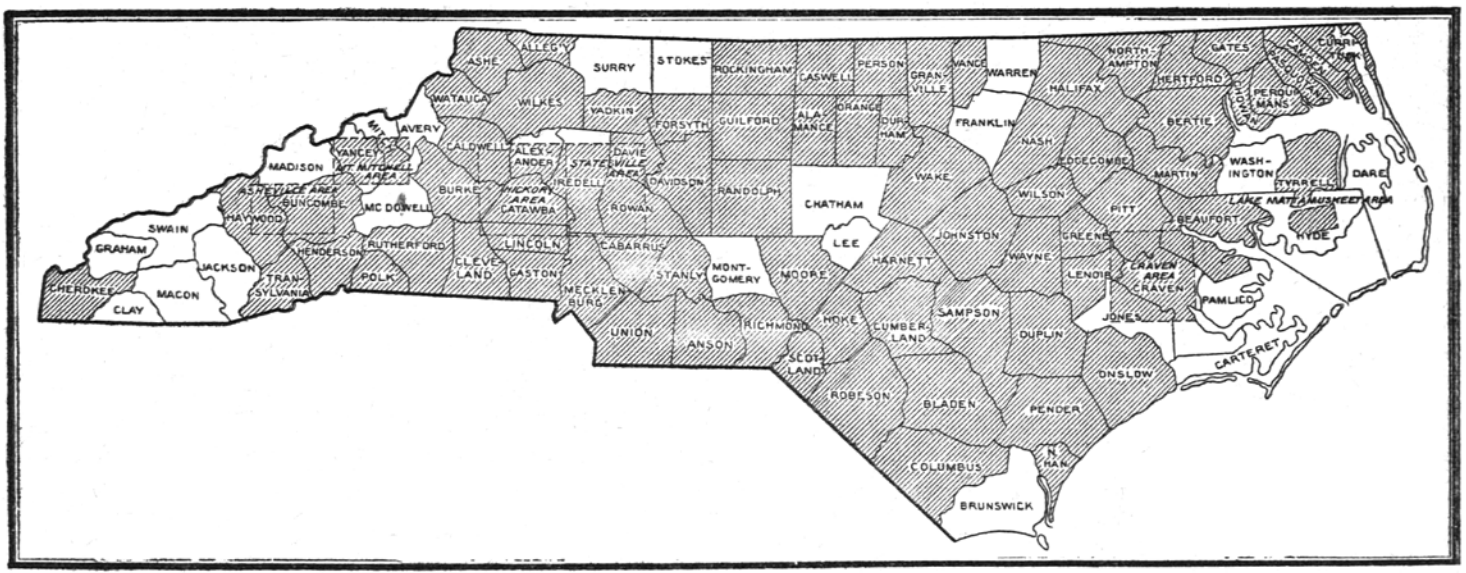
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in North Carolina, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1931

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