

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Knox County, Nebraska

By

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Nebraska Soil Survey



Bureau of Chemistry and Soils

In cooperation with the

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SOIL SURVEY OF KNOX COUNTY, NEBRASKA

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COUNTY SURVEYED

Knox County is in northeastern Nebraska adjoining South Dakota (fig. 1). Center, the county seat, in the central part, is about 75 miles west of Sioux City, Iowa. The county is nearly rectangular, although its northern boundary is somewhat irregular. It comprises an area of 1,119 square miles, or 716,160 acres.

Knox County is part of a broad nearly level or hilly plain which slopes gently downward toward the south and east. However, Missouri River is so deeply entrenched along the northern edge of the county that much of the local drainage is northward to that stream. About 90 percent of the land is upland, and the remainder is alluvial.

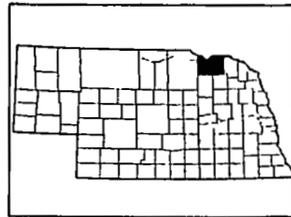


FIGURE 1—Sketch map showing location of Knox County, Nebr.

The county includes a wide variety of exposed geologic materials, and the surface features are the results of wind and water acting on these materials. The general character of the surface relief in a particular locality depends partly on the severity of erosion to which the soil in that locality has been subjected, partly on the erosive resistance of the formations exposed in it, and partly on the surface features of the formations at the time they were covered by later deposits.

The bedrock consists of thick nearly level deposits of shale, chalk, and sandstone of Cretaceous age, the uppermost of which is the Pierre formation, a blue clayey shale with thin seams of calcium carbonate. This is underlain by the Niobrara chalk, a bluish-gray limestone which weathers into yellow material. These formations are prominently exposed along Missouri River and its tributaries, but the Pierre shale exposures are by far the most extensive. Next below the Niobrara is the threefold division of the Benton formation consisting of shales and limestones, under which is the Dakota group of beds composed largely of sand. The formations beneath the Niobrara chalk are not exposed in Knox County and, therefore, have no influence on the surface features or the soils. However, all the formations mentioned are found in the deeper wells, and the Dakota formation is an important source of deep well water.

Formerly the Pierre shale was overlain by Tertiary beds consisting of light-colored loosely indurated and limy sandstone, which were largely removed from the area just prior to the glacial period. How-

ever, there are remnants of this sandstone in the southwestern part of the county, and small outliers from the main beds extend several miles eastward and northward.

During the two main glaciations, ice covered about three-fifths of the county from the northwest to the southeast, extending beyond the middle on the south. The material brought in by the ice was a heterogeneous mixture of silt, clay, sand, and gravel, containing numerous boulders. While the ice was present, vast deposits of sandy inwash from the west and outwash from the edge of the ice were formed along its western border, covering much of the western part. Consequently, two very different deposits of glacial age occur. The material carried in by the ice from the north is called "drift" and that washed in from the west and from the drift is called "sand-plain" deposits.

Subsequent to glaciation the drift deposits were extensively eroded. Erosion in many places also extended into and through the older deposits, down to a depth of about 100 feet in the Niobrara chalk, and resulted in the formation of the Missouri River Valley and its main tributaries. After this erosion period, loess or wind-blown deposits were formed over most of the area. The lower of these is a pale-red limy and slightly sandy silt known as "Loveland loess". The uppermost deposit, called "Peorian loess", consists of grayish-yellow limy and floury silt and is the surface formation over about 70 percent of the county.

Each of the exposed formations has been subjected to more or less erosion. Wind action has greatly modified the original surface of the sand-plain deposits, and to some extent that of the drift, and in many places water erosion has altered the former surface features of all the finer textured deposits. Erosion has been most severe in the western and northern parts and has resulted in the development of three major physiographic divisions¹—the loess hills, the Holt table, and the Pierre plains and hills. All these divisions extend far beyond the limits of Knox County, but only those parts occurring within the county are considered in this report. Their boundaries are very irregular and in many places are rather indefinite.

The loess hills division occupies the southeastern part and covers about 60 percent of the county, its northern boundary extending diagonally across the central part in a general southwest-northeast direction. Over most of this area the loessial mantle is intact, and in several places the surface relief is nearly level or gently undulating, as on the large tables west of Wausa, in the vicinity of Winnetoon, northwest of Crofton, and on numerous narrow divides and hilltops.

Aside from the nearly level areas, which do not occupy more than 10 percent of the loess hills division, the land surface ranges from gently rolling to extremely rough and broken. It is characterized, especially in the eastern part of the division, by round-topped hills and divides. In this part the drainage pattern is fairly intricate and steep slopes abound, but only a comparatively small percentage

¹ MCKELVIE, S R, CONDRA, G E, and others NEBRASKA RESOURCES AND INDUSTRIES Nebr Conserv and Welfare Comm and Nebr Conserv and Soil Survey Dept. Bull 14, 115 pp, illus 1920

of the land surface is rough and gullied, and the loessial mantle does not appear to owe its relief so much to erosion as to the character of the surface on which it rests.

In the central and western parts the loessial mantle has been severely eroded by the headwaters of Bazile and Verdigris Creeks which are entrenched from 150 to 200 feet below the general upland level. A few small tablelike remnants of loess remain, but most of the loessial material has been carved into a succession of sharp divides and narrow steep-sided valleys, such as occur throughout much of Valley Township, the western part of Spade Township, and the northwestern part of Cleveland Township. Over large areas the loess has been removed, exposing the underlying formation. Where the exposed material consists of sand-plain deposits the relief is usually slight, drainage channels are poorly developed, and the land surface is gently rolling or hummocky, as it is west and east of Creighton, east of Midland Store, and about 3 miles west of Bloomfield. Where erosion has cut through the loose sand into the underlying Tertiary sandstone formation, as around the headwaters of Merriman and Verdigris Creeks, the relief is pronounced. Most of the lower valley slopes are gradual, but they become steeper as elevation increases, and the upper slopes are characterized in many places by vertical rim-rock exposures. Although the tops of most of the divides are narrow, few of them are sharp. Their surfaces, where covered with loess, range from nearly level to extremely rough and broken, depending on the severity of erosion to which they have been subjected, but where covered with sandy materials they are rolling or hummocky.

The physiographic division known as the "Holt table" comprises about 12 percent of Knox County. It extends into the county from the west, occupying all the uplands south of Niobrara River, west of Verdigris Creek, and north of the loess hills division.

The surface features on that part of the Holt table occurring in Knox County are largely wind formed. The loessial mantle has been removed from all but about 15 percent of the table, exposing the underlying sand-plain deposits. These, although fairly stable in most places, owing to large admixtures of loess, have been more or less shifted about by the winds, giving the table as a whole a strongly undulating or gently rolling appearance. However, the land surface is modified here and there by rather extensive hummocky areas where the looser sands have been piled into low mounds and ridges, by nearly level areas occupied by uneroded remnants of the loessial mantle, and by strongly rolling or hilly areas where stream erosion has gullied the surface of the loessial remnants or has cut through both the loess and sand into the underlying Pierre shale. The harshness of the water-formed irregularities has been modified in most places by drifting sands, and the surface features, even in the severely eroded sections, are in most places well rounded.

The Pierre plains and hills division occupies about 18 percent of the county. It is fairly continuous across the northern edge, including the uplands between Niobrara and Missouri Rivers in the northwestern part, those in the Verdigris Creek drainage basin south of Verdigris in the west-central part, and those in a strip, ranging from 1 to 7 miles in width, between the loess hills division

and the Missouri River alluvial land in the north-central and north-eastern parts. The division as a whole has been more severely eroded than either the loess hills or Holt table divisions. It includes some of the roughest land but also includes rather large areas in which the land surface is undulating or rolling. The more even relief is on loessial material in that part of the division lying between Niobrara and Missouri Rivers, where about 40 percent of the land surface, including the higher divides, still retains a thin covering of loess. Throughout the remainder of the division erosion has removed the loessial mantle and, in most places, the underlying drift and sand-plain deposits, exposing the blue Pierre shale. The relief of the Pierre shale areas ranges from strongly rolling to extremely rough and broken, depending on the severity of erosion. The roughest areas are in the vicinity of Verdigre, southwest of Santee, and in the eastern part of Devils Nest. In these localities the blue shale has been carved into a series of sharp-topped tortuous ridges and narrow steep-sided valleys. In many of the deeper valleys it has been removed, and the streams have carved vertical channel walls in the underlying chalk rock. Vertical exposures of chalk rock are also numerous on the lower slopes of the high blufflike escarpment which borders the Missouri River alluvial land along most of the northern edge of the county. In localities where glacial drift deposits cap the blue shale, as in numerous places between Niobrara and Missouri Rivers, in much of the Verdigris Creek drainage basin south of Niobrara, and throughout most of the western part of Devils Nest, the relief although hilly is harsh and angular in few places. The hills and ridges are lower, their tops, although narrow, are more rounded, and the valley slopes are more gradual than in localities where the coarse-textured materials have been removed.

The alluvial lands, including the terraces and flood plains, occur as continuous strips along all the larger streams, except Missouri River which impinges against the bluffs in many places, dividing its alluvial land into several bodies.

The terraces occur at several distinct levels, depending on the depth to which the streams had cut prior to deposition of the terrace material. The highest and most extensive developments are between the flood plains and uplands on the south side of Niobrara River where several of the terraces are more than a mile wide and lie from 75 to 90 feet above the stream channel. Lower and smaller terraces border the flood plains along Missouri River at Niobrara, Santee, and near the mouth of Weigand Creek. Low terraces also occur along Niobrara River, Bazile Creek, and Verdigris Creek, and some of their tributaries. The surfaces of the terraces are nearly level or gently undulating, except locally on the higher and more sandy benches where the surface is slightly hummocky. None of the terraces is continuous.

The flood plains comprise the lowest land in the county, their surfaces lying only a few feet above the normal levels of the streams. The broadest, but not continuous, developments are along Missouri River, particularly north of Santee and north of Devils Nest, where the bottom lands are about 2 miles wide in places. Continuous strips, ranging from one-eighth to about one-half mile in width, are

along most of the creeks and their larger branches. The surface of the flood plains is nearly level but is modified by old and present stream channels, slight elevations, and shallow depressions.

Knox County has an average elevation of about 1,600 feet above sea level. The lowest point, approximately 1,220 feet, is where Missouri River crosses the northeastern corner of the county, and the highest, about 2,000 feet is in the uplands in the southeastern part. The elevation² above sea level of Niobrara is 1,248 feet, Verdigre 1,345, Creighton 1,600, Winnetoon 1,645, Bloomfield 1,703, and Wausa 1,780. The general slope of the county is toward the north and east.

Drainage is effected northward to Missouri River through Beaver, Weigand, Bazile, and Verdigris Creeks and their tributaries, with the exception of a small area in the northwestern part, which is drained eastward to the Missouri through Niobrara River and Ponca Creek, and a few townships in the southeastern corner, which are drained southward to Elkhorn River. All the creeks and branches have steep gradients and are actively deepening their channels, and Niobrara River is entrenching its channel, except near its mouth. Missouri River, however, has a fall of only about 6 inches to the mile, is rather sluggish, and is filling its channel in places.

The rivers, creeks, and branches afford ample drainage throughout practically all parts of the county. Over large areas the surface run-off is rapid, and erosion is severe. The only poorly drained land occupies small scattered basinlike depressions in the more nearly level parts of the upland and local spots in the Niobrara and Missouri River bottoms.

Knox County is in the prairie region of the United States. In virgin areas throughout the uplands and terraces, the predominant grasses on the finer textured soils are big bluestem, little bluestem, western wheatgrass, and slender wheatgrass. On the more sandy soils, needlegrass predominates in most places. The bottom lands support a great variety of moisture-loving grasses, except in the more poorly drained situations, where rushes and sedges grow.

Native trees, including elm, ash, oak, hackberry, boxelder, cottonwood, and willow occupy narrow strips adjacent to the stream channels in all the larger valleys, and trees are especially numerous on many of the lower slopes of the bluffs bordering the Missouri River bottom lands. The trees are used locally for lumber, but their chief value is for posts and fuel.

The quality, depth, and supply of well water differs in different parts of the county. Throughout most of the loess-covered uplands an abundant supply of good water occurs in the sandy materials immediately beneath the loess and is reached at a depth ranging from 50 to 250 feet. The depth to water in a particular locality depends on the thickness of the loessial materials, and the deeper wells are on the nearly level table west of Wausa. In localities where the sandy deposits are exposed but have not been greatly thinned by erosion, as throughout much of the Holt table division, an abundance of good water is obtained in most places between depths of 80 and 100 feet.

² GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES U. S. Geol. Survey Bull. 274, ed. 4, 1072 pp. 1906.

Throughout the Pierre plains and hills division the quality and supply of easily accessible well water are low. The best supplies of water obtained at a slight depth are from irregular areas of sand and gravel on the uplands and from the flood-plain deposits. Most of the water in the Pierre shale and Niobrara chalk contains much alkali, and in areas where water-bearing sands do not overlie these formations many of the wells extend into the Dakota sandstone which lies at a depth of more than 500 feet in most places. One of the deepest wells, which extends to a depth of 750 feet, is on the uplands north of Winnetoon. The deeper wells in the Ponca Creek and the Niobrara and Missouri River Valleys range from 500 to 550 feet in depth. The water in the Dakota formation, although somewhat mineralized, is of better quality and much more abundant than that in the Pierre and Niobrara formations. Many farmers in the Pierre plains and hills division obtain water for livestock and household use from ponds formed by damming small draws or gullies.

The wells on the alluvial lands range from 10 to 90 feet in depth, depending on the thickness of the alluvial deposits. Most of those in the southern part of the county furnish an abundance of good water. In the northern part the water in many of them, although plentiful, is of poor quality, owing to the proximity of the Pierre shale, in which the water is heavily mineralized.

There are a few artesian wells, all of which extend into the Dakota sandstone. They are chiefly in the Missouri River bottoms. Attempts to obtain water from artesian wells on the uplands have usually failed because of the altitude, as the pressure, although strong in the water-bearing beds below, is not sufficient to force the water to the necessary height.

Springs are numerous on the lower slopes in many of the valleys, especially the slopes along Bazile and Verdigris Creeks and those on the south side of Niobrara River. Most of the springs occur near the base of exposed sandy beds overlying Pierre shale, and the water is in general of good quality.

The first permanent settlement in the area now included in Knox County was made in 1856 near the present site of Niobrara. The county was established as L'Eau Qui Court County by the territorial legislature in 1857 and was organized the same year. The name was changed to Knox County in 1873, and in 1883 the area north of Niobrara River, formerly a part of Dakota Territory, was added, giving the county its present dimensions. The early settlers came largely from the Central and Eastern States, and most of them were American born.

The census of 1930 reports the population of Knox County as 19,110, all of which is classed as rural. The average density of population is given as 17.2 persons to the square mile. The population is densest in the loess hills division and in the vicinity of the towns. The Pierre plains and hills division and the sandy Holt table division are rather sparsely settled.

Center, the county seat, situated in the central part of the county, had 130 inhabitants in 1930. Bloomfield, the largest town, with 1,435 inhabitants, is in the east-central part, and Creighton, with a population of 1,388, is in the south-central part. The remaining

towns and villages, each with less than 1,000 inhabitants, are well distributed and furnish local markets and distributing points for farm supplies and produce.

Knox County has fair transportation facilities. A branch of the Chicago & North Western Railway from Norfolk, Madison County, Nebr., to Winner, S. Dak., extends in a general north-south direction across the western part of the county passing through Creighton, Winnetoon, Verdigre, Niobrara, and Verdel. A branch of the Chicago, St. Paul, Minneapolis & Omaha Railway terminates at Crofton in the northeastern part, and a branch of the same system extends through Wausa to Bloomfield in the east-central part. The central, southwestern, and northeastern parts have no railroads.

The public-road system includes two gravel-surfaced highways which extend north and south across the county, one in the eastern and the other in the central part. Most of the other roads are of earth construction but are kept in good repair. They follow land lines, except in the rougher sections where they conform to surface relief. Bridges cross Niobrara River west of Niobrara and northwest of Pishelville. Public ferries are maintained on Missouri River east of Niobrara and northeast of Verdel. Cement bridges and culverts across the smaller drainageways are common. Telephones and rural mail-delivery routes reach nearly all sections.

CLIMATE

The climate of Knox County is typical of northeastern Nebraska and is well suited to grain farming and livestock raising. The long warm summers are especially favorable for the production of corn. The spring is usually cool, with considerable rainy weather, and the autumns long and pleasant, with only occasional rainy spells. There is not enough difference in surface relief to cause an appreciable difference in climate within the county.

The average date of the latest killing frost is May 5, and that of the earliest is October 3, giving an average frost-free season of 151 days which is ample for maturing all farm crops common to the section. However, during the 20 years from 1895 to 1914, inclusive, there were 3 years in which killing frosts occurred 10 or more days later in the spring than the average date, and 5 years in which they were 10 or more days earlier in the fall. Killing frosts have been recorded as late as May 28 and as early as September 12.

About 77 percent of the mean annual precipitation falls during the principal part of the growing season, from April to September, inclusive. In the summer, most of the rainfall occurs as heavy thundershowers, but torrential rains are rare. Severe droughts are almost unknown during May and June, but in the latter part of July and through August, the rainfall varies considerably and short dry spells may occur. Except in the more sandy sections, however, crops seldom suffer from lack of moisture when proper cultural methods are followed, as most of the soils have a high water-holding capacity. The annual amount of snowfall ranges from a few inches to several feet.

From October 1 to April 1 the prevailing wind is from the northwest, and from April 1 to October 1 it is from a southerly direction. Strong winds are common, but tornadoes are rare.

Table 1, compiled from records of the Weather Bureau station at Santee, gives the normal monthly, seasonal, and annual temperature and precipitation.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Santee, Knox County, Nebr.

[Elevation, 1,225 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1905)	Snow, average depth
	°F	°F	°F	Inches	Inches	Inches	Inches
December.....	23 3	67	-37	0 65	0 06	0 00	6 8
January.....	10 6	64	-30	54	48	86	4 8
February.....	22 4	76	-38	62	.18	25	6 2
Winter.....	21 8	76	-38	1 81	72	1 11	17 3
March.....	36 0	91	-12	1 11	81	3 34	5 6
April.....	49 0	102	11	2 30	4 21	1 91	2 0
May.....	61 2	101	22	3 68	1 72	4 65	.3
Spring.....	49 0	102	-12	7 09	6 74	9 90	7 9
June.....	70 9	112	32	4 20	62	4 71	0
July.....	76 1	114	44	3 32	1 27	5 40	.0
August.....	74 3	106	40	2 83	1 51	4 70	0
Summer.....	73 8	114	32	10 35	3 40	14 81	.0
September.....	65 9	106	22	2 20	1 96	5 36	0
October.....	53 0	93	4	1 75	1 57	1 83	.9
November.....	36 4	81	-13	90	.12	2 00	4 5
Fall.....	51 8	106	-13	4 85	3 65	9 19	5 4
Year.....	49 1	114	-38	24.10	14.51	35 01	30 6

AGRICULTURE

Knox County is essentially agricultural. Prior to the entry of the white man, the land was covered with a luxuriant growth of prairie grasses, with a heavy tree growth along the larger streams. Much of the forest still remains, but most of the prairie sod, except in the more severely eroded and more sandy parts of the county, has been broken for crop production.

The first permanent settlers located near the present site of Niobrara in 1856. Settlement did not extend into the uplands until several years later, after all the desirable valley land had been homesteaded. Cattle raising was practiced extensively during the early development of the county, and large tracts were included in ranches on which beef cattle were grazed. The more severely eroded and sandy areas are still used for ranching.

The first cultivated crops consisted of sod corn and garden vegetables, followed by oats and wheat as conditions became more stable. In the latter part of the decade ended in 1879 wheat attained first rank in point of acreage, but during the next few years the corn acreage was increased at the expense of that used for wheat, and corn has been the leading crop ever since.

The early agriculture developed slowly, owing to the ravages of insect pests, the absence of transportation facilities and markets, and the lack of familiarity on the part of the farmers with local climatic and soil conditions. The early settlers had little capital to tide them over years of crop failure, and after the "grasshopper" year of 1874, when crops were destroyed over large areas, the settlers were slow in recovering.

The value of all crops produced in 1929 was \$5,833,294. Dairy products, in excess of those used in the home, were produced to the value of \$535,647 and poultry and eggs to the value of \$886,501. The total value of all domestic animals on farms on April 1, 1930, was \$6,271,878.

According to the 1930 Federal census, 61.3 percent of the farm land is classed as crop land and is used principally in the production of grain, tame hay, or wild hay; 34.1 percent is used as pasture land; 0.6 percent is included in woodland not pastured; and 4 percent in other land which includes building sites, roads, and waste land.

Corn is by far the most important crop, followed by oats, wild hay, alfalfa, sweetclover, and barley, ranking in acreage in the order named. Minor crops include wheat, rye, sorgo cane, potatoes, garden vegetables, and fruits.

Table 2, compiled from the Federal census reports, gives the acreage and production of the principal crops grown in stated years and shows the general trend of agriculture during the last 50 years.

TABLE 2—Acreage and production of principal crops in Knox County, Nebr., in stated years

Crop	1879		1889		1899	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	4,431	106,496	48,470	921,614	111,281	3,232,240
Oats.....	1,493	40,805	15,099	291,723	32,768	967,250
Wheat.....	5,195	38,586	8,752	104,672	71,198	682,640
Barley.....	368	5,620	305	4,159	3,417	90,430
Rye.....	88	1,283	770	7,151	1,632	18,350
Potatoes.....		20,084	906	64,519	939	87,938
		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
All hay.....	5,134	8,214	38,504	47,052	45,320	52,467
Alfalfa.....					31	65
Clover.....					38	106
Wild.....					41,245	44,673
Coarse forage.....					39	92

Crop	1909		1919		1929	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	150,026	4,551,315	141,102	3,820,965	190,731	5,652,020
Oats.....	90,286	2,155,400	79,487	2,160,740	93,668	3,156,854
Wheat.....	5,813	65,445	20,310	148,896	2,972	64,540
Barley.....	2,652	46,538	3,295	57,145	10,134	328,710
Rye.....	472	4,377	2,175	20,047	2,349	38,275
Potatoes.....	1,011	68,980	1,159	44,308	1,096	83,148
		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
All hay.....	89,106	104,278	79,485	104,473	86,459	84,269
Alfalfa.....	3,982	9,033	24,624	50,689	22,204	33,294
Clover.....	43	82	211	321	2,341	2,565
Wild.....	64,960	72,899	50,708	45,940	58,497	43,164
Coarse forage.....	666	1,879	6,738	13,032	1,929	13,603

The returns derived from livestock and their products are the main source of income. In 1929 the value of livestock and their products exceeded the value of all crops. Most of the crops are fed to livestock.

Table 3, compiled from the Federal census reports, gives the number and value of domestic animals and poultry on farms and ranges in 1910, 1920, and 1930.

TABLE 3.—*Number and value of domestic animals on farms and ranges in Knox County, Nebr., in 1910, 1920, and 1930*

Kind of animal	1910		1920		1930	
	Number	Value	Number	Value	Number	Value
Horses.....	17, 223	\$1, 843, 506	17, 523	\$1, 444, 855	15, 309	\$754, 039
Mules.....	853	100, 914	1, 124	133, 681	1, 368	89, 093
Asses and burros.....	11	2, 325	11	1, 516	4	240
Beef cattle.....	43, 171	1, 007, 086	46, 341	2, 176, 683	50, 300	3, 237, 030
Dairy cattle.....	21, 201	406, 000	18, 682	863, 780		
Sheep.....	1, 620	8, 003	3, 424	30, 871	8, 233	57, 974
Goats.....	44	154	01	280	89	469
Swine.....	102, 403	850, 121	110, 041	2, 245, 074	150, 852	2, 133, 033
Poultry.....	183, 479	68, 852	235, 688	190, 970	301, 041	238, 533

¹ All cattle

² Chickens only

The farm buildings in general are well painted and kept in good repair, and many of the houses are equipped with modern conveniences. According to the 1930 census, 224 of the farmhouses had electric-lighting systems, 582 had modern water systems, and 893 had radios. The farms are fenced and cross fenced, mainly with barbed wire, though many farms are enclosed with hog-tight woven-wire fencing. The work animals include heavy draft horses and mules. There were 631 tractors, 306 motor trucks, and 2,706 automobiles on farms in the same year. Most farmers have modern labor-saving machines, such as gang or sulky plows, disks, drills, corn planters, cultivators, and complete equipment for harvesting hay. Many farms are equipped with corn binders, corn shuckers, hay balers, and silos, and the Nebraska agricultural statistics report 128 grain threshers, 6 combines, and 1,907 cream separators in the county in 1929. On most farms, the more expensive farm machinery is kept under shelter.

The 1930 Federal census reports that 95.3 percent of Knox County is included in 2,632 farms and that the average size of farms is 258 acres. The greater number of farms are between 80 and 640 acres in size, although there are many small holdings and a few large ranches including more than 1,000 acres. Slightly more than 73 percent of the farm land is classed as improved land, which includes crop land and plowable pasture.

In 1930, owners operated 1,239 farms, 1,368 farms were operated by renters, and 25 farms by managers. Both the cash and share systems of rental or sometimes a combination of the two are used. The share system is most popular, 970 farms being rented on shares and 398 for cash in 1929. Under the share system the owner receives two-fifths of the grain delivered, and from \$2 to \$4 an acre for pasture land and the building site. All seed, labor, and machinery are furnished by the tenant. When alfalfa land is rented on shares the owner usually receives half the hay stacked in the field. Under

the cash system it is customary for the tenant to pay from \$4 to \$7 an acre for the use of the land, including the pasture areas. Land suited only for pasture may be rented for a lump sum. Most of the land rented under the cash system is on the more nearly level areas in the southeastern part.

In general, farm laborers are plentiful. Wages range from \$30 to \$50 a month. Those laborers receiving the higher wages usually board themselves, and they are furnished a house to live in. Day labor commands from \$2 to \$2.50 and during harvest from \$3 to \$3.50. Corn shuckers receive 4 or 5 cents a bushel. Oats are threshed for 3 or 4 cents a bushel and wheat for 6 or 7 cents, depending on whether the grain is shocked or stacked. A few farmers hire help by the year in order to insure against an inadequate supply at critical periods.

Cattle and hogs are the chief sources of revenue. Some wheat is sold for cash, but the total area devoted to this crop is usually less than 3,000 acres annually, and the local consumption of wheat greatly exceeds the production. Practically none of the feed crops—corn, oats, and alfalfa—is shipped out of the county.

The raising and winter fattening of beef cattle is the most important branch of the livestock industry. The quality of the cattle in general is very high. Grade Hereford and Shorthorn are the principal breeds, but some farmers have purebred herds, and nearly all the range cattle are headed by a purebred bull. Some of the native cattle are fattened on the farms where raised, but most of them are sold to local feeders or are shipped to outside markets. Young calves are fed oats and alfalfa during the winter and are allowed to run on the range in the summer until they are 2 or 3 years old, when they are placed in feed yards for fattening. Many ranchers annually ship in 2- or 3-year-old steers for summer grazing, and a few farmers ship in cattle for winter fattening. The animals intended for fattening are fed corn and alfalfa for a period ranging from 60 to 90 days and are then shipped to the Omaha or Sioux City markets.

Hog raising is almost as important an industry as cattle raising. Most farmers raise from 20 to 30 hogs each year, and a few maintain herds of several hundred. The hogs are fed on corn and alfalfa, although young pigs usually receive some oats. Most of the hogs are raised in connection with cattle feeding. They are of good breeding, and there are many purebred herds. Duroc-Jersey, Spotted Poland China, and Hampshire are the leading breeds. In the past heavy losses have resulted from hog cholera, but in recent years attention to vaccination and sanitary measures have greatly reduced losses from this disease. Fattened hogs are shipped to Omaha or Sioux City.

The sale of dairy products is an important source of income on many farms. Only a few farms are devoted to dairying exclusively, but from 4 to 6 milk cows are kept on the average farm, and the surplus dairy products are sold in the nearby towns. Most farmers have cream separators. Part of the cream is shipped to Sioux City and Omaha.

Sheep raising does not receive much attention. A few small flocks are raised in the rougher sections. Some farmers buy a carload or two of sheep in the fall, fatten them on corn and alfalfa,

and sell them when prices are satisfactory. The favorable climatic conditions and the abundance of feed would seem to warrant an extension of the sheep-raising industry.

Horse raising is confined chiefly to the breeding of work mares. Most of the horses are of Percheron breeding. Purebred stallions are kept on a few farms. A few mules are raised, but the raising of horses and mules has not been profitable during the last few years.

Poultry constitutes an important source of farm income. A few chickens are raised on all farms, and on many the flocks are large. The local demand for poultry products is usually good, and the poultry industry is receiving increased attention. Leghorn, Plymouth Rock, and Rhode Island Red are the principal breeds. Ducks, geese, turkeys, and guinea fowls are raised by some farmers.

Cropping methods and practices are similar to those in other parts of northeastern Nebraska. Most of the farmed land is used for the production of feed crops.

Corn, the most important crop, is planted between the first and middle of May, the greater part being planted in checkrows and the rest listed in. Listed corn is considered by some farmers to be more drought resistant than that planted in checkrows, less labor is required in preparing the land, and the stalks are less likely to lodge, which facilitates husking. Soil washing is likely to be more serious in listed than in checkrowed fields, particularly on rolling ground, but on level ground listed corn may drown out more readily than that planted in checkrows. The corn crop is cultivated 3 or 4 times during the season, two-row cultivators being commonly used. The last cultivation is usually given early in July, after which the crop is "laid by" and receives no further attention until harvest, except to remove the more injurious weeds by hoeing.

The corn crop matures in September or early in October, depending on the season. The greater part is husked from the standing stalks, after which cattle and horses are pastured in the fields during the winter. On many farms part of the corn is used for winter roughage, and on farms equipped with silos, that from 15 to 20 acres is cut for silage. Many farmers annually fence off a few acres of unhusked corn for fattening hogs and cattle, thereby saving part of the expense of husking. The chief varieties grown are Reid Yellow Dent, and Iowa Silvermine. Most of the farmers select their own seed, either early in the fall when husking, or, during favorable seed-maturing years, from the crib when shelling. Some seed corn is shipped in, although this is not advisable, as such seed usually yields less than good-type well-adapted local seed. Corn usually follows small grain or alfalfa in the rotations, although on many farms, especially tenant farms, it is grown on the same land 5 or 6 years in succession.

Treatments of seed corn have not proved beneficial under Nebraska soil and climatic conditions and are not generally practiced. Corn smut is carried over from year to year in the fields and not on the seed, which makes seed treatment ineffective as a control measure for this disease.

Oats are the leading small-grain crop, chiefly because they fit well into the rotation, are a good nurse crop, and make very desirable feed for horses and young livestock. Most of the oats grown are of the early types. The Kherson variety, or strains of it, such as

Nebraska 21, which is a white high-yielding strain developed by the Nebraska Agricultural College, is the most extensively grown. The land to be used for oats is usually disked, and the grain is broadcast or planted with a press drill late in March or early in April. Early seeding is recommended as tests show that early-seeded oats outyield those seeded later. Oats usually mature in July and are cut with a binder or header, depending on the length of the stems. The crop is either shocked or stacked for threshing. Oats are seldom grown on the same land 2 years in succession, and they usually follow corn in the rotation. Most of the oats are fed on the farms where produced. The straw is almost as valuable as prairie hay for feeding, and on most farms it is stacked at threshing time.

Smut sometimes lowers oat yields, especially during prolonged periods of rainy or cloudy weather. The injury from this source, however, can be controlled by killing the smut spores on the seed before planting.³ This may be done by spraying the seed the day before planting with a solution consisting of equal parts of formaldehyde and water. One quart of solution is sufficient for treating about 40 bushels of oats.

Only a small acreage is devoted to barley, although the production of this crop is increasing. The development of high-yielding smooth-bearded varieties of barley, such as Comfort and Glabron, has removed the disagreeable task of handling the rough-bearded varieties which made barley unpopular in the past. Beardless varieties have not yielded nearly so well as the bearded varieties and are not recommended by State agronomists. The early seeding of barley during late March or early April at the rate of 2 bushels an acre has given the best results. Most of the barley grown is fed on the farms.

Barley ranks next to corn in terms of feed produced an acre. Feeding tests show that coarsely ground barley is 90 percent as good as corn in a fattening ration. As barley is a good substitute for corn, a reasonable acreage devoted to this crop is worth while to insure feed should unfavorable weather reduce the corn yield. Barley is almost equal to oats as a nurse crop and is used in connection with alfalfa seedings.

Wheat and rye are grown on a few farms. They are planted in the fall or spring, and the crops are harvested in the same manner as oats. Wheat is grown as a cash crop, and rye is used as hog feed or for hay and pasture.

Alfalfa is grown more extensively in Nebraska than in any other State, and it is the leading tame-hay crop in Knox County. The varieties grown are among the most hardy obtainable, including Common, Grimm, and Cossack, all of which are resistant to winter-killing. Alfalfa seed is usually sown either in April or August, and thorough seed-bed preparation is important in obtaining a stand. Early plowing followed by sufficient disking, harrowing, and possibly rolling, to control weed growth and compact the soil, is desirable in most places. The best results are obtained by planting pure certified seed after the first heavy rain, at the standard seeding rate of 12 or 15 pounds an acre. Except under extremely favorable conditions, planting with a press drill is more successful than broad-

³ STEWART, P. H., and GROSS, D. L. SMUT CONTROL IN CEREALS. Nebr. Agri. Col. Ext. Circ. 132, 13 pp., illus. 1929

casting the seed, but drilled seed should not be planted deeper than 1 inch. Seed that is broadcast is usually covered by harrowing.

On most farms a stand of alfalfa is allowed to remain from 6 to 8 years, or as long as it remains profitable. A field is rarely frozen out. The crop is usually cut three times during the summer. The common practice is to stack the hay in the field and haul it to the feed lots as needed. It is fed to cattle and hogs but seldom to horses because of its laxative properties. Many farmers run hogs in the alfalfa fields during the summer, but cattle are seldom allowed to graze for long periods on green alfalfa on account of the danger of bloating.

Wild hay is an important crop, as large areas in the rougher and more sandy uplands and local poorly drained areas in the bottom lands are unsuited to grain production. The average yield in recent years has been about 1.1 tons an acre. The highest yields are obtained on the poorly drained alluvial soils. The upland hay grows less rank, although it has a higher feeding value than that produced in the bottom lands. The hay is stacked in the field and hauled to the feed lots as needed.

The use of sweetclover has increased remarkably in the last few years. This plant is a biennial and dies at the end of the second season after producing seed. It is used chiefly for pasture and to some extent for hay and seed. When hay is desired, the crop is usually cut during the first year before the growth becomes coarse. The second year the crop may be allowed to mature and reseed itself, or it may be cut with a binder and threshed for seed. The most common time of seeding is in early spring, either late in March or early in April. The seed bed is prepared in a similar manner to that required for alfalfa. The seed is generally sown broadcast and covered by harrowing, but seed is planted with a press drill, which usually insures a more uniform stand. From 15 to 20 pounds of scarified seed are ordinarily used when seeding broadcast, and this may be reduced to 12 pounds when a press drill is used.

Sweetclover has an unusually wide adaptation. It thrives on either comparatively wet or dry soils and on soils of either heavy or light texture. It is very valuable for soil improvement, and many farmers state that it is more satisfactory for this purpose than alfalfa. It is adapted to shorter rotations than alfalfa and will probably improve the productivity of the soil as fast as that crop. The roots are large and vigorous, and they decay rapidly at the end of the second year's growth. The crop is a good soil binder and is especially valuable on the steeper valley slopes where erosion is severe.

No commercial fertilizer is used. The barnyard manure is piled on the ground out of doors, where much of its fertilizing value is lost by leaching; is hauled in the fall or spring; and is usually spread on the land to be used for corn or small grain. It is often applied to the more eroded or more sandy parts of the field, in order to increase the organic content and retard erosion. On rented farms little care is used in applying manure where it is most needed, most of it being spread on the land adjacent to the barnyard.

SOILS AND CROPS

Knox is one of the leading meat-producing counties of Nebraska. It ranks twelfth in size among the Nebraska counties but, according to the Nebraska agricultural statistics for 1929, ranks sixth in the

production of hogs and ninth in the production of cattle. Its high rank as a meat-producing county is owing largely to the favorable climatic and soil conditions for the production of feed for livestock.

The spring weather is cool, favoring the rapid growth of oats, and the summers are characterized by long warm days and nights which are especially favorable to the growth of corn and alfalfa. About 61 percent of the total land area is under cultivation, and nearly all the cultivated soils are adapted to the production of one or more of the leading feed crops. Most of the uncultivated land is suited only for natural pasture and hay land. The county is within a short hauling distance of Sioux City, Iowa, an important meat-buying and meat-distributing center, and the low freight cost to this point also favors the livestock industry.

A diversified farming system, including the growing of feed crops and the raising and fattening of cattle and hogs, is almost universally practiced. Practically all the feed is consumed on the farms where produced or is sold to local feeders. Corn was grown on about 57 percent, oats on about 26 percent, and tame hay on about 9 percent of the cultivated land in 1929. Of the tame-hay acreage, about 76 percent was used for alfalfa and most of the remainder for sweetclover and Sudan grass. Among the minor cultivated crops, barley and rye, both of which are used for feed, are the most important. Wheat is the only cash crop, but it seldom occupies more than 3,000 acres, as it does not seem to be well adapted to the prevailing climatic conditions. The winter varieties of wheat frequently freeze out, and spring wheat is often injured by rust and smut. In addition, wheat, not being a feed crop does not fit well with the general-farming system. It cannot be used as a nurse crop for alfalfa and sweetclover as advantageously as oats, and wheat straw has a lower feeding value than oat straw.

The soils, although well adapted, as a whole, to the crops commonly grown, have a rather wide range in characteristics, producing capacity, and crop adaptability, making it necessary for the farmer, at least in certain sections, to adjust his farming system to the local soil conditions if he is to receive the largest returns.

Knox County is in the prairie region of the United States, and all the soils not severely eroded or not developed on the most recently deposited stream sediments have dark-colored topsoils, owing to an abundance of black organic matter derived from decayed grass roots. However, a large part of the county has been rather severely eroded by wind and water, and over rather large areas the decayed vegetation has been removed almost as fast as it has formed, leaving the soils prevalingly light in color. Geologic formations, ranging from heavy shales to coarse sands and gravels, are exposed both in spots and over large areas, and the soils in different localities naturally show marked contrasts in texture. Differences in the degree of erosion and in the character of the geologic formations have also produced differences in the structure, compaction, and chemical composition of the soils in different localities.

Throughout the upland part the soils are rather closely related to the geologic formation, in that those developed on a given formation, although differing among themselves in some respects, have a greater number of common characteristics than occur in those developed on different formations.

In the southeastern part and comprising about 60 percent of the county is the loess hill section where the loess formation, consisting of light-gray limy floury silt, covers the greater part of the land surface. The more extensive soils in this section have developed from the loessial material, are silty and friable throughout, have high moisture-retaining powers, are easily maintained in good tilth, and are well supplied with lime. About 75 percent of the area occupied by them is under cultivation. Those soils occupying the less eroded parts of the area have accumulated an abundance of organic matter and have dark-colored topsoils. They are, as a whole, more productive and adapted to a greater variety of crops than the more extensive soils in any other part of the county. Corn is grown on about 55 percent of the cultivated land, oats on about 28 percent, and alfalfa on about 10 percent. The rest is used chiefly for sweet-clover, although small fields of wheat, barley, Sudan grass, and mixed timothy and clover occur on many farms. The high organic-matter content and friable character of the dark-colored loess-derived soils make them especially adapted to corn which requires a mellow seed bed, a rather even soil temperature, and an abundance of moisture and nitrogen. The organic matter is the chief source of nitrogen, increases the water-holding capacity of the soils, assists them in maintaining a uniform soil temperature, and promotes favorable tilth. The friable character of the soils is associated with a rather granular or crumblike structure allowing easy penetration of the corn roots and free passage of air and water, which change the raw vegetal and mineral constituents of the soils into plant food suitable for the growing corn crop. Lime, which is also abundant, is not a special requirement of corn, but it is beneficial because it prevents the soil from becoming sour, or acid, and assists in preserving its organic-matter supply and crumblike structure. Lime is a necessary soil constituent for the successful production of alfalfa. Those soils occupying the more severely eroded parts of the loess hill section are low in organic matter and prevailingly light in color. They are topographically unsuited to cultivation and are used chiefly for hay and pasture land.

In the west-central part, on the Holt table, the loess formation has been removed from most of the land, exposing the underlying sands and gravels. The soils over the greater part of this section, which occupies about 12 percent of the county, are extremely porous, somewhat droughty, and low in lime. The more extensive ones are fairly stable, owing to admixtures of silt, clay, and organic matter, and have dark-colored topsoils. However, the soils over considerable areas are decidedly unstable and have been subjected to such constant wind erosion that their topsoils are prevailingly low in organic matter and light in color. Only about 40 percent of these soils, including the darker colored soils, is under cultivation. Corn is grown on about 80 percent of the cultivated land, oats on about 5 percent, sweetclover on about 10 percent, and rye or Sudan grass on most of the rest. The low oat acreage on the Holt table is largely owing to the difficulty experienced in obtaining a firm, compact, seed bed in the sandy soils and to the danger of the sand blowing, thereby exposing the young roots to drought before they are firmly established. The alfalfa acreage on the sandy soils of the section is

practically negligible also, this crop being confined largely to the subirrigated bottom lands. Both corn and sweetclover seem to be fairly well adapted to the sandy conditions and give higher returns in feed than any other crop, probably because they have wide-spread root systems and are able to obtain moisture from considerable areas and depths. The unusually large sweetclover acreage is also owing, in part at least, to the ability of this crop to continually resced itself, provided it is not severely grazed. However, yields of all crops average 15 or more percent lower than those obtained on the finer textured soils in the loess hill section. The lighter colored sandy soils of the Holt table are used for native pasture and hay land. Some of the largest cattle ranches are located in this section, and large quantities of prairie hay are produced annually.

In the north-central and northwestern parts, throughout the Pierre plains and hills section, both the loess and sand formations have been removed from much of the land, exposing the underlying Pierre shale. The soils developed on this material consist largely of dense blue clay, in which there is an intricate network of seams and cracks filled with finely divided lime. In the less eroded situations the topsoils are dark colored, in many places almost black, but in severely eroded areas, which are very extensive, they assume the color of the parent formation. Considering their heavy texture, the clay soils are remarkably porous, owing largely to the manner in which their lime is distributed, but they are not droughty.

Only about 30 percent of the Pierre plains and hills section is under cultivation. This low percentage is owing partly to the general roughness of the land surface, partly to the heavy clayey character of the more extensive soils, and partly to the difficulty experienced, over much of the section, in obtaining good well water from the shale formation which is on or near the surface. In addition, most of this land was formerly included in Indian reservations, and much of it is still owned by Indians who, as a rule, cultivate only enough land to supply their immediate need for food.

Corn, as in the other parts of the county, is the leading crop, occupying about 85 percent of the cultivated land. Oats occupy about 5 percent, alfalfa about 3 percent, and the rest is used largely for sweetclover. Crop yields over this section as a whole average a trifle higher than those on the dark-colored sandy soils of the Holt table, but they are in general lower than those obtained on the silty soils of the loess hill section.

Although the silty, sandy, and clayey soils occur chiefly in the loess hill, Holt table, and Pierre plains and hills sections, respectively, none of them is confined to these sections. Any one may occur wherever the geologic formation necessary for its development is exposed to weathering. Numerous patches of silty soils developed on loess occur both in the Holt table and Pierre plains and hills sections. The greater part of the cultivated land in the latter section consists of loess-derived soils which still cap the heavy blue shale over large areas. Clay soils occur in a few places in the loess hill section, and in many places in the Holt table section, and patches of sandy soils are scattered throughout all parts of the county. In addition, each of these sections includes soils resulting from the weathering of mixed geologic materials and, especially in the Pierre plains and hills

section, from gravel deposits and sandstone or chalk rock formations. In fact, about 30 percent of the Pierre plains and hills section is covered with exposed glacial debris consisting of a heterogeneous mixture of sand, clay, and gravel, together with numerous granitic and quartzite boulders of different sizes. Each of the sections includes bottom-land soils which have weathered from recently deposited stream sediments derived from a variety of sources. The bottom-land soils, especially the darker colored and better drained ones, are the most productive corn and alfalfa soils, regardless of the character of the material from which they have weathered.

The soils, although numerous and varied, may be separated, according to the crops which are most extensively grown on them and for which they seem to be best suited, into four broad groups as follows: General-farming soils, corn and sweetclover soils, corn and alfalfa soils, and native pasture and hay soils. This system of grouping is not intended to indicate that the crops mentioned in connection with a particular group are the only crops that can be successfully grown on the soils of that group. All the crops can be grown on nearly all the soils, except those which are topographically unsuited to cultivation. However, larger returns are obtained, year in and year out, from the soils of a particular group when those soils are used for the crops or combination of crops to which they are best adapted. The grouping is based, not only on soil and crop adaptations, but also on those soil characteristics which are responsible for these adaptations and on surface features and drainage conditions. None of the soil groups is confined to a particular part of the county, although some soils in each group are of very local occurrence.

In the following pages of this report the soils of Knox County are described in detail, and their crop adaptations are discussed; the accompanying soil map shows their distribution; and table 4 gives their acreage and proportionate extent.

TABLE 4—*Acreage and proportionate extent of soils mapped in Knox County, Neb.*

Type of soil	Acres	Per- cent	Type of soil	Acres	Per- cent
Moody silt loam.....	77,312	10 8	Wabash very fine sandy loam.....	3,136	0 4
Moody silt loam, deep phase.....	26,752	3 7	Crofton silt loam.....	37,312	5 2
Moody very fine sandy loam.....	59,840	8 4	Crofton very fine sandy loam.....	19,584	2 7
Moody very fine sandy loam, deep phase.....	41,024	5 7	Knox silt loam.....	704	1
Moody fine sandy loam.....	24,064	3 4	Boyd clay loam.....	64,576	9 0
Moody fine sandy loam, deep phase.....	12,288	1 8	Boyd clay.....	7,808	1 1
Moody sandy loam.....	7,168	1 0	Boyd sandy loam.....	9,856	1 4
Marshall fine sandy loam.....	19,136	2 7	Shelby loam.....	12,736	1 8
Marshall sandy loam.....	2,240	3	Shelby gravelly sandy loam.....	7,488	1 0
Marshall loamy sand.....	1,664	3	Shelby sandy loam.....	960	1
Hall very fine sandy loam.....	8,704	1 2	Valentine sand.....	8,128	1 1
Hall silt loam.....	4,864	7	Valentine loamy sand.....	2,368	4
Boyd clay loam, terrace phase.....	3,968	6	Holt sandy loam.....	7,616	1 1
Judson silt loam.....	5,120	7	Holt sandy loam, hilly phase.....	3,904	6
Dickinson loamy sand.....	38,016	5 2	Holt fine sandy loam.....	7,296	1 0
Dickinson fine sandy loam.....	88,448	12 4	Holt very fine sandy loam.....	896	1
O'Neill sandy loam.....	10,112	1 4	Dickinson gravelly sandy loam.....	17,216	2 4
O'Neill loamy sand.....	2,752	4	Sogn loam.....	1,408	2
Lamoure silty clay loam.....	6,720	9	Butler silt loam.....	1,856	3
Lamoure very fine sandy loam.....	20,352	2 8	Sarpy very fine sandy loam.....	3,904	6
Lamoure fine sandy loam.....	832	1	Sarpy sand.....	4,096	6
Cass fine sandy loam.....	20,736	2 9	River wash.....	3,328	5
Cass loamy sand.....	4,160	6			
Wabash silt loam.....	3,712	5			
			Total.....	716,160	-----

GENERAL-FARMING SOILS

The general-farming soils occupy 41.3 percent of the land. They include the Moody, Marshall, Judson, and Hall soils and the terrace phase of Boyd clay loam. Some of these series include several soil types or phases of types, making a total of 14 soils. The Marshall and Moody soils are in the uplands, and the other soils are in stream valleys, either on terraces or terracelike colluvial slopes.

All the soils belonging to this group have accumulated an abundance of organic matter and have dark, in places almost black, topsoils ranging from 8 to more than 18 inches in thickness. The soils are highly retentive of moisture, are well drained, and, except in local spots, are topographically suited to cultivation. They contain lime in their subsoils, but the depth of its occurrence and its abundance differ somewhat in the different soils. All the soils, except the terrace phase of Boyd clay loam, which contains an abundance of clay and is somewhat difficult to handle, are friable throughout.

The soils of this group are well adapted to all crops commonly grown in the county. They are not quite so productive of corn and alfalfa as the best bottom-land soils, but they are adapted to a wider variety of crops than those soils and are more productive of all crops than any upland or terrace soil not belonging to the group. About 90 percent of the area occupied by them is under cultivation. Corn is grown on about 50 percent, oats on about 35 percent, and alfalfa on about 10 percent of the cultivated land. The rest is used chiefly for sweetclover, although barley, wheat, and rye are grown in small fields on many farms. The uncultivated land is included largely in feed lots, building sites, and small pastures for the milk cows and work animals.

Crop yields are rather uniform. Some of the soils produce a little higher yields than others, but this is owing more to differences in the surface relief, particularly the slope of the land and its elevation with respect to surrounding areas, than to differences in the soils themselves. As a rule, the upland soils of the group have more sloping surfaces than the terrace soils, and less of the rainfall sinks into the ground than on the benches. In addition, the upland soils are not so favorably situated to receive moisture from higher levels as the terrace soils and are naturally a little less productive.

Moody silt loam.—Moody silt loam is the most extensive general-farming soil. It occurs in nearly all parts of the loess-covered upland, except on the more nearly level remnants of the old loess plain; in severely eroded localities; and around the margins of areas occupied by sandy soils. The largest developments are in the eastern part of the county. The surface relief ranges from gently to steeply rolling, and drainage is everywhere thorough.

The 10- to 12-inch topsoil is very dark grayish-brown friable silt loam which in most places is well supplied with organic matter. In some areas, especially on the steeper slopes, erosion has removed the dark-colored material, giving the soil a dark-and-light spotted appearance. However, such areas are small, and, although nearly all the land is subject to some erosion, a negligible part of it has lost its dark-colored topsoil. The subsoil, which continues to an average depth of 4 feet, is grayish-brown, light grayish-brown, or almost white mellow silt loam. It is very lmy and in the upper foot or so

contains numerous small hard, almost round lime concretions ranging from one-fourth to three-eighths of an inch in diameter.

The soil as mapped includes some patches of Moody very fine sandy loam, but the bodies are few and small, and the soil as a whole is very uniform throughout its occurrence.

About 90 percent of Moody silt loam is under cultivation or is occupied by building sites and feed yards, and the rest, including the more severely eroded areas, is used chiefly for pasture land. About 55 percent of the cultivated land is devoted to corn, about 28 percent to oats, about 8 percent to alfalfa, and the remainder largely to sweetclover, barley, rye, wheat, potatoes, and timothy and clover mixed, all of which are grown in small fields on most farms.

Crop yields on this soil are about the average for the county as a whole. They are a trifle lower than those obtained on the deep phases of the Moody soils and on the Waukeshia and Hall soils, because those soils occupy more nearly level areas where more of the precipitation sinks into the ground and where the soils, being less subject to erosion, have developed deeper topsoils than has Moody silt loam. Yields, especially of corn and alfalfa, are also lower than on most of the bottom-land soils where ground water is within reach of corn and alfalfa roots. However, Moody silt loam gives higher yields of all crops than any of the sandy or light-colored upland or terrace soils and higher yields of small grains than any bottom-land soil in the county. The average yield of corn over a period of years is about 32 bushels an acre and of oats about 31 bushels. Alfalfa yields about 2½ tons of hay an acre during the first 4- or 5-year cropping period, after which yields decline as on all upland soils in Nebraska, because the alfalfa roots exhaust the deep-seated moisture supply, and in this region the plant cannot make optimum growth on the moisture supplied by precipitation alone.

Moody silt loam is easily handled and, if care is taken to prevent erosion on the steeper hillsides, maintains its high producing power year after year. It can be cultivated under a fairly wide range of moisture conditions. Clods are formed if it is plowed when wet, but the lumps are easily reduced by subsequent tillage.

Moody silt loam, deep phase.—The deep phase of Moody silt loam is less extensive than typical Moody silt loam and differs from that soil chiefly in the greater thickness and higher organic-matter content of its topsoil. The deeper soil occurs in the more nearly level parts of the loess-covered uplands and on long gradual loess-covered slopes. The largest developments are on the tablelands west of Wausa, north of Crofton, and northwest of Winnetoon.

The soil is well drained but has been subjected to a minimum of erosion, and organic matter has naturally accumulated in larger amounts than in typical Moody silt loam. The topsoil of the deep phase is 18 or 20 inches thick, in contrast to the 10- or 12-inch thickness of the corresponding layer in the typical soil. It is very dark grayish brown, contains a little more clay, and is slightly more compact than any layer in Moody silt loam, but the compaction is so slight as to be scarcely noticeable, and the entire soil is easily penetrated by roots, air, and moisture. The lower part of the subsoil, beginning at an average depth of 32 inches, is light grayish-brown

floury silt. Lime, in sufficient concentration to be visible to the eye or to effervesce when dilute hydrochloric acid is applied, lies at much greater depth than in Moody silt loam, being about 3 feet below the surface on the gradual slopes and from 4 to 5 feet below on the more nearly level areas. However, no part of the soil appears to be deficient in lime, so far as crop needs are concerned.

The deep phase of Moody silt loam is one of the strongest and most productive soils in the uplands, and practically all of it is under cultivation. The same crops, in about the same acreage ratios, are grown as on Moody silt loam, but yields average about 5 percent higher than on that soil. The deeper soil is also a very little more easily farmed, on account of its more even surface, and it has a slightly higher sale value than Moody silt loam.

Moody very fine sandy loam.—Moody very fine sandy loam differs from Moody silt loam only in that it contains a little more very fine sand in its topsoil. The sand content, although sufficient to make the soil a trifle easier to handle than Moody silt loam, does not noticeably reduce the moisture-holding capacity of the soil or its susceptibility to erosion. The surface features are similar to those of Moody silt loam, and the soil has about the same producing power as that soil. It occurs in bodies of various sizes in nearly all parts of the county, but chiefly in the western, eastern, and southeastern parts, where the sandy soils are most extensive. Admixtures of wind-blown sand are largely responsible for the slightly sandy texture of the topsoil. Practically all the land is under cultivation.

Moody very fine sandy loam, deep phase.—Moody very fine sandy loam, deep phase, resembles typical Moody very fine sandy loam in all characteristics, except that its topsoil averages 6 or 8 inches thicker. Soil of this phase has a more even surface relief than Moody very fine sandy loam, as it occurs chiefly on nearly level divides and long gradual slopes. Large areas are around and west of Winnetoon east of Verdigris Creek, south of Middle Branch Verdigris Creek, northwest of Wausa, and around Crofton.

Practically all the land is under cultivation. It is regarded as one of the strongest and most productive upland soils and is as well adapted to all crops commonly grown as the deep phase of Moody silt loam. It is considered as productive as that soil. In fact the farmers recognize no differences between the deep phases of Moody silt loam and Moody very fine sandy loam in crop yields, crop adaptabilities, or tillage requirements, and the deep phases of both soils are regarded as superior to the typical soils, especially in their producing powers.

Moody fine sandy loam.—Moody fine sandy loam differs from Moody very fine sandy loam and Moody silt loam in that both the topsoil and subsoil are sandier, looser, and more friable. It does not produce such high average yields as those soils, but in seasons of normal rainfall the difference in crop yields is very slight. This soil is of minor agricultural importance. Most of the bodies are in the western and southeastern parts of the county.

Moody fine sandy loam, deep phase.—The deep phase of Moody fine sandy loam, like the corresponding phases of the other Moody soils, has a smoother surface relief than the typical soil, the topsoil

is thicker, and the subsoil is slightly heavier. Soil of this phase is a little more productive than typical Moody fine sandy loam, but, on account of its small extent and local occurrence, it is of minor agricultural importance. Most of it occurs in the southern part of the county.

Moody sandy loam.—Moody sandy loam is the most sandy Moody soil. In most places only the topsoil contains a large percentage of sand which is intimately mixed with an abundance of silt and organic matter, so that the soil is not unstable or droughty. The subsoil in most areas is similar to that of Moody silt loam and Moody very fine sandy loam, being fine textured and retentive of moisture, but it is more variable in its characteristics than the subsoil in any other Moody soil, owing largely to differences in the amount and distribution of the sand. In some places the sand has become so mixed with the silt in the subsoil as to make that layer rather porous, and in several small bodies an almost pure gray sand occurs below a depth ranging from 3 to 4 feet. However, these variations are of local occurrence, and the soil as a whole is equal to Moody fine sandy loam for general farming. It occupies only a few bodies. One of the largest, comprising about 400 acres, is south of Little Bazile Creek in Cleveland Township.

Marshall fine sandy loam.—Marshall fine sandy loam occupies several bodies, most of which are south of Niobrara River in the western part of the county. One of the largest, comprising about 4 square miles, is 4 miles east of Knoxville in Washington Township; a smaller body is about 2½ miles southeast of that town; and an area comprising about 900 acres is near Venus in Walnut Grove Township. The remaining bodies are small and scattered.

The surface relief is nearly level or gently undulating, except locally in the vicinity of drainageways where it may be rather steeply sloping. All the land is well drained, and practically none of it is being subjected to severe erosion.

The topsoil is very dark grayish brown and ranges from 12 to 16 inches in thickness. It contains considerable fine sand, but this is intimately mixed with an abundance of silt and organic matter which stabilizes the material. The subsoil is light yellowish-brown floury silt similar to that underlying the Moody soils, except that it does not contain sufficient lime to effervesce when dilute hydrochloric acid is applied. The light-colored silt in most places is underlain by loose gray sand at a depth ranging from 28 to 36 inches beneath the surface of the ground. This soil as a whole is not quite so retentive of moisture as the Moody soils, crop yields on it averaging from 5 to 10 percent lower than on Moody silt loam or Moody very fine sandy loam. Practically all the land is under cultivation.

A phase of this soil occurs wherever the loessial mantle is comparatively thin and overlies loose gray sand. Most bodies of this included soil are small and widely scattered, and they are not separated on the soil map from typical Marshall fine sandy loam. Such areas occur in nearly all parts of the county but are most numerous in the southwestern part. One of the largest, comprising about 400 acres, is 4 miles southeast of Middlebranch. All the bodies have nearly level or gently undulating surface relief. They are well drained, but none of them is at present subject to much erosion.

The topsoil, which ranges in thickness from 12 to 18 inches, has accumulated an abundance of organic matter and is very dark grayish brown. Its texture, although usually fairly uniform in a particular body, ranges as a whole from silt loam to fine sandy loam, the very fine sandy loam predominating. The upper part of the subsoil, which extends to an average depth of 24 inches, is light-brown silt loam, and the lower part is light yellowish-brown or almost white floury silt containing an abundance of lime, much of which occurs in small rounded concretions from one-eighth to one-fourth inch in diameter.

The accumulation of lime is characteristic of the Moody soils, but it is not practical to make the separation for these small areas. This layer extends to an average depth of 42 inches where it gives way abruptly to loose gray sand with a low lime content. The entire soil is friable. The porous sand lies at too great a depth to produce a droughty condition, and the soil is very retentive of moisture. Practically all this included soil is under cultivation.

Marshall sandy loam.—Marshall sandy loam resembles Marshall fine sandy loam in most characteristics, but the sand in its topsoil is of slightly coarser grade, and the topsoil layer is not quite so well supplied with organic matter. The subsoil is a little sandier than the corresponding layer in Marshall fine sandy loam, and the soil as a whole is not quite so retentive of moisture as that soil. However, these differences are very slight, and, although Marshall sandy loam is a little less productive in dry seasons than Marshall fine sandy loam, it returns good yields of all crops common to the county. Practically all the land is under cultivation. This soil is of local occurrence, most of it occurring in the southwestern part of the county. The largest body, comprising about 700 acres, is 1 mile west of Venus. The rest of the areas are few and small.

Marshall loamy sand.—Marshall loamy sand occurs only where wind-blown sand covers loessial material to a depth ranging from 6 to 20 inches. It occupies only a few small bodies, most of which are in the vicinity of Creighton, although the largest, comprising about 400 acres, is south of Venus.

The topsoil consists largely of loose and porous fine sand or medium sand. It contains sufficient organic matter to give the 8- or 10-inch surface layer a dark color but not enough to stabilize the sand, especially when the land is brought under cultivation. The subsoil, beginning at a depth depending on the thickness of the sand deposit, but in few places exceeding 20 inches, is light-gray floury silt or a silt and sand mixture, and it is highly retentive of moisture.

This soil is not droughty, and, although it is not well adapted to small grains and alfalfa on account of its unstable topsoil, it returns almost as high yields of corn as any of the Marshall or the more sandy Moody soils. Practically all the land is under cultivation, but, owing to its small extent, it is of minor agricultural importance.

Hall very fine sandy loam.—Hall very fine sandy loam is the most extensive terrace soil in the general-farming group, but it occupies only 13.6 square miles. It occurs in small bodies and narrow strips in some of the stream valleys. One of the largest developments, comprising about 250 acres, is west of Pishelville on the south side

of Niobrara River. Most of the other bodies and strips, although numerous, are smaller.

This soil has developed from gray loess similar to that underlying the Moody soils of the uplands, but which was carried to its present position by streams and deposited along their courses when they were flowing at higher levels. Subsequent deepening of the stream channels left the deposits from 8 to 50 feet above the present bottom lands, and prolonged weathering, together with the accumulation of organic matter, produced the present soil.

The surface relief is nearly level or very gently undulating, but the slope down the valleys and toward the streams is sufficient to afford ample surface drainage, and all the land has good under-drainage.

The topsoil ranges from 16 to 20 inches in thickness. It is friable throughout, and owing to an abundance of organic matter, is very dark grayish brown. Over most of the area classed with this soil, the topsoil has a very fine sandy loam texture, but in a few of the bodies the surface layer is fine sandy loam or sandy loam. The upper part of the subsoil is brown or grayish-brown silt loam. It is a little more compact than the topsoil but is easily penetrated by plant roots and allows free air and water movement. The lower part of the subsoil, beginning at a depth of about 36 inches, is light-gray floury silt which continues to a depth exceeding 6 feet. It is very lmy and in many places in the upper 18 or 20 inches contains scattered, hard concretions of lime from one-eighth to one-fourth inch in diameter. The soil is very retentive of moisture. Aside from the slight textural variations in its topsoil, it is remarkably uniform throughout the area of its occurrence.

Hall very fine sandy loam is well adapted to all crops commonly grown here. It occupies a much smaller area than the principal upland soils but is more favorably situated to receive moisture from higher levels, which, together with that received through precipitation, gives it a somewhat higher producing power than the best upland soil. Practically all the land is under cultivation, about 60 percent being devoted to corn, about 25 percent to oats, about 12 percent to alfalfa, and the rest to sweetclover, barley, and other crops grown for sustenance and feed.

The average yield of corn is about 40 bushels an acre, of oats about 35 bushels, and of alfalfa about 3 tons of hay. Yields of corn and alfalfa are a trifle lower than those obtained on some of the bottom-land soils, but the yields of other crops are not exceeded on any other soil in the county.

Hall silt loam.—Hall silt loam, like Hall very fine sandy loam, occupies high and low terraces along some of the larger streams. It is a little less extensive than Hall very fine sandy loam and, although as productive as that soil, is of minor agricultural importance. One of the largest developments, comprising about 800 acres, is at the mouth of Wiegand Creek in the northeastern part of the county.

This soil is identical with Hall very fine sandy loam in all characteristics except the texture of its topsoil, this layer containing less very fine sand and more silt than the corresponding layer of the fine sandy loam. Practically all the land is under cultivation and is used for the same crops as are grown on Hall very fine sandy loam.

Those areas occupying the higher terraces lie from 20 to 30 feet above the rest of the soil.

Boyd clay loam, terrace phase.—Boyd clay loam, terrace phase, is one of the least extensive terrace soils. It occurs chiefly in the northern part, on some of the terraces in the valleys of Niobrara River and Bazile, Verdigris, and Wiegand Creeks. The largest development, comprising about 800 acres, is on the west side of Niobrara River in Raymond Township.

The soil throughout is composed largely of clay, but it contains an abundance of lime, in the form of seams, streaks, and splotches, which reduces the compaction of the dense clay and renders the soil remarkably friable considering its heavy texture. The 8- to 14-inch topsoil is very dark grayish-brown heavy silty clay loam or clay, well supplied with organic matter. The rest of the soil is dark bluish-gray heavy clay.

Practically all the land is under cultivation, and it is very productive but rather difficult to handle. If plowed when wet hard lumps develop, which require freezing and thawing or wetting and drying before granulation is restored. It is almost impossible to plow the land when it is extremely dry, but under favorable moisture conditions good tilth is easily maintained.

This soil is used for all crops commonly grown, and yields during years of normal precipitation are about the same as on Hall silt loam. In dry years they are somewhat lower because the dense clay shrinks and cracks, injuring the crop roots. On account of its small extent the soil is of only local agricultural importance.

Judson silt loam.—Judson silt loam consists of very dark grayish-brown friable silt loam or very fine sandy loam, which extends with little change to a depth exceeding 4 feet. It occupies broken strips in a few of the narrower stream valleys. Few of the strips exceed 20 rods in width, and most of them are much narrower. Some of the longest are along branches of Howe Creek in Hill Township.

This soil has developed from dark-colored topsoil material which has washed or rolled down from the higher lying soils and accumulated near the bases of the slopes or in the narrow valleys. It is naturally well supplied with organic matter and is very productive, but most of it occurs in strips too narrow for profitable farming and is therefore included in pasture land. The soil is low, but not deficient, in lime.

CORN AND SWEETCLOVER SOILS

The corn and sweetclover soils occupy only 19.4 percent of the area of the county. They include two Dickinson and two O'Neill soils, all of which are composed largely of sand. The Dickinson soils occupy upland positions and occur chiefly in the Holt table section of the county, but they are also extensively developed in the Pierre plains and hills section and occur locally in the loess hill section. The O'Neill soils occur on terraces, chiefly in the Niobrara River and Verdigris Creek Valleys.

All these soils have accumulated rather large quantities of organic matter and have very dark colored topsoils. In addition, the topsoils contain small quantities of silt which, together with the organic mat-

ter, gives them considerable stability. The subsoils are composed of porous gray sand, and the soil throughout is rather low in lime.

The surface relief ranges from nearly level to gently rolling. Surface drainage is not well established because most of the precipitation is absorbed by the sand. The silt and organic matter in the topsoil layers enables these layers to retain considerable moisture, but the high sand content of the entire soil makes the soils more droughty and, during dry windy weather, more subject to drifting than any soil in the general-farming group. During seasons of high precipitation, these soils are almost as productive of all crops commonly grown as any of the upland and terrace soils, but in seasons of normal or subnormal precipitation all crops yield less than on the finer textured cultivated soils. When such seasons are accompanied by considerable windy weather, as they usually are, small-grain crops return exceptionally low yields because the drifting sand exposes their shallow root systems to drought. Oats are grown on only about 5 percent and wheat on probably less than 1 percent of the area occupied by these soils. Alfalfa does fairly well for a few seasons, provided a good stand is obtained, but this crop requires an abundance of deep-seated moisture, which is not present in the porous sandy subsoils, and alfalfa yields rapidly decline after 2 or 3 years. In addition, the loose sandy topsoil does not afford the firm seed bed so necessary for obtaining good stands of alfalfa, therefore this crop is seldom grown.

Corn, which is planted rather deeply, is not greatly injured by drifting sand. This crop has a much deeper and wider spreading root system and is able to obtain moisture from greater depths and from larger areas than are small grains. It produces fair yields even in the drier years and, because it is the most important feed crop, is grown extensively. During most years it occupies about 80 percent of the farmed land.

Continued corn production rapidly depletes the soil nitrogen, and in order to remedy this situation more sweetclover is grown on the Dickinson and O'Neill soils than on any other soil. This crop, although not valued so highly for feed as alfalfa, is much better adapted to the sandy soils than that crop. Less difficulty is experienced in obtaining a good stand of sweetclover than of alfalfa, and the crop requires less moisture, can be sown earlier in the spring, and is much hardier than alfalfa. In addition, sweetclover is as well equipped to obtain nitrogen from the air and store it in the soil as is alfalfa, and without it the farmers on the Dickinson and O'Neill soils would experience much difficulty in maintaining favorable yields of corn. Sweetclover is grown annually on about 10 percent of the area occupied by these soils.

Dickinson loamy sand.—Dickinson loamy sand is the second most extensive soil in this group. It occurs throughout the uplands wherever exposures of almost pure sand have accumulated sufficient organic matter to give their surface layers a pronounced dark color. The largest developments are on the Holt table in the western part of the county, but numerous bodies occur in the central and southern parts.

The surface relief of this soil is nearly level or very gently rolling. Drainage channels are not well developed because practically all the precipitation is rapidly absorbed by the porous sand.

The topsoil is dark grayish-brown loamy sand ranging from 7 to 12 inches in thickness. The rest of the soil is incoherent sand which is pale brown immediately beneath the topsoil and gray below a depth of 2 feet.

This soil has lower moisture-retaining powers than any soil in the general-farming group and, were it not for the moderate organic-matter content of its topsoil, would be very droughty. The organic matter enables the soil to retain more moisture than any of the lighter colored sandy soils. It also gives the sand greater stability than occurs in those soils but does not entirely prevent soil drifting, especially in cultivated fields.

About 80 percent of the land is used for corn, about 10 percent for sweetclover, and about 5 percent for oats. Most of the remainder is uncultivated, although a small part is used for potatoes, sorgo, rye, alfalfa, and other crops grown for sustenance and feed.

Corn is the leading crop. The large sweetclover acreage is owing to the necessity of using a legume in the rotation system, in order to replace the nitrogen removed from the soil by corn, and sweetclover, being much better adapted to the sandy conditions than alfalfa, is used more extensively. The moisture supply in the soil, although too low for optimum yields of corn and sweetclover, except in seasons of heavy precipitation, is sufficient to produce more feed when the soil is used for these than for other crops. Small grains occupy a comparatively small acreage on this soil, on account of the loose porous character of the seed bed and the danger of the sand drifting and exposing the shallow roots to drought.

The average yield of corn over a period of years is about 20 bushels an acre, of oats about 15 bushels, and of sweetclover about 2½ tons of hay. However, most of the sweetclover is used for pasture. The uncultivated parts of this soil are in native pasture and hay land. They produce a good growth of bluestem, needlegrass, and sandgrass, which will support about 20 head of cattle on each 160 acres or when cut for hay will yield about one-half ton an acre.

Dickinson fine sandy loam.—Dickinson fine sandy loam is more productive than Dickinson loamy sand. It differs from that soil principally in the finer texture and higher organic-matter content of its topsoil. This layer is as dark as any of the topsoil layers in the Moody soils, but the subsoil is composed largely of gray or grayish-brown sand. The soil is not so retentive of moisture as the Moody soils.

Practically all the land is under cultivation. The same crops are grown as on Dickinson loamy sand, but yields are from 15 to 25 percent higher on the fine sandy loam. This is the most extensive soil, and it occurs in all parts of the county except the southeastern corner. It is most extensively developed in the western and southwestern parts, south and east of Niobrara, and in Devils Nest. In the western part, south of Niobrara River, areas too small to separate, therefore mapped with this soil, are sandy loam rather than fine sandy loam in texture.

O'Neill sandy loam.—O'Neill sandy loam is the most extensive terrace soil in this group. It is developed on both high and low terraces and occurs chiefly in the valleys of Niobrara River, Verdigris Creek, and Bazile Creek. The surface relief is nearly level, except in a few places where wind action has produced slight depressions and low rounded ridges, but even in these localities differences in elevation in few places exceed 2 feet. The high terrace developments lie from 50 to 70 feet and the lower ones from 8 to 15 feet above the stream channels. Most of the higher terraces are south of Niobrara River.

O'Neill sandy loam, like the Dickinson soils, is composed largely of sand. The 12- to 14-inch topsoil is very dark loose sandy loam well supplied with organic matter. The upper 6 or 8 inches of the subsoil is brown loamy sand, and the remainder is gray sand. The entire soil is low in lime.

On account of its organic-matter content, the topsoil is able to hold considerable moisture, but the subsoil has low moisture-retaining powers, and the soil as a whole is rather droughty. However, it is fairly stable, is topographically suited to cultivation, and practically all the land is farmed. It is used for the same crops as are grown on Dickinson loamy sand and has about the same producing power.

A variation of this soil occurs in small bodies, chiefly on terraces along Bazile and Verdigris Creeks, which lie from 8 to 15 feet above the adjoining bottom lands. This soil differs from other O'Neill soils chiefly in that it contains more silt and organic matter in the topsoil. It is a little more stable and more retentive of moisture than those soils and produces slightly higher yields of corn and sweetclover, especially in the drier years. However, the loose porous sand of which the subsoil is composed makes the soil more droughty than any of the general-farming soils.

O'Neill loamy sand.—O'Neill loamy sand is similar in appearance to Dickinson loamy sand, but it occurs on nearly level terraces instead of on gently rolling upland areas. The dark-colored surface soil is not quite so deep as the corresponding layer of O'Neill sandy loam, in few places exceeding 12 inches in thickness. The content of organic matter is lower and the soil is not quite so retentive of moisture as is the sandy loam. The subsoil is similar in all characteristics to the corresponding layer in Dickinson loamy sand.

About 80 percent of the land is used for corn, about 10 percent for sweetclover, and the remainder is in native pasture or hay land, except a few small fields which are used for oats or rye. Crop yields are about the same as on Dickinson loamy sand.

This soil occurs on both high and low terraces. The largest developments are south of Niobrara River.

CORN AND ALFALFA SOILS

The group of corn and alfalfa soils includes all the bottom-land soils except the Sarpy soils which, on account of their low organic-matter content and extremely sandy character, are included with the native pasture and hay soils. This group is less extensive than any other soil group, occupying only 8.2 percent of the total area but it includes the most productive corn and alfalfa soils. About 95 percent of the cultivated land is devoted to these crops, in the proportion of about 8 acres of corn and $1\frac{1}{2}$ acres of alfalfa to 1 acre of sweetclover,

red clover, barley, or clover and timothy mixed. The uncultivated land occurs in strips too narrow for profitable farming, in bodies too poorly drained for cultivation, or is covered by native forest and is used for pasture or hay land.

The Lamoure, Wabash, and Cass soils, including 7 soil types, belong to this group. One or another of these soils occurs as bodies or strips of different sizes along all the larger and many of the smaller streams. The largest developments are along Missouri and Niobrara Rivers and Bazile and Verdigris Creeks.

The surface relief of the bottom land slopes almost imperceptibly down the valleys and toward the stream channels. The land is remarkably smooth except where traversed by old and present stream channels or where modified by slight elevations and shallow depressions. Surface drainage, although rather slow, is well established except locally. Much of the land is subject to overflow during high stages of the streams, but most of it lies from 3 to 5 feet above the normal level of the streams, and the water drains off within a few hours after the streams subside. The only poorly drained areas occur in small local depressions, from which the water is forced to seek outlet through seepage. The ground-water table in the larger valleys ranges from about 4 to 15 feet beneath the surface of the ground, and the lower part of the subsoil is kept well supplied with moisture even in the drier years.

The materials from which the soils of this group have developed consist of recently deposited stream sediments, none of which has been greatly altered by weathering, and the character of the sediments is the dominant factor in determining the character of the soils. The sediments deposited by the local upland streams flowing through areas of loess are naturally uniform and silty, and those deposited by the more deeply entrenched streams which have cut through the loess into the underlying sand and gravel are coarser. The mixing and reassorting of the fine and coarse particles has given rise to a varied assortment of sediments, especially in the Missouri River bottom lands where sediments came not only from the local uplands but also from regions to the north and west.

The Lamoure and Wabash soils have developed from the finer stream sediments, chiefly silt and clay, and the Cass soils have developed from sand and gravel. All these soils are naturally better supplied with moisture than the upland and terrace soils, because the precipitation received by them is supplemented by seepage from the stream channels and the underlying water table, and by run-off from higher levels. The run-off carries considerable organic matter and other plant nutrients to the lower levels. In addition, the moist conditions prevailing in the bottom lands have favored rapid vegetal growth and decay, and most of the soils belonging to this group are better supplied with organic matter and have darker colored topsoils than those belonging to any other soil group.

The high organic matter and moisture supplies make the soils of this group especially adapted to corn. The moisture supply is also very favorable to alfalfa, and this crop can be grown as continuously as desired without decreasing the subsoil moisture to the point where yields decline as they do when the higher lying soils are continually used for alfalfa. Small-grain crops grow well on the

soils of this group, but they have a tendency to produce rank vegetal growth with long weak stems which break and lodge during windy weather. In addition small grains usually mature late and yield rather low. Oats yield fairly well, provided short stiff-stemmed varieties are grown, but even these varieties have a tendency to grow rank at the expense of the grain and are of minor importance on any of these soils.

Lamoure silty clay loam.—Lamoure silty clay loam is one of the most extensive bottom-land soils. However, none of the bottom-land soils covers a large total area. Most of the soil is in the Missouri River bottom lands. One of the largest bodies, comprising about 800 acres, is in the northern part of Santee Township.

The surface relief is nearly level. Most of the bodies lie a little below the general level of the other bottom-land soils and are not quite so well drained. Practically all of them are subject to occasional overflow from the main channels, but about 80 percent of the land is sufficiently well drained for cultivated crops.

The topsoil, which averages about 16 inches thick, consists of almost black, heavy, silty clay loam, containing an abundance of organic matter. Its high clay content does not favor cultivation under so wide a range of moisture conditions as is possible on the more silty or sandy soils of the bottom lands. If plowed when wet, clods are formed which require subsequent wetting and drying, or freezing and thawing, before favorable tilth is restored. It is very difficult to cultivate this soil when it is extremely dry, but under favorable moisture conditions the topsoil is easily kept in good tilth.

The subsoil is gray, light-gray, or mottled gray and brown silty clay loam or clay which extends to an average depth of 36 inches. It is in general slightly more compact than the topsoil, but has no claypanlike features and is easily penetrated by moisture and roots. The material is very lmy, the lime occurring in rounded soft and hard nodules, in irregular-shaped spots and splotches, and in finely divided form thoroughly mixed with the subsoil material.

This soil differs from Wabash silt loam in the heavier texture of its topsoil and in the lighter color and higher lime content of its subsoil. That part of it which is sufficiently well drained for cultivation, and which is not covered by native forest, is used chiefly for corn and alfalfa in the proportion of about 8 acres of corn to 1 of alfalfa. Some barley, oats, sweetclover, and clover and timothy mixed, are grown, but the total area of these crops is practically negligible. The abundance of moisture causes all small-grain crops to make rank vegetal growth, mature late, and return rather low grain yields. These crops are used only as a step in the rotation between corn and alfalfa or as a nurse crop for alfalfa.

The yields of corn and alfalfa are higher than on any upland or terrace soil, corn yielding an average of about 50 bushels and alfalfa about $3\frac{3}{4}$ tons an acre. Alfalfa can be grown on this soil as often as desired without danger of depleting the subsoil moisture to the point where yields decline as they do under continued cropping to alfalfa on the uplands and terraces.

The poorly drained and forested areas are used for native hay or pasture land. Most of these areas are covered with a luxuriant growth of moisture-loving grasses which support a cow or horse on

each acre during the summer grazing season or when cut for hay will yield from 1 to 1 $\frac{1}{4}$ tons an acre.

Lamoure very fine sandy loam.—Lamoure very fine sandy loam occupies only a small proportion of Knox County. It occurs in small bodies and narrow strips in the bottom lands, chiefly along Missouri and North Fork Elkhorn Rivers, and Ponca, West Bow, Beaver, and Little Bazile Creeks.

The topsoil is dark friable very fine sandy loam from 12 to 16 inches thick. The subsoil is similar to the corresponding layer in Lamoure silty clay loam except that, in most places, it contains a little more very fine sand. The soil is better drained than any of the heavier textured Lamoure soils and, on account of its higher sand content, is also a little more easily handled. However, it cannot be cultivated when extremely wet without injuring its tilth. Practically all the land is under cultivation and is used for the same crops as are grown on Lamoure silty clay loam. Yields are also about the same as those produced on that soil.

A phase of Lamoure very fine sandy loam, which is transitional in its characteristics between Lamoure silty clay loam and typical Lamoure very fine sandy loam, containing less clay than the former and less sand than the latter soil, occurs in small bodies on the Missouri River bottom lands in the northern part of the county and as narrow bottom-land strips along the larger creeks in the southeastern part. However, these differences are very slight. Practically all this silty soil is under cultivation, and yields are about the same as on the typical soil.

Lamoure fine sandy loam.—Lamoure fine sandy loam is the most sandy Lamoure soil, but the sand content is not sufficient to reduce the stability or moisture-holding capacity. The topsoil is very dark grayish-brown mellow fine sandy loam from 12 to 14 inches thick. The subsoil is lighter colored very heavy sandy clay loam which rests at a depth of about 4 feet on loose gray sand. This soil occupies slightly higher positions than the other Lamoure soils and is seldom subject to overflow from the main streams. All the land is under cultivation and is used for the same crops as the finer textured Lamoure soils. Yields in normal seasons are about the same as on Lamoure silty clay loam, but in wet years they are a trifle higher because the subsoil does not become so saturated with moisture as the corresponding layer of Lamoure silty clay loam.

This is not an extensive soil and is of minor agricultural importance. The largest development, comprising about 200 acres, is on Little Bazile Creek in Central Township.

Cass fine sandy loam.—Cass fine sandy loam is the most extensive sandy dark-colored bottom-land soil. However, it occupies only small bodies and narrow strips along the larger streams, and its total area is rather small. The largest body, comprising about 2 square miles, is along Missouri River in Raymond Township.

The surface relief, in common with that of the other bottom-land soils, is nearly level. This soil lies only 3 or 4 feet above the normal level of the streams and is subject to inundation during periods of high water, but the water drains off rapidly when the streams subside, and only a small percentage of the soil remains too wet for cultivation.

The topsoil is very dark grayish-brown friable fine sandy loam ranging from 10 to 14 inches in thickness. Although composed largely of fine sand and medium sand, it contains an abundance of organic matter and silt and is very stable. The subsoil is loose gray or grayish-brown sand which in most places becomes coarser with depth and in many places is gravelly below a depth of 3 feet. The soil may or may not be limy, but in most places it contains sufficient lime to produce weak effervescence when hydrochloric acid is applied, especially the upper part of the subsoil.

The principal variation in this soil is toward a very fine sandy loam texture, and a few bodies in the Missouri River bottom lands have this texture in their topsoils, but they do not differ noticeably in their crop adaptabilities or producing powers from typical Cass fine sandy loam and are therefore included with that soil on the accompanying map.

About 90 percent of the land is under cultivation, and the remainder, including narrow forested strips along the stream channels and a few poorly drained areas, is used for native pasture and hay land.

Cass fine sandy loam is one of the most productive corn and alfalfa soils in the county, and most of the cultivated land is used for these crops in the proportion of about 8½ acres of corn to 1½ acres of alfalfa. Yields are a trifle lower than those obtained on the best Wabash and Lamoure soils, but they are higher than on any of the upland or terrace soils. The average acre yield of corn over a period of years is about 45 bushels and of alfalfa about 3½ tons. Small grains also grow well but, as on all the bottom-land soils, the abundant moisture usually causes these crops to produce a rank vegetal growth at the expense of the grain.

The soil on narrow broken strips, principally in the bottom land along Niobrara River and Verdigris Creek, differs from typical Cass fine sandy loam in that its topsoil is a little coarser and not quite so well supplied with organic matter. However, the total area of such bodies is so small that they are not separated on the soil map. About 70 percent of this included soil is under cultivation and is used chiefly for corn and alfalfa. Crop yields are about 10 percent lower than those obtained on typical areas of Cass fine sandy loam.

Cass loamy sand.—Cass loamy sand occupies a fairly continuous, though narrow strip, in the Verdigris Creek bottom lands and is locally developed along Merriman, Schindler, and North Branch Verdigris Creeks.

The entire soil is composed largely of loose gray sand. The surface layer, consisting of sandy material to a depth of 8 or 10 inches, contains sufficient organic matter to give it a dark color and loamy texture but not enough to prevent soil drifting, especially during prolonged dry windy weather. The soil is limy in only a few places.

The land surface is nearly level or gently undulating except where wind action has produced low ridges and shallow depressions, but even in such places the relief does not exceed 2 feet.

The soil, although very sandy and rather unstable, is well supplied with moisture, and yields of corn and alfalfa are almost as high as on the finer textured Cass soils. However, Cass loamy sand occupies only a small part of the farms on which it occurs and is of little agricultural value.

Wabash silt loam.—Wabash silt loam occupies a few narrow broken strips in the bottom lands throughout the southeastern part of the county. Few of the strips exceed 80 rods in width, and most of them are much narrower. The largest body, comprising about 400 acres, is in the vicinity of Bloomfield.

The surface soil is very dark grayish-brown or almost black silt loam, and the upper part of the subsoil is black silty clay loam. Below a depth of 30 inches, brown mottlings appear, and the color becomes grayish brown. This soil is very similar in appearance to Lamoure silt loam, and separation of the two soils was made principally on the basis of lime content. Lamoure silt loam is high in lime, especially in the subsoil, whereas Wabash silt loam, although not deficient in lime, contains very little above a depth of 4 feet.

This soil lies only 3 or 4 feet above the normal level of the streams and is subject to overflow after heavy rains, but the slope is sufficient in most places to carry off the surplus water shortly after the streams subside. All the land is under cultivation, except a few narrow strips which are forested.

This soil is as productive as any of the Lamoure soils. It is used chiefly for corn and alfalfa, both of which are grown in about the same acreage ratios as on Lamoure silty clay loam. Some oats are grown, but, as on all bottom-land soils, they have a tendency to grow rank at the expense of the grain, and the crop is of minor importance.

Wabash very fine sandy loam.—Wabash very fine sandy loam resembles Wabash silt loam in all characteristics, except that it has more very fine sand in its topsoil. The sand content makes the soil a little easier to handle than Wabash silt loam but does not influence its productivity or adaptability to crops, and the two soils are regarded with equal favor by most farmers. Wabash very fine sandy loam is inextensive and of little agricultural importance. It occurs in narrow strips along a few of the drainageways in the southeastern part of the county.

NATIVE PASTURE AND HAY SOILS

The native pasture and hay soils occupy 31.1 percent of the total area of the county. One or another of them occurs in all parts, wherever the land, because of surface relief or drainage, is unsuited to cultivation or the soil is poorly adapted to the production of grain and tame hay. This group includes soils of the Crofton, Knox, Boyd, Holt, Dickinson, Sogn, Valentine, Shelby, Sarpy, and Butler series, some of which have two or more types or phases of types, making a total of 20 soils. In addition areas of gravelly sand and of river wash, which do not belong in any soil series, are included.

Nearly all of these soils include some land which is under cultivation, and a few of them are used chiefly for cultivated crops, but the greater part of them remains in its virgin condition, and about 85 percent of the area occupied by the group as a whole is used for native pasture or hay land.

All the soils in this group occupy upland positions, with the exception of the Sarpy soils and river wash, which occur in the bottom lands. They have a wide range in surface relief and in soil characteristics. The Knox, Crofton, and Butler soils are composed largely

of silt, but the Knox and Crofton soils are severely eroded and the Butler are very poorly drained. The Valentine and Sarpy soils consist of almost pure sand and are rather unstable, and the Valentine soils are also very droughty. The Boyd soils are composed chiefly of clay and, except where their heavy texture is modified by mixtures of silt or sand, are extremely difficult to cultivate. Most of the area occupied by the Shelby soils is very gravelly and rather droughty, but the finer textured types are retentive of moisture and fairly well adapted to cultivated crops. The Sogn and Holt soils are characterized by numerous exposures of hard bedrock formations, and only a small percentage of the area occupied by them can be farmed. Most of the soils belonging to the group are low in organic matter, have thin topsoils, and include numerous exposures of the raw geologic material from which they have weathered. In the Knox, Valentine, and Sarpy soils, the topsoil layers are unusually thin and are prevailingly light in color.

Crofton silt loam.—Crofton silt loam, like some of the Moody soils, is not a deep soil, because of erosion. It is transitional in development between Moody silt loam and Knox silt loam, being shallower than the Moody soil and deeper than the Knox. Erosion has been sufficiently rapid to greatly thin or entirely remove the dark-colored topsoil characteristic of Moody silt loam but has not removed the concretinary lime layer of the subsoil as in Knox silt loam.

In most places a 4- or 5-inch layer of very dark colored friable silt loam remains on the surface. This is underlain by a 10- or 12-inch layer of light grayish-brown friable silt containing numerous hard lime concretions similar to those in the upper subsoil layer of Moody soils. Beneath the concretinary layer is the parent material consisting of loose grayish-yellow or almost white silt which continues to a depth exceeding 12 feet. The parent material, although very lumpy, contains only a few lime concretions. In numerous spots the dark topsoil layer has been entirely removed, bringing the lighter colored concretinary layer to the surface.

The surface relief, although not quite so harsh as in Knox silt loam, is as a whole unsuited to tame-hay and grain crops, and probably not more than 8 percent of Crofton silt loam is under cultivation. It supports a luxuriant grass cover, and most of it is included in grazing land for which it is slightly superior to Knox silt loam. Corn and alfalfa are the principal crops on the cultivated areas. Alfalfa yields are about the same as on Moody silt loam, but yields of corn average about 10 percent lower.

Crofton very fine sandy loam.—Crofton very fine sandy loam differs from Crofton silt loam principally in the higher content of very fine sand in its surface soil. The sand has been brought by the wind from more sandy areas and has been mixed with the topsoil of the silt loam to a depth of several inches. The underlying layers are not noticeably different from the corresponding layers of Crofton silt loam. The sand ranges in texture from fine to medium, but the greater part is of the finer grades, and the resultant mixture has a very fine sandy loam texture.

The agricultural value of this soil is not greatly changed by the sand content. In most places the quantity of sand is not sufficient to

make the soil droughty or susceptible to removal by the wind. Only a small percentage of the land is cultivated. Crop yields are about the same as or a trifle lower than those obtained on Crofton silt loam, but they are slightly higher than those obtained on Knox silt loam.

Knox silt loam.—Knox silt loam is the most severely eroded of the silty upland soils. It occurs chiefly in the bluff lands bordering Missouri River, in the northeastern and northwestern corners of the county, and has in most places an extremely rough and broken surface relief. The soil is formed on loess similar to that underlying the Moody and Crofton soils, but more or less constant erosion has either removed the products of soil weathering or has prevented them from accumulating so that practically no topsoil or subsoil has developed. In all places the raw limy loess is either exposed or is covered by a 4- or 5-inch layer of slightly darker colored material where the slope has not been too steep to entirely prevent the accumulation of organic matter. No zone of concretionary lime, such as typically occurs in the subsoil of the Moody soils and near the surface of the ground in the Crofton soils, has developed in the Knox soil.

Knox silt loam is retentive of moisture, and were it not for its unfavorable surface features and low organic-matter, and consequently nitrogen, content, would be a valuable farming soil. In several east-central Nebraska counties, where this soil occurs more extensively, a large part of it is topographically suited to cultivation. In these counties high yields of alfalfa and sweetclover and fair yields of corn, wheat, and oats are commonly obtained wherever care is taken to prevent erosion. The grain land is usually heavily manured. In Knox County, however, practically none of this soil is suited to the use of farm machinery. Nearly all of it remains with its native grass cover and is used for grazing land. The grasses are well established, except on the sharper hilltops and steeper slopes. They consist principally of big bluestem and little bluestem and in normal years will support about 40 head of cattle on each quarter section (160 acres) during the summer grazing season, June to September, inclusive.

Boyd clay loam.—Boyd clay loam is the most extensive native pasture and hay soil. It occurs wherever erosion has removed the gray upland loess, together with underlying sand and gravel deposits, and exposed to weathering the blue limy Pierre shale formation. This soil covers large areas in the northern part of the county and occurs extensively east of Verdigris Creek in the vicinity of Verdigre, and along Bazile Creek in Union and Spade Townships.

The land in most places is rather severely eroded, but as a whole the surface relief is not quite so rough as that of Knox silt loam, and a larger percentage of this soil is suited to cultivation. However, the soil is composed chiefly of clay which is difficult to till, and only about 25 percent of the land is under cultivation.

The 8- to 12-inch topsoil, except where erosion has been especially severe, is very dark grayish-brown, in places almost black, heavy clay loam well supplied with organic matter. It rests directly on the parent blue shale, in which occurs an intricate network of seams and cracks of various widths, filled with finely divided lime. Considering its heavy texture the soil is remarkably friable, owing partly to the manner in which the lime is distributed and partly to the addi-

tion of silty or sandy material which has been washed down from the higher lying soils and has become mixed with the clay.

The cultivated parts of this soil are used for the same crops as are grown on the Moody soils. In normal and wet years crop yields are almost as high as on Moody silt loam, but in dry years yields are usually low because the high clay content causes the soil to shrink and crack, breaking the crop roots and exposing them to drought.

The uncultivated areas are used for pasture and hay land. Much of the pasture and hay land is topographically suited to cultivation, but, on account of the heavy intractable character of the soil, it is not used for tame-hay and grain crops. The native grasses on this soil will support a cow or horse on each 2 or 3 acres or when cut for hay will yield about one-third of a ton an acre. The native hay is of good quality.

Included with this soil are small areas in which the soil has apparently developed from a light-colored limy silt or silty clay loam strata in the blue shale. The topsoil in these areas is very light grayish-brown silty clay loam about 10 inches thick. The underlying material in most places is an almost white mixture of silt and clay but in many places contains thin seams of blue shale similar to that from which the typical soil has developed. The entire soil is very limy but is practically devoid of organic matter.

The light-colored areas are all included in pasture land. They are sparsely covered with grasses and do not have a high value even for grazing. Although rather numerous, few of them occupy more than a few square rods and are not shown separately on the soil map.

Boyd clay.—Boyd clay occupies the steeper slopes and sharper ridge crests within areas of Boyd clay loam. This soil differs from the clay loam in that it has a thinner and more nearly pure clay topsoil. Most of it is topographically unsuited to the use of farm machinery, and it is all of such heavy intractable character that it cannot be profitably farmed. The soil is all included in pasture and hay land, for which it is as well suited as Boyd clay loam.

Boyd sandy loam.—Boyd sandy loam occupies a few small bodies in the northern and western parts of the county. Most of the bodies are within or adjacent to areas of sandy soils. The largest, some of which include about 640 acres, are in Bohemia and Sparta Townships.

This soil is simply Boyd clay which has been covered to a depth ranging from 6 to 14 inches by wind- or water-transported sand. The sandy deposits in most places have accumulated considerable organic matter and are dark grayish brown or very dark grayish brown. The surface relief is more even than that of the other Boyd soils, ranging from undulating to rolling. Practically all the land is suited to the use of farm machinery, and about 60 percent of it is under cultivation. The same crops are grown on the cultivated areas as on the Dickinson and O'Neill soils, and in addition considerable alfalfa is grown. This soil has an unusually high moisture-storing capacity, because the porous sand in the surface layer rapidly absorbs all the precipitation and the heavy clay in the subsoil prevents loss of moisture through seepage.

Corn, sweetclover, and alfalfa ordinarily yield as high as on Moody silt loam, and in dry years yields of these crops are in general higher than on the Moody soil.

The uncultivated areas support a luxuriant growth of needlegrass, sandgrass, and big bluestem, and they have a higher value for pasture and hay land than any other Boyd soil. Only a few farms are occupied entirely by this soil, which is of minor importance in the agriculture of the county.

Shelby loam.—Shelby loam is rather extensively developed in the northwestern part of Hill Township, and it occupies numerous small bodies throughout most of the northeastern part of the county. This soil has developed through the weathering of the finer textured glacial deposits which have been exposed by the removal of the overlying gray loess. Part of the soil is on comparatively smooth inter-stream divides, but most of it is rolling or hilly.

The topsoil is dark-colored friable loam or fine sandy loam, which varies considerably in thickness. In the more nearly level areas it is 8 or 10 inches thick, but on slopes the thickness depends on the gradient. On very steep slopes erosion has removed nearly all the dark topsoil. The upper 8- or 10-inch layer of the subsoil is brown loam or gravelly loam and, although slightly more compact than the topsoil, is friable throughout. The lower part of the subsoil is a grayish-brown silt, sand, clay, and gravel mixture resembling the parent glacial drift.

The most places the soil is not limy within a depth of 4 feet, but it contains an abundance of lime below this depth. It is more droughty than any of the Moody soils but is more retentive of moisture than the Dickinson or O'Neill soils. About 40 percent of the land, including the more nearly level areas, is used in the production of corn, oats, alfalfa, and sweetclover, ranking in acreage in the order named. Yields of these crops average about 10 percent lower than on Moody silt loam. The uncultivated areas are used for pasture and hay land, for which this soil is as well suited as any soil in the native pasture and hay soils group.

Shelby gravelly sandy loam.—Shelby gravelly sandy loam has developed from the coarser textured glacial deposits. The surface relief is normally less even than that of Shelby loam, and most of this soil occurs on rather steep slopes and narrow ridges.

The topsoil in few places exceeds 5 or 6 inches in thickness. It is composed largely of coarse sand and gravel, together with sufficient silt and clay to make it coherent, and contains sufficient organic matter to give it a very dark color. The subsoil is a heterogeneous mixture of sand, silt, clay, and gravel, brown in the upper part and grayish brown in the lower part. Numerous cobblestones and a few boulders occur, both on the surface of the ground and throughout the soil. Most of the lime has been leached beyond a depth ranging from 3 to 4 feet.

Shelby gravelly sandy loam, both on account of its high gravel content and unfavorable surface relief, is not well suited to the use of cultivating machinery. Practically all of it is used as pasture land, for which it is well suited.

This soil occurs chiefly in the northern part of the county where it occupies several small bodies, the largest in Union and Santee Townships.

Shelby sandy loam.—Shelby sandy loam differs from Shelby loam mainly in that it contains a larger percentage of sand in its topsoil.

The subsoil is composed largely of gravel, and in most places some gravel occurs on the surface.

The soil is a little less stable and more droughty than Shelby loam and has a lower agricultural value. Only a small part of the land is cultivated, and the remainder is used for pasture. It is inextensive and of little agricultural importance. Most of it occurs in the central part of the county, east and southeast of Center.

Valentine sand.—Valentine sand occupies a few bodies on the Holt table in the western part of the county. The largest area, comprising about 4 square miles, is west of Schindler Creek on the south side of Niobrara River, and the other bodies are few and much smaller.

Valentine sand resembles Dickinson loamy sand except that it contains less organic matter, is less stable, and has a less even surface relief. The greater part of the land is characterized by rounded hummocks and ridges, ranging from 8 to 12 feet in height and separated by shallow depressions. All rain water is rapidly absorbed by the soil, and surface run-off is lacking.

This soil consists of loose incoherent gray or grayish-brown sand to a depth exceeding 3 or 4 feet. The 3- or 4-inch surface layer is in general slightly darker than the rest of the soil, owing to a small content of organic matter, but the organic content is nowhere sufficient to prevent the soil from drifting when the native sod is destroyed. The soil is very low in lime.

Valentine sand is of little value for crop production on account of its unstable character, low organic-matter content, and low water-retaining capacity. Probably not more than 10 percent of the land is under cultivation. Some corn, sorgo, and sweetclover are grown in the lower situations, where moisture conditions are most favorable, but the yields are generally low except in seasons of high precipitation. Most of the soil remains with its native covering of grasses and is used for cattle grazing and hay production. The natural vegetation consists largely of sandgrass and will support about 25 head of cattle on each 160 acres during the summer grazing season, or when cut for hay will yield about one-third of a ton an acre.

Included with this soil on the accompanying map are two small bodies of dune sand. The larger one, comprising about 50 acres, is on the Knox-Holt County line between Squaw and Steele Creeks, and the smaller one is in sec. 22, T. 31 N., R. 7 W. These bodies differ from areas of Valentine sand only in that they are more hilly, the sand being piled into dunes from 15 to 30 feet high. Practically all the dunes are covered with a sparse growth of grasses.

Valentine loamy sand.—Valentine loamy sand differs from Valentine sand only in that its topsoil contains a little more organic matter and is a trifle thicker than the corresponding layer of the sand. It occurs in close association with Valentine sand but is much less extensive. The largest development, comprising about 500 acres, is east of Soldier Creek in Bohemia Township. The surface relief and drainage features are about the same as those of Valentine sand.

The higher organic-matter content of the topsoil gives this soil a greater moisture-holding capacity than Valentine sand, but the organic matter is not nearly so abundant as in Dickinson loamy sand and rapidly disappears when the land is cultivated. Corn, sweet-

clover, and sorgo are grown over about 20 percent of the area occupied by this soil. During the first 2 or 3 years, crop yields are only slightly lower than on Dickinson loamy sand, after which they decline, and the soil, if continually cultivated, reverts to Valentine sand. The uncultivated areas support the same species of grasses as grow on Valentine sand, but the grasses grow a little more luxuriantly, and the soil has a higher grazing value than Valentine sand.

Holt sandy loam.—Holt sandy loam occurs in the southwestern corner of the county, in the same general locality as the hilly phase of this soil, but it occupies areas of more even surface relief and is not so severely eroded. Most of it occupies long gradual slopes or gently or strongly rolling divides.

The topsoil is dark-brown or almost black loose sandy loam from 10 to 14 inches thick. It is rich in organic matter, contains considerable fine gravel, and is comparatively low in silt and clay. The upper subsoil layer is brown or light-brown loose sandy loam to an average depth of 24 inches. The lower subsoil layer is a loose incoherent mass of coarse sand and fine gravel, which in most places extends below a depth of 3 feet, but in many places the light-colored limy sandstone occurs within a depth of 3 feet, and many fragments of this formation are in evidence throughout the soil.

Most of the soil is topographically suited to cultivation, but it is rather droughty and unstable, and only about 40 percent of the land is used for grain and tame-hay crops. Corn and sweetclover are the principal crops. Yields are about the same as on Dickinson loamy sand. The uncultivated areas are used for native pasture and hay land, for which they are well suited.

Holt sandy loam, hilly phase.—Holt sandy loam, hilly phase, occupies only 6.1 square miles. It occurs throughout the uplands, principally west of Verdigris Creek, in Logan and Walnut Grove Townships. The soil has developed from light-colored limy sandstone which has been exposed to weathering through removal of the overlying loess and sand deposits.

The surface relief over the greater part of this soil is very rugged. Stream erosion has produced deep steep-sided valleys separated by narrow divides, giving the land a decidedly hilly appearance. Erosion has also prevented deep soil weathering, and the dark topsoil in few places exceeds 6 or 8 inches in thickness. It is extremely variable in texture, ranging from silt loam to loamy sand, but by far the greater part of it is loose sandy loam. This soil phase as mapped includes all the more hilly areas of Holt soil, regardless of the texture of the topsoil.

The subsoil is grayish-brown or light grayish-brown fine sandy loam or very fine sandy loam, which in most places rests on the parent sandstone within a depth ranging from 2 to 3 feet. In numerous places the light-colored limy bedrock is exposed, giving the soil a spotted dark and light appearance. Drainage is everywhere thorough and in most places is excessive.

All this soil is used as pasture land. It supports good growths of sandgrass and needlegrass. Big bluestem grows to some extent on the more gradual slopes and broader divides. The native grasses will support from 100 to 125 head of cattle on each square mile during the summer grazing season.

Holt fine sandy loam.—Holt fine sandy loam resembles Holt sandy loam, except that its topsoil and subsoil are finer textured, more stable, and more retentive of moisture. However, the soil is unable to absorb moisture as rapidly as the sandy loam, and during heavy rains surface run-off is more pronounced and erosion is more severe than on that soil. The surface relief ranges from gently rolling to steeply sloping, and as a whole is less even than that of Holt sandy loam.

Only about 35 percent of the land is topographically suited to cultivation. The cultivated areas are used for all crops commonly grown, and the soil on them is about as productive as Moody fine sandy loam. The uncultivated areas are used chiefly as pasture land.

This soil is inextensive and of little agricultural importance. Most of it is in Logan, Miller, and Verdigrè Townships.

Holt very fine sandy loam.—Holt very fine sandy loam is the most productive Holt soil in Knox County, but it occupies only a few small areas and is of little agricultural importance. The topsoil is dark-brown or dark grayish-brown mellow very fine sandy loam or silt loam, which is well supplied with organic matter and ranges from 8 to 14 inches in thickness. The upper part of the subsoil is brown mellow silt loam, which passes gradually at a depth of about 2 feet into light grayish-brown sandy loam or fine sandy loam. In most places the light-colored limy sandstone from which the soil has weathered lies at a depth exceeding 3 feet, but in a few places it is much nearer the surface. The topsoil has a moderate lime content, and the subsoil is very limy.

The surface relief ranges from steeply sloping to nearly level, but most of the soil occupies parts of nearly level divides or long gradual slopes. Drainage is good, but as a rule erosion is not excessive.

This soil is as productive and as well adapted to any crop as is Moody silt loam. About 50 percent of the land, including all the larger bodies, is under cultivation. Corn, oats, and alfalfa, ranking in acreage in the order named, are the leading crops. The uncultivated land, including the less accessible areas and those which are too small to profitably farm, are included in native pasture or hay land.

This is an inextensive soil. The bodies occur chiefly in the Verdigris Creek drainage basin in the southwestern part of the county. Two of the largest, comprising about 90 acres each, are in sections 27 and 28 and in section 31 of Miller Township, a slightly smaller area is in section 35 of Logan Township, and the remaining bodies are small and scattered.

Dickinson gravelly sandy loam.—Dickinson gravelly sandy loam occupies 26.9 square miles. Most of it occurs in the section known as Devils Nest, but it also occupies numerous bodies in the uplands along Bazile and Verdigris Creeks and is locally developed in many places throughout the Holt table and the Pierre plains and hills section.

This gravelly material is composed of a heterogeneous mixture of coarse sand and gravel, the latter consisting of water-worn fragments of many different varieties of crystalline rocks. The 4- to

6-inch layer is dark grayish brown, owing to an accumulation of organic matter. Beneath the dark-colored material and extending to a depth of 14 or 16 inches the material is brown, but it becomes grayish brown with increasing depth.

The material is supposed to be Rocky Mountain debris carried down by streams and deposited before the loess and sand, from which the Moody and Dickinson soils, respectively, have weathered, was laid down. It is extremely resistant to weathering and has less of the characteristics of a soil than of a geologic formation, although the surface soil has been slightly modified by organic matter.

The surface relief ranges from sharply rolling to hilly. The soil occupies rather steep slopes and narrow though well-rounded hilltops and divides. Drainage is excessive, and erosion is removing the finer materials as fast as they accumulate.

None of this land is under cultivation. It supports a fair growth of grasses and is all used as pasture land. The grasses will support about 80 head of cattle to the square mile during the summer grazing season.

Sogn loam.—Sogn loam occupies only a few small bodies, most of which occur on steep, and in places almost precipitous, slopes in the bufflike escarpment bordering the Missouri River alluvial lands in Frankfort Township. The largest body, comprising about 180 acres, is in the extreme northeastern part of this township.

This soil has developed from the lowest exposed bedrock, a soft limestone known by geologists as Niobrara chalk. The topsoil in most places is rather dark but in few places is more than 6 inches thick. It ranges in texture from silt loam to fine sandy loam, the loam predominating. In most places the dark-colored material rests on disintegrated chalk-rock fragments which extend to a depth of about 12 inches, below which the unweathered Niobrara chalk rock occurs. Over much of the area classed as this soil, erosion has removed the thin dark-colored topsoil and exposed the chalky limestone.

All the soil is included in pasture land. It is covered with a fairly dense growth of grasses which will support a cow or horse on each 4 or 5 acres during the summer grazing season.

Butler silt loam.—The soil mapped as Butler silt loam is variable, but two features—a shallow dark-colored topsoil and a heavy claypanlike upper subsoil layer—are persistent throughout the areas of its occurrence.

This soil occupies scattered and slightly depressed bodies within nearly level areas of the finer textured upland and terrace soils. All the bodies are poorly drained. In most of them water collects after heavy rains and disappears slowly through seepage and evaporation. Few of the areas exceed 80 acres in size, and most of them occupy only a few square rods. They are locally known as buffalo wallows, or lagoons.

The topsoil is friable silt loam or very fine sandy loam, ranging from less than 6 to about 8 inches in thickness. It is well supplied with organic matter and is very dark, especially in the upper part, but all of it contains more or less light-gray silty material, from which excessive moisture has leached the black organic matter, and in many of the more poorly drained depressions the lower 2- or

3-inch layer of the topsoil is gray. The upper part of the subsoil is a brown or almost black dense claypanlike layer which is almost impenetrable to moisture and is penetrated with difficulty with a spade or soil auger. It ranges in thickness from 18 to more than 50 inches. The lower part of the subsoil is light grayish brown or grayish yellow. The material differs considerably in texture in the different bodies, in most of them being loose floury silt similar to that underlying the Moody soils but in some consisting of sandy clay loam ranging from friable to slightly compact in consistence. Locally the entire soil contains scattered gravel and small rounded cobblestones, and a few boulders are scattered here and there on the surface. The lower part of the subsoil may or may not be limy, but in most places it contains an abundance of lime in finely divided form or in hard rounded concretions ranging from one-eighth to one-fourth inch in diameter.

None of this soil is under cultivation. Even if drainage conditions allowed the use of cultivating implements, the soil would remain poorly adapted to grain and tame-hay crops, because the topsoil is too thin to store much moisture, and the dense clay in the upper part of the subsoil is too poorly aerated and releases its moisture too slowly for these crops. All the land is included in farm pastures. It supports a luxuriant growth of water-loving grasses, but, as most areas are covered with water for several days after each heavy rain, it does not have a high value for grazing. It occupies only a small part of the farms on which it occurs and is of minor agricultural importance.

Sarpy very fine sandy loam.—Sarpy very fine sandy loam occupies a few areas in the bottom lands along Missouri and Niobrara Rivers and Verdigris Creek. The largest, comprising about 2 square miles, is in northern Herrick Township. The other bodies are much smaller.

The surface relief is nearly level, although it is modified in places by old and present overflow channels, slight elevations, and shallow depressions. The land lies from 3 to 4 feet above the normal level of the streams, and, although subject to occasional overflow, it is not covered with water except during unusually high stages of the streams.

This soil has developed from recently deposited very fine river sand which has not yet accumulated much organic matter. The topsoil consists of gray or grayish-brown very fine sandy loam, 6 or 8 inches thick. It contains an abundance of silt and some organic matter which gives it the loamy texture. Throughout the remainder of the soil profile the material becomes gradually coarser in texture and lighter in color with increasing depth and in most places consists of light grayish-brown coarse sand or of a sand and gravel mixture below a depth of 30 inches. The subsoil, although almost continually moist, is not poorly drained.

About 35 percent of Sarpy very fine sandy loam is used for corn and about 5 percent for alfalfa. Most of the remainder supports a scattered tree growth and is included in pasture land. Although the organic-matter content is very low, the moisture supply is abundant, and fair yields are obtained on the cultivated areas in most years. Alfalfa seems to do almost as well as on the dark-

colored Cass soils, probably because this crop does not depend on organic matter for its nitrogen supply. The average corn yield over a period of years is about 20 bushels an acre and of alfalfa about 3 tons of hay. The native grasses on this soil will support a cow or horse on each 1½ acres during the summer grazing season.

A silty phase of this soil occupies 4 or 5 small bodies in the Missouri River bottom lands. The largest includes only about 300 acres. This soil resembles typical Sarpy very fine sandy loam except that its topsoil and upper subsoil layer are composed largely of silt. It occurs principally in overflow channels which have been rather recently filled with silt. Practically all the soil is covered with a dense growth of willows and is included in pasture land.

Sarpy sand.—Sarpy sand occurs adjacent to the channels of Missouri and Niobrara Rivers and Verdigris Creek. It consists of loose gray sand or a mixture of sand and gravel. In most places it resembles river wash, but it is more stable and is not so greatly influenced by each slight rise of the streams. It differs from Sarpy very fine sandy loam principally in having a coarser texture. The soil supports a fairly dense growth of willow and cottonwood trees which are used to some extent in local buildings but are of value chiefly for posts and fuel. None of this soil is farmed.

River wash.—River wash consists of sand bars, islands, and flats adjacent to or within the channels of Niobrara and Missouri Rivers. Only the larger areas are shown on the soil map. This material differs from Sarpy sand chiefly in its less stable character. It lies only a few inches above the normal level of the water and undergoes change with each slight rise of the stream. Even during normal flow the material is shifted about, added to, or carried away by the varying current. It represents the first stages of alluvial-soil formation and with the general accumulation of organic matter will develop into Sarpy soil. Most of the land supports a fairly dense growth of small willow trees and is either used for pasture land or is regarded as waste land

SOILS AND THEIR INTERPRETATION

The soils, with few exceptions, have developed under a grass vegetation and also under a temperate subhumid climate which has favored rapid decay of the dead grass roots. All the soils, except those on the steeper hillsides or on recently exposed or recently deposited light-colored materials, have accumulated enough black organic matter to darken their surface layers. The dark layers are moderately granular or crumblike in structure, especially in the finer textured soils.

The mean annual precipitation has not been sufficient to leach the readily soluble salts from the entire soil profile except in the more sandy areas and in a few areas which are favorably situated to receive run-off from higher levels. Throughout most of the county the easily soluble salts, chiefly lime carbonate, have been leached only from the upper part of the solum and have accumulated in the lower part, forming a layer of higher lime content than occurs in any other part of the soil or in the parent material. This layer is commonly known as the lime zone.

In addition to the dark surface layer and the lime-zone layer, the more extensive soils have developed layers, or horizons, all of which lie parallel to the surface of the ground, occur in a definite sequence from top to bottom, and differ from one another in some important characteristic, such as color, texture, structure, chemical composition, or compaction. The number of layers in a particular soil, as well as the stage of development attained by them, depends largely on the surface features and drainage conditions under which the soil has developed and on the character of the geologic materials from which it has weathered. As a rule, the layers are most pronounced and numerous in those soils which have been least disturbed by erosion and have lain in their present positions for the longest time. They are also more pronounced and numerous in soils which have developed from loess than in those developed from sandy or clayey formations in comparable topographic situations.

The county as a whole is rather severely eroded, and several geologic formations are exposed. Only a few of the soils can be regarded as having received the full impress of their climatic and vegetal environment, and all of these are developed from the loess formation which is the least resistant to weathering. The deep phases of the Moody soils, in the more nearly level though well-drained parts of the loess-covered uplands, and the Hall soils, on the well-drained loessial terraces, are representative of these soils. They have developed under conditions most favorable for prolonged and deep soil weathering and have very similar profiles.

The following description of a profile of Moody silt loam, deep phase, which was observed in an excavation on the high table west of Wausa in the southeastern part of the county, is regarded as typical for these soils:

- A₁. 0 to 2 inches, grayish-brown structureless silty very fine sandy loam thickly matted with grass roots.
- A₂. 2 to 4 inches, very dark grayish-brown faintly laminated or structureless friable silt loam. The material shows practically no change in color when crushed.
- A₃. 4 to 8½ inches, very dark grayish-brown granular silt loam, in which the granules are only fairly well developed, are small, rather angular, and very fragile. The material shows no change in color when crushed.
- A₄. 8½ to 13 inches, dark grayish-brown granular silt loam, in which the granules are poorly developed, vague in outline, of irregularly angular shapes, and average about one-eighth inch in diameter. When crushed the material is grayish brown.
- A₅. 13 to 19½ inches, grayish-brown structureless silt loam which is slightly heavier than the material in the layer above.
- B₁. 19½ to 43 inches, grayish-brown heavy silt loam of a slightly lighter shade than that in the layer above. The material is structureless but contains numerous borings and a few worm casts. Most of the borings extend vertically, and their exteriors, as well as those of the casts, are slightly darker than their interiors. All the material when crushed is light grayish brown.
- B₂. 43 to 56 inches, grayish-brown moderately compact silty clay loam. This is the layer of maximum density, but the compaction is scarcely noticeable except through comparison with the material in other layers. Borings are few and scattered.
- B₃. 56 to 72 inches, the zone of maximum carbonate enrichment. The material is light grayish-brown floury structureless silt. Lime occurs in small rounded concretions, from one-eighth to one-fourth inch in diameter, and in finely divided form thoroughly mixed with the silt.

- O. 72 to 96 inches, the material is the same as in the layer above, except that carbonate concretions are very scarce and most of the lime is disseminated.
- C. 96 to 120 inches, raw loess which consists of pale-yellow floury silt or very fine sandy loam. Lime is abundant, but it is all in disseminated form.

The organic matter in the soils represented by this profile decreases gradually with depth. In the surface layer, to a depth of 6 or 8 inches, it appears to be evenly distributed throughout the soil mass, but below this depth it occurs chiefly as a film or coating on the surfaces of the structure particles. The film practically disappears about 50 inches beneath the surface of the ground.

The borings mentioned in connection with the B₁ horizon are crooked rodlike soil forms about one-fourth inch in diameter and of different lengths. They probably represent fillings in old root, worm, or insect holes.

As indicated in the profile description, the carbonates have accumulated below a depth of 4 feet. Although this depth to lime is characteristic of all deep phases of the Moody soils and of the Hall soils, it is much greater than in any of the more rolling loess-derived soils of the uplands because more of the moisture sinks into the ground on the more nearly level than on the less even surfaces, and consequently the readily soluble lime is leached to a greater depth.

The second most extensive soil is Moody silt loam. This soil, although developed from loessial material similar to that underling the deep phases of the Moody soils, occupies the gently or strongly rolling parts of the uplands where more of the precipitation is lost as run-off, and erosion is somewhat greater than on the deeper Moody soils. The topsoil is as dark and apparently as well supplied with organic matter as that of the deep phase of Moody silt loam, but it is much thinner, and the zone of maximum carbonate enrichment lies much nearer the surface of the ground than in the deep phase.

Following is a description of a typical Moody silt loam profile as observed in the uplands north of Bloomfield:

- A. 0 to 10 inches, very dark grayish-brown friable and practically structureless silt loam. The material gives a faint lime reaction at a depth of 6 inches and contains scattered rounded lime concretions from one-eighth to one-fourth inch in diameter in the lower 2 inches of the layer
- B. 10 to 32 inches, floury structureless silt loam. The material is grayish brown in the upper one-fourth of the layer and pale grayish yellow in the remainder. It contains numerous carbonate concretions similar to those in the lower part of the overlying layer, also an abundance of finely disseminated lime.
- C. 32 to 96 inches, raw loess. The material is similar to that in the lower part of the B horizon, except that the concretions are fewer, and they disappear below a depth of 52 inches.

In this profile it is not possible to distinguish any differences in the relative compaction of the different layers, but the zone of lime enrichment is very pronounced and stands out sharply in the soil profile, owing to its high concretionary content. It differs somewhat in thickness and in its depth below the surface of the ground in different localities, but it is everywhere present within a depth of 3 feet.

The Marshall soils, as mapped in this county, are not typical of Marshall soils in other counties in Nebraska and Iowa. They have developed from upland loess but occur within and around the edges of sandy soil areas, and the loessial material has become mixed with an abundance of wind-blown sand, especially in its surface layer. In addition the Marshall soils in this county generally occur where the loessial material is unusually thin and rests on sand within a depth of 3 or 4 feet. The topsoils are as dark as in any of the Moody soils. They range in thickness from 8 to 14 inches and in texture from fine sandy loam to loamy sand. The upper part of the subsoil is brown silt loam or very fine sandy loam, and the lower part, to the underlying gray sand, is very light grayish-brown floury loesslike silt. The entire soil profile is practically structureless, and as a rule the different horizons are poorly defined. The rather sandy topsoils rapidly absorb the precipitation but are able to retain only a small amount of it. Downward percolating water enters and passes through the subsoil in larger quantities than it does in the corresponding layer of any Moody soil and has removed all the readily soluble carbonates beyond a depth ranging from 8 to 10 feet, possibly to the ground water table, because the porous sands beneath the thin loessial covering offer little resistance to the removal of the lime.

The Knox soils are the most severely eroded loess-derived soils. They occupy the more hilly areas, the sharper ridge crests, and the steeper slopes in nearly all parts of the loess-covered uplands. Rapid surface run-off has removed the products of soil development almost as fast as formed, and the parent loessial material is kept at or near the surface of the ground. The topsoils, where present, are in general rather low in organic matter, being brown or grayish brown, and in few places do they exceed 5 or 6 inches in thickness. They rest on light-gray limy loess similar to that beneath the lime zone of the Moody soils. Lime concretions are very scarce or absent in the parent loess. In numerous places the topsoil layer has been removed, and the parent limy loess is exposed.

The Crofton soils, which have also developed from loess, are only slightly less severely eroded than the Knox soils. Their topsoils in most places are slightly thicker than those of the Knox soils but, as in all severely eroded soils, have been removed in places. However, erosion has not greatly affected the subsoils, and a pronounced lime zone layer characterized by an abundance of rounded lime concretions, similar to those in the Moody soils, nearly everywhere occurs just beneath the thin topsoil, or, where the topsoil has been removed, at the surface of the ground. The parent limy loess lies beneath the lime zone.

Scattered throughout the more nearly level parts of the Moody soils and occurring locally on loessial terraces, are a few small basin-like depressions, in which the soil is classed with the Butler series. Water accumulates in most of the basins after rains and in some of them covers the surface of the ground for several weeks. Downward percolation is excessive, and its results are pronounced.

The topsoil is friable or only slightly compact and in a few places exceeds 6 inches in thickness. It is variable in structure but in most places is more or less laminated and in few places contains a pronounced granular layer. The upper one-

half or three-fourths of the layer has an almost black basic color but is everywhere sprinkled with light-gray or almost white floury silt, from which the organic matter has been leached. The lower part of the topsoil may or may not be dark, its color depending on the amount of leaching to which it has been subjected, and it may range from almost black to white. Where unusually light in color, the material is nearly everywhere laminated. The subsoil is a true claypan which ranges in thickness from less than 18 inches to more than 4 feet and in color from almost black to dull gray. The thicker and lighter colored claypan usually occurs in the deeper and more poorly drained basins or parts thereof and in most places contains numerous rust-brown spots, specks, and splotches. The high clay content of this layer is probably owing largely to the downward translocation of the finer topsoil particles and their accumulation in the subsoil. A zone of lime enrichment may or may not occur beneath the claypan layer, but does in most places, especially in all areas where the claypan is less than 30 inches thick. The lime zone averages about 15 inches thick and consists of floury light-gray silt in which the lime occurs chiefly in small rounded concretions. In the deeper basins the material beneath the claypan resembles the gray upland loess of the region, except that it has been leached of its lime beyond a depth ranging from 10 to 12 feet.

A few small areas of soil have developed on materials recently removed from the uplands by surface wash or colluvial action and deposited near the bases of the more gradual slopes on narrow valley floors or on gently sloping terraces. These deposits are dark and silty, having been derived principally from the surface layers of the dark-colored loessial soils of the uplands. They are of such recent age that the soils developed from them have not acquired definite horizons, or layers. These soils are classed with the Judson series. They are very dark grayish brown or black, have no definite structure, and are uniform in color and texture to a depth below 3 or 4 feet. They are very low in lime.

The Dickinson, Valentine, Shelby, and O'Neill soils have developed from sandy or gravelly material which, prior to its exposure, was covered by gray upland loess. The first three soils named occupy upland positions and have developed in place, and the O'Neill soils are on terraces. The coarse-textured material is very resistant to weathering and in some places is subject to considerable wind erosion.

The Dickinson, O'Neill, and Valentine soils are composed almost entirely of fine sand and medium sand. The Shelby soils have weathered from glacial deposits and in addition to sand contain considerable gravel and some silt and clay. None of these soils has developed definite horizons, or layers, of true soil character, and all of them have been leached of their carbonates. The Dickinson, O'Neill, and Shelby soils have been least affected by the wind and have accumulated considerable organic matter in their surface layers which as a rule are very dark and from 8 to 15 inches thick. The organic content in few places is sufficient to prevent the soils from drifting when the native sod is destroyed, and only the Shelby loam, which contains the largest quantity of fine mineral particles,

is stable under cultivation. The Valentine soils have been subjected to considerable wind erosion which has prevented the accumulation of much organic matter, as evidenced by their grayish-brown and comparatively thin topsoils. The subsoils, in all except the Shelby soils, which are composed of a rather coherent brownish-colored mixture of silt, clay, sand, and gravel, consist largely of loose incoherent gray sand.

Table 5 gives the results of mechanical analyses of samples of several soils.

TABLE 5.—Mechanical analyses of several soils in Knox County, Nebr.

Soil type and sample no	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
Moody silt loam, deep phase								
377008	0-2	0	0	0	0 3	1 6	44 0	53 4
377009	2-5	1 2	2 9	1 6	1 6	1 6	37 0	54 2
377010	5-19	1 1	3 4	2 0	2 0	2 5	33 8	55 3
377011	19-33	1	1 2	1 1	2 6	6 2	37 8	61 0
377012	33-50	1	6	1 1	3 5	12 4	46 2	36 0
377013	50-68	0	1	1	4	7	47 4	51 2
377014	68-96+	3	3	1	3	10 4	58 2	30 3
Knox silt loam								
377076	0-4	3	3	2	7	8 6	56 6	33 2
377077	4-25	6	2	1	2	7 6	60 5	30 9
377078	25-72+	0	0	0	1	7 8	62 0	30 2
Boyd clay loam								
377079	0-7	3	1 4	4 0	7 8	2 4	20 5	63 6
377080	7-20	3	1 1	1 8	3 6	1 2	15 5	76 4
377081	20-38	1	3	3	0	2	10 1	88 3
377082	38-43	0	1	1	2	1	9 5	89 9
377083	43-62	3	8	7	1 3	6	11 5	84 9
377084	62-96	2	3	1	3	4	11 3	87 4
Boyd clay								
377085	0-2	2	7	1 0	2 4	8 5	48 2	38 9
377086	2-14	6	1 5	1 9	3 3	6 6	37 6	48 5
377087	14-33	5	1 4	1 7	3 1	5 4	28 2	59 7
377088	33-72+	1	2	4	1 2	3 0	20 6	74 5
Holt fine sandy loam								
3770100	0-2	1	1 1	6 5	24 4	19 2	29 4	19 3
3770101	2-10	1	1 3	9 2	35 3	13 7	21 1	19 2
3770102	10-18	0	9	8 0	38 8	15 0	13 2	18 9
3770103	18-30	1 4	3 5	12 6	46 5	20 4	9 5	9 0
3770104	30-48+	6	2 3	11 7	45 0	24 3	10 1	6 0

Table 6 gives the pH values of several soils, as determined by the hydrogen-electrode method.

TABLE 6.—pH determinations of several soils in Knox County, Nebr.

Soil type and sample no	Depth	pH	Soil type and sample no	Depth	pH
Moody silt loam, deep phase			Boyd clay loam—Continued		
377008	0-2	7 17	377081	20-38	8 35
377009	2-5	6 57	377082	38-43	8 42
377010	5-19	6 10	377083	43-62	8 59
377011	19-33	6 52	377084	62-96+	8 19
377012	33-50	7 27	Boyd clay		
377013	50-68	8 09	377085	0-2	7 17
377014	68-96+	8 25	377086	2-14	7 48
Knox silt loam			377087	14-33	8 33
377076	0-4	8 19	377088	33-72	9 15
377077	4-25	8 27	Holt fine sandy loam		
377078	25-72+	8 35	3770100	0-2	7 96
Boyd clay loam			3770101	2-10	7 41
377079	0-7	7 72	3770102	10-18	7 15
377080	7-20	8 33	3770103	18-30	8 60
			3770104	30-48+	8 75

SUMMARY

Knox County is in northeastern Nebraska. It is roughly rectangular and comprises 1,119 square miles, or 716,160 acres.

It is part of a broad plain ranging from nearly level to hilly, and sloping gently downward toward the south and east. About 90 percent of its area is upland, and most of the remainder is alluvial land. Missouri River is deeply entrenched along the northern edge, and nearly all the local drainage flows northward to that stream. Most of the upland area has been rather severely eroded, and the county includes a wide variety of wind- and water-formed physiographic features. The roughest sections are in the northern part and around the headwaters of Verdigris Creek in the southwestern part. The most nearly level parts of the uplands are on the high loess-covered tables north of Crofton, west of Wausa, and in the vicinity of Winnetoon. All the alluvial lands are nearly level. With the exception of scattered depressions throughout the uplands and local areas in the bottom lands, all the land is well drained.

The average elevation is about 1,600 feet above sea level, and the range in elevation is about 780 feet. The first permanent settlement was made near the present site of Niobrara in 1856. The population in 1930 numbered 19,110, all of which is classed as rural.

Transportation facilities are fair. The county is crossed in a north-south direction by a branch line of the Chicago & North Western Railway, and railroad branches terminate at Crofton and Bloomfield. Two gravel-surfaced highways extend north and south across the county, and the earth roads are kept in good repair.

The public-school system is highly developed, and telephone lines and rural delivery mail routes reach nearly all sections.

The climate is typical of northeastern Nebraska and is well suited to grain growing and livestock raising. The mean annual temperature, as recorded at Santee, is 49.1° F., and the mean annual precipitation is 24.10 inches. The average length of the frost-free season is 151 days.

Knox County is essentially agricultural. The 1930 Federal census reports 61.3 percent of the farm land classed as crop land and used principally in the production of grain, tame hay, or wild hay; 34.1 percent used as pasture land; 0.6 percent included in woodland not pastured; and 4 percent in other land. The leading crops are corn, oats, prairie hay, and alfalfa, ranking in acreage in the order named. The value of all crops produced in 1929 was \$5,833,294, and the total value of all domestic animals on farms was \$6,271,878.

The average size of the farms in 1930 was 258 acres. However, there are many small holdings and a few large ranches including more than 1,000 acres.

In general, farm laborers are plentiful.

Cattle and hogs are the chief sources of revenue, and practically all the corn, oats, and alfalfa produced is used in raising and fattening these animals for market. Some wheat is sold for cash, but the total area devoted to this crop does not exceed 3,000 acres. Most of the cattle and hogs are sold in the Omaha and Sioux City markets.

The cultivated soils, although not equally productive, are as a whole well suited to the production of one or another of the feed crops most commonly grown. The soils classed with the general-farming group, including the Moody, Marshall, Hall, and Judson soils, and the terrace phase of Boyd clay loam, occupy the greater part of the cultivated land, are highly productive, and are admirably adapted to all crops suited to the climate. All these soils, except the terrace phase of Boyd clay loam, which is composed principally of clay and is rather compact, consist largely of loose friable silt and are easily maintained in good tilth. The Moody and Marshall soils occupy nearly level or rolling upland areas, the Hall soils and the terrace phase of Boyd clay loam are on terraces, and the Judson soils occur chiefly on gradual colluvial slopes. All these soils are well drained, have deep dark-colored topsoils, and are highly retentive of moisture. About 90 percent of the area occupied by them is under cultivation, corn being grown on about 50 percent, oats on about 35 percent, and alfalfa on about 10 percent of the cultivated land. The remainder is used chiefly for sweetclover, although barley, wheat, and rye are grown in small fields on many farms. The rather uniform crop yields are not quite so high, especially those of corn and alfalfa, as those obtained on the best bottom-land soils, but they exceed those on any of the more sandy upland and terrace soils.

The soils classed as the corn and sweetclover soils include the Dickinson and O'Neill soils. These soils are composed largely of sand but have accumulated considerable organic matter and have topsoils almost as deep and dark as those of the soils in the general-farming group. The Dickinson soils occupy nearly level or gently rolling uplands, and the O'Neill soils occur on nearly level terraces. These soils occur principally in the western part of the county, and, although they are much less extensive than the general-farming soils, they are nearly all under cultivation. Corn and sweetclover are grown chiefly, corn occupying about 80 percent and sweetclover about 10 percent of the area occupied by soils of this group. The Dickinson and O'Neill soils are less retentive of moisture, therefore are less productive than any of the general-farming soils. They are not so well adapted to small grains and alfalfa as the general-farming soils, on account of their higher sand content, but they return good yields of corn and sweetclover in all but the driest years.

The group of corn and alfalfa soils includes the Lamoure, Wabash, and Cass soils, all of which occupy first-bottom or flood-plain positions. The moist conditions prevailing in the flood plains have especially favored vegetal growth and decay, and the soils of this group have very dark colored topsoils, owing to an abundance of organic matter. The Lamoure and Wabash soils have developed from silty stream sediments and are fine textured throughout. The Lamoure soils contain an abundance of lime, and the Wabash soils are rather low in this constituent. The Cass soils have developed from coarse-textured sediments and are composed largely of sand and gravel. They may or may not contain lime. Except in spots, the soils of this group are sufficiently drained for cultivation, and about 95 percent of the cultivated land is used for corn and alfalfa in the proportion of about 8 acres of corn to 1½ acres of alfalfa. The

remaining 5 percent is used for sweetclover, red clover, barley, or clover and timothy mixed.

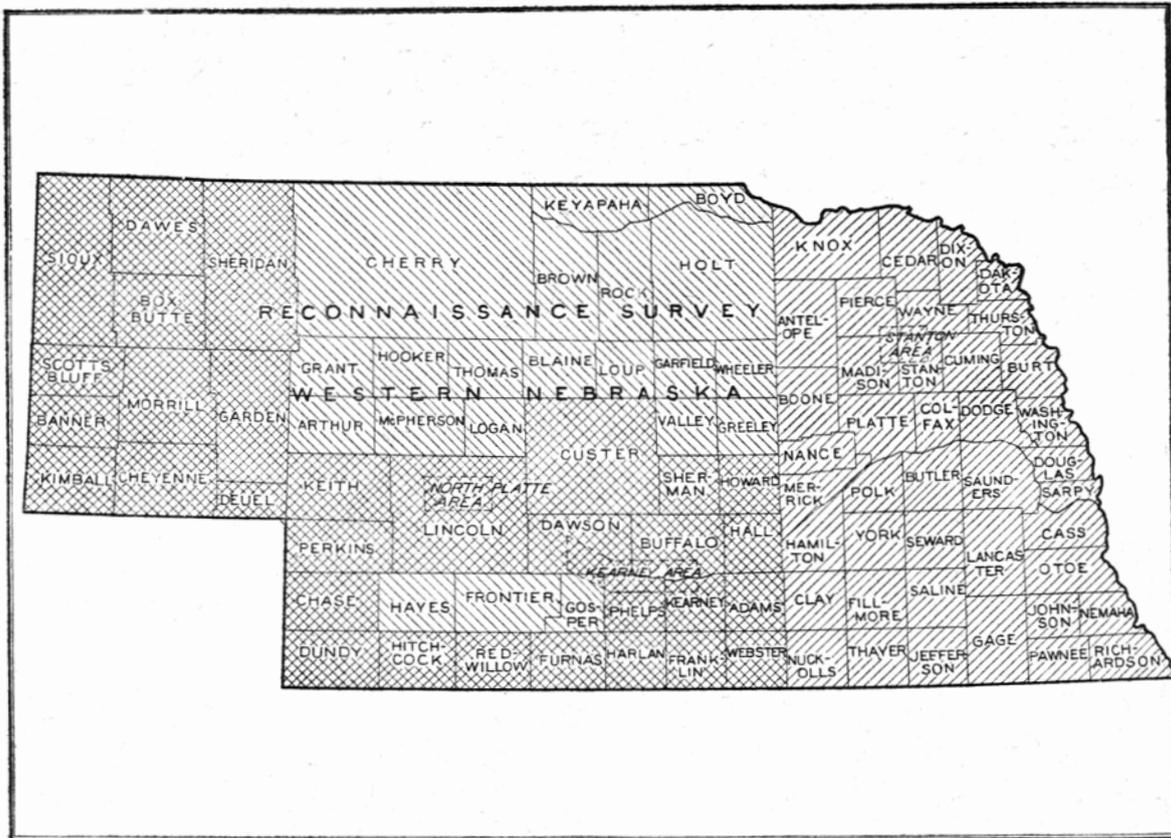
The high organic-matter and moisture supplies render the soils of this group especially adapted to corn. The moisture supply is also very favorable to alfalfa, and both corn and alfalfa yield higher on these soils than on any other. Small-grain crops grow well but have a tendency to produce a rank vegetal growth with long weak stems which break and lodge during windy weather. In addition small grains usually mature late and yield rather low. They are of slight importance on any of the bottom-land soils.

The soils classed with the native pasture and hay group include the Knox, Crofton, Boyd, Holt, Sogn, Valentine, Shelby, Sarpy, and Butler soils, all of which occupy upland positions, except the Sarpy soils which occur in the bottom lands. Most of these soils include some land which is under cultivation, but the greater part of nearly all of them is either too rough, sandy, poorly drained, or too heavy and intractable to be profitably farmed. Therefore this land is used for native pasture or hay land. The Knox, Crofton, and Butler soils are composed largely of silt, but the Knox and Crofton soils are severely eroded, and the Butler soils are very poorly drained. The Valentine and Sarpy soils consist almost entirely of incoherent gray sand and are rather unstable, and the Valentine soils are droughty. The Boyd soils are composed chiefly of clay, and, except where their heavy texture is modified by mixtures of silt or sand these soils are extremely difficult to cultivate. Most of the area occupied by the Shelby soils is very gravelly and rather droughty. The Holt and Sogn soils are characterized by numerous exposures of hard bedrock, and only a small percentage of the area occupied by them can be farmed. Nearly all the soils of this group have thin topsoils and are low in organic matter, but most of them support a good growth of prairie grasses and are valuable grazing land.



Authority for printing soil survey reports in this form is carried in the Appropriation Act for the Department of Agriculture for the fiscal year ending June 30, 1933 (47 U. S. Statutes, p. 612), as follows:

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 soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than 250 copies shall be for the use of each Senator from the State and not more than 1,000 copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in Nebraska shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; crosshatching indicates areas covered in both ways.

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