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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Keya Paha County, Nebraska

By

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United States Department of Agriculture

and

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Nebraska Soil Survey

Bureau of Chemistry and Soils

In cooperation with the
University of Nebraska State Soil Survey
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SOIL SURVEY OF KEYA PAHA COUNTY, NEBRASKA[1]

By W. D. LEE, in Charge, F. A. HAYES, and S. R. BACON, United States Department of Agriculture, and R. H. LOVALD, Nebraska Soil Survey

COUNTY SURVEYED

Keya Paha County is in northern Nebraska, adjoining South Dakota (fig. 1). Springview, the county seat, is in the central part of the county, about 170 miles northwest of Sioux City, Iowa. The shape of the county is roughly rectangular, although its southern boundary, formed by Niobrara River, is very irregular. The distance from east to west is 48 miles, the average width from north to south is about 16 miles, and the total area is 775 square miles, or 496,000 acres.

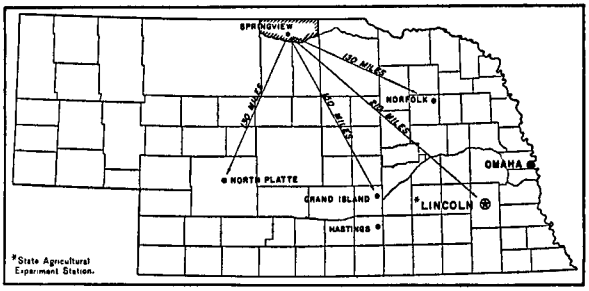

FIGURE 1.—Sketch map showing location of Keya Paha County, Nebr.

The county lies in the high plains section of the Great Plains physiographic province. It is part of a formerly smooth to rolling plain which was capped by soft light-gray, for the most part limy, sandstone containing harder beds in places. Successive periods of erosion by wind and water, extensive deposition of sand, gravel, and silt, and again severe erosion have modified considerably the surface of the former plain. The valley slopes and adjacent uplands on the north sides of Niobrara and Keya Paha Rivers, in the southern and northeastern parts of the county, have the most broken relief. These rivers and their tributaries have removed most of the sandstone and surface deposits of sand, gravel, and silt and are deeply entrenched in the underlying Pierre shale which is the lowest formation exposed in the county. There is an intricate system of deep, steep-sided drainageways separated by narrow divides. In places differences in elevation exceed 200 feet within a distance of 100 rods.

[1] Report written by F. A. Hayes.

Sandstone is exposed around the heads of many drainageways, occurs as remnants on most of the higher and narrower divides and in the Niobrara River Valley west of Meadville, and outcrops for a considerable distance down the valley slopes. Some of the exposed sandstone exposures are almost perpendicular. Nearly vertical exposures of the Brule formation, a light-gray chalk lying between the sandstone and shale formations, also occur on the Niobrara River Valley slopes.

Aside from the rough and broken areas north of these two rivers, the relief of the uplands for the most part ranges from nearly level to rolling. However, there are numerous stony areas throughout the uplands, rising from 50 to 100 feet above the surrounding plain, and small scattered areas of hilly land developed on Pierre shale or on sand. Most of the elevated stony areas are isolated hills covering less than 400 acres each, but some occupy more than 2 square miles. They are capped by remnants of the harder sandstone beds, which have resisted erosion. Many of them are buttelike and have rather flat tops.

Most of the hilly areas developed on Pierre shale are in the eastern part of the county in and around margins of the miscellaneous land classification, rough broken land, and they lie from 30 to 50 feet below the general level of the plain. Surface run-off is rapid, and erosion is severe. Drainage channels are less deeply entrenched, divides are lower and more rounded, and the surface features in general are less harsh and angular than in the areas of rough broken land. In most places the land surface is not too rough for the use of farm machinery.

Hilly areas of dune sand are scattered throughout most of the uplands. These areas consist of incoherent sand piled by the wind into dunes ranging from 25 to 50 feet in height. Drainage channels are not established, owing to rapid absorption of water by the porous sand.

The largest nearly level area in the uplands is a broad strip, ranging from 5 to 8 miles in width, extending from northwest to southeast between Norden and the vicinity of Springview. It has a gradual eastward slope, but the differences in elevation do not exceed 20 feet. Most of this area is gravelly. Smaller nearly level areas, thinly capped with light-colored loesslike silt which, where present, overlies the sand and gravel deposits and is the topmost formation in the county, occupy the highest parts of the upland in the vicinities of Jamison and Brocksburg, southeast of Springview, south of Norden, and northeast of Carns.

Alluvial soils include the terraces and bottom lands along streams. The terraces are at different levels ranging from 10 to 60 feet above the stream channels, are not subject to overflow from the main streams, and are well drained. The bottom lands have a high water table, in many places are rather poorly drained, and a part of them are subject to overflow during periods of high water. Numerous slightly depressed and poorly drained areas throughout the sandy uplands are classed as bottom land in this county on account of their

similar soil. The surface of the alluvial lands is nearly level, except on a few of the more sandy terraces where the wind has produced low hummocks and locally in the bottom land where the generally smooth surface is modified by old or active stream channels, slight elevations, and shallow depressions.

The elevation of Keya Paha County averages about 2,100 feet above sea level. The highest point, approximately 2,600 feet, is in the uplands northwest of Norden; and the lowest point, approximately 1,750 feet, is at the place where Niobrara River crosses the eastern county line. The elevation of Springview as recorded by Barbour [2] is 2,550 feet. Niobrara River has a fall of 8 or 10 feet a mile across the county.

Drainage is eastward through the Niobrara and Keya Paha Rivers and their tributaries. The drainage pattern, where well developed, is dendritic (treelike). In the north-central and northwestern parts of the county, however, there are large areas in which surface drainage is not established, because all surplus water is absorbed by the sandy surface soils and subsoils. In the eastern and southern parts of the county the streams have steep gradients and are rapidly deepening their valleys. Elsewhere they flow through shallow meandering valleys and are in places filling their channels. Except for parts of the bottom lands and depressions throughout the uplands, the land is well to excessively drained. Run-off is rapid, and erosion is severe throughout most of the eastern part of the county and in a strip a few miles wide north of Niobrara River in the southern part.

An abundance of good well water is readily obtainable at depths ranging from 80 to 150 feet throughout the uplands, except in places where the Pierre shale is at or near the surface. Water is scarce and more or less salty in this shale, and in the northeastern part of the county, where it outcrops extensively, considerable difficulty is experienced on some farms in obtaining suitable well water. The wells in the alluvial lands range from 10 to 60 feet in depth, depending on the thickness of the alluvial deposits. They usually furnish an adequate supply of good water. Flowing or seepage springs occur on the valley slopes along Niobrara and Keya Paha Rivers and some of their larger tributaries. Most of the spring water, which is of good quality, issues from the bottom level of the layers of sand or gravel immediately overlying the Pierre shale.

The native vegetation is predominantly grass. On the finer textured soils of the uplands and terraces, the leading grasses in virgin areas are little bluestem, grama, buffalo grass, and wheatgrass. On the more sandy soils, big bluestem, and *Stipa*, or needlegrass, predominate. On the bottom lands and in scattered depressions throughout the uplands, are many different moisture-loving grasses, except in local poorly drained places where rushes and sedges grow. A thin native forest of elm, ash, bur oak, hackberry, boxelder, cottonwood, and willow grows on the slopes or adjacent to the stream

[2] BARBOUR, E. H. ALTITUDES IN NEBRASKA. Nebr. State Bd. Agr. Ann. Rept. 1900: 169–180.

channels in most of the larger valleys, especially along Niobrara and Keya Paha Rivers. Fairly thick stands of western yellow pine also grow on the Niobrara Valley slopes. The trees are used mainly for posts and fuel, especially in the western part of the county.

The first permanent settlements in the area now included in the county were made near the mouth of Wyman Creek in 1871. The early settlers came largely from eastern and southeastern Nebraska. They located in unorganized territory which was made a part of Brown County in 1883. Keya Paha County was separated from Brown County and organized in 1885. Its boundaries have remained unchanged.

According to the Federal census, there were 3,920 inhabitants in the county in 1890, 3,076 in 1900, 3,452 in 1910, 3,594 in 1920, and 3,203 in 1930, or 4.1 persons a square mile. All are classed as rural. Population is densest in the vicinity of towns and in the Niobrara and Keya Paha River Valleys. Fewer people live on the sandy tableland in the north-central and northwestern parts of the county and on the areas of rough broken land north of Niobrara River.

Springview is the county seat and largest town. It has a population of 307. The other villages, Burton, Brocksburg, Mills, Meadville, and Norden, each with less than 100 inhabitants, are well distributed throughout the county and furnish local markets for a part of the farm products and supplies.

The public-road system is fairly well developed. United States Highway No. 83, running north and south, crosses the central part of the county, and State highways cross the southwestern and northeastern parts. These roads are surfaced with gravel. The county roads are of earth construction, and the more important ones are kept in good repair. They follow section lines, except in the rougher parts where they conform to the topography. Several bridges cross the Niobrara and Keya Paha Rivers. The county has no railroad.

Rural mail delivery or star mail routes reach nearly all parts, and telephones connect many of the farms and ranches. The public-school system is well developed.

CLIMATE

The climate is continental and is characterized by rather high summer and moderate to low winter temperatures. The spring is usually cool and rainy, the fall season long and only occasionally rainy. There is not enough variation in elevation or relief to cause any pronounced difference in local climatic conditions.

Complete Weather Bureau records are not maintained in the county. However, the climatic conditions are probably between those given in tables 1 and 2, compiled from the records of the United States Weather Bureau stations at Valentine and Butte, which are about 42 miles west and 48 miles east, respectively, of Springview.

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

[Elevation, 2,598 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1929)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	24.6	72	−34	0.61	0.05	0.41	5.0
January	18.9	68	−38	.48	1.09	1.13	5.8
February	21.4	69	−37	.55	.53	1.03	5.8
Winter	21.6	72	−38	1.64	1.67	2.57	16.6
March	32.3	87	−26	1.02	1.08	2.56	8.8
April	45.7	94	0	1.85	2.00	2.44	4.7
May	56.2	97	17	2.82	.17	3.08	1.1
Spring	44.7	97	−26	5.69	3.25	8.08	14.6
June	66.9	104	32	2.87	2.36	3.69	0
July	73.7	107	39	3.01	.97	5.49	.0
August	71.7	103	36	2.17	.33	2.60	.0
Summer	70.8	107	32	8.05	3.66	11.78	.0
September	62.5	102	21	1.30	.36	2.10	(1)
October	49.3	95	5	1.10	1.01	3.01	1.6
November	34.6	79	−18	.56	.19	1.37	4.8
Fall	48.8	102	−18	2.96	1.56	6.48	6.4
Year	46.5	107	−38	18.34	10.14	28.91	37.6

[1] Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Butte, Boyd County, Nebr.*

[Elevation, 1,900 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1929)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	22.8	72	−29	0.59	0.57	0.58	6.4
January	19.2	69	−36	.47	.94	1.16	5.3
February	23.5	71	−31	.70	.12	4.04	8.0
Winter	21.8	72	−36	1.76	1.63	5.78	19.7
March	35.3	92	−17	1.08	.09	2.37	7.9
April	48.0	99	5	2.49	1.20	3.06	3.6
May	58.3	98	14	3.23	1.48	5.74	.2
Spring	47.2	99	−17	6.80	2.77	11.17	11.7
June	68.9	108	35	3.95	2.37	7.56	.0
July	74.7	112	40	2.82	3.02	8.42	.0
August	72.5	106	30	2.31	1.02	1.72	.0
Summer	72.0	112	30	9.08	6.41	17.70	.0
September	63.5	102	23	2.16	1.12	3.21	(1)
October	51.0	97	2	1.69	.35	1.95	2.3
November	36.1	84	−10	.70	.20	.33	3.2
Fall	50.2	102	−10	4.55	1.67	5.49	5.5
Year	47.8	112	−36	22.19	12.48	40.14	36.9

[1] Trace.

About three-fourths of the mean annual precipitation falls during the growing season, April to September, inclusive. In summer the rainfall usually comes as heavy thundershowers, but torrential rains are rare. Droughts seldom occur in the spring, but during the summer dry spells are common, some of them lasting for several weeks.

The average date of the last killing frost is about May 6 and of the first, about October 2. This gives an average frost-free season of about 149 days, which is ample for the maturing of all farm crops commonly grown. During the 20 years from 1895 to 1914, however, there were 3 years in which killing frost occurred 10 or more days later in the spring and more than 5 years in which frost occurred 10 or more days earlier in the fall than the average date.[3] From October 1 to about 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. The relative humidity is regularly about 70 percent.

AGRICULTURE

Prior to 1870, the area now included in Keya Paha County was inhabited chiefly by Indians, trappers, and hunters. The early agriculture, beginning about 1871, consisted almost entirely of cattle raising. Water and grass were abundant; the rough forested land in the Niobrara and Keya Paha River Valleys afforded protection to the cattle during severe weather; there were no fences; the range was free; and cattle raising was very profitable. With the establishment of Fort Niobrara to the west in 1880 and the trail leading to this fort, the farming possibilities of this section became apparent. By 1885, farmers had taken up most of the better farming land under the Homestead and Timber Culture Acts, and by 1890 there were nearly 4,000 inhabitants in the county. Most of the larger cattle herds were moved farther west or north. Much of the land in the county is poorly suited to cultivation, and cattle raising, which is now conducted on fenced ranches, has remained the most important source of revenue.

Corn has been the most important cultivated crop since farming began. The acreage devoted to this crop, however, has always been exceeded by that used for native pasture and, except prior to 1890, by that used for wild hay. During the first few years, when wheat was needed for food and for cash, this crop ranked next to corn in acreage, but, when conditions became stable and more livestock feed was needed, the acreage in oats soon exceeded that in wheat.

The Federal census reports 571 farms in the county in 1935. These occupied about 95 percent of the total land area. Most of the farms range in size from 260 to 1,000 acres, and the average size is 825.4 acres. About 150 of them exceed 1,000 acres, and several include 5,000 or more acres. In 1929, crops were harvested on about 29 percent of the land. Wild hay occupied nearly half of the total crop acreage.

Farm buildings are fairly good. The houses, as a rule, are one-story wooden structures, and most of them are kept in good repair.

[3] REED, W. G. FROST AND THE GROWING SEASON. U. S. Dept. Agr., Off. Farm Management, Atlas of American Agriculture * * * pt. 2, Climate, sec. 1, p. 9 (Advance sheets no. 2), illus. 1918.

Barns and other buildings are usually large enough to house the crops, except hay, which is generally stacked in the field. The Nebraska agricultural statistics show that in 1930, 19 farmhouses had modern heating plants, 56 had running water, 54 were equipped with electricity, and 177 had radios. Farms and ranches are fenced and cross fenced, mainly with barbed wire. Work animals include heavy draft horses and mules, although some farmers use tractors and trucks for the heavier farm work. There were 100 tractors, 122 gas engines, 81 trucks, 554 automobiles, 22 grain threshers, and 2 combines on the farms in 1930. Farm machinery is of the most modern and labor-saving type.

Farm labor during the last few years has been plentiful and unusually cheap. Monthly wages range from $20 to $25 with board and lodging. Day labor is plentiful at $1 to $1.25. Corn shuckers receive 3 or 4 cents a bushel. Only a few farmers hire help.

The 1935 census shows that owners occupy 58 percent, tenants 41.2 percent, and managers 0.8 percent of the farms. According to the Nebraska agricultural statistics in 1930, 66 percent of the rented farm acreage was for cash and the remainder for a share of the crops. Under the cash system of rental, the tenant pays from $2 to $3 an acre for the better grade of farm land and $100 to $150 a section (640 acres) for pasture land. Under the share system, the owner receives one-third of the grain and usually one-half of the hay, and all labor, seed, and machinery is furnished by the tenant. Most tenants pay a lump sum for the use of pasture land and a share of the crop for the land used for hay.

The selling price of individual farms and ranches ranges widely, depending on the character of the soil, surface configuration, drainage, improvements, and location with respect to markets.

Livestock raising is the most important industry. The value of all domestic animals, poultry, and bees on farms April 1, 1930, was $2,126,417. Cattle represent about 76 percent of the value of livestock; horses, mules, and colts about 9.5 percent; and hogs about 10 percent. The remaining 4.5 percent represents the value of chickens, sheep, goats, and bees.

Table 3, compiled from the Federal census reports, gives the number and value of all domestic animals and poultry in the county in 1900, 1910, 1920, and 1930.

TABLE 3.—*Number and value of domestic animals and poultry in Keya Paha County, Nebr., in stated years*

Livestock	1900		1910		1920		1930	
	Number	Value	Number	Value	Number [1]	Value	Number [2]	Value
Cattle	26,886	----------	26,977	$623,945	31,643	$1,522,281	31,605	$1,622,659
Swine	8,694	----------	14,941	148,155	16,447	295,383	16,524	219,017
Horses	5,491	----------	7,294	669,508	7,822	365,413	4,730	190,819
Sheep	5,787	----------	326	1,616	219	2,174	6,131	43,376
All poultry	[3] 26,998	$8,932	32,104	14,371	41,846	27,892	[4] 44,077	33,499
Mules	211	----------	605	51,925	388	28,223	304	15,424

[1] Number on farms and ranges.
[2] Number on farms Apr. 1.
[3] Fowls 3 months old and over on farms and ranges.
[4] Chickens over 3 months old.

The livestock in general is of good quality. Most of the cattle are of grade stock, but the herds are generally headed by a purebred Hereford or Shorthorn bull. Practically all the beef cattle are raised locally. Most of them are shipped from the pastures as feeders when 2 or 3 years old to the Omaha or Sioux City markets. Only a few are fattened with grain.

Dairying receives little attention. Most farmers keep from 3 to 10 milk cows, most of which are of mixed beef and dairy breeds, but no farm is devoted exclusively to dairying. Surplus dairy products, mainly cream, are sold in the local markets.

Horses are raised on nearly every ranch in the county, and some ranches have herds of 50 or 60 head. The demand for horses, which had greatly declined following the World War, is now increasing, and horse raising is becoming very profitable. Practically all of the horses are of Percheron breeding. Most of them are used on local farms and ranches, though increasing numbers are being sold to farmers in eastern and southern Nebraska.

Nearly every farmer raises from 20 to 60 hogs. The principal feed for hogs is corn, although alfalfa is an important hog feed, especially in the bottom lands. Some oats are fed to young pigs. All the hogs are of good stock, and there are several purebred herds. Duroc-Jersey, Poland China, and Hampshire are the leading breeds. Practically all of the hogs are fattened on the farms where they are raised. They are sold in Omaha and Sioux City.

Poultry, mainly chickens, is raised on all farms, and many farmers maintain flocks of several hundred. The principal breeds are Plymouth Rock, Leghorn, and Rhode Island Red. Turkeys are raised in large or small flocks by many farmers and on some farms are an important source of income. Most of the poultry products are sold or are exchanged for farm supplies.

Practically all crops, with the exception of wheat, are used for feeding livestock or for home consumption. Prairie hay occupies the leading acreage, followed by corn, oats, alfalfa, rye, wheat, barley, sweetclover, and sorghum, ranking in acreage during most years in about the order named.

Table 4, compiled from Federal census data, gives the acreage of the principal crops in this county during the census years, 1889 to 1934, inclusive.

TABLE 4.—*Acreage of principal crops in Keya Paha County, Nebr.*

Crop	1889	1899	1909	1919	1929	1934 [1]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn	23,397	20,585	31,267	34,620	37,308	392
Oats	2,051	1,575	11,649	5,248	11,187	74
Wheat	3,702	8,531	8,662	4,548	1,215	55
Rye	3,627	638	2,113	7,811	4,837	160
Barley	90	319	654	805	1,564	60
Potatoes	427	262	378	260	262	43
All hay	14,615	23,781	57,333	76,830	74,735	42,281
Wild hay		21,774	51,133	62,039	62,175	39,860
Timothy			513	107		
Clover		1	26	122	965	109
Timothy and clover mixed			209	602	457	
Alfalfa		35	3,311	7,557	8,737	1,699
Millet and Hungarian grass		1,937	1,163			
Other tame grasses			674	5,343	1,700	
Grains and legumes cut for hay		34	304	1,060	701	613

[1] Acreage greatly reduced on account of drought in 1934.

Crop yields vary greatly from year to year, according to variations in the amount and distribution of the precipitation and in the length of the growing season. They also vary widely on different soils. Over the county as a whole, however, average yields of the different crops over long periods are fairly uniform.

Table 5, compiled from the Nebraska agricultural statistics, shows the average acre yields of the more important crops during the 19-year period 1912–30 and the approximate percentage of the land devoted to each crop in 1930.

TABLE 5.—*Average acre yields of the more important crops in Keya Paha County, Nebr., during the 19-year period 1912–30 and the approximate percentage of the land devoted to these crops and other uses in 1930*

Crop	Average acre yields (1912–30, inclusive)	Area in crop in 1930	Crop	Average acre yields (1912–30, inclusive)	Area in crop in 1930
	Bushels	*Percent*		*Tons*	*Percent*
Corn	20.3	8.5	Alfalfa	2.0	1.1
Spring wheat	9.8	.3	All other cultivated crops		1.1
Winter wheat	14.3	.1	Wild hay	.8	13.0
Oats	24.4	2.6	Range and pasture		[1] 59.7
Rye	12.5	1.4	Woodland not pastured		[1] .6
Barley	22.7	.5			
Potatoes	69.9	.1			

[1] Taken from the Federal census for 1930.

Soil management and cropping practices on the cultivated land of the county are similar to those generally followed throughout northern Nebraska.

Corn is planted in May, usually with a corn lister, as listed corn is thought by most farmers to be more drought resistant than that planted in checkrows. It is cultivated three or four times during the season and is laid by in July, receiving no further attention until harvest. The crop matures in September or early October. Most of it is husked from the standing stalks, and afterward cattle and horses are pastured on the fields. On most farms some corn is cut for winter fodder. Seed corn is not, as a rule, carefully selected, although most of it is gathered from corn which has been grown in the locality for several years and has become adapted to the local climate and soils. Corn usually follows wheat or oats in the rotations, except on sandy land unsuited to these crops, where it follows sweetclover or rye. Many farmers plant corn on the same land many years in succession.

Oats, the leading small grain, are mostly of the early maturing types. The Kherson variety or strains of it, such as Nebraska No. 21, are grown chiefly. The seedbed for oats generally is prepared by disking, although on the heavier soils plowing and harrowing may also be necessary. The seed is planted with a press drill early in April, and the better yields are obtained from early seeded oats. The crop matures in July and is cut with a binder or header, depending on the length of the stems. It is either shocked or stacked for threshing. This crop is seldom grown on the same land 2 years in succession. It generally follows corn, alfalfa, or sweetclover in the rotations. Most of the oats are fed on the farms where produced,

to work animals, colts, and calves. The straw has a rather high value for feed and is usually stacked at threshing time.

Spring wheat is planted at about the same time and in the same manner as oats, and winter wheat is planted in the fall. The wheat crop ripens and is cut and stacked or shocked in July. Most of it is sold immediately after it is threshed. Spring wheat occupies the greater acreage. Ceres and Marquis are the important spring varieties; and Turkey, Kanred, or improved strains of Turkey, such as Nebraska No. 60, are the favorite winter varieties.

Rye is planted on the more sandy soils where it is practically the only small-grain crop. Most of it is grown for grain, although some is used for temporary fall and spring pasture, especially for brood sows and pigs. When grown for grain, it is seeded and harvested in the same manner as winter wheat. The grain is fed chiefly to hogs. Rosen is the most popular variety of rye.

Barley occupies only a small acreage. This crop ranks next to corn in terms of feed produced an acre, and its acreage could be extended profitably, especially on the finer textured and well-drained soils. Feeding tests have shown that coarsely ground barley is 90 percent as good as corn in a fattening ration. The grain is planted early in the spring in the same manner as oats. Most of the barley is of the smooth-bearded varieties, such as Comfort and Glabron.

Alfalfa is the leading tame-hay crop. The seed commonly is broadcast on plowed, disked, and harrowed stubble land, early in the spring, often with oats or barley as a nurse crop. Nebraska-grown alfalfa seed is ordinarily used, and a field of alfalfa is allowed to remain as long as the yield is satisfactory. Yields in the uplands decrease more rapidly than those in the bottom lands. Corn or oats generally follows alfalfa in the rotations.

Sweetclover occupies only a small acreage. It is used chiefly for pasture and to some extent for hay. This crop has an unusually wide adaptation. It thrives on comparatively wet or dry soils and on soils of either heavy or light texture. It is very valuable for soil improvement, and its acreage could be profitably extended on both sandy and clayey soils. The roots are large, and they decay rapidly at the end of the second year's growth. This crop not only adds organic matter to the soil but, in common with other legumes, has the power of extracting nitrogen from the atmosphere and storing it in the nodules on its roots. It is a good soil builder and is especially valuable on unstable sandy soils or on soils subject to severe erosion. It also helps to loosen compact clayey soils because its roots, on decaying, leave an intricate network of passageways which increase the friability and aeration of the soil. The seedbed for this crop is prepared and the seed is planted in the same manner as for alfalfa.

Wild hay occupies nearly as large an acreage as all the cultivated crops combined. It is produced chiefly in the areas where the relief allows the use of farm machinery but where the soils are too sandy, unstable, or droughty for good yields of cultivated crops or are so heavy and intractable that they can be cultivated only with difficulty. Some wild hay is produced in local poorly drained areas on the bottom lands. The chief hay grasses on the sandy soils are *Stipa*, or needlegrass, and sandgrass, whereas the chief hay grasses on the silty or clayey soils are grama, wheatgrass, and little bluestem. The

poorly drained soils produce a rank growth of coarse, moisture-loving grasses which give the highest hay yields, but the hay produced on the uplands has a higher value for feeding. Most of the wild hay is stacked in the field and hauled to the feed lots as needed. Practically all of it is fed within the county to cattle and horses, generally on the farm where produced.

Commercial fertilizer is not used. The limiting factor in crop production throughout most of the county is moisture and not fertility of the soils. Some farmers apply barnyard manure to the bottom-land soils, and although it increases crop yields, the supply is seldom sufficient for more than a small part of the land. When applied to sandy soils of the uplands or terraces, the manure decomposes slowly in the rather dry surface-soil layers and does not greatly benefit the crops.

SOIL-SURVEY METHODS AND DEFINITIONS

In soil-survey procedure soils are classified according to those characteristics, both physical and chemical, which can be determined by observation, examination, and simple tests in the field.

Excavations are made at frequent intervals, and the nature of the soil is carefully observed. It will be noted that each excavation exposes a series of layers or "horizons", and the entire section from the surface down is known as the "soil profile." The classification is based on such internal characteristics of the soil profile as color, structure, and texture and such external features as drainage, relief, and stoniness. The vegetation—either native vegetation or farm crops—is observed, and its correlation with the soils is studied. In this way the natural productivity of the soil and its adaptation to various crops can be determined or estimated with a fair degree of accuracy. In classifying virgin lands which may be brought under cultivation, the observation of like soils now under cultivation is an important part of the work.

Three units are commonly used in the field mapping of soils: the series, type, and phase. Most important of these is the series, which is a group of soils having certain features in common, including color, structure, thickness, and chemical composition of the horizons of the soil profile, essentially the same natural drainage conditions, and in most instances similar relief and nature of parent material. The series are given geographic names taken from locations near which they were first identified. Valentine, Holt, O'Neill, Hall, Boyd, and Cass are names of soil series in Keya Paha County.

The soil texture—the size of the soil particles and the relative amounts of the particles of different sizes—may vary somewhat within a series. As texture is a characteristic that has importance in determining the use to which a soil is put and the ease with which it may be tilled, it is taken into consideration in soil classification. The soil types are classified according to the texture of the surface soil. Thus the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay is added to the series name to give the complete name of the soil type. For example, Boyd clay loam and Boyd fine sandy loam are types within the Boyd series. Except for the texture of the

surface soils, these soils have approximately the same general characteristics.

A phase of a soil type is a soil which varies from the type in some minor characteristic that may have special practical significance. Difference in relief, depth of soil material, and content of gravel or stone are frequently the bases for phase separations. These differences may not materially influence soil character but may be of great significance in land use.

SOILS AND CROPS

The soils over the greater part of the county are better suited for native pasture or hay than for grain or tame-hay crops. There are numerous bodies of good farming soils scattered throughout the county, but the more extensive soils are either so sandy, gravelly, or shallow that they are rather droughty or have too uneven surfaces for the efficient use of farm machinery. According to the Federal census, about 16 percent of the total land area of this county was used for cultivated crops in 1930; about 13 percent was used for wild hay; and most of the rest for grazing land. The soils nearly everywhere will support from fair to heavy growths of nutritious grasses. Wild grass for pasture and hay is the foundation of cattle raising, on which the prosperity of the county largely depends. Except for the small quantity of wheat sold for cash, all the grain and tame-hay crops are grown to supplement the feed supplied by native grasses.

The soils used for grazing occupy large or small tracts in nearly all parts. Most of them have thin topsoils which are rather low in organic matter. The largest tract of grazing land includes the broad strip of rough broken land which extends nearly across the county on the north slope of the Niobrara River Valley. Little of the land in this strip is cultivated. Other large tracts used principally for grazing land, but which include numerous small bodies where the soils are suitable and used for cultivated crops, are on the smooth or rolling uplands in the northern part of the county. Some of the largest tracts are very sandy and unstable soils in Burton, Mills, and Keya Paha Precincts and soils which are underlain at slight depths by bedrock or coarse gravel in Holt and Norden Precincts. The sandy or gravelly soils in the northern parts of Custer, Pine, and Simpson Precincts, and rough broken land, composed largely of Pierre shale, north of Keya Paha River, also comprise much of the grazing land.

Most of the wild hay is cut from fenced fields within areas that are used principally for grazing. The soils suitable for growing wild hay are very sandy, as a rule, and are similar in a general way to the surrounding grazing land, but generally they occupy the lower positions where the moisture supply is most favorable, the topsoil darkest, and the grass cover thickest. Much wild hay is cut from pockets or depressions in the sandy uplands where the water table lies near the surface, as in parts of Simpson, Mills, and Keya Paha Precincts, and from the more poorly drained parts of the bottom-land soils. Most of the poorly drained hay-producing soils have very dark topsoils containing an abundance of organic matter. Some wild hay is produced on gentle well-drained slopes within areas of rough broken land, particularly on the extensive heavy clay soils

north of Keya Paha River and on the lower valley slopes along Niobrara River. This hay is generally of better quality than that produced on sandy or poorly drained soils.

Of the cultivated crops, corn occupies the leading acreage on most of the soils suited for the production of grain or tame hay. This is due partly to the fact that corn gives satisfactory yields under a wider range of soil and moisture conditions than most other crops, but largely because corn is needed to feed the work animals and hogs and to help carry the range cattle through the winter. Oats, also needed for feed, especially for horses, colts, and calves, are grown on some of the finer textured and better drained soils of the uplands and terraces, but seldom on sandy soils or soils which constantly remain moist. Although oats rank next to corn in total acreage, they occupy only one-sixth to one-third as much land.

The grain and tame-hay crops are produced on the soils of the bottom lands, on the finer textured soils of the terraces, and throughout the uplands wherever the soils and moisture supply are favorable. One of the largest and most productive farming areas in the uplands occupies a few square miles in the northeastern part of the county. Here the sandy or gravelly material, which constitutes the greater part of most upland soils, is covered to a depth of a few feet by silty loess that is highly retentive of moisture. The soils developed from this loess have thick dark topsoils well supplied with organic matter. They are productive and well suited to all the crops commonly grown.

Small areas of clayey soils developed on heavy Pierre shale in the uplands north of Keya Paha River are suited to and used for the production of grain and tame-hay crops, where the land is not too rough for cultivation. These soils are not so productive, as a rule, as those developed on loess, because their high content of clay tends to cause excessive shrinking and cracking in dry weather with consequent injury to crop roots. In seasons of normal rainfall, however, the clayey soils produce good yields of corn, small grains, and sweetclover, especially where the topsoil is mixed with or is thinly covered by sandy material. The sand acts as a mulch and retards soil drying.

In addition to the silty and clayey soils of the uplands, there are numerous small areas of sandy soils on which certain cultivated crops do well. Most of the latter occupy slightly depressed situations where moisture conditions are most favorable and where the topsoils are well supplied with organic matter. Some of them contain an abundance of silt, especially in their subsoils, and retain moisture well. Others, although composed almost entirely of sand, have a water table within reach of crop roots. The more silty soils are used for all crops suited to the climate, and the more sandy ones and those with a high water table are used chiefly for corn. Rye and sweetclover also are grown on the sandy soils, but the total area devoted to these crops is small.

The soils of the bottom lands, except those in poorly drained situations, are used mainly for corn and alfalfa. Most of them are composed largely of sand, but nearly all contain an abundance of organic matter in their topsoils which are very dark. The only ones with light-colored surface layers have developed from the most recently deposited sandy sediments and are too young to have accumulated much organic matter. Owing to their low position, the

bottom-land soils receive considerable run-off from the higher levels, and this, together with water received through precipitation, gives them a higher moisture supply than any of the soils on uplands or terraces, except some of those in depressions. Although well suited to corn and alfalfa the bottom-land soils are not, as a rule, well adapted to small grains. The latter crops grow well, but, owing to the abundant moisture, they generally produce a rank growth of vegetation, mature late, and yield rather low.

In this report, the soils are grouped, on the basis of their suitability for growing various common crops of the area, as follows: (1) Soils suitable for the production of corn and oats; (2) soils suitable for the production of corn and alfalfa; (3) soils suitable only for grass. This grouping is not intended to imply that the crops mentioned in connection with a particular group are the only ones which can be or are produced on the soils of that group. Under a more intensive farming system most crops adapted to the climate could be grown on nearly all of the soils in the county, except those which have too broken relief for cultivation. Even under the present system, some of the cultivated crops are grown successfully on areas of soils here classed with the group suitable only for grass. Likewise, native pasture or hay may be grown on soils suitable for the production of corn and oats or those suitable for the production of corn and alfalfa. Such exceptions, however, are the result of especial farm requirements. Over the county as a whole, larger returns are obtained in the long run from soils used for the crops or combination of crops for which they are best suited. The grouping here used is based not only on soil and crop adaptations but also on those soil characteristics which are responsible for these adaptations and on the surface features and drainage conditions of the soils. The soils included in the several groups mentioned are not confined to any particular part of the county, but some soils in each group occur in small areas surrounded by soils of other groups.

In the following pages, the various soils in the different groups are described and their cropping possibilities are discussed. The soil map accompanying this report shows the distribution of the soils, and table 6 gives their acreage and proportionate extent.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in Keya Paha County, Nebr.*

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Marshall loam, sandy-substratum phase	5,568	1.1	Valentine sand	92,096	18.5
Marshall fine sandy loam, sandy-substratum phase	2,688	.5	Valentine loamy sand	2,112	.4
Holt fine sandy loam	18,048	3.6	Dune sand	23,744	4.8
Boyd clay loam	8,128	1.6	Thurman loamy sand	25,152	5.1
Boyd fine sandy loam	7,424	1.5	Holt loamy sand	24,832	5.0
Thurman fine sandy loam	9,280	1.9	Holt loamy sand, shallow phase	38,144	7.7
O'Neill loam, upland phase	2,432	.5	Holt loamy sand, hilly phase	15,680	3.2
Ewing sandy loam	4,480	.9	O'Neill loamy sand	11,264	2.3
Verdel clay loam	2,496	.5	O'Neill loamy sand, upland phase	34,752	7.0
Verdel fine sandy loam	3,200	.6	O'Neill sandy loam, upland phase	8,320	1.7
Hall loam	6,272	1.3	Sparta sand	1,728	.3
O'Neill fine sandy loam	6,528	1.3	Cass and Valentine loamy sands, undifferentiated	9,280	1.9
Cass loamy fine sand	35,584	7.2	Butler silty clay loam	64	.1
Cass fine sandy loam	11,776	2.4	Sarpy sand	6,016	1.2
Lamoure fine sandy loam	4,224	.8	Riverwash	64	.1
Rough broken land	74,624	15.0	Total	496,000	------

SOILS SUITABLE FOR THE PRODUCTION OF CORN AND OATS

The soils classed with this group occupy 76,544 acres, or 15.3 percent of the total area of the county. They cover only about one-fourth as large an area as the "grassland soils", but they produce most of the grain and tame hay. The group includes the Marshall and Verdel soils; Ewing sandy loam; Hall loam; the thicker, darker, and more level types of the Holt and Boyd soils; and the finer textured O'Neill and Thurman soils. All are in the uplands except Hall loam and a part of the O'Neill soils, which are on the terraces. They have nearly level surfaces, except the Boyd and Holt soils which are strongly rolling or hilly in places.

The soils belonging to this group have accumulated rather large amounts of organic matter and in most places have darker and thicker topsoils than the soils of the grassland group. The Marshall, Ewing, Hall, and Boyd soils are fine textured and highly retentive of moisture. The other soils are very sandy but contain some silt and clay. This finer material, together with the organic matter, enables these sandy soils to hold moisture fairly well and prevents excessive wind erosion if reasonable care is taken in managing the land. The Hall, Boyd, and Holt soils of the group contain an abundance of lime.

During most years, corn is grown on about 50 percent of the area occupied by the soils of this group and oats on about 7 percent. The combined acreage of all other cultivated crops is about equal to that of oats. The uncultivated land is occupied by building sites or is included in small pastures for the milk cows and work animals. On the finer textured soils of the group, the percentage of the land in corn is lower, and that in oats is higher. This is because nearly all of the oats are grown on the finer textured soils, whereas corn is grown rather extensively on all the soils. Most of the wheat and barley are produced on the finer textured soils, but rye and sweet-clover, which generally occupy small fields, are grown more extensively on the sandy soils. Alfalfa is grown locally on the soils of this group, chiefly on the finer textured ones. This crop does fairly well on Hall loam, but the upland soils return rather low yields, especially after the first 3 or 4 years. Alfalfa has an unusually deep root system and requires an abundant and continuous moisture supply for good growth. It thrives fairly well on the upland soils until its roots have exhausted the internal accumulation of moisture, after which yields decline because alfalfa cannot make its optimum growth in this section on the moisture supplied by rainfall alone. This condition does not prevail on upland soils which are underlain by a water table at a slight depth or on the soils of the bottom lands, classed with the group of corn and alfalfa soils. In these soils alfalfa roots are able to reach an inexhaustible moisture supply.

Marshall loam, sandy-substratum phase.—Marshall loam, sandy-substratum phase, is one of the most productive soils of the uplands in the county. It covers rather large areas in the vicinity of Jamison and southeast of Springview. Small bodies lie southwest and southeast of Norden and south of Brocksburg.

The surface is nearly level or gently undulating. This soil occupies some of the highest positions in the county and has good surface and internal drainage. It has developed from light-colored loess,

only thin remnants of which remain. The loess was originally composed almost entirely of silt, but the soil developed from it has accumulated rather large amounts of wind-blown sand and some gravel and has lost the smooth silty texture of the parent material.

The 8- to 12-inch topsoil is well supplied with organic matter and is very dark. It contains rather large quantities of fine sand and medium sand and a few pebbles but is composed largely of silt which, together with the organic matter, makes it stable. The subsoil is slightly sandy silt which is brown in the upper part and light grayish brown in the lower. At a depth ranging from 26 to 40 inches, it is underlain by loose gray sand or a mixture of sand and gravel. The soil contains little lime carbonate but apparently has enough for crop needs.

The slight depth to the underlying sand makes this soil less retentive of moisture than most of the soils developed from loess in eastern and southern Nebraska. It is not droughty, however, and, except in seasons of unusually low moisture, is very productive. It can be tilled under a wide range of moisture conditions and is adapted to all the crops commonly grown. Practically all the land is under cultivation. Corn and oats, in the proportion of about 3 acres of the former to 1 of the latter, are the chief crops. Other small grains, including wheat, barley, and rye, and tame hay crops, mainly alfalfa and sweetclover, occupy small acreages.

Crop yields vary widely, depending on the rainfall. Average acre yields of corn are about 20 bushels, oats about 22 bushels, wheat about 11 bushels, barley about the same as corn, and rye about the same as wheat. Alfalfa yields about 2 tons an acre during the first 4 or 5 years, after which the yields decline as on nearly all upland soils in Nebraska, probably because the available moisture in the deeper soil layers is exhausted.

Marshall fine sandy loam, sandy-substratum phase.—The sandy-substratum phase of Marshall fine sandy loam differs from the corresponding phase of Marshall loam only in that its topsoil layer contains a little less silt and more fine sand and in that it is slightly looser. The higher content of sand makes this soil easier to handle, especially when moist, but does not noticeably reduce the water-holding capacity or impair its resistance to wind erosion. This soil occurs in the same general localities as the loam but is less extensive. Few of the bodies exceed 200 acres in size, and most of them are much smaller. Nearly all the land is under cultivation. The surface features, crop adaptabilities, and productivity of this soil are nearly the same as those of the sandy-substratum phase of Marshall loam, and the two soils are regarded with equal favor for general farming.

Holt fine sandy loam.—Holt fine sandy loam occupies numerous small areas in the uplands in nearly all parts of the county. The largest areas, some exceeding 640 acres, are in Norden Precinct. In the other precincts, few bodies exceed 300 acres. The total area—18,048 acres—is far greater than that of any other soil of this group.

This soil differs from Holt loamy sand of the group suited only to grass in that it has a finer textured and more stable topsoil. In common with all the Holt soils it has developed from light-colored loosely cemented sandstone with a high content of lime.

The relief ranges from nearly level to strongly rolling, and most of the soil occupies undulating areas. There are fairly steep slopes on the valley sides of some of the drainageways, but practically all of the land may be cultivated. Surface drainage is well developed but not excessive except locally on some of the valley sides. Internal drainage is good.

The topsoil averages about 9 inches in thickness, but it is thinner on the steeper slopes where erosion is severe and moisture penetration is less. It is well supplied with organic matter and is dark. The color of the surface soil is slightly darker in the eastern than in the western part of the county. The topsoil varies in texture from fine sandy loam to very fine sandy loam, the former texture predominating. The subsoil consists of a mellow mixture composed largely of silt and very fine sand. It is brown in the upper part where stained by organic matter washed down from the topsoil and is light gray or almost white in the lower part. It is very limy, especially beneath the brown layer. Below a depth of 3 feet is the light-colored limy sandstone from which the soil has developed, but in many places it is much nearer the surface. Sandstone outcrops in places on the steeper slopes.

Except in places where the sandstone is near the surface of the ground, Holt fine sandy loam is nearly as productive as the Marshall soils. It is well suited for all crops commonly grown in the county, and about 60 percent of it is under cultivation. Corn, oats, and wheat, ranking in acreage in the order named, are the leading crops. Smaller and less accessible areas and patches where sandstone lies at slight depths are used for pasture or hay land, for which they are as well suited as most of the finer textured soils on the uplands.

Boyd clay loam.—Boyd clay loam in this county is developed from weathered heavy Pierre shale which has been exposed by erosion. It occurs in comparatively small bodies on the uplands north of Keya Paha River and on the lower valley slopes in the Niobrara River Valley. Only a few areas exceed 200 acres, and most of them are less than 160 acres. Because of the large number of areas, however, Boyd clay loam is one of the more extensive soils of this group.

The greater part of this soil occurs on gentle or fairly steep slopes, but some of it, especially north of Keya Paha River, extends over divides between drainageways. The surface in general is strongly rolling or hilly. Surface drainage is everywhere well established. Over most of the soil, run-off is rapid and erosion is rather severe. Internal drainage is good but rather slow, owing to the heavy clayey texture of the subsoil.

The topsoil contains much clay but has sufficient silt, sand, and organic matter to give it the texture of a clay loam or silty clay loam. It ranges in thickness from a few inches to more than a foot and in organic matter content from very low to high. This layer is thinner and contains less organic matter on steep slopes than on gentle slopes or on broader divides. The upper part of the subsoil is composed almost entirely of clay. The lower part, at a depth ranging from 25 to 36 inches, is a mixture of clay and shale. The shale increases with depth and grades into the parent Pierre shale formation, generally within a depth of 5 feet. The subsoil is limy through-

out and is more friable than might be expected from its clayey texture, because much of the lime occurs as fillings in numerous seams and cracks, thereby giving considerable porosity to the otherwise almost watertight clay.

The color of the soil varies. In localities where the relief has favored the accumulation of a large amount of organic matter the topsoil is very dark or almost black. On the steeper slopes where the content of organic matter is low, the color of the topsoil conforms closely to that of the parent shale. In most places this shale is dark olive drab or almost black, but locally it includes light-colored beds, some of which are fairly thick. In eroded areas, the topsoil is dark where the soil has developed from darker colored Pierre shale beds and is gray or almost white where the soil has developed from light-colored beds. The subsoil ranges from light to dark, also depending on the color of the shale from which it has developed. In most places it contains numerous rusty-brown splotches, streaks, and spots.

Although the surface of nearly all this soil allows tillage, the land is difficult to handle except under the most favorable moisture conditions, and only about 50 percent of it is under cultivation. The cultivated land is used for the same crops as the sandy-substratum phase of Marshall loam. In wet years, yields compare favorably with those obtained on that soil. In dry years, however, all grain and tame-hay crops return low yields because the shrinking and cracking of the clay breaks the roots and exposes them to drought.

The rest of the land is used for native-pasture and hay land. The grass will support a cow and a calf on each 8 acres or yield about one-fifth ton of hay an acre. The hay is of good quality and consists largely of grama, bluestem, and wheatgrass.

Boyd fine sandy loam.—Boyd fine sandy loam occurs throughout the uplands where the soil has developed from the Pierre shale formation but has received more or less wind-blown sand and as a result has a sandy topsoil. It occupies numerous small areas in the northeastern part of the county and on the Niobrara Valley slopes in the southeastern part. Most of the areas cover less than 160 acres each. Its total area is slightly less than that of Boyd clay loam.

The relief ranges from nearly level to steeply sloping but is nearly everywhere suited to the use of farm machinery. All the soil is well drained. Only a small part of it is subject to severe erosion.

The topsoil is well supplied with organic matter and is very dark, especially in the upper part. It is everywhere more or less sandy but varies in thickness and texture. In most places this layer is similar to the corresponding one in Holt fine sandy loam. It is very dark grayish-brown mellow fine sandy loam to a depth of 9 or 10 inches. In a few places, however, wind-blown sand has accumulated in such large quantities that the topsoil has taken on the texture of loamy sand and in places is 15 or 18 inches thick. In these places only the upper part of the topsoil is dark, and the rest is brown or light brown. The subsoil is similar to that of Boyd clay loam. It is composed of dense clay in the upper part and a mixture of clay and shale in the lower part. It varies in color.

About 65 percent of this soil is under cultivation. The same crops are grown as on the Marshall soils, but yields are from one-fourth to

one-half lower than those obtained on the sandy-substratum phase of Marshall loam. The topsoil in most of the cultivated areas is not too sandy for small-grain crops which do well. The soil has an unusually high capacity for storing moisture, because the moderately sandy topsoil absorbs the rainfall and the underlying heavy clayey shale prevents loss of moisture through seepage.

Areas in which the topsoil is too sandy to be stable after the original sod is removed and those that are too small or inaccessible to be successfully farmed, are covered with a fairly heavy growth of grass. They have a much higher value for pasture and hay land than Boyd clay loam. They occupy only a small part of the farms on which they occur, however, and are of minor agricultural importance.

Thurman fine sandy loam.—Thurman fine sandy loam occupies small areas throughout the sandy uplands in all parts of the county. Only a few areas exceed 160 acres, and most of them are much smaller. They are most numerous in McGuire, Keya Paha, and Mills Precincts.

This soil has developed from sand formerly covered with loess. A large proportion of silt has become incorporated in its surface layer, probably during the removal of the loessial cover. It resembles Thurman loamy sand except that its topsoil is finer textured and more stable.

The relief ranges from nearly level to gently undulating. Drainage channels are not established because the precipitation is absorbed by the soil.

The topsoil, to a depth ranging from 8 to 12 inches, is very dark loam, fine sandy loam, or medium sandy loam, containing an abundance of organic matter. The subsoil is composed mainly of fine sand and medium sand, but it contains a small amount of silt which holds the sand grains together loosely and makes the material a little more retentive of moisture than the subsoil of Thurman loamy sand. It is brown in the upper part from stains of organic matter leached from the topsoil but becomes much lighter with depth, and at a depth ranging from 30 to 36 inches below the surface is light grayish brown. There is little lime in the soil, but apparently enough for crop requirements.

All this soil is under cultivation, with the exception of a few small inconveniently located areas. Most of it is used for corn, although all the crops commonly grown are produced on it. The soil can be cultivated under almost any moisture condition without danger of puddling or blowing. This is one of the first soils in this group to warm and can be seeded to crops several days earlier than the silty or clayey soils. It is not so well supplied with plant nutrients as the finer textured soils, and cultivated crops usually yield from one-fourth to one-third less than on the Marshall soils.

O'Neill loam, upland phase.—The upland phase of O'Neill loam occupies an area of about 1,200 acres in Custer Precinct southeast of Springview and occurs in small and widely scattered areas in some other precincts. Its total area is small.

The land is nearly level or gently undulating. No drainage channels are established, owing to the rapid absorption of moisture, and there is practically no run-off.

This soil has developed from gravel beds similar to those from which the upland phase of O'Neill loamy sand was formed. It dif-

fers from that phase only in that its surface layer contains much more silt and is consequently finer textured, more coherent, and less subject to destructive wind erosion than the corresponding layer of O'Neill loamy sand, upland phase.

The topsoil, which ranges from 9 to 12 inches in thickness, is friable throughout and very dark, owing to an abundance of organic matter. The subsoil consists almost entirely of gravel and coarse sand, is very porous, and has little capacity to retain moisture. It is brown in the upper part and light brown or gray in the lower part. In most places, the sand and gravel mixture extends to a depth beyond 6 feet, but locally the gravel practically disappears at a depth of 4 feet, leaving only fine sand or medium sand in the lower part of the subsoil. Neither the topsoil nor subsoil contains much lime, though lime is not actually deficient.

In dry years crops on this soil suffer from drought, owing to the coarse porous character of the subsoil. The fine-textured dark stable topsoil, however, furnishes enough moisture for good yields of most tame-hay and grain crops during seasons of normal or heavy precipitation. About 70 percent of the soil is under cultivation. Corn and oats occupy approximately equal acreages. Smaller acreages, in the order named, are planted to wheat, rye, barley, and sweetclover. In average years, small-grain crops mature before the topsoil moisture supply is exhausted and yields are nearly as high as on Marshall loam, sandy-substratum phase. Corn and sweetclover, which require more moisture than small grains, usually suffer from drought during midsummer and late summer, and yields of these crops average much lower than on the sandy-substratum phase of Marshall loam, especially in dry years. In wet years all crops do as well on this soil as on the Marshall soils. The uncultivated areas are in small pastures for work animals and milk cows. They support an excellent cover of grass and are well suited for grazing.

Ewing sandy loam.—Ewing sandy loam occupies small widely scattered areas in the uplands. The largest area, comprising about 400 acres, is in Custer Precinct, about 2 miles southeast of Springview. Few of the remaining areas exceed 100 acres, and most of them are less than 50 acres in extent.

This soil occurs only on nearly level areas or in slight depressions; it all lies a little below the surrounding land. Surface drainage channels are not established. All surplus surface water is absorbed and, although internal drainage is slow, the soil is seldom too wet for cultivation even during seasons of heavy precipitation.

The 10-inch topsoil is very dark loam or loamy sand, containing an abundance of organic matter and sand and a few gravel. In most places the material contains sufficient silt, clay, and organic matter to be classed as sandy loam, and it is included with this type on the soil map. The subsoil, which ranges in thickness from 15 to about 36 inches, is much more compact than the topsoil and in many places attains the density of claypan. It is brown in the upper part and light gray in the lower. In most places the subsoil is composed largely of silt and clay, but it everywhere contains considerable sand and scattered gravel and in many places is dense sandy clay. Locally it is a mixture of sand and gravel firmly cemented with clay. It rests on loose gray sand or a mixture of sand and gravel, which extends below a depth of 6 feet. The soil contains little or no lime.

All the larger areas are cultivated. In places where the topsoil is unusually sandy and consequently unstable, the land is used almost entirely for corn. Where the topsoil is finer and more stable, all crops common to the county are grown, including wheat, oats, barley, rye, and alfalfa. None of this soil is droughty, because the topsoil is sufficiently porous to absorb all the precipitation and the heavy subsoil prevents excessive loss of moisture through seepage. Yields of cultivated crops are from 30 to 40 percent lower than those obtained on the best upland soils of the general region, but the virgin areas support almost as heavy a growth of grass as any of the upland soils. This soil occupies only a small part of any one farm and is therefore of minor agricultural importance.

Verdel clay loam.—Verdel clay loam occupies small areas and narrow broken strips on valley benches along Keya Paha River and some of its tributaries. A few areas also occur on benches along Niobrara River in the southeastern part of the county. The areas are numerous but few exceed 160 acres in size, and their total extent is small.

This soil has developed from Pierre shale, similar to that underlying the Boyd soils of the uplands, and has been transported by streams and deposited along their courses when they were flowing at higher levels. Later entrenchment of stream channels left the deposits as terraces or bench forms, and subsequent weathering, accumulation of organic matter, and other soil-forming processes produced the present soil. The benches occur as several distinct levels, their height depending on the level of the streams at the time the deposits were made. All are less than 70 feet and most of them are only 15 or 20 feet above the present valley floors. They are nearly level, but there is sufficient slope to afford ample surface drainage. Internal drainage is adequate but rather slow. Most of the older and higher benches have been destroyed by erosion or only small remnants of them remain. None of the benches now occupied by this soil is subject to destructive erosion.

This soil is composed largely of dense clay, but it contains an abundance of lime in the form of seams, streaks, and splotches, which reduces the compaction of the clay and makes the soil more friable than it otherwise would be. The topsoil, to a depth ranging from 10 to more than 20 inches, is very dark silty clay loam or silty clay, containing an abundance of organic matter. The underlying material is largely olive-gray or gray clay. It contains scattered rust-brown streaks and splotches and a few small iron concretions.

Nearly all of this soil is under cultivation. During seasons of normal or heavy precipitation, it is as productive of all crops common to the county as Hall loam and more productive than any upland soil. In dry years the high clay content causes the soil to shrink and crack, resulting in severe injury to plant roots and reduction of yields.

The soil is difficult to handle except under the most favorable moisture conditions. If plowed when wet, it forms hard lumps, and it is almost impossible to work when extremely dry. Under favorable moisture conditions good tilth is easily maintained.

The soil is used for the production of all the crops commonly grown.

Verdel fine sandy loam.—Verdel fine sandy loam differs from Verdel clay loam in that its topsoil contains more sand. These soils

have similar relief and drainage conditions, and they are used for the same crops.

The topsoil of typical Verdel fine sandy loam is fine sandy loam or loamy sand. There are only two small areas with the lighter texture. These are in secs. 24, 25, and 26, T. 33 N., R. 17 W. Owing to their small extent they are included with the fine sandy loam soil on the accompanying map. The high content of sand in the topsoil facilitates cultivation under a much wider range of moisture conditions than is possible on Verdel clay loam. It also prevents shrinking and cracking, and crops do not suffer so much from drought as those on Verdel clay loam.

Nearly all of this soil is under cultivation. It is considered as productive as Hall loam except in seasons of low rainfall. The soil has a higher wilting point than has Hall loam—that is, it will not give up so large a proportion of its moisture to plants.

This soil occurs in small scattered bodies on the terraces along Keya Paha and Niobrara Rivers in the eastern part of the county. None of the bodies occupies entire farms, and the soil is of little agricultural importance on account of its small extent. The two small bodies having a loamy sand topsoil are used chiefly for corn, because the high content of sand makes the topsoil a little too unstable for small-grain crops. The rest of the land is used for all the crops commonly grown.

Hall loam.—Hall loam occupies parts of the terraces or benchlands in the valleys of the Niobrara and Keya Paha Rivers and their tributaries. The areas are few, and most of them are small, although in Custer Precinct some exceed 400 acres.

The benches, or terraces, on which this soil lies are old gravelly stream terraces having a cover of silty material. They lie from 15 to about 60 feet above the present valley floors. They have nearly level relief but slope sufficiently to afford ample surface drainage. Internal drainage is thorough but not excessive.

The topsoil is 14 or 16 inches thick. It is friable throughout and, owing to an abundance of organic matter, is very dark. Its texture ranges from silt loam to fine sandy loam, but in most places the proportions of silt and sand are about equal, resulting in a loam texture. The upper part of the subsoil is brown or grayish-brown silt loam. It is only slightly more compact than the topsoil. The lower part, beginning at a depth of about 3 feet, is light-gray limy silt loam or very fine sandy loam. It rests on the underlying sand and gravel at an average depth of about 5 feet. The underlying material contains no lime.

Hall loam is very retentive of moisture and is admirably suited to all the crops commonly grown. It is more favorably situated to receive moisture from higher levels than the upland soils, and this moisture, together with that received through precipitation, makes it more productive than those soils. Practically all of it is under cultivation. It is used for the same crops as are grown on Marshall loam, sandy-substratum phase, although a slightly higher proportion of it is used for alfalfa than of any upland soil. Alfalfa yields about the same as on the better drained soils of the bottom lands, and corn yields a little lower than it does on those soils, but no soil in the county returns higher yields of small grains. Although highly

productive, this soil is of only local agricultural importance on account of its small extent.

A variation of Hall loam occupies a few small areas on the Niobrara River terraces in McGuire Precinct. The largest area comprises only about 200 acres. This included soil has developed from loessial material, similar to but thinner than the material from which tpyical Hall loam was formed, and it resembles that soil in surface features and drainage conditions. No part of the soil contains much lime, and in this respect it differs from typical Hall loam which has a very limy subsoil. All the land is under cultivation and is used for the same crops as are grown on the Marshall soils and typical Hall loam. It is slightly more productive than the former and about equally as productive as the latter.

O'Neill fine sandy loam.—O'Neill fine sandy loam differs from O'Neill loamy sand included with the group of soils suitable for grass only, in that its topsoil is finer textured, slightly darker, and more stable. It occupies terraces similar to those occupied by O'Neill loamy sand and has about the same surface features and drainage conditions as that soil, but it is much less extensive. It occurs chiefly in the valleys of Keya Paha River and its branches and is developed locally on the Niobrara River terraces. The areas are small, few exceeding 160 acres.

This soil is similar to Thurman fine sandy loam, from which it differs only in that it occupies lower positions. It is consequently more favorably situated to receive moisture from higher levels than the Thurman soil and is a little more productive. The difference in productivity is so slight, however, that most farmers regard the two soils with equal favor. Practically all of O'Neill fine sandy loam is under cultivation.

SOILS SUITABLE FOR THE PRODUCTION OF CORN AND ALFALFA

This group includes all the bottom-land soils except Sarpy sand which, owing to its extremely sandy and unstable nature, is included with the soils suitable only for grass. This group is much less extensive than either of the other two groups and occupies only 10.4 percent of the total area of the county. It comprises Cass loamy fine sand, Cass fine sandy loam, and Lamoure fine sandy loam, which are the most productive soils in this county for corn and alfalfa. These soils occur in broken or continuous strips in most of the large valleys. The broadest and most continuous strips are along Shadley, Lost, Cottonwood, and Holt Creeks. Broken and rather narrow strips are in the Niobrara and Keya Paha River Valleys.

These soils have nearly level surfaces except where crossed by old and active stream channels or where modified by slight elevations or shallow depressions. Local differences in elevation do not exceed 3 feet. Drainage is rather slow, and a part of the land remains too moist for cultivated crops, especially along the creeeks in the north-central and northwestern parts of the county. Most of the land occupied by the soils of this group, however, is sufficiently well drained for cultivation.

The Cass soils have developed from sandy sediments and the Lamoure soil from silty sediments, recently deposited by the streams. They are naturally better supplied with moisture than any of the

soils on the uplands or terraces, because the precipitation received by them is supplemented by run-off from higher levels and by capillary rise of moisture from the underlying water table. 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 growth and decay of vegetation, and all soils of the group have very dark topsoils because of an abundance of organic matter.

About 50 percent of the area occupied by the soils of this group is under cultivation. The remainder occurs in strips too narrow for profitable farming or in bodies too poorly drained for cultivation, and the land is used for native-pasture or hay land. About 90 percent of the cultivated land is planted to corn and alfalfa in the proportion of about 12 acres of corn to 1 of alfalfa. The rest is used for oats, sweetclover, barley, sorgo, and millet, ranking in acreage in about the order named. All small-grain crops will grow, but, owing to the abundant moisture, they have a tendency to produce a rank growth with long weak stems which are apt to break and lodge during windy weather. In addition, small grains may mature late and yield rather low. Fairly good yields of oats are obtained from the short stiff-stemmed varieties, but even these have a tendency to grow rank at the expense of the grain. Most of the oats and barley are grown on the higher lying parts of the bottom lands.

Cass loamy fine sand.—Cass loamy fine sand is the most extensive soil on the bottom lands of this county and occupies 35,584 acres. It occurs in narrow or continuous strips of various widths along all the streams. Some of the largest developments are along Shadley, Cottonwood, and Lost Creeks, where in places the strips are more than half a mile wide. The strips along Niobrara and Keya Paha Rivers are comparatively short and narrow.

This soil has developed from sandy alluvial deposits that were laid down on the flood plains of streams during periods of high water. Wind-blown sands from the stream bed and from nearby sandy uplands or terraces also have contributed to the deposits. Subsequent accumulations of organic matter have given the upper part of the sandy material a dark color and a loamy texture.

The surface of the soil is flat in most places but is modified here and there by old and active stream channels, low ridges, and hummocks. Local differences in elevation in few places exceed 3 feet. Only a small part of the land is subject to overflow from the stream channels, and its surface in most places is sufficiently well drained for cultivation. The water table is nearly everywhere within 12 feet of the surface and in some places within 6 feet. In wet seasons it rises, producing marshy spots in the lower situations.

The 8- to 12-inch topsoil is composed chiefly of fine sand and medium sand—the fine sand predominating. It contains an abundance of well-decomposed organic matter which gives the material a loamy texture, a very dark color, and also tends to stabilize the loose sand, but it does not prevent drifting when the native sod is destroyed, especially during prolonged periods of dry windy weather. The subsoil is incoherent sand similar to that in the topsoil, but it is practically devoid of organic matter and is light gray or grayish brown with numerous rusty-brown streaks and splotches. In most places it

extends below a depth of 4 feet with little change, but locally it may contain coarse sand and a few gravel in the lower part. The subsoil is everywhere limy, and in places the topsoil contains a small amount of lime.

About 65 percent of this soil is under cultivation. It is one of the best soils in the county for corn and alfalfa, and the cultivated areas are used chiefly for these crops. Neither corn nor alfalfa yields so high as on some of the finer textured soils of the bottom lands, but corn gives better yields than on any upland or terrace soil. A small part of the cultivated land is used for small grains, chiefly oats, but yields are variable. In dry years shifting sand in the topsoil exposes the roots of small-grain crops to drought, and in wet seasons the abundant soil moisture causes these crops to make a rank vegetal growth at the expense of the grain.

The rest of the soil is used for native-pasture and hay land. The heavy growth of grass in average years will support a cow and a calf on each 5 acres or will yield about three-fourths ton of hay an acre.

Included with this soil on the map are a few scattered areas, chiefly in Mills Precinct, which occupy poorly drained sandy upland basins entirely surrounded by higher lying land. None of them exceeds 80 acres, and most of them occupy only an acre or two. The included soil differs from Cass loamy fine sand in having a heavy grayish-green or grayish-blue clayey layer in the subsoil. The subsoil is within a depth ranging from 3 to 4 feet of the surface and in most places is saturated with water even during prolonged dry spells. All these included areas are either too small or too poorly drained to be used for cultivated crops, but they support an excellent cover of native grasses.

Cass fine sandy loam.—Cass fine sandy loam occurs throughout the bottom lands, closely associated in most places with Cass loamy fine sand which it resembles in surface features and drainage conditions. It differs from Cass loamy fine sand only in that its surface layer, to a depth ranging from 8 to 10 inches, contains less sand and more silt and clay and is consequently more stable.

This soil is a little more productive of corn and alfalfa than the coarser textured bottom-land soils, and about 85 percent of it, including practically all the cultivated land, is used for these crops. About 10 acres of corn to 1 of alfalfa are planted. Except in the wettest years, when even the poorer soils are very productive, yields of corn are 8 or 10 bushels higher and those of alfalfa about one-half ton higher on this soil than on any upland soil of the county. The more poorly drained areas and those in which the water table remains near the surface are used for pasture or hay land. Native grasses give slightly higher yields of hay on this soil than on Cass loamy fine sand.

Lamoure fine sandy loam.—Lamoure fine sandy loam occurs in small scattered bodies and narrow broken strips on the bottom land along some of the larger streams, chiefly in the eastern part of the county. Few of the bodies exceed 60 acres. This soil differs from Cass fine sandy loam in that it has a finer textured and more limy subsoil. It has similar surface features and drainage conditions.

The topsoil, to a depth of 10 or 12 inches, consists of friable very dark gray or almost black fine sandy loam containing an abundance of organic matter. The subsoil ranges from light gray to nearly black, but in most places it is grayish brown, irregularly splotched with lighter and darger shades and with numerous rusty-brown iron stains. It consists mostly of silt and clay and is much more compact than the topsoil but is rarely as dense as a claypan. The subsoil ranges from 36 to 48 inches in thickness and rests on loose gray sand. The entire subsoil is rich in lime and in most places contains small hard or soft nodules of this material.

Most of this soil is subject to occasional overflow from the stream channels, but, except in a few places, the surplus water drains off rapidly or is absorbed when the streams subside. Only a small part of the soil remains too wet for cultivated crops. Small or unfavorably situated areas are allowed to remain in pasture and hay land.

About 70 percent of the land is used almost exclusively for the production of corn and alfalfa. Corn yields about 30 bushels and alfalfa about 2½ tons an acre. These yields are equal to those obtained on any other soil in the county during years of normal rainfall. Lamoure fine sandy loam occupies such small bodies and narrow strips that it does not greatly enhance the total yields of corn or alfalfa on the farms on which it occurs. The soil is as well suited for sweetclover as for alfalfa but during rainy seasons is a little too moist for the highest yields of small grains.

Small scattered areas of loamy fine sand on the flood plains, chiefly along Cottonwood, West Holt, and Burton Creeks, are included with mapped areas of Lamoure fine sandy loam. The included soil has a subsoil identical with that in typical Lamoure fine sandy loam but has a sandier topsoil. This soil is similar to Cass loamy fine sand in surface soil, relief, and drainage and is about equal to that soil, or only slightly higher, in productivity for corn and alfalfa.

SOILS SUITABLE ONLY FOR GRASS

The soils of this group, the so-called grassland soils, occupy approximately three-fourths of the total area of the county. They include all the Valentine, Sparta, Sarpy, and Butler soils; the more sandy, droughty, and unstable types of the O'Neill, Thurman, and Holt soils; and such land types as rough broken land, dune sand, and riverwash.

Some of each soil of the group is cultivated; garden patches and scattered cultivated fields of a few acres each occur, even on dune sand and rough broken land; but by far the greater part of the land remains in its virgin state and is used for the production of pasturage or wild hay, which is undoubtedly the best use that can be made of it under present economic conditions.

Most of these soils are on the uplands, Sparta sand and parts of the O'Neill soils are on terraces, and Sarpy sand is on the bottom lands. There are wide variations in relief and soil features. The areas of dune sand and rough broken land range from hilly to extremely rough and broken. Much of the area occupied by the Holt soils also is rather rough, but the rest of the soils of this group have

nearly level or rolling relief. Light-colored bedrock is exposed in the Holt soils and rough broken land. Butler silty clay loam occupies poorly drained basins and has a dense clayey subsoil. The other soils of the group, as well as dune sand and riverwash, are composed largely of sand or mixtures of sand and gravel.

With the exception of the Valentine, Sparta, and Sarpy soils, which are very low in organic matter and light colored, these soils have in most places fairly dark topsoils. The darkest soils generally occur in the more nearly level situations and the lightest ones on the steepest slopes. Few are as dark as the soils of the other two groups.

All these soils support from moderate to heavy stands of nutritious pasture and hay grasses. The more sandy and less stable soils support a fair growth of *Redfieldia* and *Muhlenbergia*. Where the sand is more stable, little bluestem and needlegrass make good growths, and on the finer textured soils, grama, junegrass, and wheatgrass predominate.

Rough broken land.—Rough broken land covers 15 percent of the area of the county. It includes all land that is too rough to be cultivated but is of value for grazing and in places for growing wild hay. The largest body occupies the breaks between the tablelands and alluvial lands north of Niobrara River. Much of the land in and north of the Keya Paha River Valley in the northeastern part of the county is of this class. Most of this land owes its present character to severe erosion of the light-colored sandstone which occurs so extensively throughout the county; part, however, especially that north of Keya Paha River, has been caused by erosion into the Pierre shale formation.

Practically all of the rough broken land is steeply sloping or broken. In the Niobrara River breaks, where the relief is most pronounced, the long and steep north valley slopes are cut at right angles by many narrow V-shaped canyons. Vertical exposures of sandstone are numerous. The tops of many of the divides lie from 100 to 150 feet above the canyon floors, and the terrain is extremely harsh and angular. North of Keya Paha River the areas of rough broken land are characterized by narrow divides and valleys, but the valleys are shallower, the divides are more rounded, and there are fewer exposures of sandstone than on the Niobrara Valley slopes.

Most of the rough broken land is covered with a fairly dense growth of buffalo or grama grasses, or a mixture of them. Little bluestem and big bluestem also are fairly abundant, and there is considerable wheatgrass, especially in the areas north of Keya Paha River, where the underlying formation is Pierre shale. The grasses will support 70 to 75 cows and their calves on each section (640 acres) during the summer grazing season, from May to October, inclusive. Wild hay, which is cut on the more gradual slopes and in pockets and coves throughout the areas of rough broken land, yields one-third ton an acre in most years.

Mixed stands of pine and broadleaf trees, including western yellow pine, bur oak, ash, elm, and hackberry, grow on the Niobrara Valley slopes, locally in fairly dense stands. Scattered patches of broadleaved trees also grow on rough broken land on the valley slopes along Keya Paha River. The trees are used locally in farm buildings, but their chief value is for posts and fuel.

A negligible part of rough broken land is under cultivation, although small scattered fields of corn, sorgo, or millet occupy some of the more gentle slopes. The yields of these crops vary widely on different fields, according to differences in the degree of slope and in the character of the soil.

Valentine sand.—Valentine sand occurs throughout the uplands in all the northern and most of the southern precincts. It occupies 18.5 percent of the total area of the county. The relief of this soil ranges from nearly level to rolling, the greater part being characterized by low rounded hummocks and ridges from 5 to 10 feet high, separated by shallow depressions. There is practically no surface run-off, as the moisture is rapidly absorbed by the soil.

To a depth exceeding 4 feet the soil consists of loose gray or grayish-brown sand. The upper 3- or 4-inch layer is generally slightly darker than the rest of the soil but does not contain sufficient organic matter to prevent the sand from drifting when the native sod is destroyed. The soil is very low in lime.

Valentine sand is of little value for the production of grain or tame hay because of its instability and small content of organic matter. Not over 5 percent of it is cultivated—in small scattered fields of corn, sorgo, or sweetclover. Yields are low except in the most favorable seasons. Most of the soil retains its native covering of grass and is used for grazing cattle and producing hay. The native grasses consist chiefly of *Stipa*, or needlegrass, and sandgrass. They will support from 70 to 80 cattle on each square mile during the grazing season (May to October, inclusive) or will yield a little more than one-third ton of hay an acre.

Valentine loamy sand.—Valentine loamy sand resembles Valentine sand in all soil features except in its topsoil which contains a little more organic matter and is slightly thicker and darker. The organic matter, however, is not sufficiently abundant to hold the sand against drifting when the native sod is destroyed. In cultivated fields Valentine loamy sand rapidly changes to Valentine sand through removal of its organic matter by the wind.

The soil occupies a few small scattered bodies, most of which are in Burton and Mills Precincts. The bodies lie a little below the general level of the surrounding Valentine sand and have a slightly heavier cover of grass.

A small part of this soil is used for corn, sweetclover, or rye. These crops do fairly well during the first year, but the soil rapidly loses its organic matter under cultivation, and after a few years, it is no more productive than Valentine sand. Most of it remains in its virgin state. It is slightly superior to Valentine sand for grazing or hay land, owing to its heavier cover of grass.

Dune sand.—Hilly areas of wind-blown sand are designated on the map as dune sand. This is not a well-developed soil but is of value for pasture and is therefore classed with the soils suitable for grass. It occurs in large and small bodies throughout the more sandy parts of the uplands and has a total area of 23,744 acres. The largest body—about 4 square miles—is in the southeastern part of Mills Precinct.

Dune sand consists of gray incoherent fine or medium sand to a depth exceeding 10 feet. The upper 1 or 2 inches may be slightly

browner than the rest, owing to a small content of organic matter. The sand is derived from soft sandstone and has been deposited in its present position by wind. The general absence of fine material is probably due to its removal by the wind. The sand contains no lime. Dune sand differs from Valentine sand chiefly in that its surface is less even. In most places the sand has been whipped by the wind into irregularly distributed hills and ridges ranging from 40 to 80 feet in height, with intervening valleys, pockets, and swales. Surface drainage is not established, as moisture is quickly absorbed by the sand. Old and recent blow-outs are on many of the hills—generally on the north or northwest sides.

The dune sand areas are practically without value for cultivation. Local patches annually are broken and used for cultivated crops, but the removal of the native grasses practically ruins the land, not only in the areas where the vegetation is destroyed, but also to a distance of several rods to the leeward. At present most of the dune sand in this county is fairly well sodded, and very little of it is subject to active wind erosion. The native vegetation includes many valuable pasture, hay, and sand-binding grasses, of which little bluestem, blowout grass, sandreed, *Redfieldia*, and needlegrass are the most common. In spring and summer these grasses afford good grazing and will maintain from 60 to 70 head of cattle to the square mile, but in winter they cannot be depended on for pasturage. When cut for hay, the grasses will yield about one-fourth ton an acre.

Thurman loamy sand.—Thurman loamy sand occupies numerous, generally small, bodies throughout the sandy parts of the uplands, in many places closely associated with the Valentine soils. The largest areas, some of which exceed 1,000 acres, are south of Keya Paha River in Mills and Keya Paha Precincts. Few of the remaining bodies occupy more than 600 acres, and most of them are much smaller. The total area is 25,152 acres.

This soil is composed largely of sand with little capacity to retain water. It resembles the Valentine soils except that it contains more organic matter and has a much thicker and darker surface layer. It is identical with Thurman fine sandy loam of the group of soils suitable for the production of corn and oats, except that its topsoil is more sandy and less coherent.

The land is nearly level or gently rolling, but, owing to its rather droughty and unstable nature, it is poorly suited for the production of most grain crops. Practically all of it is surrounded by soils that have strongly rolling or hummocky relief and are composed of almost pure sand with little or no organic matter in their topsoils. Therefore, as some land is needed in these localities for feed crops, about 15 percent of Thurman loamy sand is cultivated. Corn, the principal crop, yields only about 10 bushels an acre in average years. Some rye and sweetclover are grown. Sweetclover yields only about one-fourth lower than on the finer textured soils, but yields of rye are seldom more than one-half as large as on those soils.

Unless some cover of vegetation is maintained almost constantly, the topsoil rapidly loses its organic matter through wind erosion. This layer in cultivated fields is much lighter in color than in virgin areas. The virgin areas support the same species of grasses as the Valentine soils, but the growth of grass is a little heavier and the soil has a slightly higher value for grazing and hay land.

Holt loamy sand.—Holt loamy sand occupies many, most of them small, bodies throughout the uplands in all parts of the county. The bodies are more numerous and larger in the western than in the eastern part, but few exceed 640 acres. The total area is 24,832 acres.

Holt loamy sand has developed from the weathered light-colored limy sandstone which underlies it, on smooth or gently rolling areas under conditions of good drainage and in the absence of severe erosion. The topsoil averages about 9 inches thick and is composed largely of incoherent sand. A considerable accumulation of organic matter has made the topsoil dark, but there is some variation in the intensity of the darkness. In the eastern part of the county the topsoil is nearly as dark as that of the Marshall soils, but in the western part in many places it contains only enough organic matter to make it brown or dark chestnut brown.

The subsoil is very light colored. It consists mainly of sand but contains enough silt and clay to give it some body and is fairly retentive of moisture. It is very limy, especially in the lower part where it rests on the unweathered or only slightly weathered parent material at a depth ranging from 3 to 4 feet. In places small fragments of the sandstone are scattered throughout the soil. They are rather numerous, especially below a depth of 2 feet.

Although the subsoil is fairly retentive of moisture, the topsoil becomes too loose and unstable for most grain or tame-hay crops when the native sod is destroyed, and only about 10 percent of this soil is under cultivation. Corn is grown chiefly, followed by sweet-clover and rye. In dry years yields are very low, but in seasons of heavy rainfall the moisture prevents the topsoil from drifting, and yields are almost as high as on the finer textured soils.

Owing to the uncertain yields when used for grain or tame-hay crops, most of the soil remains in its virgin state and is used for native-pasture or hay land. It supports a heavier grass cover than any of the Valentine, Thurman, or O'Neill soils of this group. During average years the grass will support a cow and a calf on each 8 acres, or when cut for hay will yield about one-half ton an acre.

Holt loamy sand, shallow phase.—The shallow phase of Holt loamy sand is much more extensive than typical Holt loamy sand, totaling 38,144 acres. Most of it is in the western part of the county where some of the bodies occupy several square miles. The relief ranges from nearly level to gently rolling. A comparatively small proportion of the soil is subject to severe water erosion. This soil differs from typical Holt loamy sand only in that the mantle of soil over the bedrock is not so thick. The topsoil in most places is 7 or 8 inches thick and consists of dark chestnut-brown incoherent loamy sand. The subsoil is not more than 14 inches thick and in places is entirely lacking. It consists of a mixture of very light gray sand and silt, containing many fragments of limy sandstone. The unweathered soft sandstone lies within a depth of 2 feet and in many places is much nearer the surface. It outcrops in small patches, but over most of the area it is covered by weathered soil material to a depth ranging from a few inches to 2 feet.

Included with this shallow soil in mapping are two small areas in which the soil contains a large quantity of limy coarse gravel. One such area is along the north edge of sec. 24 and the other is along the

east edge of sec. 26, T. 35 N., R. 18 W. Their combined area is about 15 acres, and both occupy low rounded ridges.

Practically all of the shallow phase of Holt loamy sand is used for native-pasture and hay land. Small scattered fields are used for the production of cultivated crops, chiefly corn. Both the instability of the topsoil when brought under cultivation and the nearness of the bedrock to the surface are unfavorable to grain or tame-hay crops, and yields are usually low except in the most favorable seasons.

Although unsuited for the production of cultivated crops, this soil supports a good grass cover and is considered only slightly inferior to typical Holt loamy sand for grazing and hay land. The included bodies of limy coarse gravel are of little value, even for pasture land.

Holt loamy sand, hilly phase.—The hilly phase of Holt loamy sand differs from the shallow phase of this soil type in having a more rolling relief and a thinner soil mantle over the underlying bedrock. It is everywhere hilly and in many places is extremely rough and broken. As mapped in this county, this hilly soil does not differ greatly in surface features from the areas mapped as rough broken land. Practically all of it lies above the general level of the uplands, whereas rough broken land is below this level. Most of this phase of Holt loamy sand occupies high buttelike hills and ridges capped by hard beds of sandstone, which have resisted erosion. Some of the hills occupy several hundred acres and rise from 100 to 150 feet above the surrounding tableland. A few of them have nearly flat tops covered by a thin layer of soil resembling Holt loamy sand, shallow phase, but all the larger areas of this land and most of the smaller ones have been severely carved by erosion and have little or no soil cover.

All this soil is in pasture. It supports only a sparse cover of grass and is of low value, even for grazing.

O'Neill loamy sand.—This soil occupies sandy terraces or benches in the Niobrara and Keya Paha River Valleys. The largest areas are in the Keya Paha Valley east of Mills and along Spring Creek south of Mills. The other bodies are fairly numerous, but few exceed 200 acres, and most of them are much smaller. The terraces on which this soil occurs range in height from 10 to more than 75 feet above the stream channels. Most of the older and higher terraces have been destroyed by erosion. The relief ranges from nearly level to gently rolling. Surface drainage is not developed, as all moisture is absorbed by the soil and passes downward.

The 10- or 12-inch topsoil consists largely of sand, but it contains sufficient organic matter to make it very dark. The subsoil is composed of incoherent fine sand or medium sand. The upper part is brown from stains of organic solutions washed from the topsoil, and below a depth of 2 feet the material is light grayish brown or gray.

Owing to the high content of organic matter in its surface layer, this soil retains moisture remarkably well for a sandy soil. It supports as heavy a grass cover as Holt loamy sand and is equal to that soil for grazing land or for the production of wild hay. Only about 5 percent of it, most of which is used for growing corn, is cultivated. Yields are good for the first few years after the sod is broken, but,

when the grass roots which hold the soil against drifting have decayed, wind rapidly removes the organic matter and leaves the soil extremely unstable and of low value even for grazing land.

O'Neill loamy sand, upland phase.—The upland phase of O'Neill loamy sand resembles the typical soil in general appearance, but it differs from that soil in two important respects. One of these is that it occurs only in the uplands, whereas typical O'Neill loamy sand occurs only on stream terraces; the other is that its subsoil layer is composed largely of gravel, whereas the corresponding layer of typical O'Neill soil as mapped in this county consists almost entirely of fine sand and medium sand. The two soils do not differ greatly in their productivity or crop adaptations; both are better suited for native pasture or hay than for cultivated crops.

This soil covers large areas throughout the uplands in Pine, Custer, and Garfield Precincts. Most of the land is nearly level or gently undulating. Some areas occur on ridges and slopes, wherever erosion has exposed to weathering the coarse gravel beds of the uplands. Surface drainage channels are few except on slopes where run-off has carved short shallow sags in the gravel deposits. Practically all surplus water passes rapidly downward through the porous sands and gravels.

The topsoil to a depth of about 10 inches is fine sand and medium sand, containing an abundance of organic matter which gives it a dark color. The material is rather incoherent and is subject to destructive wind erosion when brought under cultivation. The subsoil is a loose porous mixture of fine gravel, coarse gravel, and sand. The upper 12 or more inches of the subsoil are brown, but the lower part is gray. The subsoil has little capacity for retaining moisture.

Nearly all of this soil is used for pasture or hay. A few small bodies southwest of Springview have a slightly finer textured and more coherent topsoil and are used for corn and sweetclover, but yields are low except in the most favorable seasons. This soil in general supports a somewhat sparser grass cover than typical O'Neill loamy sand and has a slightly lower value for grazing and hay land.

O'Neill sandy loam, upland phase.—This soil differs from the upland phase of O'Neill loamy sand only in that its topsoil is slightly finer in texture and consequently slightly more stable. This soil occupies many small areas southeast of Norden and larger areas south and southeast of Springview.

Owing to the greater stability of its topsoil, a larger proportion—about 15 percent—of this soil is used for grain and tame-hay crops than of the upland phase of O'Neill loamy sand. Corn and sweetclover are the main crops, and some oats are grown. In seasons of normal or heavy precipitation, the cultivated crops yield fairly well, but in dry seasons they may fail to make sufficient returns to compensate for the cost of the seed. Most of this soil retains its native grass cover and is used for grazing and hay land for which it is about as well suited as Holt loamy sand.

Sparta sand.—Sparta sand occupies terraces similar in appearance to those on which the O'Neill soils are developed, and it has about the same surface features and drainage conditions as those soils. It occurs chiefly in the Keya Paha and Niobrara River Valleys. The largest areas, none of which exceeds 400 acres, are in Burton and McGuire Precincts. The total area is small.

This soil, in common with the O'Neill soils is composed largely of sand. It has a much lower content of organic matter and is lighter in color than any other terrace soil of the county. The 8-inch topsoil consists of loose fine sand or medium fine sand, containing barely enough organic matter to darken it slightly. The subsoil consists of porous gray sand containing little or no organic matter and no lime. This soil does not differ greatly from dune sand or Valentine sand, but it has more level relief and occupies lower positions. It is all included in pasture land. It supports a rather sparse cover of grass and does not have a high grazing value.

Cass and Valentine loamy sands, undifferentiated.—Cass and Valentine loamy sands, undifferentiated, include areas of these two soils so intricately intermixed that they cannot be shown separately on a small-scale map. These mixed soils occur in numerous, generally small, areas within the sandy uplands in the eastern half of the county and locally in the western half. The largest area, comprising about 400 acres, is 4 miles northwest of Burton, and the other areas are much smaller. The total area is not large.

The Valentine, mainly Valentine loamy sand, soils occupy the higher situations, on small irregular-sized and irregular-shaped hummocks and mounds, with gradually sloping sides. The mounds range in height from 2 to 6 feet, and few of them are more than 400 feet long. They are completely surrounded by shallow swales ranging from 50 to 150 feet in width, which are occupied by Cass soils—mainly Cass loamy sand.

The soil material is composed largely of fine sand or medium sand. The topsoil in the swales is 10 or 12 inches thick, has accumulated an abundance of organic matter, and is very dark. The topsoil on the mounds is low in organic matter, rather light colored, and in most places does not exceed 5 inches in thickness. The subsoil in both situations is loose gray sand.

The water table even during dry seasons is within 6 or 8 feet of the surface. It usually rises in the spring and may remain within a foot or two of the surface in the swales for several weeks.

This mixture of soils is used almost entirely for the production of native hay. The grass growth is naturally ranker in the swales where moisture conditions are more favorable than on the low mounds and hummocks, but all the more elevated areas support a good cover of grass. The land as a whole will yield about two-thirds of a ton of hay an acre during average years.

Butler silty clay loam.—Butler silty clay loam occupies a few small bodies in the northeastern part of the county with a combined area of only about 64 acres. Most of them are on the nearly level loess-capped tableland in the vicinity of Jamison.

The soil occurs in shallow poorly drained basins, locally known as "buffalo wallows", or "lagoons." Few of the basins are larger than 5 acres, and most of them cover only a few square rods. In all of them water accumulates after heavy rains and disappears slowly through seepage and evaporation.

The topsoil, to a depth ranging from 6 to 8 inches, is rather heavy though generally friable silty clay loam. It contains an abundance of organic matter and is very dark, especially in the upper part. It everywhere contains more or less light-gray silt from which exces-

sive moisture has leached the black organic matter, and in many of the more poorly drained basins the lower part of the topsoil is gray.

The subsoil averages about 50 inches thick. The upper 40 inches or so consists of very dark grayish-brown or almost black dense clay which is almost impervious to moisture and is penetrated with difficulty by a spade or auger, especially when dry. The lower part of the subsoil is light-gray limy friable silt. The material beneath the subsoil is incoherent gray sand containing little or no lime. The soil has developed under very poor drainage from a thin loess deposit.

None of the soil is under cultivation. Even if drainage conditions allowed the use of machinery, 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 for these crops. All the soil is included in farm pastures. It supports a luxuriant growth of water-loving grasses and weeds, but most of the land is covered with water for several days after heavy rains and does not have a high value even for grazing. As it occupies only a small part of the farms on which it occurs, it is of minor importance.

Sarpy sand.—Sarpy sand occupies several small areas in the bottom lands along the rivers and some of the larger creeks and is on some islands in Niobrara River. Few of the bodies exceed 80 acres, and the total area of the soil is only 6,016 acres.

The relief is nearly level, modified in places by stream channels, slight elevations, and shallow depressions. The land is subject to occasional overflow, as it lies at an elevation ranging from 3 to 4 feet above the normal level of stream channels.

The soil has developed from recently deposited sand that has not yet accumulated much organic matter. It somewhat resembles riverwash but is more stable and not so greatly influenced by each slight rise of the streams. The topsoil is very thin and only slightly darker than the rest of the soil profile. The subsoil is gray incoherent sand containing rusty-brown stains and splotches, owing to the poor drainage.

Nearly all of this soil is included in pasture or woodland, although a few small fields are used for the production of corn, sweetclover, and rye, all of which return rather low yields. Most of the land supports a scrub growth of willow and cottonwood trees which are used chiefly for posts and fuel.

Riverwash.—Riverwash includes sand bars and islands in Niobrara River. Only the larger bodies, with a combined area of 64 acres, are shown on the map. This material differs from Sarpy sand chiefly in being less stable. The surface lies only a few inches above the normal water level, and the boundaries of the areas change with slight fluctuations in the stream channel. Riverwash represents the first stages of soil formation, and with the general accumulation of organic matter, will, if undisturbed, develop ultimately into Sarpy sand. Most of it supports a dense growth of seedling willow and cottonwood trees. It is of little value even for pasturage.

CLASSIFICATION OF SOIL TYPES ACCORDING TO PRODUCTIVITY

The soils of Keya Paha County are classified in table 7 according to their ability to produce the more important crops of this general area. This classification compares the inherent productivity of each

soil for each of the leading crops in the county to a standard, namely 100, which is the rating given a soil that is inherently the most productive in the United States for the crop under consideration and which occupies sufficient acreage to warrant classing it as the standard soil for that crop. The rating (100) is called the base index and is the standard with which the productivity of all other soils for any particular crop is compared. Thus a soil estimated to be one-half as productive of a given crop as the one having the base index rating, receives an index of 50. A few unusually productive soils of small total acreage may have an index above 100 for a specified crop.

TABLE 7.—*Classification of soil types in Keya Paha County, Nebr., according to productivity* [1]

Soil type [2]	Crop productivity index [3] for—									Principal crops or type of farming
	Corn	Oats	Wheat	Rye	Barley	Alfalfa	Sweetclover	Wild hay	Pasture	
Hall loam	55	55	55	55	50	50	60	60	30	Corn and oats (general farming).
Lamoure fine sandy loam (well drained)	50	40	40	45	40	50	70	85	43	Corn and alfalfa.
Cass fine sandy loam (well drained)	45	30	30	30	30	45	75	80	40	Do.
Marshall loam, sandy-substratum phase	45	45	45	45	40	20	60	60	30	Corn and oats (general farming).
Marshall fine sandy loam, sandy-substratum phase.	40	35	35	40	35	20	50	65	26	Do.
Verdel fine sandy loam	35	30	30	35	30	20	50	55	26	Do.
Cass loamy fine sand (well drained)	35	25	25	30	25	40	65	70	35	Corn and alfalfa.
Holt fine sandy loam	30	30	30	35	30	20	40	65	26	Corn and oats (general farming).
Verdel clay loam	30	35	35	35	35	15	40	50	26	Do.
Ewing sandy loam	30	25	25	30	25	20	45	65	30	Do.
Boyd fine sandy loam	30	25	25	30	25	15	45	50	26	Do.
O'Neill fine sandy loam	30	25	25	30	25	25	45	50	26	Do.
Thurman fine sandy loam	25	20	20	25	20	15	35	50	26	Do.
O'Neill loam, upland phase	25	20	20	25	20	15	35	50	26	Do.
Boyd clay loam	20	25	25	25	25	10	35	20	23	Do.
O'Neill sandy loam, upland phase	20	15	15	20	15	10	30	50	20	Pasture and wild hay.
Holt loamy sand	15	10	10	15	10	10	35	50	23	Do.
O'Neill loamy sand	15	10	10	15	10	10	30	50	23	Do.
Thurman loamy sand	15	10	10	15	10	10	30	50	23	Do.
O'Neill loamy sand, upland phase	15	10	10	15	10	10	30	35	20	Do.
Valentine loamy sand	10	10	10	15	10	10	25	40	23	Do.
Lamoure fine sandy loam (poorly drained)	----	----	----	----	----	----	----	110	45	Do.
Cass fine sandy loam (poorly drained)	----	----	----	----	----	----	----	100	45	Do.
Cass loamy fine sand (poorly drained)	----	----	----	----	----	----	----	75	36	Do.
Cass and Valentine loamy sands, undifferentiated.	----	----	----	----	----	----	----	65	30	Do.
Butler silty clay loam	----	----	----	----	----	----	----	50	23	Do.
Sarpy sand	----	----	----	----	----	----	----	50	23	Do.
Holt loamy sand, shallow phase	----	----	----	----	----	----	----	40	20	Do.
Sparta sand	----	----	----	----	----	----	----	35	20	Do.
Valentine sand	----	----	----	----	----	----	----	35	20	Do.
Rough broken land	----	----	----	----	----	----	----	35	20	Do.
Dune sand	----	----	----	----	----	----	----	25	18	Do.
Holt loamy sand, hilly phase	----	----	----	----	----	----	----	----	15	Pasture.
Riverwash	----	----	----	----	----	----	----	----	10	Do.

[1] This table has been prepared jointly by officials of the following organizations: Soil Survey Division, U. S. Bureau of Chemistry and Soils; Land Use Planning Section, U. S. Resettlement Administration; Conservation and Survey Division and the Agricultural College, University of Nebraska.

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

[3] Soil types inherently most productive for the specified crop in the United States are given the index 100. Only those inherently most productive soil types of significant acreage in the more widely known crop regions have been given the standard of 100. The other indexes give the approximate production in percent of the standard.

NOTE.—No ratings on grain and tame-hay crops are given to soils that are definitely unsuited for cultivation, although some areas of these soils are farmed.

The inherent productivity indexes are based on the ability of the soil to produce under a management that is capable of maintaining the inherent or natural level of productivity but which does not involve irrigation, terracing, drainage, or the use of fertilizers other than those produced from crops grown on the soil.

The soils are listed in the order of their general productivity which is determined chiefly by their ability to produce the more important staple crops. No attempt is made to group the soils best suited for specified crops or to account for differences in the quality of the crops.

As the soils in this county do not receive amendments, such as lime, phosphate fertilizer, and complete fertilizer, no rating is given to indicate their response to fertilization. The use of manure produced on the land is not considered an amendment.

The factors influencing productivity of land are mainly climate, soil, and relief, or lay of the land. As long-time crop yields furnish the best available summation of the factors contributing to soil productivity, these have been made the basis for determining the productivity indexes in this table, which are based on the average annual yields of the crops during the period 1923 to 1932, inclusive.[4]

The rather low indexes given to most of the soils do not necessarily indicate that these soils are not well suited for the crops grown on them. Many of the soils are among the strongest and most productive in this section. Few of them give as high yields of a particular crop as are obtained on what is regarded as the ideal, or standard, soil for that crop, but this, in the majority of instances, is due mainly to less favorable moisture conditions and surface features, or both, than occur in the section occupied by the standard soil. Most of the soils in the county contain enough plant nutrients to insure much higher yields were moisture more abundant.

In rating the soils on the bottom lands or flood plains two index ratings are given, one applying to the better drained areas and the other to poorly drained areas. The map, however, does not distinguish between these areas, except in localities where drainage is so poor that a marshy condition prevails the greater part of each year. Here, the conventional marsh symbol is used. Elsewhere on the bottom lands the poorly drained tracts, although numerous, occupy such small patches and narrow strips that they could not be legibly indicated on a map of the scale used in this survey.

Streams occasionally overflow small local tracts on the flood plains, but no productivity ratings were given to these tracts because overflow is of little importance in the agriculture of the county.

Table 7 is not based on enough of the factors which influence land use to warrant interpreting the ratings directly into specific land values. It is based on essentially permanent factors relating to the inherent productivity of the soils, and no consideration has been given transitory economic factors. In some instances the information on which the ratings are based is not so complete as desired, and further study may suggest changes.

The following tabulation gives the more important crops of the county and the acre yield that has been set up as a standard of 100

[4] Unpublished estimates supplied by the Bureau of Agricultural Economics, U. S. Department of Agriculture, cooperating with the Nebraska State Board of Agriculture.

for each crop. These yields represent long-time production averages of the inherently most productive soils of significant acreage in the United States for products of satisfactory quality and are obtained without the use of soil amendments other than those produced directly or indirectly by the soil.

Crop	*Bushels*
Corn (grain)	50
Oats	50
Wheat (all kinds)	25
Rye	25
Barley	40
	Pounds
Alfalfa	9,000
Sweetclover	4,000
Wild hay	2,000
	Cow-acre days per year [5]
Pasture	100

[5] "Cow-acre days" is a term used to express the carrying capacity of pasture land. It is the numerical equivalent of the number of animal units supported by 1 acre during a given period of days.

MORPHOLOGY AND GENESIS OF SOILS

The county is in the Chernozem belt and near the western edge of the tall-grass prairie section of the United States. All the soils, except those which are subject to severe wind or water erosion or are developing on the most recently deposited stream sediments, have dark topsoils, owing to an accumulation of black well-decomposed grass remains. Throughout the smoother parts of the uplands and terraces the color of the finer textured soils, where the grass growth is most luxuriant, averages slightly darker than that of the coarser textured soils. The color in the surface layers of the soils of the smoother uplands and terraces also averages a trifle darker in the eastern than in the western part of the county. This is owing chiefly to the more uniformly sandy nature of the soils westward but partly to the fact that the county is near the edge of the tall-grass prairie section where westward the grasses are decreasing in height and supplying less organic matter to the soils.

Throughout the bottom lands of the county, where abundant moisture promotes a luxuriant growth of grasses and rapid vegetal decay, nearly all of the soils have very dark topsoils, the only exceptions being the soils developing on the most recently deposited sediments.

The parent materials of the soils on the uplands and terraces are composed largely of highly siliceous sand and gravel or of dense and rather impervious clay. Most of the sandy material was derived through the breaking down of a soft light-colored fine-grained sandstone of late Tertiary age, which formerly covered the entire area. Numerous remnants of this formation still remain. A part of the sand and most of the gravel reached this county as inwash from areas to the west, north, and northeast, probably during the latter part of the ice age. The clays are from highly colloidal Cretaceous shales of the Pierre formation which is extensively exposed throughout the uplands north of Keya Paha River and on the low valley slopes along Niobrara River.

The siliceous sand and gravel are extremely resistant to weathering and soil development, especially in this section where the annual precipitation averages only about 20 inches. The clays and shales also weather and develop into soils slowly because of their rather poor aeration and their resistance to penetration of moisture. In addition, most of the clay in the upland parts of the county occurs on rather steep slopes where much of the precipitation runs off the land and erosion removes the weathered soil material almost as fast as it is formed.

The soils on the bottom lands consist of, or are developed largely from, stream sediments, and although topographic and drainage conditions are in most places favorable for deep soil development, the soils have not yet had time to develop distinct profiles.

The county is in a section where the moisture falling as precipitation on well-drained smooth or gently rolling areas is insufficient to penetrate the finer textured soils to a greater depth than about 3 feet. In such soils the readily soluble salts, chiefly lime carbonate, accumulate at about this depth, creating a layer of higher lime content than occurs in any other part of the soil profile. This layer is commonly known as the lime zone, or horizon of lime carbonate accumulation. In this county, however, the greater parts of the soils have been entirely leached of their carbonates to a depth exceeding 6 feet. This is due mainly to the coarse porous character of most of the soils, which greatly increases depth of penetration and the leaching efficiency of the rather low precipitation. It may also be due, in part at least, to the low carbonate content of much of the coarse material at the time of its deposition.

Throughout the uplands and terraces, the only soils that are not rather thoroughly leached of their lime are those in which the fine or moderately fine textured material is more than 3 feet thick, or which rest on bedrock impervious to water at or near a depth of 3 feet. Nearly all of the bottom-land soils are more or less limy, regardless of their texture. These soils are of such recent origin that sufficient time has not elapsed for much leaching, and they are continually receiving dissolved carbonates in the run-off water and seepage from higher levels.

Of the limy soils, only two have developed sharply defined lime horizons. One of these, Butler silty clay loam, which will be described later, occupies poorly drained upland basins, has a rather thin topsoil, and plainly shows the influence of excessive moisture. The other has formed under good drainage, has a thick dark well-developed topsoil, and seems to have reached a stage of development more nearly in equilibrium with the regional climate and vegetation than any other soil in the county. This soil is shown on the accompanying map as Hall loam. It has developed from loessial deposits on well-drained terraces in the Keya Paha and Niobrara River Valleys.

Following is a description of the profile of this soil examined on a smooth bench along a tributary to Wolf Creek in Mills Precinct:

1. 0 to 7 inches, very dark grayish-brown friable loam containing an abundance of well-decomposed organic matter. The topmost 2 or 3 inches of material is structureless, and the remainder has a mealy structure.
2. 7 to 12 inches, material about the same as that in the overlying layer, except that it is a little lighter in color and a trifle more compact and cloddy, owing to a decreased organic matter and increased clay content.

3. 12 to 31 inches, dark grayish-brown moderately compact silty clay loam with a prismatic breakage and a cloddy structure. This is the layer of maximum compaction, but it nowhere attains the density of a claypan.
4. 31 to 45 inches, very light grayish-brown structureless silt or silt loam with a high carbonate content. This is the lime horizon. The lime occurs in finely divided form and as scattered hard concretions from one-sixteenth to one-fourth inch in diameter.
5. 45 inches to 6 feet +, light grayish-yellow loose incoherent fine sand or medium sand. The sand is calcareous, but less so than in the layer above, and contains few or no spots in which the carbonates are segregated.

All color and texture transitions between the different layers of the profile described are very gradual. The organic matter so abundant in the surface layer gradually decreases downward. To a depth of about 10 inches it appears to be evenly distributed throughout the soil mass, but below this depth it occurs as a film or coating on the surfaces of the structure particles. The film practically disappears a few inches above the lime zone. Insect casts are fairly abundant between depths of 10 and 30 inches, and numerous borings or crooked rodlike forms, about three-eighths of an inch in diameter and of various lengths, occur in the layer of maximum compaction. The borings probably represent fillings in old root, worm, or insect holes. In general they are a trifle lighter or darker than the surrounding matrix.

The Marshall soils of the uplands resemble Hall loam in general appearance. They have developed from silty loessial deposits similar to those underlying the Hall soil. In this county, however, the loess under the Marshall soils is thinner than that beneath the Hall. It rests on sand, in most places within a depth of 3 feet. The surface layer is as dark and thick as in the Hall soil. The upper part of the subsoil is dark grayish brown, prismatic, and moderately compact, and the lower part is light-gray loose silt as in the Hall soil. All the fine-textured material, however, lies within the average depth to which moisture penetrates, and the soil throughout has been rather thoroughly leached of its carbonates.

Small poorly drained basins, scattered throughout areas of the Marshall soils, are occupied by Butler silty clay loam. Water accumulates in the basins after heavy rains and in some of them remains on the surface of the ground for several days. The excessive moisture has greatly influenced the character of the soil. The topsoil is friable or only slightly compact and generally does not exceed 8 inches in thickness. In most places, especially in the lower part, it has a more or less laminated structure. The upper one-half or three-fourths is almost black but is sprinkled with white silt particles from which the organic matter is leached. The color of the remainder may range from almost black to white, depending on the amount of leaching that has taken place. The upper 12 to 30 inches of the subsoil is an almost black true claypan. The high clay content, dark color, and compaction of this layer are due largely to an accumulation of colloidal mineral and organic material carried down from the topsoil by percolating waters. The soil material is sticky and plastic when wet but becomes extremely hard and brittle on drying. A lime horizon generally occurs beneath the claypan, especially in all bodies of this soil where the dense clay is less than 30 inches thick. The lime horizon averages about 14 inches thick and

consists of light-gray floury silt in which the lime occurs mainly as small concretions. Beneath the lime zone is loose gray sand containing little or no lime.

The soils of the sandy uplands and terraces of the county, including the Thurman, O'Neill, Sparta, and Valentine soils, are composed almost entirely of sand or mixtures of sand and gravel. In the first two soils, organic matter is sufficiently abundant to produce dark-colored topsoils and brown upper subsoil layers. The Sparta and Valentine soils are low in organic matter and are light colored throughout. All these soils have been rather thoroughly leached of their lime.

The Holt soils have developed from light-colored, fine-grained, and slightly indurated sandstone of late Tertiary age, which has been exposed to weathering over large areas through the removal of the overlying sand, gravel, and loess deposits. These soils have dark surface layers, except on the steeper hillsides, but the subsoils have not, as a rule, been greatly influenced by the soil-forming processes. Lime is abundant in the subsoils but is rather evenly distributed, and the soil profile does not contain such well defined layers or horizons as occur in Hall loam. Fragments of the parent sandstone are present at slight depths in many places.

The Boyd soils of the uplands and the Verdel soils of the terraces have developed from the Pierre shale formation of late Cretaceous age. This formation consists of heavy shale containing numerous seams and cracks, filled in most places with finely divided lime and here and there with gypsum. It ranges in color from almost black to nearly white. Soils which have developed from it have imperfectly developed and dense subsoils. The subsoils are highly calcareous, but a lime horizon, if present, is poorly formed. Where it does occur it lies much nearer the surface of the ground than in the Hall soil. The surface layer of the Verdel soil is very dark, but that of the typical Boyd soils ranges from dark to light depending on the slope, the amount of run-off, the severity of erosion, and the color of the underlying shale.

All the soils on the bottom lands are forming on rather recently deposited stream sediments, and they are very immature. Most of them have dark topsoils but otherwise have not developed definite horizons or layers of true soil character. The more sandy ones belong to the Cass and Sarpy series and the finer textured ones to the Lamoure series. The Sarpy soils are low in organic matter and are light colored even at the surface of the ground.

SUMMARY

Keya Paha County is in northern Nebraska, adjoining South Dakota. It has a total area of 775 square miles. The area included is part of a formerly smooth to rolling plain formed on soft light-gray sandstone, in places containing beds of harder rock. Erosion into and locally through the sandstone by wind and water, followed by extensive deposition of sand, gravel, and loess from areas to the northwest, north, and northeast, and by a later period of erosion have considerably altered the surface of the former plain. Most of the upland is deeply covered with sand or a mixture of sand and gravel, and the relief ranges from nearly level to strongly rolling.

This surface configuration is modified in numerous places by high buttelike hills and promontories where the harder sandstone beds have resisted erosion. A nearly level loess-capped tableland, part of a larger table to the east and north, covers a few square miles in the extreme northeastern part of the county, and small outlying areas of this tableland continue nearly to the western county line. In the Niobrara and Keya Paha River Valleys in the southern and northeastern parts of the county, these rivers and their tributaries have removed the sandstone and overlying deposits, they have become deeply entrenched in the underlying Pierre shale formation, and an extremely rough and broken surface has resulted.

Alluvial lands, including the terraces and flood plains, occur chiefly along Niobrara and Keya Paha Rivers and along some of the larger creeks in the northern and northwestern parts of the county. All the alluvial lands have nearly level or gently undulating relief.

The county is in the western part of the tall-grass prairie section of the United States. In well-drained virgin areas, the leading grasses on the finer textured soils are little bluestem, grama, buffalo grass, and wheatgrass and on the sandy or gravelly soils *Stipa* and big bluestem. Mixed stands of scrub conifers and broad-leaved trees grow on the valley slopes along Niobrara River.

Good well water is readily obtained, except in areas where the Pierre shale formation is at or near the surface of the ground. Water in this shale is scarce and for the most part alkaline. The upland wells range from 80 to about 150 feet in depth, and those in the alluvial lands from 10 to 60 feet.

The climate is characterized by rather high summer and moderate to low winter temperatures. The mean annual precipitation is about 20 inches and the mean annual temperature is about 47° F. The relative humidity is rather consistently about 70 percent. Occasionally severe droughts occur, sometimes accompanied by dust storms.

According to the Federal census, only about 16 percent of the total land area was used for grain or tame hay crops in 1929; about 13 percent was used for wild hay; and most of the remainder was used for grazing land. Practically all of the crops, except the small quantities of wheat grown for cash, are fed to livestock, chiefly cattle and hogs, which are the main sources of revenue. During most years the value of livestock produced is more than twice as great as that of all crops, including wild hay.

Corn has occupied the largest cultivated acreage since farming began. Oats, alfalfa, rye, wheat, barley, sweetclover, and sorghum rank in acreage in the order named during average years.

The soils over the greater part of the county are so sandy, gravelly, or shallow, or have such uneven surfaces, that they are best suited for pasture or wild hay. The better drained, less eroded, and finer textured soils range from moderately to highly productive of the crops commonly grown.

Most of the soils, owing to an abundance of organic matter derived through decay of grassy vegetation, have dark topsoils. Throughout the rougher and more sandy sections, however, there are large areas in which the content of organic matter is small, and the soils are predominantly light colored, even on the surface. Only the finer textured soils contain an abundance of lime carbonate, but none of

the cultivated soils is so deficient in lime as to adversely affect the production of crops.

On the basis of their productivity and suitability for growing various crops, the soils of this county are grouped as follows: (1) Soils suitable for the production of corn and oats; (2) soils suitable for the production of corn and alfalfa; and (3) soils suitable only for grass.

The soils most suitable for the production of corn and oats are the darker, more stable, and less droughty soils of the uplands and terraces. All have good surface and internal drainage, and most of them are capable of retaining a large quantity of moisture. They are adapted to all the crops commonly grown but are used chiefly for the production of corn and oats because these crops are needed for livestock feed. The Marshall, Ewing, and Hall soils, the thicker, darker, and more nearly level types of the Boyd and Holt soils, and the finer textured and more stable O'Neill and Thurman soils are included in this group. The first three are silty, the Boyd soils are clayey, and the others consist chiefly of sand. All soils of this group have thick dark topsoils, owing to an abundance of organic matter, and even the more sandy ones contain sufficient fine material to make them fairly retentive of moisture. The Hall soils are the most productive.

The soils suitable for the production of corn and alfalfa, of which there are only three, include all the soils of the bottom lands, except Sarpy sand, which is extremely sandy and low in organic matter. This soil group is less extensive than either of the others. Owing to their large supply of moisture, these soils are more productive of corn and alfalfa than are the soils on the uplands or terraces, and they are used chiefly for these crops. The Cass and Lamoure soils belong to this group. They all have an abundance of organic matter in the surface layer which is very dark. The Cass soils are sandy throughout, whereas the Lamoure soils are composed largely of silt or silt and clay. The soils of the bottom lands are not well suited to small grains.

The soils suitable mainly for grass are those which are so shallow, sandy, eroded, or poorly drained that they are unsuited to cultivation. Valentine sand, Valentine sandy loam, Sparta sand, Thurman loamy sand, Sarpy sand, Butler silty clay loam, the more sandy droughty and unstable types of the O'Neill and Holt soils, and areas of rough broken land, dune sand, and riverwash are included in this group. Except for the areas of rough broken land, most of which are rather fine textured, and areas of Butler silty clay loam, which occupies poorly drained upland basins where the subsoils are extremely dense claypans, all the soils of this group are composed mainly of loose, incoherent sand, or a porous mixture of sand and gravel. Butler silty clay loam and the O'Neill and Holt soils have accumulated sufficient well-decomposed organic material to have dark topsoils, but the remaining soils of the group, as well as rough broken land, dune sand, and riverwash, have a small content of organic matter and are light colored throughout. Although unsuitable for tame-hay and grain crops, most of these soils support a good cover of native grasses on which cattle raising largely depends.

U. S. GOVERNMENT PRINTING OFFICE: 1937

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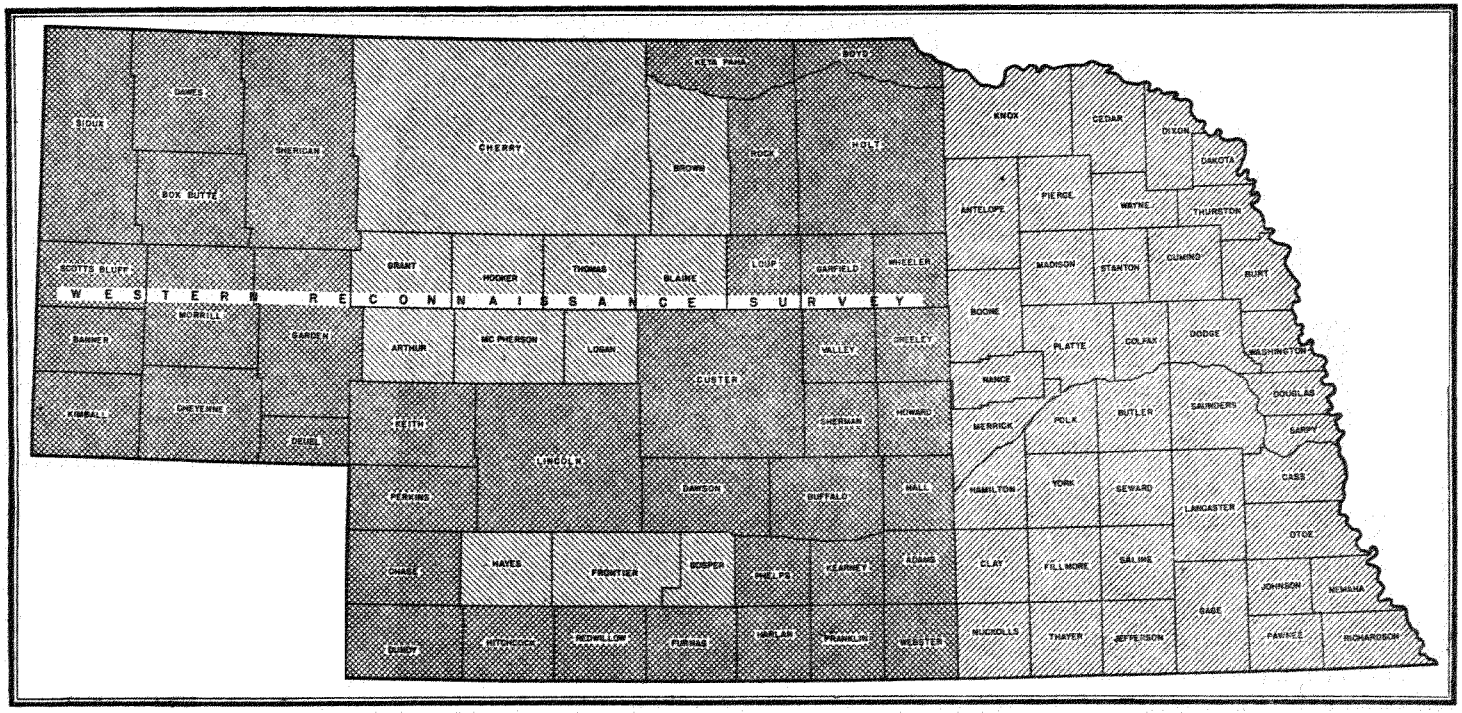

Areas surveyed in Nebraska shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; cross-hatching indicates areas covered in both ways.

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