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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey

of

Holt County, Nebraska

By

W. J. MORAN, in Charge, F. A. HAYES, W. D. LEE, and
S. RANKIN BACON
United States Department of Agriculture

and

BASIL ABASKIN, R. L. GEMMELL, and R. H. LOVALD
Nebraska Soil Survey

Bureau of Chemistry and Soils

In cooperation with the
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Department of the Conservation and Survey Division

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SOIL SURVEY OF HOLT COUNTY, NEBRASKA

By W. J. MORAN, in Charge, F. A. HAYES, W. D. LEE, and S. RANKIN BACON, United States Department of Agriculture, and BASIL ABASKIN, R. L. GEMMELL, and R. H. LOVALD, Nebraska Soil Survey

COUNTY SURVEYED

Holt County is in northeastern Nebraska (fig. 1). It is nearly square with an average north-south length of 49.9 miles and an east-west width of about 48 miles. The northern boundary is formed by Niobrara River and is irregular. The county comprises an area of 2,404 square miles, or 1,538,560 acres. O'Neill, the county seat, is about 125 miles west of Sioux City, Iowa.

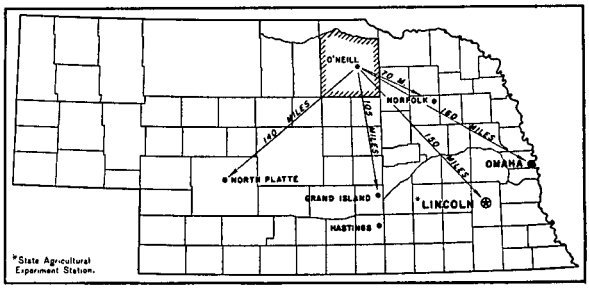

FIGURE 1.—Sketch map showing location of Holt County, Nebr.

This county is in the Great Plains region of the United States, on a former nearly level to rolling constructional plain, the surface of which has been considerably modified by water and wind erosion. Throughout nearly all of the uplands, there is a gentle slope downward toward the south and east, but Niobrara River is so deeply entrenched that most of the drainage in the northern half is northward to that stream.

The county includes parts of four rather well-defined physiographic divisions, known by the State physiographers as Niobrara Valley, Holt table, prairie plains, and sand-hill region.

That part of the Niobrara Valley within the county varies in relief. It comprises the older and higher terrace remnants, the bluffs, and the flood plains immediately south of Niobrara River. The flood plains here comprise only a small part of the total alluvial lands and are mentioned elsewhere in this report. They are from 150 to 250 feet below the uplands to the south.

The high terraces lie only a few feet below the general level of the uplands. They are remnants of a former nearly flat and probably continuous east-west bench that was formed before the Niobrara River became so deeply entrenched. This bench, which at one time ranged from 3 to 5 miles in width, was subsequently cut through at places by tributaries flowing northward to the trunk stream. The present terrace, or bench, remnants are covered by sandy or gravelly water-laid deposits resting at different depths on bedrock. In most places the sandy materials have been whipped

by the wind to a low rolling to hummocky relief, but locally there are nearly level areas, marked by the O'Neill and Sparta soils, where the former surface of the terrace has been modified but little.

The bluffs, locally known as the Niobrara River "breaks", are on both sides of the stream. Within this county they occupy a strip of steeply sloping or blufflike land between the high terrace remnants and the valley floor. They were formed by the river which has cut through its former deposits of sand and gravel, an underlying light-colored and loosely indurated sandstone (the Ogallala formation), and is now deeply entrenched in the lowest exposed bedrock of the county, a gray or dark-blue shale (the Pierre formation).

The breaks, which are occupied chiefly by the Boyd soils, range from less than one-eighth to about one-half of a mile in width. They are widest near the mouths of tributary creeks where erosion has cut narrow, in places almost vertical-walled, canyons, some of which are more than 100 feet deep.

The bluff land is not continuous across the county, and its slopes are not everywhere equally steep. In numerous places wind-blown sand from the adjoining terraces or uplands has greatly modified the harshness of the relief. Throughout most of their distribution, however, the breaks are so gullied and steeply sloping that they are of little value except for grazing land.

The Holt table extends both east and west of this county. The section included within the county occupies nearly all the area north of Elkhorn River to the southern edge of the high terraces in the Niobrara Valley. At its northern edge it lies from 20 to 50 feet above the general level of the terraces and in places is considerably dissected by streams. The general relief of this table is that of an undulating or gently rolling plain modified here and there by narrow stream valleys, some of which are entrenched to the sandstone bedrock, and by small areas of sand hills. The less eroded parts of the table appear nearly level but slope gently eastward. Part of this table is capped by gravel deposits that resist local erosion. Here occasional shallow drainageways and low sand mounds and hummocks afford the only relief. In some localities the tableland is mantled with loess which rests at slight depths on the sand and gravel deposits.

South of the Holt table and extending from northwest to southeast across the county is a broad slightly depressed belt known as the prairie plains, or locally as "the hay flats." It lies south of Elkhorn River and extends toward the headwaters of South Fork Elkhorn River and Cache Creek. This area is for the most part flat and poorly drained, but its nearly level relief is modified in places by hummocks and hills of wind-blown sand. Its northern boundary is marked by a rather sharp rise, ranging from 30 to 50 feet, to the Holt table, but the southern boundary merges with the sand hills proper through a sandy transitional zone of low rolling or hummocky land.

Most of the prairie plains section has the general appearance of a sandy bottom land. The area is much broader, however, than would seem possible were it formed by its present drainage system. In places it attains a width exceeding 15 miles and occupies the greater part of several townships. A few permanently flowing streams occur

within it, but these are small, rather sluggish, and tortuous and are entrenched to a depth of only 4 or 5 feet. There is an intricate system of scarcely perceptible swales in which water slowly works its way to the streams in early spring and following long periods of rainy weather. The relief over large areas does not exceed 4 feet except locally where isolated outliers of the sand hills rise from 20 to 50 feet above the surrounding land. The water table on the flats is constantly within a depth of 4 or 5 feet and during the spring rises enough to waterlog most of the land. Even during dry periods, marshes, ponds, and shallow lakes are characteristic features of the landscape.

The southwestern part of the county is in the vast sand-hill section of Nebraska. Here, wind has been the controlling element in forming the relief which ranges from gently undulating to hilly. Wind has piled the incoherent sand into an irregular succession of hills and ridges, which rise from 10 to 80 feet above the intervening valleys, pockets, and swales. The monotony of this landscape is broken occasionally by small lakes and marshes.

Bottom lands, basin floors, and terraces built up wholly or in part by water-laid deposits occur in each of the physiographic divisions of the county. The largest stream bottoms are along Elkhorn River. The alluvial lands of Niobrara River are narrow along the greater part of its course and rarely exceed one-half mile in width. The tributaries of both Niobrara and Elkhorn Rivers are bordered by comparatively narrow strips of alluvial land. In the prairie plains and the sand-hill division wide flats and basinlike areas have been filled with alluvium or with wind-blown sandy materials, which have subsequently been more or less reworked by water. The extensive areas of Cass soils in these sections have developed over flats of this kind.

Holt County has an average elevation of about 2,050 feet above sea level. The elevation at Stuart is 2,155 feet, at Atkinson 2,109 feet, at O'Neill 1,987 feet, and at Page 1,955.7 feet.

Niobrara and Elkhorn Rivers, together with their primary and secondary tributaries, afford ample drainage through practically all of the uplands. The low flat land, or prairie plains areas, along Elkhorn River are, as a rule, poorly drained. Here, seepage water from the sand hills nearly everywhere maintains a high water table. In early spring and following periods of prolonged rainy weather the ground water is within a depth of 2 feet on the flats, and in numerous shallow depressions it either waterlogs or inundates the land.

In virgin areas throughout the uplands and terraces, the principal grasses on the finer textured soils are big bluestem, little bluestem, western wheatgrass, and slender wheatgrass. On the more sandy soils, needlegrass predominates in most places. On the bottom lands are many varieties of moisture-loving grasses, except in the more poorly drained situations where rushes and sedges grow. Native trees, including elm, ash, oak, hackberry, boxelder, cottonwood, and willow, occupy narrow strips adjacent to the stream channels in all the larger valleys, and trees are especially numerous on many of the lower slopes of the bluffs bordering the Niobrara bottom lands. The trees are used chiefly for posts and fuel.

The quality, depth, and supply of well water differ in different parts of the county. In the upland, good water is obtained at a depth ranging from 30 to 150 feet, except in some places on the slopes and throughout the adjacent uplands along Niobrara River where the Pierre shale formation is exposed or lies near the surface of the ground. This formation contains only a small amount of rather alkaline water. Throughout the prairie plains and in the bottom lands along streams, good well water lies at depths ranging from 10 to 60 feet. Artesian water is obtained at a depth ranging from 65 to 130 feet in a number of places throughout the southern and southwestern parts of the county, and springs are numerous on many of the lower valley slopes in the northern part. Most of the springs occur near the bases of exposed sandy beds overlying Pierre shale. The water here is generally of good quality.

One of the first permanent settlements in this county was made by Gen. John O'Neill, who arrived with a colony of settlers of Irish descent on May 12, 1874, and after whom the town of O'Neill was named. Later colonies, headed by the same man, were brought into the county in 1875, 1876, and 1877.

At a special election held August 26, 1876, an attempt was made to organize Holt County, but on account of numerous difficulties connected with the canvassing of the vote, the election was invalid. Another election, held December 27, 1876, effected the organization. The original county seat was Paddock, but it was moved to O'Neill in 1879.

According to the 1930 census, the population of the county is 16,509, all classed as rural. The average density of the population is given as 6.9 persons a square mile. Most of the inhabitants are in the northern part. The sand hills and the prairie plains are rather sparsely settled. Of the total population, 977 are foreign-born whites and 15,524 are native whites. The foreign-born people are from Germany, Czechoslovakia, Canada, Ireland, and Austria. O'Neill, with a population of 2,019 in 1930, is the largest town. Stuart, Atkinson, and Ewing are distributing points and markets for farm supplies and produce.

Railroad transportation is provided by a main line of the Chicago & North Western Railway and a branch of the Chicago, Burlington & Quincy Railroad. The latter line terminates at O'Neill. The public-road system includes a north-south Federal highway, an east-west State highway, and several branches. The highways are surfaced with gravel or oil pavement. Most of the other roads are of earth construction and are usually kept in good repair. Nearly all of the roads in the rougher sections follow land lines. Concrete bridges and culverts are common, even on the minor roads.

The county is well supplied with rural mail delivery routes, telephones are in common use, and the public-school system is well developed.

CLIMATE

The climate of Holt County is continental and is characterized by a wide variation in temperature between winter and summer. It is well suited for the growing of corn, grain, and hay, and for the raising of livestock. The long warm summers are especially favor-

able for corn. The spring is usually cool with considerable rainy weather, and the autumns are long and pleasant with only occasional rains. There is not sufficient variation in relief to cause appreciable differences in climate. Table 1, compiled from the records of the United States Weather Bureau station at Atkinson, gives the more important climatic data.

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

[Elevation 2,108 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1902)	Snow, average depth
	° F.	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	22.2	80	−30	0.79	(1)	2.10	6.0
January	18.9	68	−35	.57	0.65	.45	5.6
February	22.4	78	−34	.78	.60	.40	6.8
Winter	21.2	80	−35	2.14	1.25	2.95	18.4
March	34.5	90	−18	1.10	1.00	1.94	7.2
April	46.3	98	5	2.46	2.14	1.84	2.8
May	55.5	98	18	3.30	.77	2.32	(1)
Spring	45.4	98	−18	6.86	3.91	6.10	10.0
June	66.8	106	34	2.83	1.08	4.12	0
July	73.3	106	41	3.05	.79	4.95	0
August	71.1	106	34	2.55	.70	5.25	0
Summer	70.4	106	34	8.43	2.57	14.32	0
September	62.2	105	19	1.82	1.90	6.57	0
October	49.6	97	1	1.40	1.35	.61	2.1
November	35.5	83	−13	.78	.26	.18	3.7
Fall	49.1	105	−13	4.00	3.51	7.36	5.8
Year	46.5	106	−35	21.43	11.24	30.73	34.2

[1] Trace.

The average length of the frost-free season is 146 days, from May 9 to October 2, inclusive, but killing frosts have occurred as late as May 27 and as early as September 11.

Approximately 75 percent of the mean annual precipitation falls during the principal part of the growing season, between April 1 and October 1. In summer the rainfall generally occurs as heavy thundershowers, but torrential rains are infrequent. Severe droughts are rare during May and June, but in the latter part of July and through August the amount of rainfall varies considerably, and prolonged dry spells sometimes occur.

The prevailing wind is from the northwest from October 1 to April 1 and from the south the rest of the year. Strong winds are common, but tornadoes are rare.

AGRICULTURE

General farming and livestock raising have been the chief occupations since the first settlement was made. Many of the early home-

steaders were unfamiliar with the soils and climate and did not at first employ the best farming practices. They were not aware that the sandy soils over the greater part of the county are better suited for pasture land and the production of hay than for grain farming, and large tracts that should have been left in grass were broken for cultivated crops. This resulted in severe wind erosion and low crop yields. Many fields were rendered temporarily useless, even for grazing land. Within a few years, however, the proper management practices were adopted, and a better system of land utilization was worked out.

Of the farmed acreage in 1934, 45.7 percent was cropland, 51.3 percent was in pasture, and 3 percent was used for other purposes, chiefly building sites and roads. Native hay is produced on the greater part of the cropped land, and corn, oats, rye, wheat, and barley, ranking in acreage in about the order named, are the principal cultivated crops.

According to the Federal census the value of all crops produced in the county in 1929 was $3,933,000. Dairy products with a value of $627,321 were sold, and the poultry and eggs produced were valued at $644,424. The total value of all hay and forage on farms was $1,427,788, that of cereals was $2,194,054, and that of all domestic animals, was $6,280,958.

Table 2, compiled from the Federal census reports, gives the acreage of the principal crops in 1879, 1889, 1899, 1909, 1919, 1929, and 1934. It shows the general trend of agriculture since about the time the county was organized.

TABLE 2.—*Acreage of principal crops in Holt County, Nebr., in stated years*

Crop	1879	1889	1899	1909	1919	1929	1934 [1]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn for grain	5,554	88,668	86,178	104,393	119,288	133,029	[2] 50,733
Oats	1,119	16,894	20,857	38,814	32,682	45,396	[2] 11,371
Wheat	2,796	7,998	19,613	6,027	14,008	2,096	2,174
Rye	184	6,073	7,767	6,775	24,535	38,005	12,025
Barley	295	466	1,170	523	734	3,471	1,524
All tame or cultivated grasses	--------	--------	3,735	24,958	24,871	28,152	--------
Wild, salt, or prairie grasses	10,610	74,953	149,812	259,309	374,132	347,512	[3] 361,806
Potatoes	--------	2,722	1,204	1,791	1,740	1,464	668

[1] Acreages of most crops greatly reduced because of drought.
[2] Sown for all purposes.
[3] All hay and sorghums for forage.

The returns from livestock and their products, which in 1929 had a higher value than all crops, are the main sources of income. Cattle and hogs have the highest value. Practically none of the feed crops—corn, oats, rye, and barley—and only about 25 percent of the hay are shipped out of the county. The rest is fed to livestock, mostly on the farms where produced.

The raising and winter fattening of beef cattle is the most important branch of livestock farming. The quality of the cattle, in general, is high. Most of the animals are grade Hereford, Shorthorn, and Aberdeen-Angus, but nearly all of the herds are headed by pure-blooded bulls. Some of the cattle are fattened on the farms

where raised, but most of them are sold to local feeders or are shipped to outside markets. Young calves are fed oats, cottonseed cake, and prairie hay during the winter and are allowed to run on the range in the summer, until they are 2 or 3 years old, when they are either shipped as feeders or are placed in feed yards for fattening. Many ranches annually ship in 2- or 3-year-old animals for summer grazing, and a few farmers ship in cattle for winter fattening. The animals intended for fattening are fed for a period ranging from 90 to 180 days and are then shipped to the Omaha or Sioux City markets.

Hog raising on most farms is directly connected with cattle fattening. From 20 to 30 hogs, which are fed chiefly corn and rye, are raised each year on the average farm. They are of good breeding, many being purebred. Hampshire, Spotted Poland China, Duroc-Jersey, and Chester White are the leading breeds. Fattened hogs are shipped to Omaha or Sioux City. Losses from hog cholera were heavy in the past but have been greatly reduced in recent years by vaccination and increased sanitation. The county is now unusually free from this disease, and about 30 percent of the hogs, weighing from 70 to 130 pounds each, are sold for the production of cholera serum. Nearly all of these hogs are purchased by local men, usually above the market price, and are shipped to serum companies at Sioux City, Kansas City, Omaha, and St. Joseph.

The sale of dairy products is an important source of income on many farms. Dairying is seldom practiced exclusively, but from two to six milk cows are kept on the average farm. The surplus dairy products are sold in the nearby towns.

Sheep are of minor importance. The principal breeds are Shropshire, Lincoln, and Rambouillet. The sheep destined for market are fattened in the fall on corn and oats and are shipped to Sioux City or Omaha. Those kept on the farm are wintered, chiefly on hay, although some corn, oats, and cottonseed cake are fed during severe weather.

Horse raising is confined chiefly to colts produced by the work mares. A few mules are raised, mainly for shipment to other sections of the United States. Most of the horses are of Percheron breeding. Purebred stallions are kept on a few farms. The raising of horses and mules has not been profitable during the last few years, but the number seems to be increasing.

Poultry is an important source of farm income on all farms, and some farmers have large flocks. There is usually a good demand for poultry products, and the poultry industry receives considerable attention. White Plymouth Rock, Buff Orpington, Rhode Island Red, and White Leghorn are the principal breeds of chickens. Turkeys are a source of some income. Bronze are raised chiefly, as this breed is usually thrifty and free from disease. The birds live largely on grasshoppers and other insects during the summer. They are either shipped directly to market or are sold to local buyers. A few ducks, geese, and guinea fowls are raised on some farms.

Table 3, compiled from the Federal census reports, gives the number and value of domestic animals on farms and ranges in 1920, 1930, and 1935.

TABLE 3.—*Number and value of domestic animals on farms and ranges in Holt County, Nebr., in 1920, 1930, and 1935*

Kind of animal	1920		1930		1935 [1]
	Number	*Dollars*	*Number*	*Dollars*	*Number*
Horses	20,745	1,170,320	16,125	643,258	14,612
Mules	1,941	173,471	1,774	95,454	950
Beef cattle	91,870	4,181,813	[2] 90,856	[2] 4,782,799	[2] 100,579
Dairy cattle	9,565	519,342	([3])	([3])	----------
Sheep	3,863	32,476	12,417	87,279	8,917
Swine	50,299	952,784	55,854	668,839	19,367
Poultry	186,814	130,979	[4] 194,361	[4] 147,714	[5] 154,862

[1] Value not reported. [2] All cattle. [3] Included in beef cattle. [4] Chickens only. [5] Chickens and turkeys.

The farm buildings, in general, are well painted and are kept in good repair, and many of the houses are equipped with modern conveniences. According to the Nebraska agricultural statistics, 101 farmhouses had electric lighting systems, 125 had modern water systems, and 683 had radios in 1930. The farms are fenced, and most of them are cross fenced with barbed wire, although a few are enclosed with hog-tight woven-wire fencing. The work animals include heavy draft horses and mules. There were 311 tractors, 213 trucks, and 1,854 automobiles on the farms in 1930. Most farmers have modern labor-saving machines, such as gang or sulky plows, disks, drills, corn planters, cultivators, and complete equipment for harvesting hay. There were 73 grain threshers, 13 combines, and 1,645 cream separators in 1930. Generally the more expensive farm machinery is sheltered.

The Federal census reports 93.7 percent of the county included in 2,471 farms in 1935. The average size of the farms in that year was 580.8 acres. The size ranges from 3 to more than 1,000 acres. About 51.5 percent of the farm land is improved.

Table 4 gives selected farm statistics in the census years, 1880–1935, inclusive.

TABLE 4.—*Selected farm statistics for Holt County, Nebr., in stated years*

	1880	1890	1900	1910	1920	1930	1935
Farms ... number	488	2,349	1,876	2,191	2,263	2,410	2,471
Average size ... acres	158	220	390.3	523.5	590.0	560.0	580.8
Improved land per farm ... acres	55.6	112	205.5	327.8	327.8	312.6	298.9
Land value per acre ... dollars	([1])	--------	5.82	21.80	39.36	[2] 23.74	[2] 13.40
Cost of labor ... do	([1])	--------	71,010	261,586	670,900	392,652	([1])
Cost of feed ... do	([1])	--------	--------	156,736	751,024	625,384	([1])
Cost of fertilizers ... do	105	48	850	520	51	954	([1])
Farm operation:							
Owners ... percent	100	85.14	77.4	72.5	61.8	54.1	51.0
Tenants ... do	--------	14.86	21.4	25.8	36.1	44.5	48.2
Managers ... do	--------	--------	1.2	1.7	2.1	1.4	.8

[1] Not reported. [2] Including buildings.

In 1880 all the farms were operated by owners, but since that time the number of owner-operated farms has gradually decreased. In 1935, 51 percent of the farms were operated by owners, 48.2 percent by tenants, and 0.8 percent by managers. Both the cash and share systems of rental and sometimes a combination of the two are used. The share system is the more popular. Under it the owner receives one-third of the grain delivered and one-half of the hay stacked in

the field. During 1931 and 1932, when this survey was made, pasture land rented for only a trifle more than the cost of taxes. Farm laborers are plentiful, and wages range from $20 to $30 a month. Laborers receiving the higher wages generally are furnished a house but board themselves. Corn shuckers receive 2 or 2½ cents a bushel for shucking corn. Oats are threshed for 2 or 2½ cents, and rye, barley, and wheat, for 4 or 4½ cents. A few farmers hire help by the year in order to insure an adequate supply at critical periods.

According to the records of the registrar of deeds at the county seat, there were 31 land transfers in Holt County during the 12 months preceding March 31, 1932. These transfers involved 9,426 acres, and the average price was $18.47 an acre. The assessed valuation of the land during 1931 averaged $10.52 an acre. The selling price of individual farms varies widely, depending on the character of the soil, topography, drainage, improvements, and location with respect to markets.

SOIL-SURVEY METHODS AND DEFINITIONS

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

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil is studied in detail; and the color, structure, porosity, consistence, texture, and the content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [1] and its content of lime and salts are determined by simple tests. The drainage, both internal and external, and other external features, such as the relief, or lay of the land, are taken into consideration, and the interrelation of soil and vegetation are studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into mapping units. The three principal ones are: (1) Series, (2) type, and (3) phase. In places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a map, but must be mapped as (4) a complex. There are areas of land, such as coastal beach or bare rocky mountain sides, which have no true soil, and these are called (5) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus the series includes soils having essentially the same color, structure, and other important internal characteristics, and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that

[1] The reaction of the soil is its degree of acidity or alkalinity, expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values alkalinity, and lower values acidity.

commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Clarion, Webster, Carrington, and O'Neill are names of important soil series.

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

A phase of the soil type is recognized for the separation of soil within a type, which differs in some minor soil characteristic that may, nevertheless, have an important practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for a soil type, there may be areas adapted to the use of machinery and the growth of cultivated crops and other areas which are not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated plants. In such instances the more sloping parts of the soil type may be shown on the map as a sloping or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The soils of Holt County have, for the most part, sandy surface soils and sandy or gravelly subsoils. As a result of this texture they are porous. This feature of the soil, together with the rather low precipitation, greatly influences the kinds of crops that can be grown and the average yields. As a result of soil and climatic conditions, several types of farming have been adopted, and the distribution of each type is determined to a large extent by local soil and drainage conditions. According to the 1930 Federal census, less than 25 percent of the farms are classed with the general-farming type, which includes farms where the value of products from any one source is less than 40 percent of the total value of all products. Less than 10 percent of the farms produce grain as a cash crop. General farming and cash-grain farming are practiced almost entirely on the better class of sandy loams in the northern part of the county. On the general type of farms, a large acreage is devoted to the production of feed for livestock. More than one-half of the total number of farms

and nearly two-thirds of the total acreage of land in farms are used for raising livestock or for the production of animal products, including beef, wool, milk, and eggs. According to the 1930 census, 51 ranches, depending largely on grazing, utilized 11 percent of the total area of the county. Nearly one-half of the total area is used for a type of farming, in which grazing for livestock is supplemented by forage and grain crops grown for feed and by native hay cut on the better grasslands. The value of dairy and poultry products makes up only a small part of the agricultural income.

The dominance of livestock production over cash-grain farming is largely determined by the character of the soils. No soil in this county is particularly well suited to growing grain as a cash crop. The greater part of the land is best suited for hay and pasture. Grain and forage crops can be grown, however, over a large part of the county in sufficient quantity to supplement the pasture and to carry livestock through the winter. Such supplementary feed crops must be grown where they are needed, even though yields are too small to be profitable in a cash-grain type of farming. The system of agriculture now practiced is encouraged by the marketing facilities for livestock for slaughter and for animal products. This county is within a short hauling distance of two important livestock markets—Omaha, Nebr., and Sioux City, Iowa.

The adaptation of the types of farming to soil, climate, drainage, and economic conditions has resulted in an agricultural income which compares favorably with that in counties having better soils and higher rainfall.

Under any of the systems of farming practiced, all the feed grown either is consumed on the farms where it is produced or is sold to local feeders. Corn was grown on about 59 percent, oats on about 17 percent, rye on about 14 percent, and tame hay on about 10 percent of the cultivated land in 1929. More than half of the tame-hay acreage was used for alfalfa, 6 percent for red clover, and about 39 percent for red clover and timothy mixed. Among the minor crops, barley, wheat, emmer, spelt, and potatoes are most important.

The outstanding feature of the soils is their sandy texture. With the exception of a clay loam, which occupies relatively small areas on the uplands and terraces, and of a silt loam in a few small depressions, the soils are either sandy loams or sands. The well-drained sandy soils have not accumulated such large amounts of black organic matter as have the heavier soils of the area, partly because they support a less luxuriant vegetation and partly because the surface soil, in many places, is shifted by the wind. These soils have leached more rapidly than the heavier soils and have lost their lime and other constitutents that favor the accumulation of organic matter. Vast areas of sandy flats have slow surface drainage and a high water table. Soils in these areas have accumulated a large store of organic matter from the heavy growth of native grasses. These sandy but well-watered soils are well suited to pasture and to hay grasses. For this reason, less than half the total area of farms is used for cultivated crops. Of the cultivated land, about one-third is used for grain crops and the remainder for hay and forage crops. Nearly all of the untilled land can be used for pasture.

The soils, in general, have dark-colored topsoils resulting from an abundance of black organic matter derived from the decayed grass roots. Some of the sand and loamy sand soils that have been mixed or severely eroded by the wind, however, have a lower content of organic matter and consequently a lighter color. Geological formations, ranging from heavy shales to coarse sands and gravels, are exposed both in spots and over large areas, and the soils developed over these rocks naturally show marked contrasts in their textural features. Differences in the degree of erosion and in the character of the geological formations have also produced differences in the structure, compaction, and chemical composition of the soils in different localities.

The soils may be placed, on the basis of the use to which they are best suited, into three broad groups, as follows: Soils suited to general farming, soils suited to hay farming, and soils suited to grazing. This system of grouping is not intended to indicate that the crops mentioned in connection with any particular group of soils, based on use, are the only crops that can be grown on the soils of the group. All the crops commonly grown can be produced successfully on nearly all of the soils, except those which are topographically unsuited or are too sandy or too poorly drained for cultivation. Larger returns, however, are obtained, year in and year out, from the soils of a particular group when those soils are used for the crops or combination of crops for which they are best suited. The grouping is based not only on soil and crop adaptations but also on those soil characteristics which are responsible for these adaptations, and on the surface features and drainage conditions of the soils. None of the soil groups is confined to any particular part of the county, although some of the soils in each group are of very local occurrence.

The soils of the different groups and their crop adaptations are described in the following pages; the soil map accompanying this report shows the distribution of the soils; and table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreage and proportionate extent of soils mapped in Holt County, Nebr*

Soil type	Acres	Percent
Marshall very fine sandy loam, sandy-substratum phase	18,688	1.2
Marshall fine sandy loam, sandy-substratum phase	17,856	1.1
Thurman fine sandy loam	57,856	3.7
Thurman sandy loam	32,384	2.2
Thurman loamy sand	141,056	9.1
Ewing fine sandy loam	7,552	.5
Ewing loamy sand	10,304	.7
O'Neill fine sandy loam	18,624	1.2
O'Neill fine sandy loam, deep phase	2,432	.2
O'Neill loamy sand	60,928	3.9
O'Neill sandy loam, upland phase	102,784	6.7
O'Neill loam, upland phase	58,496	3.8
Verdel fine sandy loam	2,752	.2
Verdel clay loam	832	.1
Cass loamy fine sand	233,600	15.2
Cass loamy fine sand, claypan phase	9,536	.6
Cass fine sandy loam	86,144	5.6
Cass fine sandy loam, claypan phase	9,856	.6
Cass very fine sandy loam	18,304	1.2
Cass very fine sandy loam, claypan phase	2,176	.1
Lamoure very fine sandy loam	5,888	.4
Lamoure fine sandy loam	7,104	.5
Lamoure loamy fine sand	4,480	.3
Gannett loamy sand	5,440	.3
Valentine sand	301,952	19.6
Valentine loamy sand	50,176	3.2
Dune sand	176,640	11.5
O'Neill gravelly sandy loam, upland phase	10,688	.7
O'Neill loamy sand, upland phase	18,368	1.2
Boyd clay loam	9,600	.6
Boyd fine sandy loam	18,624	1.2
Holt fine sandy loam	24,320	1.6
Fillmore silt loam	320	.1
Cass and Valentine loamy sands, undifferentiated	1,600	.1
Sarpy sand	10,496	.7
Riverwash	704	.1
Total	1,538,560	------

SOILS SUITED TO GENERAL FARMING

The group of soils suited to general farming includes those soils which are not too sandy, rough, or poorly drained for the production of corn, small grains, and cultivated forage crops. These soils have accumulated rather large amounts of organic matter and have darker and thicker topsoils than those of the other groups. They all are on the well-drained uplands and terraces. With the exception of two minor types, the soils of this group are sandy loams and loamy sands of the better class. All contain some finer material and organic matter mixed with the sand, especially in the topsoils. These constituents add greatly to their productiveness. Only a few of the soils have silty or clayey subsoils and are highly retentive of moisture, but all, except the upland phases of the O'Neill soils, are able to hold most of the moderate precipitation until the absorbed moisture can be drawn off by crops. Only the soils with heavier subsoils are well supplied with lime.

Corn occupies more than 75 percent of the land used for grain crops, rye about 20 percent, and barley and wheat the remainder. None of these crops gives high yields on the soils of this group in average years. Corn does better than the small grains, especially on the sandy soils, and, because of its value for feed to supplement hay and pasture in a livestock ration, it is grown wherever possible.

Marshall very fine sandy loam, sandy-substratum phase.—The surface soil of Marshall very fine sandy loam, sandy-substratum phase, is dark-brown or dark grayish-brown loose and friable very fine sandy loam to an average depth of 8 inches. The material contains considerable silt and medium sand and in places approaches loam in texture. The dark surface soil generally grades into the subsoil through an intermediate layer, from 4 to 6 inches thick, in which the color becomes lighter. Below this is brown friable very fine sandy loam which gives way, at a depth of about 3 feet, to gray or grayish-brown sand.

The soil varies a little in texture and depth from place to place and includes some areas of related soils, such as very fine sandy loams of other series. The latter areas, however, are so small that it is not practical to show them on a map of the small scale used in this survey.

This phase of Marshall very fine sandy loam occurs between Page and the head of Turkey Creek in irregular-shaped areas ranging from a few to several hundred acres in size. The largest developments are east and northwest of Town Hall in Shields Township and north and east of Page in the eastern part of the county. There is an area of about 600 acres northeast of O'Neill and one of about 500 acres north of that town.

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

About 98 percent of this soil is under cultivation, and the remainder is occupied by building sites, feed lots, pasture land, and roads. About 60 percent of the cultivated land is devoted to corn, about 25 percent to oats, and about 10 percent to rye and barley.

The rest is used largely for growing potatoes, wheat, and garden vegetables. The yields obtained are among the highest in the county. Corn yields range from 20 to 30 bushels an acre, oats 20 to 25 bushels, barley 18 to 20 bushels, and potatoes 75 to 85 bushels.

North and northeast of Page, the sandy substratum is absent or lies at a depth of many feet below the surface. Here the soil is not so deeply leached of its lime which, in most places, is abundant in the subsoil. A few areas north of Page, the largest including about 100 acres, have much heavier subsoils than is general. The areas having the limy or the heavy subsoils are a little more productive than the rest of the soil.

Marshall fine sandy loam, sandy-substratum phase.—The topsoil of the sandy-substratum phase of Marshall fine sandy loam is dark-brown or dark grayish-brown fine sandy loam, similar in all respects, except texture, to the surface soil of the corresponding phase of Marshall very fine sandy loam. The topsoil ranges from 6 to 10 inches in thickness, and the average thickness is 7 inches. It is underlain by brown or grayish-brown friable fine sandy loam. Below a depth of 28 or 30 inches is loose grayish-brown or brown fine sand. Lime is not sufficient in any part of the soil profile to cause effervescence with hydrochloric acid.

Areas of this soil generally are closely associated with those of the finer textured Marshall soil.

The relief ranges from almost flat to moderately rolling, the greater part of the soil having a gently rolling surface. Drainage is good and, for the most part, is not excessive. Erosion is not abnormal except in a few places. The soil absorbs moisture rapidly and allows little run-off.

The proportion of this soil under cultivation is not quite so large as that of the sandy-substratum phase of Marshall very fine sandy loam, but crop yields are about the same as on that soil. The same crops are grown in about the same relative acreages.

Thurman fine sandy loam.—The surface soil of Thurman fine sandy loam, to a depth of about 9 inches, is very dark grayish brown and contains a high percentage of organic matter. This material grades into dark grayish-brown fine sandy loam which has slightly less organic matter than the layer above but is otherwise similar to it. Between depths of about 16 and 24 inches the brown color becomes more prominent, and the soil material becomes more sandy. The remainder of the profile is light grayish-brown incoherent sand which, in places, grades into grayish-yellow sand below a depth of 3 feet.

The relief is nearly level or very gently rolling. Surface drainage channels, as a rule, are not well established, as the precipitation is rapidly absorbed by the porous sand. Because of its high organic content this soil holds sufficient moisture to maintain a grass cover that prevents drifting.

Thurman fine sandy loam is one of the leading agricultural soils. It is not so productive as Marshall fine sandy loam, sandy-substratum phase, but its total area is more than three times as great. The total crop yields obtained on this soil are larger than those on any other soil in the county.

Nearly all of this soil lies north of Elkhorn River north and east of Atkinson. The largest areas are in the vicinity of Prairie Belle School, a few miles north of O'Neill, and in the vicinities of Agee and Meek.

About 60 percent of the land is devoted to corn, 25 percent to oats, 3 percent to barley, 2 percent to rye, and 2 percent to alfalfa. Most of the remainder is used for potatoes, emmer, spelt, sorgo, and other crops grown for sustenance, feed, and pasturage.

Thurman sandy loam.—Thurman sandy loam differs from Thurman fine sandy loam mainly in having a slightly coarser textured topsoil and a lower organic-matter content.

The largest areas are in the vicinity of Page, north and northwest of Emmet, north of Atkinson, on the southeastern side of Eagle Creek, and east of Turkey Creek.

About 60 percent of this soil is cultivated. Corn occupies about 50 percent of the cultivated land, rye about 35 percent, oats about 5 percent, and forage crops, chiefly sorgo and millet, most of the remainder. The average acre yield of corn over a period of years is about 15 bushels, that of rye about 8 bushels, and that of oats about 13 bushels. Forage crops yield from ¼ ton to 2 tons of hay or fodder an acre, depending on the precipitation and the kind of crop grown.

Of the uncultivated acreage, about equal parts are used for pasture land and the production of wild hay. The land has a fairly dense growth of nutritious grasses which will support a cow or steer on about 6 acres during the summer grazing season, May to October, inclusive, or when cut for hay will yield about three-fifths of a ton an acre.

Thurman loamy sand.—Thurman loamy sand has the largest acreage of the soils in this group. It occurs throughout the uplands wherever exposures of nearly pure sand have accumulated sufficient organic matter to give their surface layer a pronounced dark color. This layer, to a depth ranging from 8 to 12 inches, is dark grayish-brown or very dark grayish-brown loamy sand. The upper part of the subsoil, which is about 10 inches thick, is grayish brown changing downward to brown. It consists largely of fine sand but contains some silt and clay, which in most places weakly binds the sand grains together and gives the material slight coherence. Below this is incoherent gray sand similar to that beneath the Valentine soils and dune sand. Neither surface soil nor subsoil contains lime.

The largest developments of Thurman loamy sand are in the eastern and northwestern sections of the county, where all, except a small part of the soil occurs.

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

This soil has a lower moisture-retaining power than the more silty soils but is not droughty. Were it not for the moderate organic-matter content of its topsoil, it would be very unstable. The organic matter enables this soil to retain more moisture than any of the Valentine soils and also gives it greater stability, but it is not abundant enough to prevent soil drifting, especially in cultivated fields.

About 50 percent of the soil is under cultivation. The farmed areas are used mainly for corn and to some extent for rye and sweetclover. The average corn yield, in well-managed fields, is about 10 bushels an acre and that of rye about 5 bushels. Sweetclover yields about four-fifths of a ton an acre during most years.

Of the uncultivated land, about 70 percent is in pasture and the rest is hay land. The native grasses will support about 22 cattle on each 160 acres or will yield about one-half ton of hay an acre.

Ewing fine sandy loam.—Ewing fine sandy loam has developed over gravelly deposits similar to those that underlie the upland phases of the O'Neill soils. The Ewing soils are characterized, however, by a heavy layer in the upper part of the subsoil. In this particular type, the topsoil is about 10 inches thick and consists of friable fine sandy loam containing a small percentage of gravel, together with sufficient organic matter to impart a very dark grayish-brown color. The upper layer of the subsoil, which ranges in thickness from 10 to 20 inches, is more compact than any other layer of the profile, attaining the density of a claypan in some places. The material of this layer is rather variable in color and composition. Throughout most of the areas of this soil it consists of brown fine gravel or coarse gravel, the interstitial spaces of which are filled with a mixture of silt, clay, and fine sand. The finer material holds the gravel together so that the layer becomes extremely hard and compact, especially when dry. Over many areas the fine-grained binding material is more abundant than the gravel and is rather light in color. In some localities the compact layer contains few or no gravel. The material beneath the heavy layer everywhere consists of loose gravel or mixtures of coarse sand and gravel to a depth below 6 feet. The soil is low but not deficient in lime.

Ewing fine sandy loam occupies several areas in the north-central part of the county, mainly north of Elkhorn River. Most of them are near O'Neill and northwest of Emmet, and the largest is northeast of O'Neill.

The relief is nearly level, and surface drainage channels are not established. All surface water, however, is rapidly absorbed, and, although the soil has rather slow underdrainage, it seldom becomes too wet for cultivation even in seasons of heavy rainfall.

Because of the heavier subsoil, which prevents excessive downward loss of water, the soil is not droughty and is somewhat more productive than the Thurman and O'Neill soils. A large part of the land is under cultivation. The greater part of the cultivated land is used for growing corn and nearly all the remainder for growing oats and rye. The average yield of corn is about 18 bushels an acre, of oats about 15 bushels, and of rye about 10 bushels.

Ewing loamy sand.—Ewing loamy sand occurs in irregular-shaped bodies, ranging in size from small patches to several hundred acres, in nearly all parts of the county except the southwest quarter. More than three-fourths of the total area of this soil is north of Elkhorn River between Emmet and Stuart. The relief is nearly level or undulating.

The 12- to 18-inch surface soil of Ewing loamy sand is dark grayish-brown loose loamy sand with a high content of organic matter.

Beneath this is a brownish-gray layer of moderately compact gravelly sandy clay ranging from 10 to 15 inches in thickness. The lower part of the subsoil and the substratum are gray incoherent gravelly sand.

The crops grown, their acreage ratios, and the percentages of the land under cultivation and in pasture are about the same as on Thurman loamy sand, but the yields average a trifle higher than on that soil, because the heavy layer in the Ewing soil concentrates the absorbed moisture nearer the surface of the ground.

O'Neill fine sandy loam.—The topsoil of O'Neill fine sandy loam, which extends to a depth of 12 or 14 inches, is loose very dark grayish-brown fine sandy loam. Below this and continuing to a depth of about 30 inches is dark-brown fine sand or fine sandy loam. This grades into brown medium sand, in which there is a small amount of coarse sand and fine gravel in places. At a depth ranging from 50 to 70 inches the sand becomes light grayish brown. This soil is low in lime throughout.

O'Neill fine sandy loam is one of the most extensive soils on the terraces. It occurs on both high and low benches along Elkhorn River, where it lies from 8 to 90 feet above the stream. The largest areas are in the vicinities of Stuart, Atkinson, and O'Neill.

The soil absorbs most of the precipitation that falls on it and is able to hold, until drawn off by plants, practically all of the absorbed moisture. As it is fairly stable and is topographically suited to cultivation, most of the land is farmed. The same crops are grown as on Thurman fine sandy loam, and yields are slightly higher than on that soil.

O'Neill fine sandy loam, deep phase.—The deep phase of O'Neill fine sandy loam has a very dark grayish-brown friable fine sandy loam topsoil from 12 to 15 inches thick. This is underlain by brownish-gray slightly heavier though friable clay loam which rests, at a depth ranging from 30 to 40 inches, on incoherent gray sand. No part of the profile contains sufficient lime to show effervescence when dilute hydrochloric acid is applied.

This soil occurs on high well-drained terraces. The largest developments are in the southeastern part of the county along Clearwater Creek, and north of Elkhorn River near O'Neill. The total area of the soil in this county is less than 4 square miles, nearly all of which is under cultivation. The crops grown and their acreage ratios are about the same as on the sandy-substratum phase of Marshall very fine sandy loam, but the yields are from 5 to 15 percent lower than on that soil.

O'Neill loamy sand.—O'Neill loamy sand is similar to Thurman loamy sand, but it occupies smooth or gently undulating terraces, whereas the latter soil is on the gently rolling uplands. The topsoil, to an average depth of 10 inches, consists of very dark grayish-brown loose loamy sand. The upper 10 inches of the subsoil is brown loamy sand, and the remainder of the profile, to a depth of many feet, is gray sand. The entire subsoil is incoherent, and the soil throughout is low in lime.

This soil is extensively developed on high terraces in the northwestern part of the county, mainly along Niobrara River and its

larger tributaries. Owing to a rather large amount of organic matter in the surface soil, the soil is fairly stable and can be used profitably for growing corn, rye, and sweetclover, if care is taken to control wind erosion. A slightly larger proportion of this soil than of Thurman loamy sand is under cultivation, and crop yields average about the same on the two soils.

O'Neill sandy loam, upland phase.—The upland phase of O'Neill sandy loam has a profile that does not differ essentially from that of typical O'Neill soils of corresponding texture in their topsoils. The typical O'Neill soils, however, occur on stream terraces, whereas this soil is on flat-topped divides high above the present stream valleys. The origin and the age of the material on which this soil has developed have not been determined with certainty by geologists. It is presumed that the material was water-laid, but its age and its elevated position have probably brought about changes in its composition that justify its designation as a phase of the O'Neill soil.

The topsoil, which ranges from 10 to 14 inches in thickness, is very dark grayish-brown mellow sandy loam containing a small percentage of fine gravel. A little silt and clay and an abundance of organic matter have given the surface soil considerable coherence and stability. The subsoil, which is about 12 inches thick, is generally heavier in the upper part than the layer above but becomes increasingly sandy and gravelly with depth. At a depth ranging from 24 to 30 inches the soil material consists largely of coarse gravel. In places there is sufficient silt and clay in the lower part of the subsoil and substratum to give the gravelly mass a slightly sticky feel when moist. The soil is leached of lime throughout.

The topsoil is stable and is retentive of moisture. The upper part of the subsoil also retains moisture fairly well, but the lower part has low moisture-holding capacity.

The porous gravelly nature of the subsoil makes this a droughty soil in most years, and only about 50 percent of it is cultivated. Nearly two-thirds of the cultivated land is used for corn, and most of the remainder for rye, oats, sweetclover, and sorgo. During prolonged periods of dry weather and hot winds, corn may not produce enough grain to warrant harvesting, and oats may fail to mature. In wet seasons, crop yields are only a little lower than on Thurman fine sandy loam. The average acre yield of corn over a period of years is about 13 bushels, that of oats about 10 bushels, that of rye about 8 bushels, and that of sweetclover about 1 ton of hay.

Grasses, of which the bluestems, needlegrass, and sandgrass are the most important, grow on the uncultivated land, about one-half of which is used for hay, yielding from one-third to one-half of a ton an acre. When used for pasture, these grasses will support a cow or horse on each 9 acres during the summer grazing season.

O'Neill loam, upland phase.—The upland phase of O'Neill loam is similar to the corresponding phase of O'Neill sandy loam in all respects except that its topsoil is less sandy and a trifle thicker. Therefore, the loam has a slightly higher moisture-holding capacity. The surface, in general, is smoother than that of the sandy loam. The soil has good drainage, is loose and friable, and can be tilled under widely different moisture conditions.

The general distribution of areas of this soil is similar to that of the upland phase of O'Neill sandy loam, but its total area is much less. The largest developments are south of Opportunity, around the head of Redbird Creek, and around the head of East Branch Eagle Creek.

About 60 percent of the land is under cultivation. All crops common to this section of the State are grown, but corn occupies the largest acreage. In average years corn yields about 15 bushels an acre, oats about 13 bushels, rye about 8 bushels, and sweetclover about four-fifths of a ton of hay.

Verdel fine sandy loam.—Verdel fine sandy loam occurs chiefly along Niobrara River and Eagle Creek, where it is on high terraces ranging from 8 to 70 feet above the stream channels.

The 8- to 10-inch topsoil is very dark grayish-brown friable fine sandy loam well supplied with organic matter. The rest of the soil profile consists of dark grayish-blue dense clay. It contains an abundance of lime in the form of seams and splotches, which tends to reduce the compaction of the clay and make the soil remarkably friable, considering its heavy texture.

Practically all of this soil is under cultivation. It is very productive and, because of the high percentage of sand in its surface layer, is easily handled. Good tilth can be maintained with little difficulty under a fairly wide range of moisture conditions.

Nearly all of this soil is under cultivation and is used for the crops commonly grown. Corn yields average about 20 bushels to the acre, oats 18 bushels, and barley 15 bushels.

Verdel clay loam.—Verdel clay loam is one of the least extensive soils on terraces in Holt County. Practically all of it is in the northwestern part. The largest body is in the Niobrara River Valley east of Grand Rapids Island. More than half the total area of this soil is on high terraces from 30 to 50 feet above the stream channel.

Except for having a clay loam topsoil, this soil is almost identical with Verdel fine sandy loam. It is, however, more difficult to handle. If plowed when wet, hard lumps develop, which can be reduced only by wetting and drying or freezing and thawing. If too dry, the soil becomes extremely difficult to plow. In dry years, crop yields are not so high as on Verdel fine sandy loam because the clay loam topsoil shrinks and cracks, thereby breaking crop roots and exposing more surface to drying, but in seasons of normal or above-normal precipitation, all crops give profitable yields.

SOILS SUITED TO HAY FARMING

This group includes the Cass, Lamoure, and Gannett soils. The first two occupy all the extensive hay flats in the prairie plains division of the county and most of the flood plains along streams. The Gannett soil is in wet undrained valleys, pockets, and swales throughout the sand hills.

All these soils are underlain, even during dry spells, by ground water within a depth of 6 feet. In most of them the water table rises, over large areas, to or near the surface of the ground in the spring and following prolonged periods of rainy weather.

The abundant moisture supply has promoted a rapid growth and decay of vegetation, and all soils of the group have accumulated enough black well-decomposed organic matter to produce very dark topsoils. The Cass and Gannett soils have almost pure sand subsoils, whereas the Lamoure subsoils are silty or clayey.

Of these soils only the better drained areas, which are comparatively inextensive and widely scattered, can be used for cultivated crops, chiefly corn. Most of the land remains in its virgin state and is used almost exclusively for the production of native hay. The wild grasses grow unusually dense and luxuriant and yield between 1,000 and 2,200 pounds of hay an acre during most years. Much of the hay is coarse and of rather low feeding value, but the high yield tends in a large measure to offset the inferior quality. Many ranchers have sown timothy and alsike clover among the wild grasses on these soils, thereby greatly improving the quality of the hay. A part of the land is used for the production of bluegrass seed.

Cass loamy fine sand.—The topsoil of Cass loamy fine sand ranges in thickness from 7 to 12 inches and consists of loose fine sand containing sufficient organic matter to give it a loamy texture and dark color. Beneath the topsoil is a grayish-brown transitional layer, through which the organic matter and the intensity of darkness decrease downward. Below a depth ranging from 20 to 30 inches is the substratum of gray or light grayish-brown incoherent fine sand.

The relief is nearly level or gently undulating, except where the wind has produced low ridges and shallow depressions. Even in these localities the relief in few places exceeds 4 feet. The soil is well supplied with moisture, and, although not highly calcareous, it contains sufficient lime for crop needs.

Cass loamy fine sand is one of the most extensive soils of this group. The largest areas are south and west of Inman, in the vicinity of Ewing, west and northwest of Goose Lake, and west of Chambers.

Were this soil adequately drained, most of it could be used for the production of grain and tame-hay crops, particularly corn, alfalfa, sweetclover, and clover and timothy mixed. Effective drainage, however, would necessitate such an elaborate system of long deep ditches, that the cost, in most localities, would not be warranted. Under present conditions, corn gives good yields in a few places where natural drainage is adequate, but about 85 percent of the soil is poorly suited to cultivated crops and is used for the production of native hay. It supports a heavy growth of grasses, including big bluestem and needlegrass in the higher places and reed canary grass and pony grass in the lower situations. These grasses yield about one-half ton of hay an acre in average years.

Cass loamy fine sand, claypan phase.—The claypan phase of Cass loamy fine sand includes areas of that soil, in which the upper part of the subsoil is abnormally heavy and compact. In many of these areas the heavy layer has the properties of a claypan, but it varies somewhat in density from place to place. In areas where the heavy layer is only moderately dense the topsoil, which ranges in thickness from 6 to 12 inches, consists of almost black loamy fine sand with a high content of organic matter. The upper layer of

the subsoil, which is massive and about 12 inches thick, is composed largely of loamy fine sand but contains some silt and clay and an abundance of organic matter. The consistence of this material ranges from firm to moderately compact, and the color is almost black. Below the compact layer is loose gray sand similar to that composing the lower layers of the other Cass soils.

In areas where the claypan is extremely dense, the surface layer does not differ materially from the one described, but the claypan is made up of hard dense black round-topped columns composed mainly of sand firmly cemented by clay and colloidal organic matter. In places a thin layer composed partly or entirely of leached gray sand lies between the rounded tops of the columns and the almost black surface soil.

The soil is very limy below an average depth of 20 inches.

The claypan phase of Cass loamy fine sand occupies a number of small areas on flats and in depressions, within or adjoining areas of typical Cass loamy fine sand. The land is poorly drained. It occupies areas below the general level of the other Cass soils, and the water table nearly everywhere is within a depth of 3 feet. Most of this soil supports a heavy growth of grasses which yield from three-fourths to 1 ton of hay an acre in seasons of normal precipitation. The hay is coarse and of rather poor quality except in localities where timothy and alsike clover have been sown among the native grasses.

Cass fine sandy loam.—Because of its large content of organic matter, the topsoil of Cass fine sandy loam is slightly darker than that of Cass loamy fine sand. It is also more coherent and a trifle thicker. This soil may or may not be limy but, in most places, the upper part of the subsoil contains sufficient lime to effervesce weakly with hydrochloric acid.

The relief is nearly level. The water table is everywhere high, but about 40 percent of the soil is fairly well drained and is under cultivation. Of the cultivated land, about 85 percent is used for corn, about 10 percent for oats, and most of the remainder for sweetclover, rye, and barley. During average years, corn yields about 25 bushels an acre, oats about 18 bushels, rye about 12 bushels, and sweetclover about 1½ tons of hay. Of the uncultivated part, 70 percent is used for hay, yielding from one-half to 1 ton an acre, and the remainder is used for pasture, 3 to 4 acres of which are required to support a cow or horse during the summer. The largest areas are in Elkhorn River Valley, principally between Inman and Stuart, and south to the county line.

Cass fine sandy loam, claypan phase.—This soil resembles Cass fine sandy loam in general appearance, but it has a much heavier upper subsoil layer. This layer, which lies between depths of 7 and 18 inches, is composed of very dark massive and moderately compact sandy clay with a high content of organic matter. Otherwise the two soils are almost identical.

Areas of Cass fine sandy loam, claypan phase, range from flat to slightly depressed. Drainage, in most places, is poor. The water table is within a depth ranging from 4 to 6 feet in dry seasons, and water remains on the surface in many places following prolonged periods of wet weather.

This soil occurs mainly in small areas on the bottom lands. The largest developments are southeast of Stuart, west and south of Emmet, south and southeast of Inman, and at the corner of Lake and Deloit Townships along the Wheeler County line. Few of them exceed 300 acres in size.

Ninety percent of this soil is used for the production of hay, yields of which are slightly higher than on Cass fine sandy loam, but the hay is of poorer quality as it contains a large percentage of coarse water-loving grasses. The remainder of the soil is used for pasture land, for which purpose it is about equal to Cass fine sandy loam.

In several small patches, mainly within the larger bodies of this soil, the heavy layer is much more compact, is a trifle thicker, and is made up of columns with rounded tops. These patches have a combined area of less than 1 square mile and are not indicated separately on the soil map. The largest patches are north of Dora Lake and 4 miles southwest of Stuart.

Cass very fine sandy loam.—Cass very fine sandy loam differs from Cass fine sandy loam principally in that it has a slightly finer textured topsoil layer. This layer, which ranges from 8 to 12 inches in thickness, consists of very dark grayish-brown mellow very fine sandy loam. It gradually gives way, through a thin grayish-brown transitional layer, to incoherent gray sand similar to that beneath the other Cass soils.

Cass very fine sandy loam occurs on nearly level areas throughout the prairie plains and on flood plains along streams. The water table is nowhere more than 4 feet below the surface, even during prolonged droughts.

The largest areas are on the prairie plains south of Stuart, and north of O'Neill along the upper reaches of Redbird and Blackbird Creeks. Small bodies are along Niobrara River.

Less than one-half of the total area of this soil is sufficiently well drained for the production of grain and tame-hay crops, and not more than 40 percent of the land is cultivated. Where drainage is adequate, corn is the principal crop, and a small acreage is devoted to oats, sweetclover, and other forage crops. Yields are slightly higher than on Cass fine sandy loam. The uncultivated areas are used almost exclusively for native-hay land, for which they are about as well suited as is Lamoure very fine sandy loam.

Cass very fine sandy loam, claypan phase.—Cass very fine sandy loam, claypan phase, is similar to the corresponding phase of Cass fine sandy loam, except that it has a larger proportion of very fine sand in its surface layer. The topsoil, which is about 9 inches thick, consists of very dark grayish-brown mellow very fine sandy loam containing an abundance of well-decomposed organic matter. This layer is underlain by a moderately compact layer of almost black massive sandy clay which rests, at an average depth of 25 inches, on loose gray sand.

Several areas of this soil are in the Elkhorn River Valley and on low sandy flats in the southern part of the county. They occupy the same topographic positions as areas of typical Cass very fine sandy loam. The water table is at a depth of about 4 feet.

This land is used mainly for the production of hay, yields of which are slightly higher than on the typical soil, but the quality is lower

because of a larger proportion of coarse water-loving grasses, sedges, and rushes.

Lamoure very fine sandy loam.—The 7-inch surface layer of Lamoure very fine sandy loam is very dark grayish-brown friable very fine sandy loam. This is underlain by dark grayish-brown fine sandy loam that contains considerable clay which makes the material plastic when wet and hard and cloddy when dry. At a depth of about 16 inches there is an abrupt change to the lower subsoil layer which is light-gray gravelly silt loam or sandy clay loam, having rusty-brown spots, splotches, and stains. The material in this layer is slightly heavier than that in any layer above, but it is not compact and is readily penetrated by air, moisture, and roots, except in situations where it is saturated with water. The light color of this material is due mainly to a large content of lime. The substratum, which lies below an average depth of 30 inches, is similar in texture to the layer above, but it is nearly white. A few gravel may occur throughout the soil profile.

Lamoure very fine sandy loam is the second most extensive Lamoure soil in the county. None of the Lamoure soils covers a large total area. The largest developments of the very fine sandy loam are south and southeast of Stuart. Several small areas are between Amelia and the territory north and east of Goose Lake. The soil is developed over rather fine textured water-laid material on stream bottoms and on scattered areas throughout the prairie plains.

The relief is nearly level, and water remains on the surface in a number of places during periods of prolonged wet weather. Here and there, the soil contains a noticeable amount of salt, chiefly calcium and sodium chlorides, but these alkalies are in few places sufficiently abundant to injure crops. Because of its higher silt content, this soil cannot be cultivated under as wide a range of moisture conditions as is possible for most of the Cass soils, but it is more productive than those soils and, with reasonable care, is easily maintained in good tilth.

About 20 percent of the soil, including the better drained areas, is under cultivation. The remainder is used mainly for the production of wild hay. Corn, which yields about 28 bushels an acre, is the leading crop on the cultivated land. The average yield of native hay is about 1 ton an acre.

Small and irregular-shaped patches, in which this soil has developed a claypan, occur within areas of the heavier textured Cass soils and the Lamoure soils. The patches are most numerous in the vicinity of Chambers and west of O'Neill. In such areas the topsoil is typical, but the subsoil, which continues to an average depth of 30 inches, is light grayish-brown massive and extremely dense sandy clay containing an abundance of lime in finely divided form and in numerous small concretions, some of them one-fourth inch in diameter. These areas are, for the most part, poorly drained and are used almost exclusively for wild-hay land. They are not large enough to show on a map of the scale used in this survey.

Lamoure fine sandy loam.—The topsoil of Lamoure fine sandy loam is very dark grayish-brown mellow fine sandy loam, from 12 to 14 inches thick. The subsoil is lighter colored very limy and

moderately compact sandy clay loam. This soil occupies slightly higher positions than Lamoure very fine sandy loam.

Lamoure fine sandy loam is the most extensive Lamoure soil in the county. The largest developments are west of Stuart. Smaller areas lie south of Elkhorn River between Emmet and Atkinson. Patches of this soil are around the head of Dry Creek, in the northern part of Lake Township, in the vicinity of Chambers, northwest of Amelia, and southeast of Goose Lake.

About 25 percent of the land is sufficiently well drained for cultivation. It is used mainly for growing corn and to less extent for the production of oats and barley. The remainder is in its virgin state and is used for native-hay land. Yields are about the same as on Lamoure very fine sandy loam, or only a trifle lower.

In places the subsoil of this soil is claypanlike in character, but the patches in which this condition exists are not sufficiently large to warrant indicating on the map. They are all poorly drained and are used exclusively for hay land.

Lamoure loamy fine sand.—Lamoure loamy fine sand differs from the other Lamoure soils only in having a more sandy, a slightly less coherent, and a trifle lighter colored topsoil. The surface layer, which ranges from 6 to 9 inches in thickness, consists of loose fine sand containing enough organic matter to give it a loamy texture and a very dark grayish-brown color. This material rests on light grayish-brown moderately heavy silt loam or sandy clay loam containing numerous rusty-brown, black, and almost white splotches, spots, and streaks and an abundance of lime.

The soil has developed from silty and clayey sediments that have been mixed with considerable sand and later have been covered to a slight depth by sandy wind-blown material. It occurs on the prairie plains and in some of the valleys of the sand hills. Areas are near Emmet, near the head of Dry Creek, in the vicinity of Chambers, and in the northwest corner of Lake Township. An area including about 100 acres is north of Inman.

This soil is used mainly for growing hay which yields from three-eighths to three-fourths of a ton an acre.

Like the other Lamoure soils, the loamy fine sand includes patches in which the subsoil is claypanlike in character. In these patches, the combined area of which does not exceed 1 square mile, the surface layer is thinner than that of the typical soil, and the subsoil is much more compact, consisting of light grayish-brown extremely dense sandy clay containing numerous rusty-brown and black spots and splotches and a large amount of lime. One of the largest areas of this claypan soil, comprising about 180 acres, is northeast of Martha School in McClure Township. Small patches are southwest of Inman and southwest of O'Neill. The relief of this heavy soil is nearly level, and in rainy seasons drainage is deficient. The land is used almost exclusively for the production of hay, for which purpose it is about as well suited as is the typical loamy fine sand.

Gannett loamy sand.—Gannett loamy sand has developed in poorly drained depressions and valleys in the sand hills. Its surface soil, to a depth ranging from 8 to 12 inches, consists mainly of medium sand, together with a large amount of well-decayed organic matter. The character of the soil varies with the organic-matter

content. In the more poorly drained areas, where the growth and decay of vegetation have been favored, the topsoil is almost black, is spongy, and is noticeably light in weight. In many of the drier localities, it contains barely sufficient organic matter to give it a dark grayish-brown color and loamy texture. The subsoil is light grayish-brown or yellowish-brown incoherent sand which continues downward for many feet with little change. As the color indicates, it is very low in organic matter.

Gannett loamy sand is principally in the lower valleys and depressions throughout the sand hills. Some of the most typical areas occur as narrow strips bordering the numerous sand-hill lakes. Areas of this soil are flat, and drainage is poor.

Because of the poor drainage, this soil is not suited for cultivated crops and is used mainly for the production of hay and to some extent for pasture land. About 2 acres of the native grasses will support a cow during the summer grazing season or will yield about 2 tons of hay. The hay is coarser and has a lower feeding value than that obtained on the better drained soils, but its higher yield tends, in a large measure, to offset the inferior quality.

SOILS SUITED TO GRAZING

Ten soils, dune sand, and riverwash have been classed with the group of soils best suited to grazing. One or another of them occurs wherever the relief or drainage prevents the use of farm machinery or where the soil is poorly suited for grain or hay crops. Most of the soils in this group include small areas suitable for cultivation, and nearly all of them are used to some extent for the production of native hay, but the greater part of each soil remains in its virgin state, and about 75 percent of the total area of the soils of the group as a whole is included in pastures.

The largest areas of grazing land are on the hilly dune sand which occurs extensively in the southwestern part of the county and in numerous places within the prairie-plains division. The topsoil on the sand dunes in few places exceeds 2 inches in thickness, and in many places the grayish-brown sand is exposed. Most of the thin, sandy, and light-colored soils of the Valentine series on rolling or hummocky terrain, within and around the margins of the dune sand areas, also are used for grazing. In addition, grazing land, much of it of poor quality, is on the severely eroded breaks along Niobrara River and its tributaries in the northern part of the county. Here the soils are not everywhere sandy. Erosion has exposed shales, from which silty and clayey soils have developed, but the topsoils are thin, the slopes are steep and gullied, and the land is of little value except for pasture.

Valentine sand.—Valentine sand occurs in nearly all parts of the county and is the most extensive soil. In the southern part it is chiefly in dry valleys and pockets between the ridges and hills of dune sand, but in the northern part it occupies extensive tracts.

This soil differs from dune sand only in having less hilly relief, a heavier grass cover, and a trifle more organic matter in its surface layer. The topsoil consists of a layer of grayish-brown incoherent and unstable sand 6 or 8 inches thick. The upper half is generally somewhat darker than the lower part, owing to a small content of

organic matter. The rest of the soil, to a depth ranging from 4 to 5 feet, is similar in texture to the topsoil but is lighter colored. The entire profile has been leached of its lime.

Valentine sand is of little value for cultivated crops chiefly because of its tendency to drift where the native sod has been destroyed. Most of this land is used for pasture. The native grasses are mainly sandgrass, needlegrass, and big bluestem, which will support 70 or 75 head of cattle on each square mile. Some corn, rye, and sorgo are grown in low and protected situations where moisture conditions are most favorable and wind erosion is least harmful, but the yields are low except in very favorable seasons. Some areas are mowed for native hay. Valentine sand has a slightly higher value than dune sand, both for the production of hay and for grazing land.

Valentine loamy sand.—Valentine loamy sand differs from Valentine sand only in that its topsoil contains a little more silt, clay, and organic matter and is slightly darker and thicker. It occurs in close association with Valentine sand but is much less extensive. Small areas are in all parts of the county, but they are most numerous in the south-central part. A few fairly large bodies are near the mouth of Eagle Creek and north of that stream. About 90 percent of this soil is included in pasture and hay land. The native grasses on each square mile will carry 85 or 90 head of cattle during the summer grazing season. About 10 percent of the soil is used for growing corn and rye, which yield an average of 5 and 4 bushels, respectively, an acre. About 15 percent is used for the production of hay which yields an average of half a ton an acre.

Dune sand.—The name dune sand is applied to the material of the sand hills. Most of this material in Holt County represents outliers of the main sand-hill area to the west and south.

Dune sand consists of grayish-brown incoherent sand of medium or fine grades, the medium sand predominating. It contains a small amount of organic matter in the topmost 3 or 4 inches but not enough to prevent drifting when the grass cover is removed. The color and texture of the sand remain uniform to a depth of several feet, and the lower part differs little from the upper except in its smaller content of organic matter. Considering its sandy nature, dune sand is unusually retentive of moisture. Lime has been entirely removed by leaching.

Dune sand has been derived through the disintegration of the soft sandstone formations of the area and has been deposited in its present position by the wind. Nearly all of the fine material was removed during the more or less continual shifting of the dunes.

The surface features in areas of dune sand are variable. In the southwestern part of the county, the areas include a monotonous succession of irregularly distributed hills and ridges, with intervening valleys, pockets, and swales. Hummocks of wind-blown sand, hollows, and blow-outs vary the otherwise billowy appearance of the landscape. In other parts, dune sand occupies hilly areas surrounded by smoother and lower lying sandy land.

The sand is without surface drainage, because all rainfall is absorbed by the porous material.

Dune sand has not been succesfully cultivated, although numerous attempts have been made to farm small areas. The sand drifts so readily that removal of the sod is followed by destructive erosion which may damage the land for a considerable distance leeward from the disturbed area. At present most of the sand hills are fairly well sodded and are not subject to active wind erosion.

The native vegetation includes many valuable pasture grasses, of which little bluestem, blow-out grass, sandreed grass, *Redfieldia*, and needlegrass are the most common. In the spring and summer these grasses afford good grazing and will maintain from 65 to 70 head of cattle on each section (640 acres), but in winter they cannot be depended on for pasturage.

O'Neill gravelly sandy loam, upland phase.—The upland phase of O'Neill gravelly sandy loam occupies 16.7 square miles. It occurs only north of Elkhorn River in scattered areas which range in size from a few square rods to several acres. The largest bodies are on slopes and divides in the vicinity of the larger creeks

The 12-inch topsoil is very dark grayish-brown friable gravelly sandy loam containing an abundance of organic matter and sufficient fine material to give it moderate coherence, or "body." The subsoil is gray incoherent gravelly sand or sandy gravel.

This soil has a rolling to moderately hilly and in places rather hummocky relief. Much of it is on low rounded ridges. The soil absorbs moisture rapidly but has low water-holding capacity and is very droughty. It is of little value for cultivated crops and is used almost exclusively for pasture land. The native vegetation consists chiefly of big blustem, little bluestem, sandgrass, and needlegrass. Cactus is abundant in places. The soil does not have a high value even for grazing purposes.

O'Neill loamy sand, upland phase.—The upland phase of O'Neill loamy sand occupies the same general physiographic position as the other upland phases of this series. The 8- to 12-inch surface layer consists of loamy sand darkened by organic matter. In most places, there are a few small gravel in this layer. The upper subsoil layer is composed of brown or grayish-brown sand which becomes increasingly gravelly with depth. Below a depth of about 25 inches is a mass of gravel and coarse sand. The soil material contains no lime.

The topsoil is unstable and porous and is not so retentive of moisture as the corresponding layer in the heavier upland phases of the O'Neill soils. The gravelly subsoil and substratum hold only a little water, and the soil as a whole is droughty.

Practically all areas of this soil are in the northern half of the county, several are south and southwest of Dustin and north of Middle Branch, and a few are between O'Neill and Emmet.

On account of its low water-holding capacity, this soil is used mostly for grazing land, for which purpose it has about the same value as Valentine sand.

Boyd clay loam.—The topsoil of Boyd clay loam, except where erosion has been especially severe, is very dark grayish-brown, in many places almost black, clay loam well supplied with organic matter. It is from 8 to 10 inches thick. This layer rests directly on the parent Pierre shale, in which there is an intricate network of

seams and cracks filled with finely divided lime. Considering its heavy texture the soil is remarkably friable and porous, owing largely to the manner in which the lime is distributed.

This soil occurs on steep severely eroded valley slopes along Niobrara River and its larger tributaries, particularly Eagle and Redbird Creeks. One large area, comprising about 600 acres, is northeast of Paddock Union Church in Paddock Township.

Owing to its generally unfavorable relief, only about 7 percent of this soil is tilled. Corn and oats are the chief crops on the cultivated areas. In wet years crop yields are almost as high as on the best soils, but in dry seasons, they are usually low because the clay shrinks and cracks, thereby breaking the crop roots and increasing the droughty condition. The native grasses on the virgin areas will support a cow on each 9 acres during the grazing season or when cut for hay will yield about one-third of a ton an acre.

Boyd fine sandy loam.—Boyd fine sandy loam occupies a few small areas in the northwestern and northern parts of the county. The largest are on valley slopes along Eagle and Redbird Creeks.

This soil is simply Boyd clay loam, the surface layer of which has been modified by wind- or water-laid sand to a depth ranging from 4 to 10 inches. The surface is sloping but is not so steep as that of Boyd clay loam. The soil receives an unusually large amount of moisture, because the porous sand in the surface layer rapidly absorbs all the precipitation, and the heavy clay in the subsoil prevents loss of water through seepage.

Most areas of this soil are too rough for cultivation and are used for pasture land. A few nearly level areas, ranging in size from a few to 300 acres, are near the mouth of Honey Creek and near Town Hall in Paddock Township. About 95 percent of the land in these areas is under cultivation. Here, the same crops are grown as on Marshall fine sandy loam, although the yields average considerably lower. The uncultivated land supports a dense cover of grasses, mainly big bluestem and little bluestem, which furnish good pasturage.

Holt fine sandy loam.—Holt fine sandy loam occupies only 38 square miles in this county. It occurs throughout the uplands, principally north of Elkhorn River. The soil has developed from light-colored limy sandstone which has been exposed by removal of the overlying deposits.

The topsoil, which ranges in thickness from 9 to 12 inches, is dark grayish brown or almost black. It is extremely variable in texture, ranging from silt loam to sandy loam or even loamy sand. The fine sandy loam texture predominates. The soil as mapped includes all areas of Holt soils regardless of the texture of the topsoil. The subsoil is grayish-brown or light grayish-brown limy fine sandy loam or very fine sandy loam, which rests on the parent sandstone, generally within a depth of 3 feet.

The relief of most of this soil is rolling or hilly. Drainage is everywhere thorough, and in many places run-off is rapid and erosion severe. There are many places where the light-colored limy bedrock is exposed, giving the soil a spotted dark and light appearance.

About two-thirds of the soil remains in its virgin state and is used mainly for pasture land and to some extent for the production

of hay. The native grasses will support from 90 to 100 cattle on each square mile during the grazing season, or when cut for hay will yield about one-half ton an acre. On the cultivated land about the same crops are grown as on Thurman fine sandy loam, and yields are slightly higher on the Holt soil.

Included within areas shown as this soil on the accompanying map are a few bodies in which a heavy gray or grayish-brown silty clay layer, from 12 to 15 inches thick, lies just beneath the topsoil. These areas have nearly level relief. The largest, comprising about 300 acres, is south of South Fork Elkhorn River in McClure Township. Bodies ranging in size from a few to 100 acres are scattered over the Holt table throughout its distance across the county. About 60 percent of the soil in these included bodies is under cultivation.

Fillmore silt loam.—Fillmore silt loam occupies a few slightly depressed areas of extremely heavy soil on the smoother parts of the Holt table in the northern part of the county. It has two characteristic features—a shallow dark-colored topsoil and a heavy claypan layer in the upper part of the subsoil.

The topsoil, to an average depth of about 6 inches, is dark grayish-brown friable silt loam. In most places it is underlain by a 2- to 4-inch layer of light-colored silt loam or silty clay loam, from which the black organic matter has been removed by leaching. This, in turn, is underlain by very dark brown or almost black dense clay that is almost impenetrable for moisture and is difficult to dig into with a spade. The clay ranges in thickness from 18 to more than 50 inches. Below it is grayish-brown limy sandy clay which continues downward to a depth of several feet. All areas of this soil are poorly drained. Water collects in them after heavy rains and disappears slowly by seepage and evaporation.

The soil is of little agricultural importance in this county, and none of it is under cultivation. It supports a good growth of water-loving grasses and weeds, which furnish fair pasturage.

Cass and Valentine loamy sands, undifferentiated.—Cass and Valentine loamy sands, undifferentiated, occupy only a small total area. The largest areas are in the western part of the county, south of Atkinson, and 8 miles north of Stuart south of Gravel Ridge. The latter area includes about 320 acres.

This mixed soil consists of areas of Cass loamy fine sand and numerous small bodies of Valentine loamy sand. These soils are nearly equally divided and are so intricately associated that they cannot be separately delineated on a map of the scale used.

The land is used principally for the production of hay. Crop yields on the larger areas of these soils are similar to those obtained on Cass loamy fine sand and Valentine loamy sand.

Sarpy sand.—Sarpy sand occupies elongated strips, ranging in width from 100 feet to about one-quarter of a mile, along nearly all the large streams and on a number of islands in Niobrara River.

Areas of this soil are nearly flat except where modified by overflow channels, slight elevations, and slight depressions. The soil lies from 2 to 5 feet above the normal level of the streams and, although subject to occasional overflow, is not covered except during periods of unusually high water.

This soil has developed from recently deposited sand which has not accumulated much organic matter. The topsoil consists of gray or grayish-brown sand from 6 to 8 inches thick. It contains some silt and organic matter but not enough to give it a loamy texture, except in a few places. Throughout the rest of the soil profile the material gradually becomes coarser and of lighter color, and in most places it consists of light grayish-brown coarse sand or sand and gravel below a depth of 30 inches. Although almost continually moist, the subsoil is not poorly drained.

Practically all of this soil is used for pasture land. The grasses on it will support a cow or horse on each 8 acres during the grazing season, May to October, inclusive. Along the larger streams, especially Niobrara and Elkhorn Rivers, scattered trees, principally willow and cottonwood, grow in many places. They are used mainly for posts and fuel.

Riverwash.—Riverwash consists of sand bars, islands, and flats adjacent to or within the channels of Elkhorn and Niobrara Rivers. This material differs from Sarpy sand chiefly in its less stable nature. It lies only a few inches above the normal water level of the channels, and its boundaries change with each slight rise of the streams. Even during normal flow, small areas are shifted about, added to, or carried away by the varying current. The material represents the first stages of the formation of alluvial soil. With the ordinary accumulation of organic matter, if undisturbed, riverwash will develop into Sarpy soil. Most of the land supports a fairly dense growth of seedling willow trees and is either used for pasture land or is regarded as waste land.

CLASSIFICATION OF SOILS ACCORDING TO PRODUCTIVITY

In table 6 the soils of Holt County are classified according to their estimated ability to produce the more important crops of this general section. 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 a 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 an index above 100 for a specified crop.

FOOTNOTES — Boyd

1/ Prepared jointly by officials of: 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. No ratings on grain and tame-hay crops given to soils that are definitely unsuited for cultivation, although some areas of these soils are farmed.

2/ Cow-acre-days term used to express carrying capacity of pasture land; numberical equivalent of number of animal units supported by 1 acre during a given period of days.

3/

Table 6.—*Classification of soil types in Holt 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	
Lamoure very fine sandy loam (fairly well drained).	55	50	50	50	45	55	75	85	85	Corn.
Marshall very fine sandy loam, sandy-substratum phase.	50	50	50	50	45	30	65	70	35	General farming.
Lamoure fine sandy loam (fairly well drained).	55	45	45	50	40	55	75	85	80	Corn.
Cass very fine sandy loam (fairly well drained).	55	45	45	50	40	55	75	85	85	Do.
Cass fine sandy loam (fairly well drained)	50	35	35	45	35	50	75	80	80	Do.
Marshall fine sandy loam, sandy-substratum phase.	45	40	40	45	40	25	55	65	29	General farming.
Verdel fine sandy loam	40	35	35	40	35	25	55	60	31	Do.
Holt fine sandy loam	35	30	30	35	30	20	50	55	26	Do.
Verdel clay loam	35	40	40	40	40	20	45	55	26	Do.
Lamoure loamy fine sand (fairly well drained).	45	35	35	40	35	50	75	80	60	Corn.
Cass loamy fine sand (fairly well drained)	40	30	30	35	30	45	70	75	65	Do.
Ewing fine sandy loam	35	30	30	35	30	25	50	70	35	General farming.
Boyd fine sandy loam	35	30	30	35	30	20	50	60	30	Do.
O'Neill fine sandy loam, deep phase	40	35	35	40	35	35	55	65	35	Do.
O'Neill fine sandy loam	35	30	30	35	30	30	50	60	32	Do.
Thurman fine sandy loam	30	25	25	30	25	20	40	60	32	Do.
Thurman sandy loam	30	25	25	30	25	20	40	60	30	Do.
O'Neill loam, upland phase	30	25	25	30	25	20	40	50	30	Do.
Boyd clay loam	25	30	30	30	30	15	40	35	20	Do.
O'Neill sandy loam, upland phase	25	20	20	30	20	15	35	40	20	Do.
Ewing loamy sand	25	20	20	25	20	20	40	60	30	Pasture and wild hay.
O'Neill loamy sand	20	15	15	20	15	15	35	55	26	Do.
Thurman loamy sand	20	15	15	20	15	15	35	55	26	Do.
O'Neill loamy sand, upland phase	15	10	10	15	10	10	30	40	23	Do.
Valentine loamy sand	10	10	10	15	10	10	25	40	23	Do.
Lamoure very fine sandy loam (poorly drained).	----	----	----	----	----	----	----	115	90	Do.
Lamoure fine sandy loam (poorly drained)	----	----	----	----	----	----	----	110	85	Do.
Cass very fine sandy loam, claypan phase (poorly drained).	----	----	----	----	----	----	----	105	90	Do.
Cass very fine sandy loam (poorly drained)	----	----	----	----	----	----	----	105	90	Do.
Cass fine sandy loam, claypan phase (poorly drained).	----	----	----	----	----	----	----	100	85	Do.
Cass fine sandy loam (poorly drained)	----	----	----	----	----	----	----	100	85	Do.
Lamoure loamy fine sand (poorly drained)	----	----	----	----	----	----	----	80	65	Do.
Cass loamy fine sand, claypan phase (poorly drained).	----	----	----	----	----	----	----	80	65	Do.
Cass loamy fine sand (poorly drained)	----	----	----	----	----	----	----	80	60	Do.
Gannett loamy sand (poorly drained)	----	----	----	----	----	----	----	105	65	Do.
Cass and Valentine loamy sands, undifferentiated.	----	----	----	----	----	----	----	70	43	Do.
Sarpy sand (poorly drained)	----	----	----	----	----	----	----	50	20	Do.
Fillmore silt loam	----	----	----	----	----	----	----	50	22	Do.
Valentine sand	----	----	----	----	----	----	----	40	22	Do.
Dune sand	----	----	----	----	----	----	----	25	16	Do.
O'Neill gravelly sandy loam, upland phase	----	----	----	----	----	----	----	20	15	Do.
Riverwash	----	----	----	----	----	----	----	----	14	Pasture.

[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; and the Conservation and Survey Division and Agricultural College, University of Nebraska.

[2] Soils are listed in approximate order of their productivity in this 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 are 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 to cultivation although some areas of these soils are farmed.

The inherent-productivity indexes show the natural ability of the soil to maintain production at or near the level existing when the soil has become adjusted to tillage. These indexes are established

under the assumption that the best cropping and soil-management practices are followed, excepting those that would materially modify the soil, such as the use of commercial fertilizers, residues, and manures from crops not grown on the soil, terraces, irrigation, and artificial drainage.

In this table the soils are listed in the order of their general productivity, which is determined chiefly by their ability to produce the most important staple crops. No attempt is made to group the soils best suited for particular crops, and no consideration is given to differences in the quality of the crops.

As the soils in this county do not receive lime or commercial fertilizers, no rating is given to indicate their response to these materials.

The factors influencing the productivity of the soils are mainly climate, soil characteristics, and surface configuration. Since long-time yields [2] furnish the best available summation of the factors contributing to soil productivity, they were among the data used in determining the inherent productivity indexes given in this table.

The rather low indexes given to most of the soils do not necessarily indicate that these soils are poorly suited for the crops grown on them. Some of the soils are among the strongest and most productive in this general 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 most instances, is due mainly to less favorable moisture conditions and surface features, or both, than occur in areas of the standard soil. Most of the soils in the county contain enough plant nutrients to insure 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 soil map, however, does not distinguish between these areas except in localities where drainage is so poor that a marshy condition prevails a 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 cannot 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 special consideration is given to these tracts because overflow is of little importance in the agriculture of the county.

The table here presented 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

[2] Data on long-time yields for specific soils were collected by the field parties during and subsequent to the soil survey. In addition, free use was made of unpublished estimates on average annual crop yields for the period 1923 to 1932, inclusive, supplied by the Bureau of Agricultural Economics, U. S. Department of Agriculture, cooperating with the Nebraska Department of Agriculture.

for each crop. These yields when applied to the inherently most productive soils of significant acreage in the United States are accompanied by a product of satisfactory quality and are obtained without the use of amendments that would materially modify 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[1]
Pasture	100

[1] "Cow-acre-days" is a term used to express the carrying capacity of pasture land. As used here, it is the product of the number of animal units carried per acre multiplied by the number of days of the grazing season. For example, a soil type able to support 1 animal unit per acre for 360 days of the year rates 360, while another type able to support 1 animal unit per 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days, the rating is 25.

MORPHOLOGY AND GENESIS OF SOILS

Holt County is in the Chernozem soil region of the United States. It has the climatic and botanic environment of this region, but few or no typical Chernozem profiles can be found. Several factors have prevented the development of the normal regional profile. Chief among these are resistant parent materials, unfavorable relief, poor drainage, and insufficient time. Most of the county is covered by wind- or water-laid quarzitic sands that are extremely resistant to weathering and the formation of soil. Large areas are underlain at slight depths by ground water which keeps the subsoils almost continually wet and which periodically rises enough to waterlog the entire soil profile, thereby reducing the influence of the regional environment. Parts of the county have been subjected to such constant erosion by wind or water that soil development has been greatly retarded. In most of the soils the distinguishing characteristics are the result of local parent materials and drainage conditions rather than of the broader environmental influences—climate and vegetation.

All the soil types and classes of soil material, except those that are severely eroded or are composed mainly of recent stream or wind deposits, have developed under a grass vegetation. On the finer textured soils of the uplands and terraces, the grasses are chiefly *Stipa comata*, *Bouteloua gracilis*, and *Buchlöe dactyloides*, with *Koleria cristata*, *Agropyron smithii*, and *Andropogon scoparius* as secondary species. On the sandy uplands, *Calamovilfa longifolia*, *Andropogon halii*, and *Bouteloua hirsuta* dominate, with *Redfieldia flexuosa* and *Muhlenbergia pungens* in scattered associations, especially in sand-hill blowouts and in heavily grazed areas. On the subirrigated flood plains, on the hay flats of the prairie plains, and in moist sand-hill valleys, *Andropogon furcatus*, *Sorgastrum nutans*, *Panicum virgatum*, and *Spartina pectinate* are abundant, and *Carex* sp., *Typha latifolia*, and

Scirpus validus, in the order named, extend from the tall-grass associates into the marshes and lakes.

The grass vegetation characteristic of the general section has given most of the soils much darker surface horizons than subsoil horizons, but the intensity of the darkness varies greatly from place to place, generally in accordance with the local relief and moisture conditions. Soils having the darkest, in places almost black, surface layers, are generally in the lower and more poorly drained situations where the growth and decay of grass have been most rapid. The lightest colored soils are ordinarily in eroded situations and on sands that have been recently deposited by wind or water. With only a few exceptions the surface layers of the soils in this county are as dark as, or darker than, those in normally developed Chernozems. Few of the soils, however, have the horizon of lime accumulation so characteristic of the Chernozem type of soil development. This horizon, which in this county is confined mainly to the clayey soils of the uplands and terraces, in most places is higher in the soil profile and less pronounced than it is in a normal Chernozem.

The only soils which have been formed under conditions that can be regarded favorable for normal development are on the more nearly level areas of the Holt table and on some of the terraces in the northern part of the county. Even in these localities most of the soils have such sandy or gravelly subsoils that the moderate precipitation has been able to remove all readily soluble salts from the solum, thereby preventing the development of a lime horizon.

All the soils in the county, with the exception of a few minor types, have developed over unconsolidated deposits laid down by wind and water. The origin of these parent materials and their geologic relationships are fairly well understood by geologists. The most extensively distributed deposits are sands and gravels of Pleistocene age. The unconsolidated deposit that covers the southern part of the county, and occurs in considerable areas in other parts, is sand. The surface covering of the sand-hill section is indicated on the soil map as dune sand. The material composing this sand was derived partly through the disintegration of loosely cemented Ogallala sandstone of Tertiary age and partly from the Grand Island and Holdrege sands and gravels which were deposited west of the Kansan and Nebraskan glaciers, respectively, during Pleistocene time. Closely associated with dune sand are the soils of the Valentine series. The parent material of these soils and of dune sand is of similar origin, but the Valentine soils have been more stable and have been longer in an undisturbed condition. Consequently, the weathering of the sands has contributed more clay to the surface soils, and the grass cover has increased slightly the content of organic matter in the Valentine soils.

North of the main sand-hill section, in what is known as the prairie plains or the wet hay flats, the soils have been modified by a high water table, and a luxuriant grass vegetation has imparted an abundance of organic matter to their surface layers. The sands from which these soils have developed have also been shifted by wind and water. The soils here are classed with the Cass series.

North of Elkhorn River the Tertiary bedrock is covered by sand and gravelly deposits over which is laid a thin mantle of finer

materials ranging in texture from silt to fine sand. On the silty mantle, the sandy-substratum phases of the Marshall soils have developed, whereas the upland phases of the O'Neill soils and the soils of the Ewing series are on the sandy mantle.

Following is a description of a typical profile of the upland phase of O'Neill loam observed along United States Highway No. 281 just south of the O'Neill cemetery. The soil is excessively drained and is considered very droughty by the farmer who owns the land.

0 to ½ inch, dark grayish-brown single-grain very fine sandy loam. This is apparently a wind-deposited mulch. It is thickly matted with grass roots.

½ inch to 4 inches, very dark grayish-brown loam containing considerable sand, chiefly of the very fine and fine grades. This layer has a fine crumb or faintly laminated structure. The laminae are rather poorly defined but are much thicker than in the corresponding layer of more silty topsoils in the loess regions farther south and east. The material when crushed becomes slightly lighter in color.

4 to 9 inches, very dark grayish-brown coarse loam containing an abundance of fine sand, medium sand, and silt and a large amount of fine gravel. This is the heaviest layer of the soil profile, but it is friable throughout. The material in this layer is massive. It breaks into clods of irregular shapes and various sizes. Organic matter is abundant, and the soil material is as dark as, or darker than, that in any overlying layer.

9 to 18 inches, a transitional layer, both in color and in texture between the one above and the one below. It has about the same consistence as the overlying layer.

18 to 27 inches, brown or light-brown porous incoherent gravelly sand. The brown color is partly due to oxidized iron and partly to organic staining.

27 to 38 inches, grayish-brown incoherent sandy gravel which is considerably coarser in texture and slightly lighter in color than the material in the layer above.

38 to 54 inches, grayish-brown or light grayish-brown coarse sand or medium sand containing considerable gravel, chiefly of the finer grades.

The rather fine texture of the topsoil is due largely to an admixture of silty material, probably of loessial origin.

The sands and gravels on the Holt table are mixed, in places, with more or less light-gray silt identified as Peorian loess. No thick deposits of loess extend into this county, but the soils of the Marshall and the Thurman series are composed in part of loessial silts and sands, that have been transported by the wind and mixed with coarser materials.

Bedrock formations—Ogallala sandstone and Pierre shale—which have been previously mentioned, are exposed here and there. The sandstone, which lies above the shale, is light-colored, loosely indurated, and generally calcareous. Over the greater part of the county, it either is buried by Pleistocene sands and gravels or has been removed by erosion. Its largest outcroppings are in the northern part, especially in the northeast corner. The soils of the Holt series, which in this county are for the most part shallow and immature, have developed on this formation.

Pierre shale of Cretaceous age underlies the entire county but is exposed only on the lower slopes of the Niobrara Valley and in similar situations along some of the larger creeks tributary to Niobrara River. Lithologically, it is a fine-grained dark-olive shale which, in most places, is traversed by an intricate network of thin cracks filled with almost pure lime. From this shale (in situ) have developed

immature soils of the Boyd series. The Verdel soils have developed over reworked Pierre material now occupying terrace positions.

Nearly all areas, in which the Ogallala and Pierre formations are at or near the surface, have been severely dissected by geologic erosion, and the soils have been unable to make much progress in development.

Throughout the prairie plains in the central part of the county, the Cass soils have developed a heavy upper subsoil layer in some places. Where such development occurs, the areas are shown on the accompanying map as claypan phases of the Cass soil to which they belong, and in the less advanced stages of this development, namely the Solonchak and slightly solonized stages, the almost black friable and sandy topsoil is underlain abruptly, at a depth ranging from 8 to 12 inches, by a heavy black massive sandy layer, in which the sand is cemented to moderately firm consistence by clay and colloidal organic material. The entire soil profile is limy, and there is a noticeable concentration of carbonates in the lower part of the cemented layer which rests on incoherent gray sand at a depth of about 2 feet.

In the more advanced, or Solonetz, stage of development, the heavy layer becomes extremely dense, especially in the upper part where it cracks vertically into columns. The lower part includes a pronounced horizon of carbonate accumulation. The following description of a profile examined about 500 feet east of the center of sec. 34, T. 28 N., R. 10 W., is typical of this stage of development.

0 to 3½ inches, very dark grayish-brown or almost black friable loamy very fine sand with poorly defined structure.

3½ to 5 inches, material similar in texture and consistence to that in the layer above but containing a rather large quantity of leached very fine sand which gives it a lighter color.

5 to 10 inches, very dark grayish-brown or black dense material consisting mainly of the finer grades of sand cemented with a small amount of clay and an abundance of organic matter. This layer, which is the upper part of the claypan, has cracked vertically, thereby producing numerous round-topped columns ranging from 2 to 6 inches in diameter. The columns are made up of cubical or prismatic structural units which are about one-half inch in their longer, usually vertical, dimension. Almost white leached sand covers the tops of the columns and partly fills the cracks between them.

10 to 20 inches, this layer, which is the lower part of the claypan, is slightly less compact than the one above, is massive, and is much lighter in color, being brown or grayish brown. It contains an abundance of lime, chiefly in the form of hard concretions, between which the soil material is not calcareous.

20 to 24 inches, black slightly compact sandy loam containing no lime.

24 to 72 inches, gray fine sand with scattered rusty-brown stains.

The water table stood at a depth of 54 inches at the time the soil was examined.

Areas in which the Cass soils have this profile are rather numerous on the prairie plains section of this county, but they occupy only a few square rods each and are so widely scattered that all are included with the claypan phases of the Cass soils on the soil map.

SUMMARY

Holt County is in northeastern Nebraska. It comprises 2,404 square miles, or 1,538,560 acres.

The county is on a broad nearly level to hilly plain sloping gently downward toward the south and east. Niobrara River is deeply

entrenched along its northern boundary, and Elkhorn River, flowing in a southeasterly direction, divides the county in two almost equal parts. The drainage north of Elkhorn River flows to Niobrara River, and most of the run-off from the southern part of the county is received by Elkhorn River. The slopes bordering Niobrara River and its larger tributaries have been severely eroded, but over most of the county local drainageways have not been established.

Aside from the Niobrara Valley, which includes the flood plains, terraces, and bluff lands south of Niobrara River, the county has three main physiographic divisions. A high nearly level to hilly area north of Elkhorn River is known as the Holt table. A low flat and subirrigated area through the central part of the county is called the prairie plains, or hay flats. The hilly sand-covered area in the southern part is the eastern extension of the great sand-hill section of Nebraska. The average elevation is about 2,050 feet above sea level.

The climate is continental and is characterized by a wide range between winter and summer, in both temperature and precipitation. The mean annual temperature is 46.5° F., and the mean annual precipitation is 21.43 inches.

The population in 1930 was 16,509, all classed as rural. The density of population is 6.9 persons a square mile. About 94 percent of the inhabitants are native born.

The county was organized in 1876, and O'Neill was made the county seat in 1879.

Railroad facilities are provided by a main line of the Chicago & North Western Railway, which extends east and west across the county, and by a branch line of the Chicago, Burlington & Quincy Railroad, which terminates at O'Neill.

This county is essentially agricultural. In 1934, 45.7 percent of the farm acreage was classed as cropland, used mainly for the production of grain and tame and wild hay; 51.3 percent was classed as pasture land; and 3 percent was devoted to other uses.

Wild hay is the most important crop, followed by corn, oats, rye, wheat, and barley, ranking in acreage during most years, in about the order named.

More than one-half of the total number of farms, including nearly two-thirds of the farm acreage, is used for the raising of livestock or the production of livestock products. About 25 percent of the farms are of the general farming type, and about 10 percent produce grain as a cash crop. The type of farming practiced and the kind of crops grown are determined largely by the character of the soils and the relief.

On the basis of the principal use made of them, the soils of this county have been placed in three broad groups, namely, soils suited to general farming, soils suited to hay farming, and soils suited to grazing.

The soils of five series have been included in the group of soils suited to general farming. They range in texture from loams to loamy sands and include the most productive soils of the uplands and terraces.

The sandy-substratum phases of the Marshall soils occupy nearly level to rolling uplands. These soils have a good content of organic

matter and are fairly retentive of moisture. They rank among the best in the county for general farming. The soils of the Thurman series are well suited to most crops, except some of the small grains. They have more rolling relief than the Marshall soils, are more sandy, and contain less organic matter. About 60 percent of the area occupied by them is used mainly for corn and oats. The typical O'Neill soils are on stream terraces, whereas their upland phases are on the high table north of Elkhorn River. All the upland phases of these soils are underlain at a slight depth by gravel and are rather droughty. The Ewing soils are similar in a general way to the upland phases of the O'Neill soils, but they have a heavy layer between the surface soil and the gravelly subsoil and, as a result, are more productive. The Verdel soils have dark-colored surface soils and heavy clay subsoils. They have developed on terraces over heavy sediments washed from higher lying shales.

The group of soils suited to hay farming occupy flat areas on the subirrigated prairie plains, occur on the bottom lands along streams, and are in wet hay valleys throughout the sand hills. Most of these soils are sandy, and all have a high water table. The Cass and Gannett soils are composed largely of sand, whereas the Lamoure soils have fine-textured subsoils. All soils of the group have very dark surface layers. They are used mainly for the production of native hay.

Because of their rough relief, imperfect drainage, or extremely sandy character, ten soils, in addition to dune sand and riverwash, have been placed in the group of soils suited to grazing. The material of the sand hills in the southern part of the county has been classed as dune sand. On account of its susceptibility to wind erosion, this material is unsuited for cultivation. Valentine sand and Valentine loamy sand are slightly more stable than dune sand but can be used profitably for cultivated crops in only a few favorable localities. Because of their extremely gravelly and sandy character and their low agricultural value, two upland phases of the O'Neill soils are placed in this group. The Boyd soils, also included, have developed over fine-textured shales and are composed mainly of heavy clay. Most of them are on slopes and are so badly eroded that they are used only for pasture land. The Fillmore soils occur in shallow undrained depressions throughout the finer textured parts of the uplands. They are of practically no value except for hay and pasture land. Sarpy sand and riverwash are recently deposited sandy alluvium of little agricultural value.

O

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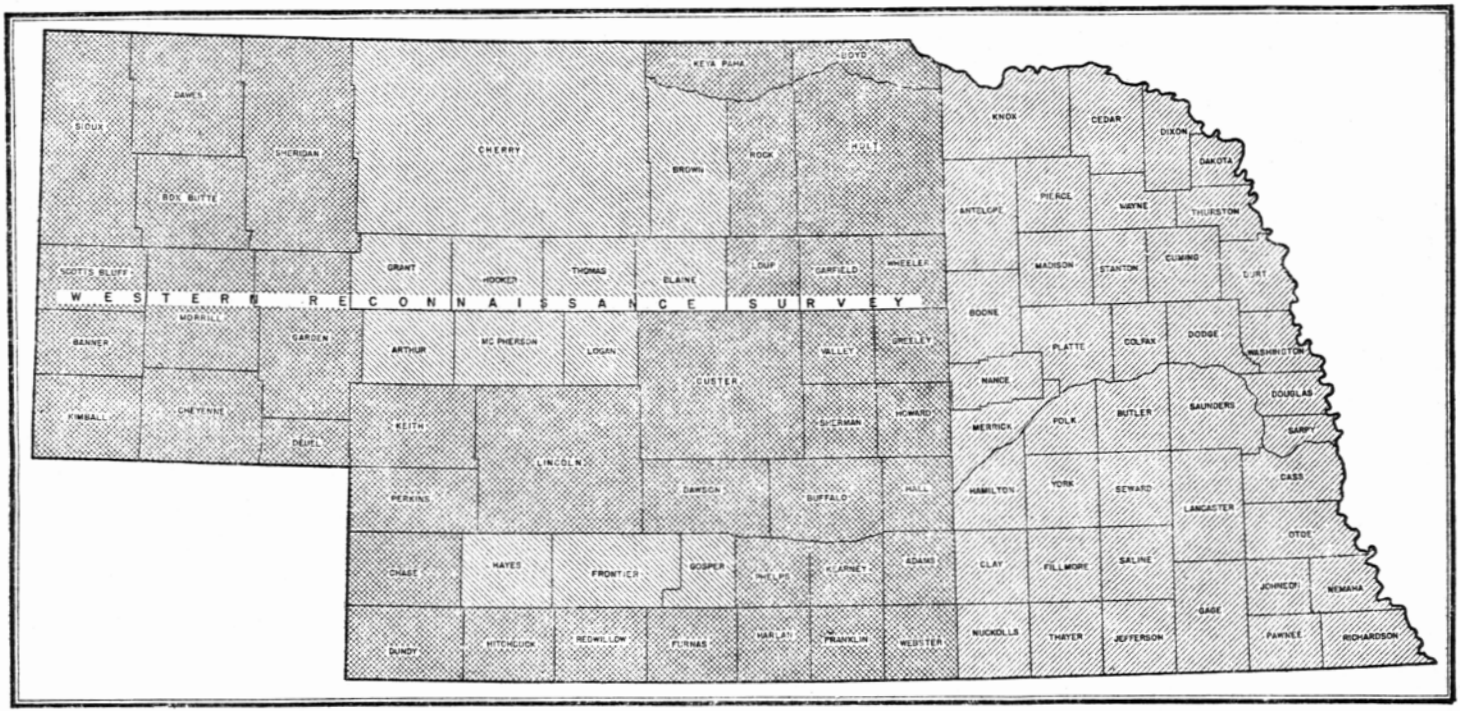
There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than two hundred and fifty copies shall be for the use of each Senator from the State and not more than one thousand copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



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

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