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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Hayes County, Nebraska

By
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Nebraska Soil Survey

Bureau of Chemistry and Soils
In cooperation with the
University of Nebraska State Soil Survey
Department of the Conservation and Survey Division

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SOIL SURVEY OF HAYES COUNTY, NEBRASKA

By L. A. BROWN, Nebraska Soil Survey

COUNTY SURVEYED

Hayes County is in the southwestern part of Nebraska (fig. 1). Hayes Center, the county seat, is about 225 miles west of Lincoln, the State capital, and about 200 miles northeast of Denver, Colo. The county is rectangular, extending 30 miles from east to west and 24 miles from north to south. It includes 709 square miles, or 453,760 acres.

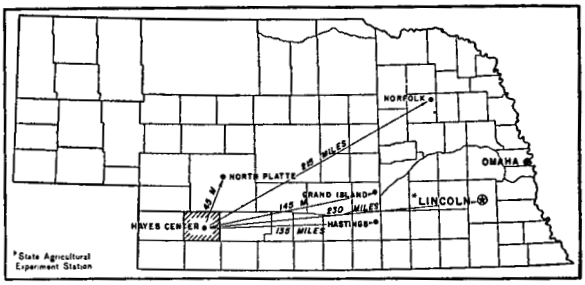

FIGURE 1.—Sketch map showing location of Hayes County, Nebr.

The relief, in general, is that of a nearly level to rolling plain. The underlying rock is soft light-colored sandstone mantled in most places with loess and sand. Geologic dissection of the mantle material and of the sandstone bedrock has produced considerable relief along drainageways, where run-off of water is rapid, and in the more sandy sections, where wind action has been severe. Within the county are parts of three major physiographic divisions [1]—the loess plain, the sand-hill region, and the Perkins tableland—each of which is more extensively developed in other counties of the State.

The northern fringe of the loess-mantled plains, which extend throughout southern Nebraska and northern Kansas, occupies the southeastern, central, and southwestern parts of the county, or about three-fifths of the total land area. Here the greater part of the terrain is characterized by a series of narrow flat-topped divides capped by loess and separated by drainageways, the canyonlike walls of which are nearly perpendicular in many places. The divides, which range from a few hundred yards to more than a mile in width, rise from 50 to 100 feet above the intervening canyon floors. They extend in a general north-south or northwest-southeast direction and are dotted with shallow basinlike depressions. An area of the loess-mantled plain in Antelope Precinct, about 20 square miles in extent, has escaped dissection by drainage channels, whereas strips of vary-

[1] CONDRA, G. E. GEOGRAPHY, AGRICULTURE, INDUSTRIES OF NEBRASKA. 307 pp., illus. Lincoln, Nebr. 1934.

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ing widths, but mostly narrow, along some of the larger streams have been reduced to a series of sharp tortuous ridges and steep slopes.

The large areas of sand hills in the northeastern and northwestern parts constitute outliers of the vast sand-hill section that covers north-central Nebraska. Their surface features are the result largely of wind acting on loose sand and consist of a succession of rounded and irregularly distributed hills and ridges, ranging from 10 to 40 feet in height, capped in places by drifting sand and pitted with blow-outs. The billowy surface is relieved here and there by nearly level or gently undulating valleys and basins of various sizes. Few drainage channels are established, as most of the valleys are obstructed by sand dunes, and surplus surface moisture escapes mainly through the porous substratum. Intermittent marshy areas and small shallow lakes occupy some of the valleys and basins.

Perkins tableland, a physiographic feature of western Nebraska, occupies an area, several square miles in extent, in the extreme northwestern part of the county. It overlies soft light-colored sandstone. The surface of this tableland has been covered in most places by deposits of sand and loess. Where exposed in Hayes County it has a nearly level to gently rolling relief modified by shallow depressions, or lagoons, wherein storm waters accumulate, and by a few, mostly short and barely perceptible, drainageways, in which surplus surface moisture slowly flows to one or another of the depressions.

Alluvial lands, including the terraces and flood plains along the larger streams, occupy about 5 percent of the area of the county. The largest developments are the continuous strips averaging about three-fourths of a mile in width along Frenchman Creek. Elsewhere the alluvial lands are in few places more than one-quarter of a mile wide.

The terraces, which are more extensive than the flood plains, lie at levels ranging from 10 to 30 feet above the streams, and they are not subject to overflow from the main channels. The relief is flat or very gently undulating, except where shallow steep-sided dainageways issuing from the uplands have become entrenched. Short steep slopes mark the transition between the different terrace levels and between the terraces and the flood plains.

The flood plains, or first bottoms, lie only a few feet above the normal flow of the streams. The broadest developments are along Frenchman Creek, where the flood plain ranges from about 20 rods to nearly one-half mile in width. Narrow continuous or broken strips border most of the larger streams. The relief of the first bottoms is for the most part nearly level, but it is modified by numerous flood channels, slight elevations, and shallow depressions.

The average elevation of the county is about 3,000 feet above sea level. The elevation of Palisade, lying across the southern boundary mostly in Hitchcock County, is 2,765 feet; of Hayes Center, 3,058 feet; of Hamlet, 2,829 feet; and of the uplands in the northwestern

part, about 3,250 feet. The general slope is downward toward the south and east.

Most of the county is well drained. Drainage is effected through tributaries of Republican River, of which Frenchman, Stinking Water, and Red Willow Creeks are the largest. They flow continuously, whereas Blackwood Creek and the other minor dainageways flow only during periods of rainy weather. The only poorly drained land is in spots on the flood plains of the larger valleys and in small basinlike depressions throughout the sand hills and the more nearly level parts of the loess plain and Perkins tableland. The streams have steep gradients and are actively deepening their channels. Most of the smaller drainageways in the southern part of the county are widening the valleys in their lower courses and are extending their channels into the loessial uplands.

Well water of good quality, in quantities sufficient for the needs of the family and the livestock, is available in nearly all sections. Throughout the uplands, the well water is obtained from Tertiary sands and gravels at a depth ranging from 75 to about 400 feet, but only a few of the wells are more than 250 feet deep. Wells in the alluvial lands range from 10 to 40 feet in depth, depending on the thickness of the alluvial deposits. They furnish water of good quality, except in a few places along Red Willow and Stinking Water Creeks where the well water, probably originating in the Pierre shale formation, is alkaline. This shale underlies the Tertiary sandstone throughout the entire county. It furnishes only a small supply of saline water. Springs occur at several places but are not an important source of water supply. One of the largest is in the SE¼ sec. 14, T. 7 N., R. 32 W., near Red Willow Creek.

The native vegetation consists mostly of grasses. Trees, including native broad-leaved species—chiefly willow, ash, elm, boxelder, and cottonwood—grow in narrow strips along most of the larger drainageways. They are not of merchantable size but are of value for shade, posts, and fuel.

Hayes County was established and organized from unorganized territory in 1877, but it did not have county government until a few years later. Its boundaries have remained unchanged. Most of the early settlers came from eastern Nebraska, Iowa, Illinois, Missouri, and more eastern States.

According to the Federal census, the county had 3,603 inhabitants in 1930, all classed as rural. The density of the population is five persons to the square mile. Settlement is rather evenly distributed, although it is somewhat denser in Frenchman Creek Valley and on the more nearly level parts of the loess plain and the Perkins tableland than elsewhere.

Hayes Center, the county seat, is an inland town located about 3 miles southeast of the center of the county. It is a trading point for a part of the farm produce and supplies. Hamlet, the only other town wholly within the county, is situated on a branch of the Chicago, Burlington & Quincy Railroad in the southwestern part.

Palisade, mostly in Hitchcock County, lies across the southern boundary.

Shipping facilities are good in the southwestern part which is served by the railroad but are only fair in the rest of the county. Most of the farm produce from the uplands is hauled to Grainton, Wallace, Dickens, Maywood, and Culbertson in adjoining counties.

The public-road system is well developed. United States Highway No. 6 parallels the railroad in Frenchman Creek Valley, and State highways, most of which are surfaced with gravel, cross the county in several directions. The other roads are of earth construction and are kept in good repair. All roads, except parts of the highways and some in the rougher areas, follow land lines.

Rural mail delivery routes serve most sections, telephones are in common use, and the public-school system is well developed.

CLIMATE

The climate of Hayes County is typical of the high plains section and is characterized by wide seasonal variations. The winters are long and cold, and the summers are short and hot. The rainfall and humidity range from moderate to low, and the rate of evaporation is high. There is not sufficient variation in relief to cause any pronounced differences in the climate.

Even during years of normal precipitation a close balance exists between the amount of moisture available to crops and the amount required for profitable yields. The mean annual precipitation at Hayes Center is 24.22 inches, of which 17.74 inches fall during the principal part of the growing season—April to September, inclusive. Most of the precipitation comes as torrential rains and runs off the land rapidly, subjecting it to severe erosion, especially in the sloping areas of the more silty soils. Long dry spells may occur in the latter part of July and during August, but the crops, although generally injured to some extent by the droughts, are seldom killed where properly tended, as most of the soils have a high moisture-retaining capacity. In dry seasons the crops do better, as a rule, on the sandy soils than on the finer textured soils.

The average length of the frost-free season, May 5 to October 7, is 155 days, which is ample to mature all the crops commonly grown. The date of the latest recorded killing frost is May 27, and of the earliest is September 20.

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

Table 1, compiled from records of the United States Weather Bureau station at Hayes Center, gives the normal monthly, seasonal, and annual temperature and precipitation at that station.

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

[Elevation, 2,900 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1915)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	27.8	74	−30	0.89	0.65	1.10	6.3
January	26.2	75	−30	.53	.70	.42	4.7
February	31.2	76	−19	1.04	.15	1.05	9.5
Winter	28.4	76	−30	2.46	1.50	2.57	20.5
March	38.2	96	−12	1.35	.09	2.95	8.5
April	48.9	97	10	2.73	.73	6.32	8.1
May	58.4	98	18	3.45	2.85	5.89	1.0
Spring	48.5	98	−12	7.53	3.67	15.16	17.6
June	68.8	108	34	3.53	3.17	8.55	.0
July	75.3	110	42	3.01	.99	9.69	.0
August	73.9	107	34	3.17	2.95	4.01	.0
Summer	72.7	110	34	9.71	7.11	22.25	.0
September	65.4	103	25	1.85	2.70	1.90	(1)
October	52.7	93	2	1.80	.01	2.03	2.8
November	39.4	83	−12	.87	.03	.92	2.6
Fall	52.5	103	−12	4.52	2.74	4.85	5.4
Year	50.5	110	−30	24.22	15.02	44.83	43.5

[1] Trace.

AGRICULTURE

During the sixties and seventies great herds of Texas cattle were driven into or through Nebraska, some for shipment from Ogallala, then known as the end of the Texas Trail, and others for fattening in the grass areas to the north and west. Several of the cattle trails passed through Hayes County where the herds were grazed in favorable localities for several days on their way northward. The abundant grass and water along the larger streams and the excellent shelter afforded the cattle in the numerous canyons of the adjoining uplands favored the use of the land for cattle raising, and in the early seventies a few ranches were established in the larger valleys.

The completion of the Burlington & Missouri River Railroad to Culbertson in 1881 and on to Denver in 1883 was followed by an influx of settlers who established themselves chiefly along the railroad under the Homestead, Timber Claim, and Preemption Acts. Most of the county remained in unfenced cattle range until the greater part of the tillable land near the railroad was put under cultivation, after which settlement spread over all the cultivable areas, and stockmen were forced to confine their operations to fenced ranches in the more sandy and rougher sections of the county where cattle raising has continued to be the leading occupation.

During most years since farming began, corn has been the principal cultivated crop, with wheat ranking second in acreage. The area devoted to wheat is determined mainly by the price and demand for that crop, and it fluctuates more than the corn acreage.

Table 2, compiled from Federal census data, gives the acreage used for the principal crops grown in this county in 1889, 1899, 1909, 1919, 1929, and 1934 and shows the general trend of agriculture.

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

Crop	1889	1899	1909	1919	1929	[1] 1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn	29,649	35,609	56,470	58,821	97,808	4,514
Wheat	5,449	14,520	11,073	42,098	46,325	14,700
Barley	57	580	5,269	5,010	6,824	233
Oats	3,702	606	4,098	1,455	3,142	60
Rye	537	1,936	1,415	2,402	2,285	165
Potatoes	760	320	348	105	139	44
All hay	10,626	7,019	15,326	21,128	10,815	[2] 16,252
Alfalfa	----------	603	1,951	2,752	2,846	1,859
Grains cut for hay	----------	254	196	277	361	160
Other tame hay	----------	1,633	2,761	2,120	1,813	10
Wild hay	----------	4,529	10,418	15,979	5,795	1,259
Sorghums for silage, hay, or fodder	----------	----------	----------	[3] 8,601	7,365	12,964

[1] Acreages greatly reduced by drought.
[2] Includes sorghums for silage, hay, and fodder.
[3] Excludes sorghum for hay.

The returns derived from livestock form an important source of revenue. The value of livestock and their products was $1,879,548 and the value of all crops was $2,231,889 in 1929. During the same year, butter, cream, and whole milk were sold for $76,810, and the poultry and eggs were valued at $159,602.

Table 3 gives the number and value of domestic animals on farms as reported by the Federal census in 1900, 1910, 1920, 1930, and 1935.

TABLE 3.—*Number and value of livestock on farms in Hayes County, Nebr., in stated years*

Livestock	1900		1910		1920		1930		1935 (number) [1]
	Number	Value	Number	Value	Number	Value	Number	Value	
Horses	4,203		6,209	$550,562	7,478	$409,572	5,164	$218,184	4,015
Mules	455		694	70,605	964	77,503	782	42,400	508
Asses and burros	7		45	5,670	31	4,578	26	1,040	----------
Cattle	17,298	$691,647	14,821	310,474	22,804	973,994	20,384	1,012,847	20,545
Sheep	41		167	752	374	4,769	146	971	846
Goats	5		13	48	41	357	119	619	105
Swine	14,389		19,272	174,815	16,769	321,698	27,176	366,897	11,844
Poultry	37,239	12,368	41,220	17,819	53,232	41,125	[2] 54,441	40,831	[2] 43,894

[1] Value not reported in 1935.
[2] Chickens only.

Of the 441,036 acres in farms in 1934, 195,922 acres, or 44 percent of the land in the county, were classed as cropland, and 236,797 acres, or 54 percent, were classed as pasture. Less than 1 percent was in woodland. Most of the remainder was occupied by roads and building sites.

The farms, as a rule, are well improved. A large proportion of them have pressure water systems, and practically all are equipped

with the most modern labor-saving machinery. Most of the buildings are painted and are kept in good repair. The farms are fenced and cross fenced, mainly with barbed wire, but some fields are enclosed with woven wire, especially in the valleys where many hogs are raised. Four- and six-horse teams perform most of the farm work, although the light-type, all-purpose tractor is used rather extensively. There were 230 tractors, 179 trucks, and 582 automobiles on the farms in 1930. The machinery and equipment includes gang plows, disks, harrows, drills, listers, cultivators, wagons, headers, binders, and complete equipment for harvesting hay. There were 101 grain threshers, 84 wheat combines, and 384 cream separators in the county in 1930. Many farms are equipped with corn binders, corn shuckers, hay balers, and silos. The more expensive machinery is sheltered.

The Federal census reports that 95.4 percent of the county was in farms in 1935 and that 48.6 percent of the farm land was cultivated or in plowable pasture. The average size of the farms during that year was 666.2 acres. Tenants operated 43.7 percent of the farms; owners, 55.1 percent; and managers, 1.2 percent. The most popular system of land rental is the share system, under which the owner receives from one-third to one-half of the grain delivered to the nearest elevator. Generally enough pasture for the work horses and milk cows is included with the farm land without extra charge. All seed, labor, and machinery are furnished by the tenant. When alfalfa land is rented on the share basis, the owner receives one-half of the hay stacked in the field. Few farms rent for cash. Land suited only for pasture may be rented for a lump sum.

Farm labor during the last few years has been plentiful and unusually cheap. Monthly farm wages range from $10 to $20 with board and lodging. Day labor is plentiful at prices ranging from 75 cents to $1. Most farmers do their own work, except at harvest time when some help is hired.

On the smoother lying and finer textured soils grain growing is the principal occupation, with corn and wheat the chief crops. On farms operated by owners most of the corn is fed to cattle and hogs, but on the tenant farms more of the crop is sold. Wheat is grown entirely as a cash crop. More than one-half of the county is in native pasture and hay land which is used in connection with the production of beef cattle—the leading branch of animal husbandry. Most of the herds are of good quality grade cattle headed by a purebred bull. The principal breeds are Hereford, Aberdeen Angus, and Shorthorn. Some ranchers ship in cattle for summer grazing, but most of the animals are raised locally. A few feeders, located where corn and alfalfa can be grown easily, purchase cattle for winter fattening.

Hogs are raised chiefly in connection with cattle fattening and are numerous in the stream valleys where grain feed is abundant. Most farmers raise several hogs, and a few maintain large herds. All the hogs are of good breeding, and some are purebred. The principal breeds are Duroc-Jersey and Poland China. Sanitary measures prevail, and the hogs are kept practically free from disease.

Chickens are raised on every farm, and some farmers have flocks of several hundred birds. The poultry consists of heavy dual-purpose breeds for dressed poultry and egg production, and it is an important source of income.

From 2 to 10 cows, chiefly of mixed beef and dairy breeding, are kept on the average farm. Most of the surplus dairy products are sold in local cream stations, from which they are shipped to creameries outside the county.

Horse raising is confined chiefly to the breeding of work mares. Percheron blood predominates in most of the horses. Purebred stallions are kept on a few farms. Owing to the increased use of tractors, horse raising is declining and at present is not profitable.

The farming practices in Hayes County are similar to those prevailing in other southwestern Nebraska counties. Corn, the most important crop, is planted about the middle of May. A lister ordinarily is used, because a minimum of labor is required to prepare the land and because listed corn is thought by most farmers to be more drought-resistant than that planted in checkrows. The corn is cultivated three or four times until early in July, after which it receives no further attention until harvest, except to remove the more obnoxious weeds by hoeing. The grain matures in September or early in October. The greater part is husked from the standing stalks, and some farmers annually fence off a few acres of the unhusked corn for fattening hogs and cattle. Only early-maturing dent varieties, which have become adapted to local soil and climatic conditions, are grown.

Practically all the wheat grown is of the winter varieties, chiefly Kanred, Turkey, and Nebraska 60.[2] Nebraska 60 and local Turkey varieties usually produce the best yields on the upland, and Tenmarq is considered superior on valley farms.

The land to be used for wheat is plowed and harrowed or disked during the summer, and the seed is planted with a press drill in September. Some wheat is drilled between the corn rows. Other factors being equal, the earlier in the summer that the land is plowed, the larger are the yields of grain,[3] due chiefly to the control of weeds which otherwise would use much of the moisture and plant nutrients needed by the crop. Wheat usually makes a good growth before killing frosts occur. It remains dormant during the winter, resumes growth in the spring, and matures early in July. The crop is either headed and later threshed from the stack or is harvested with a combine.

Not much barley is grown, but the acreage devoted to this crop is increasing. Barley, which ranks next to corn measured in terms of feed value per acre, is a good substitute for corn and insures a supply of feed should unfavorable weather materially reduce the corn yields. Barley is planted and harvested in the same manner as wheat, but the land is prepared and the seed is sown in the spring instead of the fall. Trebi and smooth-bearded varieties, such as Comfort, are grown chiefly.

Rye and oats are grown on a few farms. Much of the rye is used as a cover crop for sweetclover and alfalfa and for winter pasture. The grain is planted in the fall or spring in the same manner as wheat and is fed mainly to hogs. Oats, which are planted in the spring, are used chiefly for horse feed.

Sorgo (sweet sorghum) is grown on most of the upland farms and is the main forage crop. The yield ranges from 1 to 5 tons an

[2] JODON, N. E. CEREAL VARIETY EXPERIMENTS AT NORTH PLATTE. Nebr. Agr. Expt. Sta. Bull. 272, 35 pp., illus. 1932.

[3] ZOOK, L. L. DRY-LAND CROP PRODUCTION AT THE NORTH PLATTE EXPERIMENTAL SUBSTATION. Nebr. Agr. Expt. Sta. Bull. 279, 49 pp., illus. 1933.

acre, depending on the rainfall. Sorgo remains dormant during dry periods, making it very resistant to drought, and it is highly productive. The best quality of feed is produced by cutting the crop when the earliest heads begin to mature. Most of the sorgo is used to supplement the corn and barley ration. Its feed value compares favorably with that of the wild hays. Black Amber, Sumac, and Atlas are the chief varieties of sorgo grown.

Alfalfa is next in importance as a tame-hay and forage crop. Most of it is produced on the bottom lands and terraces, parts of which are under irrigation. The varieties grown are among the most hardy obtainable, including Common, Grimm, and Cossack, all which are resistant to winter-killing. Thorough preparation of the seedbed is important in obtaining a good stand of alfalfa. Early plowing followed by sufficient disking, harrowing, and possibly rolling to control weed growth and to compact the soil is desirable in most places. About 15 pounds of good seed to the acre are sown. A stand of alfalfa generally is allowed to remain as long as it yields profitably. A field is rarely frozen out. The crop generally is cut three times during the summer, and occasionally a fourth cutting is obtained. Most of the alfalfa is fed to cattle and hogs. Many farmers run hogs in the alfalfa fields during the summer.

Most of the wild hay is produced on the more nearly level areas throughout the sand hills, although some is cut on poorly drained parts of the bottom lands and on narrow canyon floors throughout the loess-covered sections of the county. The hay, which is of good quality, usually is stacked in the fields and hauled to the feed lots as needed. It is fed chiefly to cattle and horses.

Sweetclover, although still a minor crop, is being grown more extensively each year. It is handled in the same manner as alfalfa, but it fits into shorter rotations than that crop and is more drought-resistant. It is considered by many farmers to be better suited for soil improvement than alfalfa. Sweetclover is used chiefly for pasture and hay, and some seed is produced. The plant is a biennial and dies at the end of the second year after producing seed.

Many farmers annually sow a few acres to millet which is very drought-resistant. This crop is planted in early summer and is cut for hay in the fall. The main varieties grown are Siberian, German, and Common. The millet acreage is increasing.

Irrigation is practiced to a limited extent. The Nebraska agricultural statistics report 1,140 acres under irrigation in 1930. All the irrigated land is in Frenchman Creek Valley, where it is used chiefly for the production of alfalfa.

No commercial fertilizer is used. Considerable barnyard manure is produced, especially on the irrigated farms. The manure is hauled in the fall or spring and generally is spread on the land to be used for corn. On most tenant farms little care is taken to apply the manure where it is most needed, and the greater part is spread on land nearest the barnyard.

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. The excavation exposes a series of distinct soil layers or horizons called, collectively, the soil profile. Each horizon of the soil, and the parent material beneath the soil, is studied in detail. The color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [4] and the presence or absence of lime and salts are determined by tests. The drainage, both internal and external, and other features, such as the relief, or lay of the land, are taken into consideration, and the interrelation of soil and vegetation is 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 planted crops as well as native grasses and trees. On the basis of these characteristics the soils are grouped into classification units. The three principal ones are (1) series, (2) type, and (3) phase.

The most important classification unit is the series which includes soils having the same genetic horizons that are similar in their important characteristics and position in the soil profile, and are 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 commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Keith, Valentine, and Tripp are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture in the upper part of the soil. Thus the class name of the soil texture, such as sand, loamy sand, very fine sandy loam, loam, silt loam, clay loam, or clay, is added to the series name to give the complete name of the soil type. For example, Keith silt loam and Keith very fine sandy loam are soil types within the Keith 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 is generally the soil unit to which agronomic data are definitely related.

A phase of a soil type is recognized for the separation of soils that differ within a type in some minor soil characteristics which may, nevertheless, have an important practical significance. Differences in relief, stoniness, and degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important variations in the internal features of the soil type or in its ability to produce native vegetation throughout its range in relief, there may be important variations relating to the growth of cultivated plants brought about by differ-

[4] 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.

ences in the rapidity of surface run-off. In such instances the more sloping parts of the soil type may be shown on the map as sloping or hilly phases of that type. 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 and phases in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

Hayes County is in the Chestnut (dark brown) soils region of the United States where nearly all of the soils are potentially productive but where the mean annual precipitation is only a few inches in excess of the minimum required for profitable farming, and soil moisture is the chief factor limiting crop yields. As previously mentioned, about 42 percent of the land is under cultivation, and the rest is used mainly for native pasture and hay land. The uncultivated areas are on steep and severely eroded valley sides, on rolling to hilly sandy land, in poorly drained patches throughout the bottom lands, and in shallow undrained basins on the uplands.

Corn occupies about one-half of the cultivated acreage. Wheat, however, is important on the finer textured uplands and terraces and takes up about 28 percent of the cultivated acreage. Alfalfa is grown extensively on the lower lying alluvial lands. Of the minor crops, barley, an important feed, oats, rye, and millet are produced principally on land well suited to the production of wheat, and potatoes are grown in patches on nearly all of the cultivated soils. Sorgo forage furnishes much feed, especially in the drier years.

More than three-fifths of the land is either so uneven that much of the rainfall is lost through run-off or is so sandy and incoherent that the soil drifts badly when the native sod is broken. The strongly rolling to steeply sloping areas of fine-textured soils are unable to furnish sufficient moisture for satisfactory crop yields, whereas the more sandy soils, although fairly well supplied with moisture, are so unstable that the production of grain and tame hay is unprofitable. These nonarable areas, which occupy most of the sand hills and all the hilly and steeply sloping land in the loess section, support, however, a good growth of native grasses. Their profitable utilization is possible only through livestock raising, on which the agriculture of the county is based.

The soils of this county differ considerably in their profile features and crop adaptabilities. The characteristics of any soil are the result of a number of factors, chief among which are climate, vegetation, drainage, the character of the parent soil material, and the length of time this material has been subjected to comparatively undisturbed soil development. The climate throughout the county is rather uniform, but the other factors differ from place to place with the result that various soils have developed. Throughout the more nearly level but well-drained sections of the finer textured up-

lands and on the more silty terraces, the parent soil material is mainly loess, a light-colored, limy, and floury silt which is fairly productive, even in its raw condition, and which lends itself readily to the formation of soil. In these situations the loess has lain for long periods undisturbed by abnormal erosion, and the soils are deep and friable throughout, with high water-holding capacities. Here the thick dark grayish-brown surface soils are well supplied with organic matter, and the lighter colored subsoils are very limy. These soils are among the most productive in the county for small grains and are used largely for growing these crops, corn, and sorgo.

The soils developed on steep slopes, where run-off is rapid, and on incoherent sands have accumulated little organic matter and are characterized by thin grayish-brown surface soils. In general, these soils are used for native pasture and hay land.

The soils of the bottom lands owe their features mainly to the character of the sediments on which they are developing. They range in texture from silt to sand and in color from almost black to very light brown. All are subirrigated. The darker and more silty soils, where well drained, are the most productive of corn and alfalfa in this section and are used mainly for growing these crops. The extremely sandy and the poorly drained soils of the bottom lands retain their native cover of grasses and are used for pasture and hay land.

The soils of the county may be grouped, on the basis of the crops which are most extensively grown on them and to which they are best suited, as follows: (1) Soils suitable for the production of corn, small grains, and forage crops; (2) soils suitable for the production of corn and native hay; (3) soils suitable for the production of corn and alfalfa; and (4) soils suitable mainly for the production of native grasses. This system of grouping is not intended to indicate that the soils of a particular group are the only ones which can be used for the crops mentioned in connection with that group. Under a more intensive farming system involving, where necessary, artificial drainage, incorporation of organic matter, and control of wind and water erosion, most crops adapted to the climate could be grown on nearly all of the soils. Even under present conditions, small well-managed fields throughout the more sandy uplands have been made to produce profitable yields of corn, sorgo, and millet, all which gave larger returns than the original native grasses. Likewise, most of the poorly drained soils of the bottom lands will, when adequately drained, grow any crop common to the section.

Under the present farming system, however, larger returns are obtained, year in and year out, when the soils are used for the crops to which they are naturally best suited. The grouping is based not only on soil and crop adaptations but also on those characteristics that are responsible for these adaptations and on the surface features and drainage conditions of the soil. None of the soil groups is confined to any particular part of the county, and small areas of soils of other groups occur within the larger areas of each group.

The approximate percentage of each soil devoted to the more important crops is given in table 4.

TABLE 4.—*Approximate percentage of each soil devoted to the more important crops of the county* [1]

Soil type	Corn	Wheat	Barley	Sorgo	Alfalfa	Wild hay	Pasture
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
SOILS SUITABLE FOR THE PRODUCTION OF CORN, SMALL GRAINS, AND FORAGE CROPS							
Keith silt loam	50	41	2	2	(2)	(2)	3
Keith silt loam, deep phase	41	50	2	2	(2)	(2)	(2)
Keith silt loam, slope phase	50	40	2	4	(2)	(2)	(2)
Keith very fine sandy loam	55	30	3	2	(2)	(2)	8
Keith fine sandy loam	65	20	3	(2)	(2)	(2)	10
Keith fine sandy loam, deep phase	65	20	3	(2)	(2)	(2)	10
Rosebud very fine sandy loam	30	15	3	2	(2)	10	40
Anselmo very fine sandy loam	55	30	3	(2)	(2)	(2)	10
Anselmo fine sandy loam	50	10	2	2	(2)	10	24
SOILS SUITABLE FOR THE PRODUCTION OF CORN AND NATIVE HAY							
Valentine fine sandy loam	50	10	5	5	(2)	5	23
Valentine loamy fine sand	40	5	(2)	5	(2)	10	38
Valentine fine sand	25	5	(2)	(2)	(2)	15	50
Anselmo loamy fine sand	53	10	5	5	(2)	5	20
SOILS SUITABLE FOR THE PRODUCTION OF CORN AND ALFALFA							
Tripp silt loam	57	15	3	5	4	6	10
Tripp fine sandy loam	65	10	2	5	4	5	8
Bridgeport very fine sandy loam	60	10	4	(2)	10	5	10
Bridgeport silt loam	60	10	(2)	5	15	5	5
Sarpy very fine sandy loam	55	(2)	(2)	5	30	5	5
Sarpy fine sandy loam	55	(2)	(2)	5	25	5	10
Laurel silt loam	55	(2)	(2)	5	30	5	5
SOILS SUITABLE MAINLY FOR THE PRODUCTION OF NATIVE GRASSES							
Colby silt loam	20	16	2	2	(2)	5	55
Colby silt loam, broken phase	(2)	(2)	(2)	(2)	(2)	3	96
Colby very fine sandy loam	20	16	2	2	(2)	5	55
Colby very fine sandy loam, broken phase	(2)	(2)	(2)	(2)	(2)	3	95
Colby fine sandy loam, broken phase	(2)	(2)	(2)	(2)	(2)	3	95
Scott silt loam	5	10	5	20	(2)	5	55
Scott very fine sandy loam	30	5	3	15	(2)	10	35
Butler silt loam	20	20	10	10	(2)	10	30
Canyon loam	(2)	(2)	(2)	(2)	(2)	4	95
Dune sand	(2)	(2)	(2)	(2)	(2)	5	93

[1] Estimates made during the progress of the survey.
[2] Less than 2 percent.

In the following pages, the several soils in the different groups are described and their crop adaptations are discussed. The accompanying soil map shows the distribution of the soils, and table 5 gives their acreage and proportionate extent.

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

Soil type	Acres	Percent	Soil type	Acres	Percent
Keith silt loam	106,176	23.4	Sarpy very fine sandy loam	1,344	0.3
Keith silt loam, deep phase	2,624	.6	Sarpy fine sandy loam	960	.2
Keith silt loam, slope phase	5,568	1.2	Laurel silt loam	3,648	.8
Keith very fine sandy loam	20,160	4.4	Colby silt loam	8,896	2.0
Keith fine sandy loam	10,368	2.3	Colby silt loam, broken phase	110,976	24.4
Keith fine sandy loam, deep phase	1,280	.3	Colby very fine sandy loam	2,624	.6
Rosebud very fine sandy loam	3,904	.9	Colby very fine sandy loam, broken phase	19,392	4.3
Anselmo very fine sandy loam	7,168	1.6	Colby fine sandy loam, broken phase	4,096	.9
Anselmo fine sandy loam	22,656	5.0	Scott silt loam	576	.1
Valentine fine sandy loam	19,520	4.3	Scott very fine sandy loam	576	.1
Valentine loamy fine sand	18,112	4.0	Butler silt loam	256	.1
Valentine fine sand	30,400	6.7	Canyon loam	1,408	.3
Anselmo loamy fine sand	13,504	3.0	Dune sand	21,056	4.6
Tripp silt loam	3,648	.8			
Tripp fine sandy loam	1,088	.2			
Bridgeport very fine sandy loam	8,448	1.9	Total	453,760	--------
Bridgeport silt loam	3,328	.7			

SOILS SUITABLE FOR THE PRODUCTION OF CORN, SMALL GRAINS, AND FORAGE CROPS

This group includes the greater part of the cultivated land and occupies about 40 percent of the total area of the county. It comprises all the Keith and Rosebud soils, and the finer textured types of the Anselmo series. One or another of these soils occurs in nearly all parts of the less eroded uplands.

The Keith soils have developed on loess, the Rosebud on limy sandstone, and the Anselmo on a mixture of loess and incoherent sand. All have dark-colored surface layers, although, in general, the surface soils of the Anselmo soils are not so dark as those of the Keith and Rosebud soils. The relief ranges from nearly level to rolling, and drainage everywhere is good.

The soils of this group have not been subjected to severe water erosion and are fairly stable against wind erosion, even under cultivation. They are highly retentive of moisture and are friable throughout. All are well suited for the production of corn, small grains, sorgo, and millet, and they return about the same average yields. Their rates of absorbing moisture vary somewhat, however, and are reflected in variations in the annual yields of crops. In years of normal or heavy precipitation, the Keith soils are the most productive, with the Rosebud and Anselmo ranking next, in the order named. In dry seasons, on the other hand, the Anselmo soils, which are more sandy than the others and which allow practically no run-off, supply more moisture to the crops and produce higher yields than either the Keith or Rosebud soils.

Keith silt loam.—Keith silt loam, which is the most extensive soil of this group, covers the greater part of the more nearly level to gently rolling loessial uplands throughout the southeastern, central, and southwestern parts of the county. The largest development covers about one-third of Antelope Precinct. Elsewhere this soil occupies comparatively narrow tabular divides between deeply entrenched and steep-sided drainageways.

The surface soil, a friable dark grayish-brown silt loam, is 10 or 12 inches thick and is well supplied with organic matter. The latter constituent, which comprises about 2.8 percent of the upper 12 inches,

is largely responsible for the friable nature of the surface layer and greatly increases its absorbing power for both moisture and heat. The organic matter also is the chief source of nitrogen, an important plant nutrient. The subsoil, which extends to a depth ranging from 3½ to 4½ feet, is friable silt loam, grayish brown in the upper part, where it has been stained by solutions of organic matter from the surface soil, and light grayish brown or almost white in the lower part. Lime is abundant below an average depth of about 2 feet and occurs chiefly as filmlike coatings on the surfaces of clods or in finely divided form, thoroughly mixed with the silt. Beneath the subsoil is light grayish-yellow floury uniformly limy silt which continues to a depth of many feet. This, the material from which the soil has developed, is known as Peorian loess which is exposed in nearly all the stream and deeper roadside cuts throughout the southern and central parts of the county.

This soil is highly retentive of moisture, and it is sufficiently porous to allow good aeration and easy penetration of roots and water. Practically all the land is under cultivation and, in common with the other arable soils, is used mainly for the production of corn. Yields of this crop vary considerably, ranging from about 50 bushels an acre in seasons of unusually heavy rainfall to total crop failure in very dry years.

Winter wheat, which is the principal small grain produced, is grown more or less extensively on all areas of this soil, but the proportion utilized for wheat is greater in the western than in the eastern part of the county. Yields of wheat are less variable than those of corn, as wheat matures on moisture from spring and early summer rains and is not subject to the frequent midsummer and late summer droughts that so greatly reduce yields of corn. The average yield of wheat is about 13 bushels an acre.

Sorgo, barley, and millet hay are grown on most farms occupied by this soil, generally in small fields. Alfalfa is grown on some areas, but the yields in general are unsatisfactory after the first few years as the deep subsoil moisture, upon which profitable production of alfalfa depends in this section, is rapidly depleted.

Keith silt loam is easily tilled, is naturally strong and fertile, and returns high yields of all crops common to the section in years of heavy precipitation. It can be cultivated under a fairly wide range of moisture conditions. Clods are formed if the soil is plowed when wet, but the lumps are easily reduced by subsequent tillage.

This soil, although remarkably uniform throughout its distribution in the county, presents a few variations. On the broader and more nearly level divides, the surface soil is slightly thicker, and lime in the subsoil lies at a slightly greater depth than is typical. The more nearly level areas, where run-off is least, have a slightly higher agricultural value than the gently rolling tracts, mainly because of more favorable moisture conditions. On a few of the rolling areas, associated with the Colby soils where run-off is rapid, erosion has somewhat thinned the surface soil, and lime lies nearer the surface than is typical.

Also included within areas mapped as this soil are several nearly level to rolling tracts, in which the upper 3 feet of soil material is typical, but it rests on a lower soil profile that is identical with it except for white streaks and splotches of lime. The lower profile

apparently is a buried soil which acquired all the characteristics common to typical Keith silt loam, including a well-developed dark surface soil, but which was later covered by loess upon which the present soil has developed. The abundance of lime in the buried soil is probably the result of downward percolation of moisture, which has carried some of the lime from the upper soil into the lower one. Areas in which this double soil profile occurs are neither sufficiently extensive nor sufficiently important agriculturally to warrant separation on the soil map. They occur chiefly on the divide between Stinking Water and Frenchman Creeks, but small areas are developed in other parts of the county. They do not differ noticeably from the typical soil in their crop adaptabilities or producing powers.

Keith silt loam, deep phase.—The deep phase of Keith silt loam differs from the typical soil only in that its surface soil is slightly thicker, and lime lies at a slightly greater depth. It has developed from loess in nearly level or slightly depressed areas, chiefly in the northwestern part of the county.

Drainageways are not well established, but the soil absorbs all surplus surface water and is everywhere well drained.

The surface soil, which is about 14 inches thick, is dark grayish-brown friable silt loam well supplied with organic matter. The upper subsoil layer is grayish-brown silt loam and is about 20 inches thick. It is slightly heavier than the surface soil, but its increased density is scarcely noticeable, and the material is friable throughout. The lower subsoil layer, which extends to a depth of about 5 feet, is grayish-yellow loose silt. This material is very limy below a depth of about 3 feet. It rests on Peorian loess similar to that underlying typical Keith silt loam.

The land is used for the same crops as the typical soil and has about the same or only slightly higher agricultural value.

Keith silt loam, slope phase.—The slope phase of Keith silt loam resembles the typical soil in all except surface soil features. It has developed from grayish-yellow limy silt similar to that underlying the other Keith soils, but it occupies slopes between those soils and lower lying land. Most of it occurs in small irregularly shaped areas and narrow strips on the valley sides along the larger streams throughout the southern and north-central parts of the county.

Owing to its sloping position, this soil has been subjected to more erosion than typical Keith silt loam. Its surface soil, therefore, varies in thickness and averages considerably thinner than that of the other Keith soils. The slopes on which this soil occurs are more gradual than those occupied by the severely eroded Colby soils, and areas in which the dark surface soil is less than 8 inches thick are few and small. The surface soil in most places is silt loam, although some areas include small patches in which the texture of this layer is fine sandy loam or very fine sandy loam.

The soil is suited to the production of the same crops as those grown on Keith silt loam, but its sloping position is conducive to rapid run-off of surface water, and less rainfall is absorbed than in areas of that soil. Crop yields average about 15 percent lower than those obtained on the more nearly level Keith soils.

Keith very fine sandy loam.—Keith very fine sandy loam differs from Keith silt loam only in that it contains more very fine sand

in the surface layer. The other layers of the two soils and the loess material on which they have developed are similar in all characteristics.

The surface soil, to an average depth of about 11 inches, is pulverulent very fine sandy loam containing enough organic matter to impart a dark grayish-brown color. The material has sufficient coherence, or body, to prevent excessive wind erosion even under intensive cultivation. The upper part of the subsoil is brown silt loam that is slightly heavier than the material in the layer above, but it is not compact. It rests on a light grayish-brown lower subsoil layer composed of loose mellow silt. Finely divided lime is abundant below an average depth of 30 inches. The unweathered or only slightly altered limy loess is reached about 4 feet below the surface of the ground.

Areas of this soil occupy nearly level to rolling upland situations, and most of them lie between areas of Keith silt loam and the more sandy soils. The largest developments are in Antelope Precinct. All the soil has good surface and internal drainage, and practically none of it is subject to severe wind or water erosion.

Owing to the slightly higher sand content of its surface layer, Keith very fine sandy loam absorbs moisture a little more rapidly than Keith silt loam and can be cultivated sooner after rains. It suffers less loss of moisture through run-off than that soil and during dry seasons gives slightly higher yields. Over a period of years, however, the productivity of the two soils is about equal. They are used for the same crops and are considered to have about the same value for general farming. Practically all of Keith very fine sandy loam is under cultivation.

Keith fine sandy loam.—Keith fine sandy loam is closely associated with Keith very fine sandy loam, but it has received more wind-blown sand and the upper part of its profile is coarser than that of most of the other Keith soils. The largest developments are in Antelope and Fairfield Precincts, and smaller tracts are in transitional areas between the sand-hill and loess sections.

The relief ranges from nearly level to gently rolling, and both surface and internal drainage are good.

The surface soil, in most places, consists of dark grayish-brown friable fine sandy loam 12 or 14 inches thick, but in some places it is thinner, lighter in color, and coarser in texture. The upper subsoil layer is somewhat coarser and looser than the corresponding layer in the finer textured Keith soils but has about the same grayish-brown color. The lower part of the subsoil, which is light grayish brown, is very limy below an average depth of 3 feet, and below a depth of 5 feet the material rests on almost white unweathered loess similar to that underlying Keith silt loam.

Keith fine sandy loam is somewhat unstable under cultivation, especially during dry windy periods. For this reason it is not used so extensively for growing small grains as are the finer textured Keith soils. It takes up moisture rapidly, however, and in years of subnormal rainfall is one of the most productive soils of the uplands for corn. Nearly all of it is under cultivation.

Keith fine sandy loam, deep phase.—The deep phase of Keith fine sandy loam occupies a few nearly level or slightly depressed areas

in the well-drained uplands, chiefly in Deerfield Precinct. The largest tract comprises about 400 acres.

The surface soil is similar in texture to that of Keith fine sandy loam, but it is much thicker and is slightly darker. It consists of pulverulent dark grayish-brown or very dark grayish-brown fine sandy loam which continues to a depth ranging from 20 to 26 inches with little change. The upper part of the subsoil, which is about 15 inches thick, is brown moderately heavy but friable silt loam. The lower subsoil layer is light grayish-brown floury silt with a high lime content. The parent material is Peorian loess similar to that beneath the other Keith soils.

Owing to its nearly level or slightly depressed position, this deeper soil nowhere loses much moisture through run-off. In the depressed situations it receives some additional water from higher land. Its deep dark-colored and moderately sandy surface soil absorbs moisture rapidly and contains an abundance of plant nutrients. During seasons of normal or slightly subnormal precipitation, this soil is one of the most productive on the uplands for corn and sorgo. It is a little too sandy and unstable for the highest yields of small grains, especially during dry windy seasons when even corn yields are somewhat reduced by drifting sand. Over a long period of years, however, this soil is about as productive as Keith silt loam. Practically all of the land is under cultivation. Corn is grown chiefly, but all crops common to the section are produced. The total area of this soil is small, and it is therefore of minor agricultural importance in this county.

Rosebud very fine sandy loam.—Rosebud very fine sandy loam has developed in the uplands from light-gray limy and soft sandstone of Tertiary age. It occurs chiefly in Swan Lake and Deerfield Precincts.

The surface soil, which is friable, dark grayish brown, and from 6 to 12 inches thick, consists, in most places, of very fine sandy loam, but in several small areas the texture is silt loam, and in numerous patches it contains so much fine sand and medium sand that its texture approaches fine sandy loam. These variations from the typical are not sufficiently extensive or important agriculturally to warrant recognition on the soil map.

The subsoil, which is about 3 feet thick, is light brown in the upper one-third and very light grayish brown below. It grades downward from very fine sandy loam to fine sandy loam and rests on the unweathered or only slightly altered parent sandstone at a depth of about 4 feet. In many places disintegrating fragments of the sandstone are present throughout the subsoil. The profile is very limy below an average depth of 18 inches.

The relief ranges from nearly level to rolling. Surface drainage channels are developed in some areas but are absent in others.

About 80 percent of Rosebud very fine sandy loam is under cultivation, and the rest, including areas where the surface soil is thinnest, is used for native-pasture and hay land. The soil as a whole is highly productive, considering the low precipitation of the sections in which it occurs. The cultivated areas are used mainly for the growing of corn but are suited to all crops commonly produced in this section. Yields are about the same as or only slightly lower than those obtained on Keith silt loam.

Anselmo very fine sandy loam.—Anselmo very fine sandy loam is developed from a mixture of very fine sand, fine sand, and silt or from material similar to loess but containing a much higher percentage of sand than ordinarily occurs in true loess. The soil occupies small transitional areas between the sand hills and the silty soils of the Keith and Colby series, mainly in the south-central and northern parts of the county.

The surface soil is dark-brown or dark grayish-brown friable very fine sandy loam, from 8 to 12 inches thick. This rests on brown or light grayish-brown material of about the same texture and consistence, which continues, in most places, to a depth exceeding 5 feet. The material may or may not be limy below a depth of 4 feet.

The relief ranges from nearly level to rolling. The surface soil in the rolling areas is thinner and lighter in color than on the flats. Surface drainage channels are poorly developed, but practically all of the light rainfall is absorbed rapidly.

This soil, although rather sandy, has a high water-holding capacity, and it loses little or no precipitation through downward percolation or surface run-off. It can be cultivated when moist without danger of becoming cloddy, and it is sufficiently coherent to prevent excessive wind erosion even during prolonged periods of dry windy weather. About 80 percent of the land, including the more nearly level and the gently rolling areas, is used for the growing of corn, wheat, and oats, which rank in acreage in about the order named. During dry seasons the soil is more productive of all crops than is Keith silt loam, but in years of normal or heavy precipitation it is slightly inferior to the Keith soil in productivity. The more strongly rolling areas, in which the surface soil is comparatively thin and light colored, retain their native cover of grasses and are used for pasture and hay land.

Anselmo fine sandy loam.—Anselmo fine sandy loam has developed from a mixture of loess and sand as has Anselmo very fine sandy loam, but the sand is more abundant and of a coarser grade in the upper soil layer, making it less coherent and slightly lighter colored than the corresponding layer of the very fine sandy loam type.

This soil is remarkably uniform to a depth ranging from 3 to more than 4 feet. It consists largely of fine sand or medium sand but includes enough silt to give the sandy material considerable body. The 7- or 8-inch surface soil contains sufficient organic matter to give it a dark grayish-brown color, but the material below is light grayish brown, owing to a scarcity of organic matter. In places the soil is limy below an average depth of 30 inches.

The relief ranges from nearly level to slightly hummocky and, for the most part, is a little more pronounced than that of Anselmo very fine sandy loam. Surface drainage channels are not established, as all the precipitation is absorbed by the sandy soil.

This soil, most of which is cultivated, is used mainly for the growing of corn. It is a little too unstable, especially during dry windy seasons, for high yields of small grains whose fine root systems are more readily injured by drifting sand than are those of corn. Sorgo also is grown extensively. In dry seasons, yields of corn and sorgo are higher than on the finer textured soils of the uplands, mainly because the high sand content of Anselmo fine sandy loam pro-

motes more rapid, and consequently greater, absorption of water than takes place in the finer textured land. In seasons of normal or heavy precipitation, however, this soil is less productive than most of the more silty soils of the county, mainly because of its lower organic matter content.

SOILS SUITABLE FOR THE PRODUCTION OF CORN AND NATIVE HAY

The soils of this group, which are composed largely of loose sand, include all the Valentine soils and Anselmo loamy fine sand. They occupy 18 percent of the county and occur principally in dry valleys, pockets, and swales within and around the edges of the sand hills.

Owing to their high sand content and rather unstable nature, these soils have accumulated less organic matter than the soils of the group previously discussed and are subject to considerable drifting when tilled. On the whole, however, they are better suited and more extensively used for the growing of cultivated crops and wild hay than are the soils classed as suitable mainly for the production of native grasses.

The relief ranges from nearly level to hummocky. Drainage channels are absent or poorly established, because most of the precipitation is absorbed by the porous sands.

During seasons of dry windy weather all crops on the cultivated areas of the soils of this group return low yields. Small grains, which are subject to the most damage from drifting sand, are not grown except in a few low-lying and well-protected fields. Only about 40 percent of the area occupied by these soils is under cultivation, and this is used chiefly for growing corn and sorgo to supplement the pasturage and native-hay ration on the cattle ranches situated on this land. The average yields of corn and sorgo are not high, but these crops seldom fail to produce more feed than could be obtained from comparable areas of the native grasses, and they are needed to help carry the cattle through severe cold spells during the winter. The soils of this group allow no loss of moisture through run-off, and, were it not for their unstable nature and generally low organic-matter content, they would give as high yields of corn and sorgo as any of the finer textured soils of the uplands. The areas not under cultivation remain with their native cover of grasses and are used mostly for the production of hay.

Valentine fine sandy loam.—Valentine fine sandy loam occupies many irregular-shaped areas, chiefly in the northeastern, northwestern, and north-central parts of the county. The soil is composed largely of fine sand, but it contains enough silt to make its upper layers moderately coherent.

The relief is nearly level or gently rolling, and surface drainageways are poorly developed, as nearly all the precipitation rapidly enters the porous sand.

The 6- to 10-inch surface soil is dark grayish-brown or brown mellow fine sandy loam. It rests on brown loamy fine sand which gives way, at an average depth of about 20 inches, to incoherent gray sand similar to dune sand. The soil is not limy.

Valentine fine sandy loam is the most stable Valentine soil, and about 85 percent of it is cultivated. Corn and sorgo occupy most

of the tilled areas and return satisfactory yields in nearly all years. Small grains also do fairly well, except in the most windy season when the soil drifts too much for profitable yields of these crops. The virgin areas of this soil, which support a good growth of *Stipa*, or needlegrass, and big and little bluestem, are used mainly for the production of hay.

Valentine loamy fine sand.—Valentine loamy fine sand differs from Valentine fine sandy loam only in that its surface soil is a little lighter in color and contains less silt and more sand. It is closely associated with the other Valentine soils, all which are within or adjacent to the sand hills, but it is most extensively developed in the sand-hill lobe northwest of Palisade, where it occupies several rather large tracts.

The profile of this soil is characterized by a grayish-brown or dark grayish-brown loamy sand surface soil, 3 or 4 inches thick, underlain by light-brown loamy sand to a depth of about 12 inches, below which is gray sand. Neither surface soil nor subsoil is limy. The immediate surface layer contains some fine organic and mineral material but not enough to prevent drifting when the soil is cultivated.

The relief ranges from gently undulating to hummocky, and surface drainage is undeveloped, as practically all of the precipitation is absorbed by the sand.

The greater part of this soil retains its virgin grass cover, and it is used mainly for native-hay land. Some corn and sorgo are grown for feed in a few low-lying protected areas where wind erosion is least injurious, but practically none of the soil is used for the growing of small grains. In protected fields the corn and sorgo yields equal or exceed those obtained on the Keith soils during dry years, but they are much lower in seasons of normal or heavy precipitation.

The hay yields on this soil are slightly lower than those obtained on Valentine fine sandy loam, but they exceed those obtained on Valentine fine sand.

Valentine fine sand.—Valentine fine sand occurs chiefly in association with dune sand in the northeastern part of the county, where it occupies nearly level to undulating or hummocky valleys between higher lying ridges and hills of sand. This soil has no surface drainage channels because all the precipitation that does not evaporate is rapidly absorbed.

The 6- or 8-inch surface soil consists of incoherent grayish-brown fine sand and medium sand, the upper 3 or 4 inches of which is somewhat darkened by a small quantity of organic matter, in some places attaining a dark grayish-brown shade. The organic material, however, is not sufficient to prevent the soil from drifting when the protective vegetation is removed. The subsoil, which continues to a depth ranging from 24 to 30 inches, differs from the surface soil only in its lower organic-matter content and consequently lighter color. In most places it is light grayish brown, but in some places it is tinged with yellow. The color becomes gradually lighter with depth, until the material merges with the very light gray parent sand which contains sufficient silt and clay to give it a barely perceptible sticky feel when moist. Below a depth ranging from 4 to 5 feet the silt and clay disappear, and the material is similar to that underlying dune sand. Neither the surface soil, subsoil, nor parent material is limy. The

sand of which this soil is so largely composed consists chiefly of quartz and feldspar of medium, fine, and very fine grades, the fine sand predominating.

The color and depth of the surface soil vary somewhat according to the relief. In the more depressed situations, where conditions have been most favorable for the growth and decay of plant life and where the land has been least subject to wind erosion, the soil is somewhat darker and thicker than elsewhere. On the crests of hummocks and low ridges, however, the organic matter has been removed largely by wind, leaving the soil very shallow and prevailingly light in color. In many cultivated areas the light color persists even in the depressions, because frequent stirring of the surface soil is conducive to excessive wind erosion and consequent removal of organic matter.

In Hayes County about one-half of the area occupied by this soil has been broken and is used chiefly for the production of corn, average yields of which are rather low, as strong winds during the spring and early summer may cover many of the small corn plants with drifting sand, thereby greatly reducing the yields. In some areas of this soil, sand has drifted so badly since the native sod was destroyed that the land cannot be used for cultivated crops and is of little value even for grazing.

The uncultivated areas of Valentine fine sand are used mainly for the production of hay and, to some extent, for pasture land. They support a somewhat denser grass cover and have a slightly higher grazing value than dune sand.

Anselmo loamy fine sand.—Anselmo loamy fine sand occupies a few nearly level or undulating areas of slightly lower elevation than the surrounding land, chiefly in Germanville Precinct.

In common with other Anselmo soils, the soil has developed from a mixture of silt and sand, the former constituent being sufficiently abundant to make the upper soil layers more coherent than the corresponding layers of the Valentine soils or dune sand. Surface drainage channels are not established, but the soil rapidly absorbs all surplus moisture and everywhere is well drained.

The surface soil ranges from 8 to 12 inches in thickness and consists of dark-brown friable loamy fine sand. This rests on light-brown material of about the same texture and consistence, which continues to a depth of about 3 feet and gradually gives way to incoherent gray sand similar to that in the dune sand areas. Lime, where present, is reached below an average depth of 4 feet.

Although Anselmo loamy fine sand is subject to considerable wind erosion when the native sod is destroyed, it is more stable than any Valentine soil, and about 70 percent of it is used for cultivated crops, chiefly corn. Some sorgo is grown but practically no small grain. The soil has a high moisture-retaining capacity, and, since it absorbs nearly all the moisture that falls, it is able to make very efficient use of the precipitation. In extremely dry seasons, corn yields on this soil are higher than on any of the silty soils of the uplands, provided reasonable care is taken to prevent excessive wind erosion. Averaged over a long period of years, however, corn yields on Anselmo loamy fine sand are only about one-half as high as those obtained on the Keith soils.

SOILS SUITABLE FOR THE PRODUCTION OF CORN AND ALFALFA

The soils especially suited for the growing of corn and alfalfa occur in the valleys along the larger streams, where the moisture received through precipitation is supplemented to greater or less extent by run-off from the uplands and by a comparatively high water table. The group includes the Tripp soils of the terraces, the Bridgeport soils of the terracelike colluvial slopes, and the Laurel and Sarpy soils of the bottom lands or flood plains. All except the Sarpy soils, which are sandy throughout, consist largely of silt.

The soils of this group have nearly level or gently undulating relief, and they slope gradually toward the stream channels and down the valleys. Except in a few places on the flood plains, they are well drained. None of them is subject to destructive wind or water erosion, and all, except the Sarpy soils, which are subirrigated, have high moisture-holding capacities. The Tripp soils are the oldest, that is, they have lain in their present positions longer than any of the others, and, owing to larger accumulations of organic matter, their surface soils are darker and thicker. The Bridgeport, Laurel, and Sarpy soils are comparatively recent in origin, and their surface soils are comparatively thin and light colored. All soils of the group, however, are amply fertile, and, owing to the nearly level relief and favorable moisture supply, from 60 to more than 90 percent of the area occupied by them is cultivated. The combined area of these soils is less than 5 percent of the total area of the county.

This group includes the most productive soils in the county for the production of corn and alfalfa, and about 70 percent of the cultivated land is used for the former crop. The use made of the remaining 30 percent is governed largely by the depth to the water table. On the flood plains and low-lying subirrigated terraces, alfalfa is grown on most of the tilled land not used for corn, whereas on the higher terraces, where the water table is below a depth of 20 feet, there is less alfalfa and more small-grain and forage crops. Wild hay is cut on most of the poorly drained patches throughout the bottom lands.

Tripp silt loam.—Tripp silt loam occupies smooth well-drained terraces, chiefly along Red Willow and Blackwood Creeks. In general, it occupies elongated discontinuous strips of less than 60 acres each, crossed by narrow steep-sided channels of tributary drainageways issuing from the uplands. Most of this soil lies from 15 to 30 feet above the creeks, and none of it is subject to overflow from the main streams.

The surface soil in most places has accumulated enough organic matter to make it dark grayish brown or very dark grayish brown. It consists of friable silt loam about 18 inches thick and rests on a 12- to 15-inch layer of brown slightly more compact silt loam, beneath which the material is light grayish-brown loose silt with a high lime content.

About 70 percent of the land is under cultivation and is used for the growing of corn, small grains, and alfalfa, which, during most years, rank in acreage in the order named. A large part of the soil

occupies high terraces, where alfalfa roots cannot reach the water table readily.

The uncultivated areas of this soil are well suited to the production of grain and tame hay, but they occupy such small and inaccessible bodies that they cannot be farmed profitably. Practically all of the areas not under cultivation are used for pasture and hay land.

Although highly productive, the small extent of Tripp silt loam renders it of minor agricultural importance.

Tripp fine sandy loam.—Tripp fine sandy loam occurs along Red Willow Creek in the northern part of the county. It occupies well-drained terraces similar to those on which Tripp silt loam occurs, and it differs from that soil mainly in that its surface soil is slightly lighter colored and more sandy. The increased sand content, however, is not sufficient materially to reduce the stability of this layer which is grayish brown or dark grayish brown and from 12 to 16 inches thick. This layer is friable throughout and in most places consists of fine sandy loam, but in a few places it has a very fine sandy loam texture. The subsoil is almost identical with that of Tripp silt loam. It consists of brown slightly compact silt loam in the upper part and light grayish-brown or grayish-yellow loose limy silt in the lower part.

This soil is well suited to all the crops commonly grown in the county. It can be cultivated a little sooner after rains than the finer textured Tripp soil and absorbs moisture a little more rapidly. These differences, however, do not seem to be strongly reflected in crop yields, and both soils are regarded with about equal favor for general farming.

Bridgeport very fine sandy loam.—Bridgeport very fine sandy loam is more extensive than any other soil in this group, although its total area is not large. It occupies nearly level or gently undulating terraces and terracelike colluvial slopes between the uplands and alluvial lands, principally along Frenchman, Stinking Water, and Red Willow Creeks. Both surface and subsurface drainage are well established.

As typically developed, this soil consists of grayish-brown friable very fine sandy loam which continues with little change in color, texture, or consistence to a depth exceeding 4 feet. In most places, however, the upper 3- or 4-inch layer is a little darker than the rest of the soil, owing to a slightly higher organic matter content. Lime is everywhere abundant below a depth of 12 inches, and it is present in some places within a depth of 3 or 4 inches from the surface. It is in finely divided form, thoroughly mixed with the mineral soil particles.

Along Frenchman Creek are a few small included areas, in which the surface soil is a little thicker and darker and lime lies at a slightly greater depth than is typical in the Bridgeport soils. In agricultural value, these bodies do not differ materially from the typical soil. Also included with this soil on the accompanying map are a few small bodies, in which the surface soil approaches fine sandy loam in texture. These areas, most of which lie just north of Palisade, likewise are similar in agricultural value to typical Bridgeport very fine sandy loam.

About 90 percent of this soil is under cultivation, and about 2 square miles along Frenchman Creek are irrigated. On the lower terraces or where irrigated, about one-half the soil is devoted to corn and most of the rest to alfalfa. On the higher terraces and colluvial slopes, about 70 percent of the soil is used for the growing of corn, and most of the remainder is used for the production of alfalfa, wheat, and barley in about equal proportions.

Bridgeport very fine sandy loam absorbs the precipitation rapidly and is favorably situated to receive supplementary moisture through run-off from higher levels. The favorable moisture conditions result in considerably higher yields of all crops on this soil than can be obtained on the uplands.

Bridgeport silt loam.—Bridgeport silt loam differs from Bridgeport very fine sandy loam only in having a more silty profile. It is closely associated with that soil, has similar surface features and drainage conditions, and occupies a similar physiographic position on the terracelike colluvial slopes along the larger streams, principally Blackwood and Stinking Water Creeks.

The soil consists of friable silt loam from the surface downward. The upper 3- or 4-inch layer is dark grayish brown, owing to a moderate supply of organic matter, and the rest of the soil profile is light grayish brown. Lime is abundant below a depth of 12 inches, and, in places, the soil is highly calcareous even at the surface.

Bridgeport silt loam is well suited for all the crops commonly grown in this section, and about 90 percent of it is cultivated. Corn is grown on about 60 percent of the land and alfalfa on about 15 percent. The rest of the tilled land is used mainly for the production of wheat, barley, and sorgo, which, during most years, rank in acreage in about the order named. All crops yield about the same as on the better soils of the terraces. The uncultivated areas of this soil are included in small pastures for work horses and milk cows.

Sarpy very fine sandy loam.—Sarpy very fine sandy loam occupies narrow elongated strips near or adjacent to the stream channels. The largest developments are along Frenchman and Stinking Water Creeks near Palisade.

The soil has a nearly level or gently undulating surface which lies from only 4 to 8 feet above the normal level of the streams. The land is subject to overflow during periods of high water, but only a few small patches remain too wet for cultivation after the streams subside.

This soil has developed on recently deposited sandy and gravelly bottom-land sediments that have not lain in place long enough to have accumulated much organic material. The surface layer, which is 8 or 10 inches thick, consists of grayish-brown friable very fine sandy loam. It is underlain, to a depth exceeding 4 feet, by gray or almost white fine or very fine sand, containing small quantities of silt in the upper part and more or less lime throughout. The soil is fairly uniform in its characteristics over the rather limited area of its occurrence in this county.

Most of the land is under cultivation. Corn and alfalfa occupy nearly all of the tilled land, in the proportion of about 6 acres of the former to 1 acre of the latter. As indicated by its light color,

the soil is low in organic matter and consequently in nitrogen. It is well suited to the production of alfalfa, however, which can be grown with sufficient frequency to insure an adequate amount of nitrogen and to maintain the yields of corn at an optimum consistent with the moisture supply. Under the present system of management, the yields of corn and alfalfa are nearly as high as those obtained on the most productive soils in the county. This soil warms earlier in the spring than most of the other arable soils and is used in a small way for the production of truck crops, most of which are consumed locally.

Sarpy fine sandy loam.—Sarpy fine sandy loam resembles Sarpy very fine sandy loam in surface features, drainage conditions, physiographic position, and color. It has developed, however, from slightly coarser sandy sediments than those underlying the very fine sandy loam. Its 6- to 8-inch surface soil is grayish brown and consists, in general, of fine sandy loam, but in a few places it contains so much sand and so little silt and organic matter that it assumes a loamy fine sand texture. The soil material in the rest of the profile is composed largely of incoherent gray sand which generally becomes coarser with depth and here and there contains considerable fine gravel below a depth of 3 feet. In some areas the soil is limy, and in others it is not.

This soil is suited to the same crops as those grown on Sarpy very fine sandy loam, and it has about the same or only slightly lower productive capacity. Over 80 percent of it is used for the growing of corn and alfalfa. In common with all the soils on the bottom lands, the water table is only a few feet below the surface, and crops seldom suffer for moisture even during prolonged droughts. The more poorly drained areas of the soil are used mainly for wild-hay land.

Although very productive, Sarpy fine sandy loam is of minor agricultural importance in Hayes County on account of its small extent. Most of it lies adjacent to the stream channel along Frenchman Creek.

Laurel silt loam.—Laurel silt loam differs from the Sarpy soils mainly in having a more silty profile. It has developed from fine-textured alluvial sediments and occupies numerous bodies on the bottom lands along all the larger streams.

The 7- to 10-inch surface soil is grayish-brown very fine sandy loam or silt loam, the latter texture predominating. This layer is underlain by light-gray or almost white silt which extends to a depth exceeding 3 feet. In most places the light-colored silt is loose and floury, but here and there it is slightly heavier in the upper than in the lower part of the subsoil. An abundance of finely divided lime is thoroughly mixed with the mineral soil particles in both surface soil and subsoil, and rust-brown stains caused by imperfect drainage are numerous below a depth of 2 feet.

This soil lies only a few feet above the normal level of the stream channels and is subject to occasional overflow, especially during early spring. Water drains off rapidly, however, and more than 80 percent of the land is under cultivation. Corn and alfalfa occupy most of the tilled land and, over a period of years, return higher yields than are obtained on any other soil in the county. This soil is of only local agricultural importance because of its small total acreage.

Included with areas shown as Laurel silt loam on the accompanying map are numerous narrow and discontinuous strips of poorly drained Laurel loam on the bottom lands, chiefly along Red Willow, Stinking Water, and Frenchman Creeks. Here the soil has formed on very light colored and recently deposited alluvial silts containing a small amount of fine sand and medium sand in the upper layers. The growth and decay of vegetation have been rapid, but sufficient time has not elapsed for the soil to have acquired a very dark colored surface layer. In general, the profile consists of grayish-brown or almost white loam from the surface downward, mottled throughout with rusty brown and gray. The surface of this poorly drained soil is smooth and lies less than 3 feet above the normal level of the streams. The soil is wet most of the year and is covered with water during freshets. It supports a thick growth of coarse grasses, sedges, and cattails, and most of it is included in pastures, although hay of rather poor quality is cut from some of the areas.

SOILS SUITABLE MAINLY FOR THE PRODUCTION OF NATIVE GRASSES

The soils of this group occupy nearly 40 percent of the total land area of the county. One or another of them occurs in all parts, wherever the land is too rough or too poorly drained for cultivation, or the soil is too thin, unstable, or droughty to be used for the growing of grain or tame hay. The group includes dune sand and the Colby, Canyon, Scott, and Butler soils, a few of which include cultivated fields, although the greater part of each remains in its virgin state. Over 90 percent of the area occupied by the soils of this group is used for native-pasture or hay land.

These soils are on the uplands, but the Scott and Butler soils occupy shallow basins below the general upland level. The soils include a wide range in topographic and soil features. Dune sand is rather unstable, and its relief is strongly rolling or hilly. The Colby soils are on steep valley sides and narrow tortuous ridges throughout the more severely eroded loess-covered areas. They are composed largely of unweathered or only slightly weathered silt mixed in places with small quantities of sand. They are very light colored throughout. The Scott and Butler soils have developed from loess under periodically wet conditions and have accumulated large quantities of organic matter. Their surface layers are dark, and their subsoils contain well-developed claypans. The Canyon soil, which is extremely shallow and stony, has developed on steep slopes from light-colored limy sandstone.

The utilization of the soils of this group depends on cattle raising, because none of the soils can be profitably farmed except in small and widely scattered fields, where they are deeper, better drained, more stable, or less droughty than typical. Such fields are chiefly on the longer, more gradual, and less eroded slopes within areas of the Colby soils and in some of the better drained basins occupied by the Butler soils. Even in these localities, cultivated crops return lower average yields than are obtained on most of the soils of the other groups.

Colby silt loam.—Colby silt loam is closely associated with its far more extensive broken phase, from which it is distinguished by its less rugged relief and a trifle thicker surface soil. Few bodies cover

more than 80 acres, and most of them are less than 50 acres in extent.

This soil has strongly rolling or hilly relief and has been subjected to considerable erosion during its development, but the land is not so steeply sloping or so severely gullied as that of the broken phase. The surface soil, in most places, has accumulated enough organic matter to impart a grayish-brown or chestnut-brown color to a depth of 5 or 7 inches. It is composed largely of loose friable silt and rests directly on unweathered or only slightly altered loess. The surface soil is not limy, except in a few areas, although the underlying loess is very limy.

The greater part of this soil is topographically suited to the use of farm machinery, but the steepness of the slopes subjects the land to severe erosion when the native sod is broken, unless provision is made to retard the rapidity of the run-off and to maintain a cover of vegetation on the slopes during most of the year. About 40 percent of the land is used for cultivated crops, chiefly corn and wheat. Yields of these crops on recently broken sod are only about 10 percent below those obtained on Keith silt loam, but, unless the Colby soil is carefully managed, erosion rapidly removes the loosened surface soil, forms gullies, and renders the land uncultivable. Most of the soil is used for pasture and hay land, for which purpose it is slightly superior to the broken phase.

Colby silt loam, broken phase.—Colby silt loam, broken phase, is the most extensive soil in the county. It comprises almost one-fourth of the total area. It occurs throughout the uplands, wherever erosion has carved the silty Peorian loess into a rugged relief, characterized by steep and precipitous valley slopes and sharp tortuous ridges. The only smooth land is on some of the canyon floors which, although nearly level, are too narrow to be indicated separately on a map of the scale used in this survey.

This broken soil has developed on the same kind of parent material as that underlying the Keith soils, but the land has been subjected to such severe erosion that little organic matter has accumulated and surface run-off has reduced the soil moisture, thereby retarding soil development. The surface soil, even in the less eroded areas, does not exceed 5 inches in thickness, except in a very few places. In most places the soil consists of gray floury loess, the upper 2 or 3 inches of which has been only slightly darkened by organic matter. The material is very limy from a point near the surface downward.

Owing to its unfavorable relief, the broken phase of Colby silt loam is unsuited to cultivation. It supports a rather dense growth of prairie grasses, chiefly little blustem and grama, and is used almost exclusively for grazing land. The grasses on some of the narrow canyon floors are cut for hay.

Colby very fine sandy loam.—Colby very fine sandy loam is closely associated with its broken phase, but it has less rugged relief and is less extensive. Most of it occupies smooth but steep slopes and rounded divides. This soil has developed from loess under conditions of severe erosion, and it differs from Colby silt loam only in having a larger content of very fine sand in its surface layer. The greater

sand content of this layer allows more rapid absorption of the rainfall than does Colby silt loam, and the sandier soil supports a grass growth which is slightly denser, taller, and more valuable for grazing than that on the finer textured soil.

About 40 percent of Colby very fine sandy loam is used for the growing of wheat and corn, but the cultivated areas lose considerable moisture through run-off and erode rather severely under the present systems of management. Yields of grain are much lower than those obtained on the more nearly level Keith soils.

Within areas of this soil are a few patches, in which the surface soil approaches fine sandy loam in texture. These included bodies are of little agricultural importance and are not separated from Colby very fine sandy loam on the soil map. They have about the same grazing value as the typical soil, and nearly all of them are used for pasture land.

Colby very fine sandy loam, broken phase.—The broken phase of Colby very fine sandy loam closely resembles the broken phase of Colby silt loam, but it has received a little wind-blown sand from the sand hills to the north and, therefore, has a slightly coarser textured surface layer. This layer, which, for the most part, does not exceed 6 inches in thickness, consists of loose light-colored very fine sandy loam darkened slightly by organic matter. The remainder of the profile consists of the grayish-yellow or almost white limy and floury silt of the Peorian loess and is identical with the corresponding material of Colby silt loam, broken phase.

Most of this soil occurs on steep and, in places, almost precipitous valley sides along Red Willow and Blackwood Creeks and their tributaries in the northern part of the county. Nearly all the land is included in pastures, although some hay is cut from a few nearly level canyon floors. The value of this soil for pasture land slightly exceeds that of the broken phase of Colby silt loam, chiefly because the very fine sandy loam absorbs more of the precipitation.

Colby fine sandy loam, broken phase.—Colby fine sandy loam, broken phase, occurs along and between a few deeply entrenched drainageways in areas where wind-blown fine sand has become mixed with eroded loess material. This soil occupies steep slopes and sharp divides, but its relief is not quite so harsh and angular as that of the other broken phases of Colby soils. A part of the soil is on narrow and nearly level canyon floors. The surface soil does not exceed 6 inches in thickness and consists of a mixture of fine sands and silt, in which the topmost 3 or 4 inches are slightly darkened by organic matter. In some places, the subsoil is very limy, and below a depth of 18 inches it is composed largely of silt. In other places, the entire soil profile has a fine sandy loam texture and is low in lime. The soil on the narrow canyon floors is much deeper and darker than that on the slopes and ridges.

The soil is used almost exclusively for pasture land, for which it is slightly superior to the corresponding phase of Colby very fine sandy loam.

Scott silt loam.—Scott silt loam occupies numerous shallow basins, locally called "lagoons" and "buffalo wallows", in the more nearly level parts of the loessial uplands throughout the county. Most areas

of this soil are small and occupy less than 10 acres each. One of the largest, which comprises about 60 acres, is near the southeast corner of Deerfield Precinct. The basins have no surface drainage outlets, and after heavy rains water remains in them for several weeks.

The surface soil is friable and, in most places, is less than 8 inches thick. The upper one-half is well supplied with organic matter and is very dark. The lower part may or may not be dark, but in most places it contains sufficient leached silt to give it a grayish-brown or almost white color. The subsoil is a very dark grayish-brown or grayish-blue dense claypan, to a depth ranging from 3½ to 5 feet. It is almost impervious to water and is difficult to penetrate with digging tools. Beneath the claypan is light grayish-yellow silt similar to the material underlying the Keith and Colby soils, except that it has been leached of its lime.

Scott silt loam has such a dense subsoil and such poor drainage that it does not produce satisfactory yields of grain and tame hay. About 40 percent of it is included in small fields of corn, wheat, barley, and sorgo. Wild hay is produced on some of the larger areas, but most of the smaller areas are included in pastures or are regarded as waste land. Most of the hay from this soil contains much coarse material, such as rank-growing weeds, rushes, sedges, and cattails, and is of rather low quality. During dry periods, water evaporates from the basins, the clay shrinks and cracks, and the vegetation withers and dies. The soil does not have high value, even for pasture. It occupies such small and widely scattered areas, however, that it does not seriously reduce the productivity of the farms on which it occurs.

Scott very fine sandy loam.—Scott very fine sandy loam differs from Scott silt loam only in having a thicker and more sandy surface soil. It has developed mainly from loess in poorly drained basins within the transitional zone between the sand hills and the loessial uplands and has received a large quantity of wind-blown sand. The areas are small. Two of the largest, occupying about 60 acres each, are in Swan Lake Precinct.

The surface soil, which is friable and from 8 to 12 inches thick, consists of fine sandy loam or very fine sandy loam, the latter texture predominating. It is very dark grayish brown in the upper part, but in places the lower 2 or 3 inches of material is leached of its organic matter and is rather light in color. The subsoil, a claypan, differs little in most places from the corresponding layer of Scott silt loam. It is dense almost impervious grayish-blue clay, ranging from 3 to 5 feet in thickness. In a few basins, however, this layer is much thinner and contains a rather high percentage of sand. These variations are not important or extensive, and bodies in which they occur are classed with the typical soil.

About one-half of Scott very fine sandy loam is used for grazing and wild-hay land, for which purpose it is slightly superior to Scott silt loam. The rest of the land is cultivated, owing largely to its rather deep, sandy, and friable surface soil. Corn, sorgo, and wheat, ranking in acreage in the order named, occupy most of the tilled

areas. In extremely favorable seasons these crops give profitable yields, but in wet or dry seasons they may fail to return the seed.

Butler silt loam.—About 80 very small, shallow basins on the loessial uplands, chiefly in Antelope Precinct, are occupied by Butler silt loam. The 12- to 15-inch surface soil is friable dark grayish-brown silt loam which rests on a layer of dark-brown dense clay loam, ranging from 1½ to 2½ feet in thickness. This is underlain by light grayish-brown limy and floury loess.

Most of the basins occupied by this soil are included in cultivated fields, and about 80 percent of the land, as a whole, is tilled. The basins become ponds after heavy rains, but the water does not remain in them as long as it does in the basins occupied by the Scott soils. Corn, sorgo, and wheat produce satisfactory yields in about one-half of the seasons. This soil, however, is not considered very suitable for tilled crops, and, were it not surrounded by cultivated soils, probably all would be used for pasture and hay land. Virgin areas support a rank growth of moisture-loving grasses but contain few weeds, rushes, and sedges.

Canyon loam.—Canyon loam occupies areas in which white limy sandstone lies within 12 inches of the surface and is exposed in numerous places, giving the land a white and brown spotted appearance. The topsoil consists of mellow fine sandy loam or very fine sandy loam, but it has accumulated very little organic matter and is brown or grayish brown. In most places white sandstone fragments and, in a few places, considerable water-worn gravel are present in the surface soil. The sandstone resembles that underlying the Rosebud soils, and Canyon loam may be regarded as a very shallow and poorly developed phase of Rosebud loam.

This soil occupies a few small bodies in the sand-hill section and on the hard-land slopes between Stinking Water Creek and the uplands north of that stream. In the sand hills the land is nearly level and the surface soil is very sandy; but on the hard-land slopes, the relief ranges from strongly rolling to broken and the material in this layer is finer textured.

Nearly all of Canyon loam is included in pastures. It supports a rather sparse growth of grama and little bluestem, together with some sandgrass, and does not have a high value even for grazing land.

Dune sand.—Dune sand consists of incoherent gray sand which has been whipped by the wind into a succession of irregularly distributed hills and ridges, the tops of which are from 20 to 40 feet above the intervening valleys and pockets. Surface drainage channels are not developed, as all moisture that does not evaporate is rapidly absorbed by the loose porous sand. In most places this material supports a sparse growth of needlegrass, sandgrass, and little bluestem, but bare spots known as blow-outs occupy a square rod or two on many of the hills, especially on the northwest side.

Practically all of the dune sand is used for pasture land. The largest area is in the northeastern part of the county. Smaller areas are in the northwestern part and a few miles northwest of Palisade.

Dune sand should not be overgrazed, as its stability depends on its grass cover. When the land is brought under cultivation or the

grasses are otherwise destroyed, drifting sand may cover the vegetation over a much larger area than the one originally disturbed.

PRODUCTIVITY RATINGS

The soils of Hayes County have been classified according to their estimated ability to produce the more important crops of the section. This classification compares the inherent productivity of each of the soils for each of the leading crops in the county to a standard, namely, 100, which is the rating given to 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.

Inherent-productivity indexes show the 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 materially would increase the natural productivity of the soil, such as the use of commercial fertilizers, residues, and manures from crops not grown on the soil, terracing, irrigation, and artificial drainage.

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

As the soils are not limed or treated with 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 relief, or lay of the land. Since long-time yields [5] 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 classification.

The rather low indexes given to most of the soils in this county 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 the general area. Few of them return as high yields of any particular crop as are obtained on the standard soil for that crop, but this, in most instances, is due mainly to less favorable moisture conditions and surface features, or both, than are characteristic of the standard soil. Most soils in the county contain enough

[5] Data on long-time yields for specific soils were collected by the field parties during and subsequent to the soil survey. Also 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, and the Nebrbaska State Department of Agriculture, cooperating.

plant nutrients to insure higher yields if moisture were more abundant. Throughout a small irrigated tract in the Frenchman Creek Valley, crop yields are about twice as high as those obtained on similar soils under dry-farming methods.

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 does not distinguish between these areas, except in localities where drainage is so poor that a marshy condition prevails a part of each year. This is indicated by the conventional marsh symbol. Elsewhere on the bottom lands 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 this county.

The classification made 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 lists the more important crops grown in this county, together with the acre yield that has been set up as a standard of 100 for each crop. These yields represent long-time production averages of the inherently most productive soils of significant acreage in the United States for products of satisfactory quality and are obtained without the use of amendments other than those produced directly or indirectly by the soil.

Crop:		
Corn (grain)	bushels	50
Oats	do	50
Wheat (all kinds)	do	25
Rye	do	25
Barley	do	40
Alfalfa	pounds	8,000
Sweetclover	do	4,000
Wild hay	do	2,000
Pasture	cow-acre-days per year[1]	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 the animals are grazed without injury to the pasture. For example, the soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another soil 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. The animal unit is a means of measuring the feed requirements of livestock. It is the equivalent of a mature horse, cow, of steer; 5 hogs; 7 sheep or goats; or 100 poultry. For very young animals, double the equivalent of an animal unit for mature stock of the same kind is allowed. On semiarid grazing land, the ratio is more properly 3 to 5 mature sheep to each cow.

The classification of soils according to productivity is given in table 6.

TABLE 6.—*Classification of soil types in Hayes 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	Sweet-clover	Wild hay	Pasture	
Laurel silt loam (well drained)	50	55	55	55	50	60	70	80	50	Corn and alfalfa.
Bridgeport silt loam	50	55	55	55	50	55	55	60	36	Do.
Bridgeport very fine sandy loam	50	55	55	55	50	55	55	60	36	Do.
Tripp silt loam	50	55	55	55	50	55	55	60	36	Do.
Sarpy very fine sandy loam (well drained)	45	50	50	50	45	60	65	75	45	Do.
Sarpy fine sandy loam (well drained)	45	40	40	45	45	55	55	70	40	Do.
Tripp fine sandy loam	45	40	35	45	40	45	45	60	31	Do.
Keith silt loam, deep phase	40	50	50	50	45	25	50	60	26	Corn, small grains, and forage.
Keith silt loam	40	50	50	50	45	25	50	60	26	Do.
Keith very fine sandy loam	40	50	50	50	45	25	50	60	26	Do.
Rosebud very fine sandy loam	40	50	50	50	45	25	50	60	25	Do.
Keith fine sandy loam, deep phase	40	45	45	45	40	25	45	60	21	Do.
Anselmo very fine sandy loam	40	45	45	45	40	25	45	60	25	Do.
Keith fine sandy loam	40	40	40	45	35	25	40	55	25	Do.
Anselmo fine sandy loam	35	30	30	35	30	25	35	50	24	Do.
Keith silt loam, slope phase	25	25	25	30	25	----	35	50	23	Do.
Valentine fine sandy loam	25	25	25	30	25	----	30	45	21	Corn and native hay.
Anselmo loamy fine sand	20	20	20	25	20	----	25	40	21	Do.
Valentine fine sand	10	10	10	10	10	----	10	30	18	Do.
Valentine loamy fine sand	15	15	15	20	15	----	20	40	20	Do.
Colby very fine sandy loam	15	15	15	15	15	----	15	35	21	Pasture and native hay.
Colby silt loam	15	15	15	15	15	----	15	35	21	Do.
Butler silt loam	15	15	15	15	15	25	25	50	40	Do.
Laurel silt loam (poorly drained)	----	----	----	----	----	----	----	85	72	Do.
Sarpy very fine sandy loam (poorly drained).	----	----	----	----	----	----	----	85	69	Do.
Sarpy fine sandy loam (poorly drained)	----	----	----	----	----	----	----	75	65	Do.
Scott very fine sandy loam	----	----	----	----	----	----	----	----	26	Do.
Scott silt loam	----	----	----	----	----	----	----	----	25	Do.
Colby fine sandy loam, broken phase	----	----	----	----	----	----	----	----	20	Do.
Colby very fine sandy loam, broken phase	----	----	----	----	----	----	----	----	20	Pasture.
Colby silt loam, broken phase	----	----	----	----	----	----	----	----	20	Do.
Dune sand	----	----	----	----	----	----	----	----	15	Do.
Canyon loam	----	----	----	----	----	----	----	----	10	Do.

[1] This table has been compiled jointly by officials of the following organizations: Soil Survey Division, Bureau of Chemistry and Soils, and Land Use Planning Section, Farm Security Administration. U. S. Department of Agriculture; and the University of Nebraska State Soil Survey Department of the Conservation and Survey Division.

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

MORPHOLOGY AND GENESIS OF SOILS

The soils of any area are formed by climatic and biotic (principally vegetative) forces acting on parent soil materials. The intensity and duration of these forces and the kind of parent materials determine, to a large extent, the character of the soils. In Hayes County the climate, which is continental and temperate and characterized by a moderate precipitation, conforms to that required for the development of the pedocalic Chestnut soils, in which the zone of lime enrichment is at rather slight depths. The results of the climatic and biotic forces, however, as expressed in terms of soil development, have varied in different parts of the county with differences in the relief, parent materials, and length of time that the materials have been subjected to the undisturbed action of these forces.

In the northeastern and northwestern parts, the parent soil materials consist chiefly of rather unstable quartzitic sand and the relief

ranges from hummocky to hilly. The sand is very resistant to chemical and physical change, and its porous nature has allowed leaching of all or nearly all of the readily soluble salts, chiefly lime carbonate, to depths below 6 feet. These soils are composed mainly of yellowish-brown incoherent sand and are immaturely developed. Their surface soils vary in thickness, depending on the relief and severity of wind erosion, but do not exceed 8 inches. They have accumulated only small quantities of organic matter and are not much darker than the lower part of the profile. The Valentine soils and dune sand occupy the greater part of the more sandy lands. They differ mainly in surface features, dune sand being more hilly and more susceptible to wind erosion than the Valentine soils.

In places throughout nearly level to hummocky tracts within and adjacent to the sandy areas, fine-textured wind-blown material from nearby silty soils has become mixed with the sand to a depth ranging from 8 inches to 3 feet. Here the surface soils are a little darker and more stable than those of the Valentine soils and dune sand, and the subsoils have not everywhere been leached of their carbonates. These tracts include the Anselmo soils which in reality are transitional both in character and position between the soils developed on sand and those formed on silt.

Throughout the sandy and semisandy areas, the native vegetation consists almost entirely of tall grasses, chiefly little bluestem (*Andropogon scopárius*) and needlegrass (*Stipa spártea*), which do not occupy dense enough stands to form a sod.

In the southern and central parts the parent material is chiefly Peorian loess, a grayish-yellow floury and limy silt that lends itself readily to soil development wherever erosion is not severe. In these localities the soils have formed on three distinctly different types of relief—nearly level to gently rolling, basinlike, and steeply sloping—each of which is characterized by a different type of soil formation.

The influence of climate and vegetation in changing the raw loess into soil is best expressed in the Keith soils, which occupy nearly level to gently rolling loess-covered divides and in the Tripp soils which are on the smooth loess terraces. These soils have been developing for long periods under good drainage, in the absence of abnormal erosion, and under the influence of a short-grass vegetation consisting chiefly of buffalo grass (*Buchloë dactyloides*) and blue grama (*Bouteloua gracilis*), with little bluestem as a secondary species. The grass roots thoroughly mat the soil to a depth ranging from 6 to 10 inches and on decaying have produced enough black and brown organic matter to make the surface layers dark grayish brown, or noticeably darker than the rest of the soil profile. The upper horizons of these soils have been leached of their carbonates. To a depth of 3 or 4 inches, the surface soil may be very slightly acid in reaction, but the rest of the material in this layer ranges from neutral to alkaline. The subsoils have a well-developed zone of lime enrichment between depths of 18 and 30 inches.

The Keith and Tripp soils are similar in their characteristics. They have reached a more mature stage of development than any other well-drained soil in the county. The following description of a profile of Keith silt loam, as observed on a nearly level loess-covered divide 930 feet east of the northwest corner of sec. 11, T. 6 N., R.

32 W., may be regarded as typical of maturely developed soils in this county.

1. 0 to 1 inch, grayish-brown silt loam.
2. 1 to 5 inches, dark grayish-brown friable silt loam. The upper part of this layer has an ill-defined laminated structure, and the lower part is crumblike.
3. 5 to 15 inches, dark grayish-brown friable silt loam with crumb structure, mostly very fine.
4. 15 to 23 inches grayish-brown heavy but friable silt loam with a fine nut structure and a slightly higher clay content than that of the overlying layers.
5. 23 to 32 inches, grayish-brown friable and cloddy silt loam containing an abundance of lime carbonate in soft segregations and in finely divided form thoroughly mixed with the silt. This is the upper part of the zone of lime enrichment.
6. 32 to 48 inches, very light grayish-brown friable silt loam with considerable visible and disseminated lime. The visible lime becomes less noticeable with depth, and the layer merges downward into unweathered loess which, although very limy, contains few spots in which the carbonates are segregated.

The chemical analyses of Keith silt loam [7] (table 7) indicate a zone of carbonate accumulation at a depth between 21 and 48 inches, but the carbonate is probably not of sufficient quantity to account for its removal from the surface horizons. The high percentages of potash and of sodium oxide indicate the presence of much undecomposed feldspar and a low degree of weathering. The relatively large concentration of soluble salts in the lower part of the profile indicates very little, if any, percolation of water through the profile. There is but little evidence of the presence of dolomitic limestone. The chemical composition of the entire profile is very constant except in the respects mentioned. This soil sample was taken from an area 1,628 feet north of the southwest corner of sec. 34, T. 14 N., R. 36 W., Dundy County, Nebr.

TABLE 7.—*Chemical analyses of Keith silt loam* [1]

Sample no.	Horizon	Depth	SiO_2	Fe_2O_3	Al_2O_3	MgO	CaO	K_2O	Na_2O
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
9222	1	0 - ½	72.82	3.04	10.86	1.06	1.86	2.48	2.35
9223	2	½- 3½	71.00	3.44	11.66	1.17	1.88	2.34	2.23
9224	3	3½-14	71.10	3 60	12.02	1.26	1.88	2.32	2.10
9225	4	14 -21	71.46	3.92	11.88	1.44	2.08	2.28	2 15
9226	5	21 -33	68.22	3.60	12.00	1.65	3.94	2.82	1.92
9227	6	33 -40	64.80	3.68	11.84	1.66	6.14	2.45	1.42
9228	7	40 -48	65.82	3.36	11.84	1.63	5.44	2.48	1.99
9229	8	48 -72	69.66	3.36	11.88	1.67	4.30	1.98	1.06
9230	9	72 -96	69.36	3.36	11.42	1.63	4.46	2.51	1.38

Sample no.	TiO_2	MnO	P_2O_5	Ignition loss	SO_3	Total	CO_2 [2]	N	pH	Soluble salts [3]
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*		*Parts per million*
9222	0.60	0.02	0.10	4.63	0 16	99.98	0.05	0.14	7.4	580
9223	.60	.03	.11	5.55	.14	100.15	.03	.17	7.4	500
9224	.64	.03	.09	4.70	.18	99.92	.03	.12	7.6	400
9225	.64	.04	.09	3.90	.20	100.08	.10	.09	8.2	1,160
9226	.58	.03	.08	4.94	.24	100.02	1.48	.09	8.5	1,400
9227	.60	.05	.19	6.98	.15	99.96	3.83	.05	8.4	1,480
9228	.58	.05	.18	6.33	.30	100.00	3.04	.04	8.5	1,460
9229	.57	.07	.15	5.34	.23	100.27	2.42	.03	8.6	1,460
9230	.58	.05	.16	5.08	.16	100.15	2.24	.03	8.6	1,400

[1] Determinations (except pH and soluble salts) by J. G. Smith.
[2] CO_2 of the carbonates.
[3] Determined by bridge method.

[7] BROWN, I. C., and BYERS, H. G. THE CHEMICAL AND PHYSICAL PROPERTIES OF DRYLAND SOILS AND OF THEIR COLLOIDS. U. S. Dept. Agr. Tech. Bull. 502, 56 pp. 1935.

The colloid composition (table 8) emphasizes the constancy of composition shown otherwise in the soil. Whatever movements of the colloid have occurred have not been accompanied by fractionation. The most marked variations are in the content of organic matter and of carbonates.

TABLE 8.—*Chemical analyses of Keith silt loam colloid*

Sample no.	Horizon	Depth	Colloid extracted	SiO_2	Fe_2O_3	Al_2O_3	MgO	CaO	K_2O
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
9222	1	0 - ½	46	51.92	6.92	19.13	3.00	2.12	2.42
9223	2	½- 3½	46	51.45	6.92	18.61	2.64	2.21	2.41
9224	3	3½-14	79	51.80	7.13	19.67	3.07	2.70	2.33
9225	4	14 -21	76	53.00	7.22	20.49	3.37	1.93	2.34
9226	5	21 -33	87	47.80	6.19	17.88	3.51	7.59	2.16
9227	6	33 -40	89	43.60	5.39	16.62	3.31	11.92	1.82
9228	7	40 -48	68	46.00	5.77	17.58	3.39	9.72	1.91
9229	8	48 -72	92	49.50	6.45	19.09	3.48	6.54	2.12
9230	9	72 -96	90	52.61	6.98	19.75	3.52	3.63	2.21

Sample no.	Na_2O	TiO_2	MnO	P_2O_5	SO_3	Ignition loss	Total	Organic matter[1]	CO_2[2]	N
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
9222	0.24	0.66	0.19	0.29	0.28	13.43	100.60	5.32	0.06	0.37
9223	.29	.71	.22	.36	.25	14.38	100.45	6.32	.09	.48
9224	.28	.72	.13	.22	.24	13.05	101.34	5.68	.00	.31
9225	.45	.67	.08	.11	.16	11.09	100.91	2.98	.22	.23
9226	.43	.54	.09	.27	.17	13.94	100.57	1.67	4.71	.16
9227	.37	.51	.11	.29	.15	16.70	100.79	1.75	8.34	.14
9228	.39	.52	.12	.23	.13	15.03	100.79	1.86	6.46	.08
9229	.38	.56	.11	.20	.13	12.33	100.89	1.21	3.56	.13
9230	.34	.66	.09	.21	.14	10.71	100.85	.89	1.32	.10

[1] Determined by combustion method ($CO_2 \times 0.471$). [2] CO_2 of the carbonates.

The derived data (table 9), as is usual, bring into clear relief the degree of variation of the composition of the inorganic colloid. The greater silica-sesquioxide and silica-alumina ratios of the topmost two layers are indicative of colloidal silica, but if it is present the quantity is small. The silica-total base ratio indicates a small degree of eluviation. Taken as a whole, all the data, and particularly the silica-water ratios, the combined water, and the combined water of the soil acid, indicate an inorganic colloid of constant composition.

TABLE 9.—*Derived data: Keith silt loam colloid*

Sample no.	Horizon	Depth	Molecular ratio						Combined water	Combined water of the soil acid[3]
			$\frac{SiO_2}{Fe_2O_3.Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{Fe_2O_3}{Al_2O_3}$	$\frac{SiO_2}{\text{Total bases}^1}$	$\frac{SiO_2}{H_2O^2}$		
		Inches							*Percent*	*Percent*
9222	1	0 - ½	3.74	19.91	4.61	0.229	6.14	1.46	8.07	11.22
9223	2	½- 3½	3.78	19.70	4.68	.238	6.41	1.48	7.97	11.08
9224	3	3½-14	3.62	19.21	4.46	.232	5.59	1.53	7.37	10.74
9225	4	14 -21	3.58	19.44	4.38	.225	6.06	1.53	7.89	10.74
9226	5	21 -33	3.71	20.44	4.53	.222	5.51	1.41	7.55	11.57
9227	6	33 -40	3.69	21.52	4.45	.207	5.53	1.44	6.61	11.41
9228	7	40 -48	3.67	21.13	4.43	.210	5.55	1.49	6.73	11.05
9229	8	48 -72	3.61	20.32	4.40	.216	5.45	1.42	7.56	11.43
9230	9	72 -96	3.72	21.02	4.52	.215	5.77	1.55	8.50	11.57

[1] Carbonates deducted.
[2] Combined water plus water equivalent of the bases.
[3] Combined water plus water equivalent of bases, corrected for organic-matter and carbonate content.

The Keith and Tripp soils collectively include several soil types and phases, but, with the exception of differences in the texture of the surface soil and in the relative thicknesses of the various horizons, all are similar to the profile described.

Within areas characterized by a basinlike relief the soils of the loess-covered uplands owe their features more to poor drainage than to the regional climatic and biotic forces. In these areas, occupied by the Scott and Butler soils, storm water is impounded and disappears slowly through seepage and evaporation. The wet conditions have favored the accumulation of organic matter in most of the basins and have promoted considerable downward leaching in them all. Where the moisture supply has been least excessive the surface soils are darker and thicker. In the lower part of those areas where water stands for long periods they are very thin and light colored. The upper part of the subsoils ranges from dark to light, depending on the amount of leaching to which the material has been subjected, but they are everywhere extremely dense and claypanlike. The lower part of the subsoil is light colored. In the deeper and more frequently inundated depressions, the soils have been leached of their carbonates, but in some of the smaller and shallower basins they have a well-developed zone of lime enrichment immediately beneath the claypan. The following description of a profile of Scott silt loam, as observed in a basin 1,040 feet west of the southeast corner of sec. 35, T. 7 N., R. 35 W., is typical of this soil.

1. 0 to 6 inches, light grayish-brown or grayish-black friable and faintly laminated silt loam.
2. 6 to 20 inches, dark grayish-blue or nearly black dense massive clay containing numerous rusty-brown stains, streaks, and splotches. This layer, the upper part of the claypan, is plastic when wet and, on drying, breaks into hard irregular-shaped clods.
3. 20 to 27 inches, dark grayish-brown massive heavy clay loam which constitutes the lower part of the claypan.
4. 27 to 40 inches, brown or yellowish-brown moderately heavy silt loam with no definite structure. This is a transitional layer between the claypan and the parent material.
5. 40 to 70 inches, light yellowish-brown silt loam which differs from the parent loess underlying the Keith and Colby soils mainly in that it contains no lime.

Butler silt loam, which also occurs in poorly drained basins on the loessial uplands, has not been subjected to such excessive leaching as has Scott silt loam. The surface soil is much thicker and darker, the claypan is more nearly black, and the lower part of the subsoil is much more limy.

Throughout the loessial uplands within areas of steeply sloping to rough and broken relief, the products of soil development are removed by erosion almost as fast as they are formed. Here the unweathered or only slightly altered grayish-yellow floury and limy loess is at or near the surface of the ground. These areas comprise the immaturely developed Colby soils which differ from raw loess mainly in having moderately dark colored surface layers, few of which exceed 5 inches in thickness.

In the northwestern part of the county, some of the soils have formed over light-colored limy and loosely indurated sandstone on nearly level to steeply sloping relief. None of these soils is so fully developed as the Keith and Tripp soils, although Rosebud very fine

sandy loam, which occupies the smoother areas, has made considerable progress in development. The surface soil is nearly as dark and deep as that of Keith silt loam, and the subsoil is light colored throughout. The Rosebud soil has a fairly well developed zone of lime enrichment, which begins at an average depth of 18 inches and, in places, extends below a depth of 3 feet, where the soil rests on parent sandstone. Aside from the rather dark surface soil and the zone of carbonate enrichment, this soil has no layers comparable to those in Keith silt loam. In places it contains partly disintegrated sandstone fragments to the surface of the ground.

In the more steeply sloping and severely eroded areas of Tertiary sandstones, Canyon loam, which is simply an immature Rosebud soil, has made little progress in development. This soil consists, in most places, of partly decomposed limy bedrock, the surface layer of which has been only slightly darkened by organic matter.

The other soils of the county are developing on recently deposited alluvium or colluvium and owe their features more to the character of the parent materials than to the broader environmental influences of the region. They include the Bridgeport, Sarpy, and Laurel soils. The Bridgeport soils are composed of recently deposited silts and very fine sands at the bases of slopes and on gently sloping terraces, whereas the Sarpy and Laurel soils are derived from flood-plain deposits of sand and silt, respectively. All these soils have accumulated a little organic matter in their surface layers and have more or less lime in their subsoils, but none has well-developed horizons of true soil character.

Mechanical analyses of three soils in this county are given in table 10.

TABLE 10.—*Mechanical analyses of 3 soils from Hayes County, Nebr.*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Rosebud very fine sandy loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
378945	0- 3	0.1	0.3	0.3	1.7	32.1	47.5	18.1
378946	3-10	.0	.2	.2	1.7	27.5	37.9	32.5
378947	10-20	.0	.4	.2	1.3	26.4	44.1	27.6
378948	20-40+	.0	.3	.2	1.1	29.4	46.6	22.3
Valentine fine sand:								
378921	0- 4	.0	.3	.4	33.6	54.7	5.4	5.6
378922	4-12	.0	.2	.2	30.7	58.3	4.7	5.9
378923	12-48+	.0	.2	.2	29.9	51.3	12.5	5.9
Bridgeport very fine sandy loam:								
378907	0- 7	.2	.3	.3	2.5	40.8	40.8	15.1
378908	7-23	.1	.2	.3	3.9	45.6	34.4	15.5
378909	23-48	.1	.1	.2	3.4	49.3	32.7	14.3

SUMMARY

Hayes County is in southwestern Nebraska. It is rectangular and comprises 709 square miles, or 453,760 acres.

The county is in the Chestnut (dark-brown) soils region of the United States. It occupies a nearly level to rolling plain underlain by soft light-colored sandstone mantled in most places with loess and sand. It includes parts of three major physiographic

divisions—the loess plain, the sand-hill region, and the Perkins tableland. The loess-plain division covers the southeastern, central, and southwestern parts of the county, or about three-fifths of the total land area. Here the greater part of the terrain is characterized by a series of flat-topped divides capped by loess and separated by drainageways, the canyon walls of which are nearly vertical in many places. Throughout the sand-hill section, which covers rather large areas in the northeastern and northwestern parts, the surface features are mainly the result of wind action on loose sand. They consist of a succession of irregularly distributed sand hills and ridges, ranging from 10 to 40 feet in height, interspersed with nearly level or gently undulating valleys and basins of different sizes. The Perkins tableland occupies an area of several square miles of nearly level to rolling land in the northwestern part. It is underlain by limy sandstone.

The average elevation of the county is about 3,000 feet above sea level. Drainage is effected through tributaries of Republican River. The only poorly drained land is in isolated areas on the flood plains of the larger valleys and in small basinlike depressions throughout the sand hills and the more nearly level parts of the loess plain and Perkins tableland.

The climate is typical of the high-plains section. It is well suited to the growing of grain and tame-hay crops under dry-farming practices and to the raising of livestock. The mean annual temperature at Hayes Center is 50.5° F., and the mean annual precipitation is 24.22 inches. The average frost-free season is 155 days, which is sufficient to mature all the crops commonly grown.

The county is essentially agricultural. The principal branches of agriculture are the growing of grain and hay crops and livestock raising. About 42 percent of the land is used for crops, and about 51 percent is in range and pasture. Corn, wheat, and alfalfa are the principal crops, and barley, sorgo, millet, and oats are minor crops.

The average size of the farms is 666.2 acres. The farm machinery is of the most modern and labor-saving types.

There are 23 soil types and 6 phases of types, in addition to dune sand, recognized in Hayes County. These are grouped, according to the crops which are most extensively grown on them and for which they seem to be best suited, in four broad groups, as follows: (1) Soils suitable for the production of corn, small grains, and forage crops; (2) soils suitable for the production of corn and native hay; (3) soils suitable for the production of corn and alfalfa; and (4) soils suitable mainly for the production of native grasses.

The soils of the first group occupy about 40 percent of the total area of the county. This group includes the Keith and Rosebud soils and the finer textured Anselmo soils. These soils are well drained, have nearly level or gently rolling relief, and are friable throughout. They have accumulated considerable organic matter, have rather dark surface soils, and are fairly stable under cultivation. All are on the uplands, and, although they do not produce such high yields of corn and alfalfa as do some of the soils on the bottom lands and terraces, where the moisture supply is greater, they give satisfactory yields of all the crops commonly grown on them, except in the driest years. Keith silt loam is the most extensively cultivated soil in the county.

The soils best suited for the production of corn and native hay occupy about 18 percent of the total land area. This group includes all the Valentine soils and Anselmo loamy fine sand. These soils occupy nearly level to hummocky areas throughout the more sandy parts of the county, where they are closely associated with each other and with dune sand. They are lighter in color, less stable under cultivation, and produce lower yields of small grains than do the soils of the first group, but they absorb the precipitation more rapidly and have sufficiently high water-retaining capacity to hold practically all the moisture which falls on them until it is drawn out by the crops. During extremely dry years, most of these soils produce higher yields of corn than do the finer textured soils of the uplands.

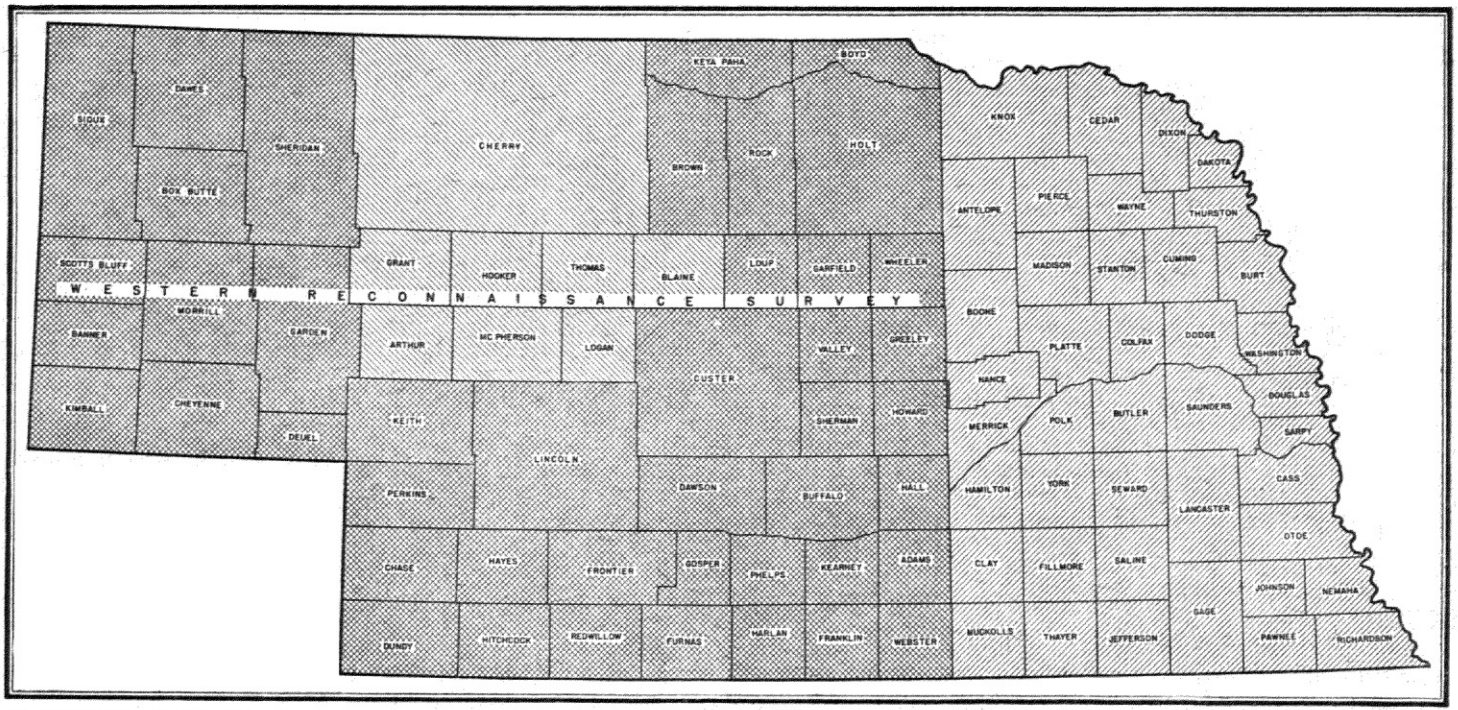
The soils suitable for the production of corn and alfalfa include less than 5 percent of the total land area. They occupy the alluvial lands along the larger creeks and are in general well supplied with moisture. The group includes the Tripp, Bridgeport, Sarpy, and Laurel soils. The Tripp soils occur on the terraces and the Bridgeport on the terracelike colluvial slopes. The Sarpy and Laurel soils are developing on recently deposited alluvium and have very light colored surface soils. About one-half the area of the soils of this group is used for alfalfa, and the roots of this crop extend down to the water table in most areas. Corn produces higher yields on these soils than on any other soil in the county, and it is grown on most of the land not devoted to alfalfa.

The soils classed as suited mainly for the production of native grasses comprise about 40 percent of the total land area. They include the Colby, Canyon, Scott, and Butler soils and dune sand. These soils occur wherever the land is too rough or poorly drained for cultivation, or where the soil is too thin, unstable, or droughty to be used for the production of grain or tame-hay crops. The Colby soils and dune sand are the most extensive. The Colby soils are composed largely of silt, but they are severely eroded. Dune sand is loose incoherent gray sand which becomes very unstable when overgrazed or when the native sod is broken. The Scott and Butler soils occupy poorly drained depressions throughout the loessial uplands where the land is too wet, at least a part of each year, to produce optimum yields of grain and tame-hay crops. The Canyon soils occur in areas where the Tertiary bedrock is at or near the surface of the ground. They are extremely shallow, stony, and immature and are of value only for grazing land.

U. S. GOVERNMENT PRINTING OFFICE: 1938

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

There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than 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; crosshatching indicates areas covered in both ways.

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