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UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
Greeley County, Nebraska

By

S. R. BACON, in Charge, and F. A. HAYES
United States Department of Agriculture

and

E. A. NIESCHMIDT
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 GREELEY COUNTY, NEBRASKA

By S. R. BACON, in Charge, and F. A. HAYES, United States Department of Agriculture, and E. A. NIESCHMIDT, Nebraska Soil Survey

INTRODUCTION

Greeley County is in east-central Nebraska. It is square and comprises 571 square miles.

The county is in a section of moderate though well-distributed rainfall and of moderate mean annual temperature characterized by rather cold winters and warm summers. The climate is continental. Climatic conditions are favorable for diversified agriculture, which here consists principally in growing feed crops and pasture grasses and in raising cattle and hogs.

The area included in this county is part of a formerly nearly level or rolling plain, on which minor relief has been produced by stream erosion and wind action. More than half the county, including practically all the southern and eastern parts, is mantled to various depths with light-gray floury and limy silt, known geologically as Peorian loess. Wind-blown sands cover the north-central and northwestern parts. The relief of the upland ranges from almost level to strongly rolling and hilly. The average elevation above sea level is about 2,100 feet.

This county lies within the belt designated as the black-soil plains of central United States. Before settlement by man the land was covered with a heavy growth of grasses, the annual decay of which imparted a dark color to the topsoil.

All the county is well drained except some of the lower lying first bottoms, that are frequently inundated, and a few small basinlike depressions scattered over the nearly level tableland.

About 55 percent of the total area is under cultivation, and most of the remainder is used for grazing cattle. The principal cultivated crops are corn, oats, alfalfa, and barley, ranking in acreage in the order named. Other crops are sweetclover, rye, wheat, potatoes, and sorghum. Most of these crops are fed to cattle and hogs, which are the most important sources of revenue.

The population in 1930 was 8,442, all classed as rural. The largest towns are Greeley, Spalding, Scotia, and Wolbach.

Transportation facilities are good. Three railroads enter the county, and public roads follow most of the section lines. The State highways are surfaced with gravel, and many of the county roads are graded.

On the basis of soil characteristics and other features that affect agriculture, the soils may be separated into three general groups, as follows: Well-drained soils, excessively drained soils, and poorly drained soils.

All the soils of the first group are naturally productive, provided an adequate supply of moisture is assured. Most of them contain

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an abundance of lime at a slight depth and have accumulated enough organic matter that the color of their topsoil layers ranges from dark grayish brown to almost black. They all are friable and are easily penetrated by air, moisture, and crop roots. Differences in the yields of grain and tame hay on the different soils of this group are owing largely to differences in the supply of soil moisture, which is controlled by the relief, particularly the slope of the land and its elevation with respect to the surrounding soil areas or to the underlying water table. Some of the soils are not very important agriculturally, owing to their small extent. Holdrege silt loam occupies the largest area and is one of the best soils. In order of productivity for crops these soils rank as follows: Lamoure silt loam, Wabash silt loam, Hall silt loam, Waukesha silt loam, Holdrege silt loam, colluvial phase, Lamoure very fine sandy loam, Hastings silt loam, Holdrege silt loam, Holdrege very fine sandy loam, and Marshall very fine sandy loam. The least productive soils of this group are almost as productive as the best soils and are more productive than any soils of the other groups. The bottom and terrace soils are slightly more valuable than the upland soils, owing to their level position and the closeness of the water table to the surface. The Wabash and Lamoure soils are bottom soils, and, although they are considered the most productive, their value is somewhat impaired by their susceptibility to damage to crops from flooding. The Hall and Waukesha soils occupy terraces, and the Holdrege, Marshall, and Hastings soils occur on the uplands.

The excessively drained soils are not so well supplied with organic matter and have lighter colored topsoils than the well-drained soils. All, except those of the Colby series, which occupy the more severely eroded parts of the loess-covered upland, are composed mostly of sands. The Colby soils occur wherever surface run-off has prevented or greatly restricted the accumulation of organic matter, and their topsoils are prevailingly light colored. In the loess-covered areas, the unweathered gray silt is exposed in many places. The Colby soils are used principally for grazing land, although many areas of them on the more gradual slopes are used for the production of crops. The Thurman soils of the uplands and the O'Neill soils of the terraces are of small extent. They are adapted to general farming and produce well during normal years. They contain an abundance of organic matter that binds the sand grains together, making the land fairly stable under cultivation. The Anselmo soils are similar to the Thurman, except that they contain a smaller quantity of organic matter and are therefore less stable, particularly when cultivated. The Valentine soils and dune sand are the most sandy soils of the upland and contain only a very small quantity of organic matter. Dune sand is very unstable, and the relief of such areas is strongly rolling. The Valentine soils, although subject to considerable wind erosion, are fairly stable provided they are left in pasture. For use for crops and pasture, the soils of the excessively drained group may be ranked, in order of their productivity, as follows: Colby silt loam, Colby very fine sandy loam, O'Neill fine sandy loam, Thurman fine sandy loam, Anselmo fine sandy loam, O'Neill loamy fine sand, Thurman loamy fine sand, Anselmo loamy fine sand, Valentine loamy fine sand, Colby silt loam, broken phase, Valentine sand, and dune sand.

The group of poorly drained soils includes several members of the Cass series. These soils occur along all the larger streams and have developed from recently deposited stream sediments. They have very dark surface soils underlain by loose rather incoherent sand or loamy sand, which in places contains some gravel. The area covered by these soils is, for the most part, poorly drained and is used largely for pasture and hay land.

COUNTY SURVEYED

Greeley County is situated in the east-central part of Nebraska (fig. 1). Greeley, the county seat, which is less than 2 miles from the center of the county, is about 150 miles northwest of Omaha and about 105 miles from the South Dakota and the Kansas State lines. The county is square and includes a total area of 571 square miles, or 365,440 acres.

Originally the physiography of the area in this county was presumably a nearly level plain, on which minor relief has been produced by wind action and stream erosion. Throughout the upland the loessial mantle, although reduced in most places below the general level of the former plain, remains intact over approximately all of the southern half of the county and over much of the northeastern part. North of Cedar River the loess extends west about 8 miles from the eastern boundary, and south of Freeman Creek it extends west to the middle of the county. The other upland areas are occupied by wind-blown sand and mixtures of sand and loess, producing sandy loams and loamy sands. The sand was blown over much of the northern part from the northwest during unusually high winds. The sandier soils cover about three-fifths of the northern part and extend east between Freeman Creek and Cedar River in a wedge-shaped area to a point near the junction of these streams.

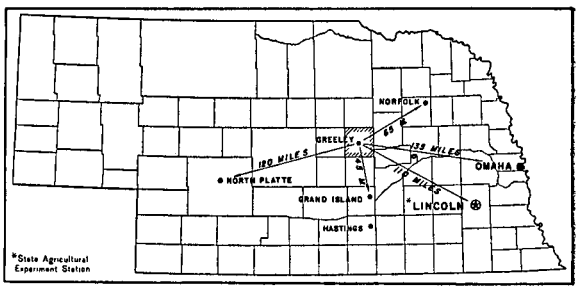

FIGURE 1.—Sketch map showing location of Greeley County, Nebr.

The upland is dissected in the southwestern and northeastern sections of the county by North Loup and Cedar Rivers, respectively. These streams have cut broad valleys in the loessial material and have developed their flood plains on underlying sands. Three smaller streams have developed valleys ranging from one-half mile to 2 miles in width. Numerous primary and secondary tributaries of these streams and rivers, together with smaller drainageways, ramify all sections of the loessial territory and produce some large sections of rolling or hilly land, with narrow valleys, and other land that is gently rolling, with wider valleys. The relief near the mouths of most drains and along the larger streams is in general more gentle than that in the vicinity of the heads of drains, especially where both are totally within the loessial area. A few small tablelike areas, occurring mostly in the southwestern part of the county, remain near

the level of the former plain. In general, the range in relief is from level to steeply rolling, hilly, and broken. The fall from the higher areas to the surrounding stream bottoms ranges from 125 to 200 feet. The area of high sand hills in the northwestern part of the county is the southern extremity of a vast sand-hill area of north-central Nebraska. In this section the sand has been piled into irregularly distributed dunes ranging from 30 to 80 feet in height, interspersed with numerous small enclosed valleys, pockets, and swales. The rest of the sandy upland occupies a broad lower lying belt between the typical sand hills and the loessial uplands. Although as a whole it is undulating or gently rolling, there are numerous low rounded knobs and ridges which give it a rather hummocky appearance in places.

The alluvial land, which occupies about 16 percent of the county, includes the terraces and flood plains along the larger streams. The largest developments are along North Loup and Cedar Rivers, where they occur as continuous strips ranging in width from 1½ to 3 miles.

The average elevation of the county is about 2,100 feet above sea level. The highest point is in the northwestern part where the high loessial divide is thinly covered with sand, and the lowest is where Cedar River leaves the county. Elevations of the railroad at important towns are as follows: Greeley, 2,021 feet; Spalding, 1,878 feet; Scotia, 1,909 feet; and Wolbach, 1,845 [1] feet. The general slope of the land is to the south and east.

All the county is well drained, with the exception of a few small areas of overflowed land along Cedar and North Loup Rivers and a few small basinlike depressions on the more nearly level divides throughout the loessial upland. In many places surface run-off is rapid and erosion is severe. Practically all the terrace land has sufficient slope, toward the main stream along which it lies, for the removal of surplus surface moisture. Drainage in the sandy uplands is subterranean. Some of the streams have steep gradients, are swift-flowing, and are actively deepening their channels. Other streams traverse sections that are less sloping and have gently rolling relief. In many places the smaller upland drainageways have partly filled their channels with sediments and water spreads over the surface of the valley before reaching the main stream.

Well water of excellent quality is readily obtained in all sections. The wells in the uplands range in depth from 150 to 300 feet, a few of those on the higher tablelands being more than 300 feet deep; those in the valleys of Cedar and North Loup Rivers range from 20 to 75 feet, and in other valleys from 40 to 90 feet. In the northwestern part of the county wells throughout the sand hills range in depth from 200 to 350 feet, and they are more shallow (usually less than 200 feet deep) in the lower lying sandy areas that border the loessial uplands.

Native timber grows in narrow belts along the larger drainageways. It consists chiefly of cottonwood, ash, elm, boxelder, and willow but includes some oak and hackberry. Groves of cottonwood, ash, elm, and pine have been planted on many farms and in the towns. Although the timber is not of merchantable size, it is valuable for firewood and posts.

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[1] GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bull. 274, ed. 4, 1,072 pp. 1906.

Native grasses, where not destroyed by cultivation, consist largely of big bluestem, little bluestem, and grama in the loessial section and needlegrass and sandgrass on the sandy uplands.

The first settlement in the area now included in Greeley County was made in 1871 along North Loup River by Seventh Day Baptists. The county was organized in 1872. By 1877 the southwestern part of the area along North Loup River Valley was well settled. Large numbers of Irish homesteaded on the Spring Creek Valley and a few years later on Cedar River Valley.

According to the Federal census, the population was 1,461 in 1880 and had increased to 8,442 by 1930. All is classed as rural, as there is no town of over 2,500 people. The density of population is 14.8 persons to the square mile. The population is rather unevenly distributed, but it is densest near the various towns and in the alluvial valleys along the larger streams. The more sparsely settled sections are in the sandhills throughout the northwestern and north-central parts of the county. Greeley, the county seat and largest town, located near the center of the county, had a population of 857 in 1930. Other towns are Spalding, with a population of 839; Scotia, with 474; and Wolbach, with 501. Horace, Brayton, and Belfast are small villages. All these towns and villages are located on railroads and offer markets for local produce. They also act as distributing points for farm implements and supplies.

Transportation facilities are good. A branch of the Union Pacific Railroad crosses the southwestern part of the county following the North Loup River Valley. A branch of the Chicago, Burlington & Quincy Railroad extends southeast-northwest across the county. There is a junction point at Greeley, one spur extending to Burwell and the other to Ericson. The Columbus branch of the Union Pacific extends up the valley of Cedar River into Greeley County as far as Spalding. No point is more than 12 miles distant from a railroad station.

The public-road system is well developed. A gravel State highway crosses the county from east to west, another from north to south, and a third serves the North Loup River Valley. Dirt roads, which are usually kept in good condition, pass within one-half mile of most of the farmsteads.

Trucks for the delivery of grain and livestock to markets and for the collection of dairy products are used throughout the year. Nearly one-half of the cattle and a smaller percentage of the hogs are transported by truck to the Omaha market, and the rest are sold locally and shipped by rail.

Schools for grade pupils are maintained in the rural districts, and high schools are located in Spalding, Greeley, Scotia, Wolbach, and Horace. Spalding and Greeley each have a Catholic school. Churches are located in all the towns and in many rural localities.

CLIMATE

The climate is continental and is characterized by rather wide extremes in temperature. The winters are fairly cold, but periods of unusually low temperatures are of short duration. The summers are long, with warm days and nights, which are especially favorable to the growth of corn. There are brief periods of extreme heat. The autumns are long and pleasant, with only occasional periods of cold

or rainy weather, giving the farmer ample time in which to prepare and seed the land for winter wheat and to harvest the corn crop.

The greater part of the mean annual precipitation of 25.18 inches falls from April to September, inclusive, or during the principal part of the growing season. A large proportion of the rain in summer occurs as heavy thundershowers, and much of it is lost through run-off. Droughts sometimes occur in the summer or early fall, but are of short duration.

The average date of the last killing frost is May 7 and of the first is September 22. This gives an average frost-free season of 138 days, which is ample for the maturing and harvesting of all farm crops commonly grown. Killing frosts have occurred as early as September 5 and as late as May 27.

The average daily wind movement is high during most of the year, and sometimes dry hot winds from the south continue for 5 or 6 days.

As there is no Weather Bureau station in Greeley County, the climatic data were compiled from records of the station at North Loup, Valley County, which is about 2 miles from the western boundary of this county. These data are set forth in table 1 and are believed to be representative of conditions in Greeley County.

TABLE 1. *Normal monthly, seasonal, and annual temperature and precipitation at North Loup, Valley County, Nebr.*

[Elevation, 1,961 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1905)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	25.7	76	−28	0.65	1.05	(1)	4.3
January	21.5	74	−39	.55	.24	1.25	4.7
February	24.8	76	−33	.68	.84	.79	6.7
Winter	24.0	76	−39	1.88	2.13	2.04	15.7
March	35.6	90	−19	.99	.57	1.28	5.1
April	49.3	103	6	2.86	.04	4.59	2.5
May	59.5	100	21	3.63	.40	7.04	.2
Spring	48.1	103	−19	7.48	1.01	12.91	7.8
June	69.3	104	32	4.68	.68	10.17	.0
July	74.5	107	40	3.70	1.31	8.80	.0
August	72.7	108	34	2.96	1.04	2.10	.0
Summer	72.2	108	32	11.34	3.03	21.07	.0
September	64.1	105	20	2.12	3.45	4.23	.0
October	51.6	93	7	1.56	1.62	.42	.9
November	36.8	87	−28	.80	1.27	1.63	2.7
Fall	50.8	105	−28	4.48	6.34	6.28	3.6
Year	48.8	108	−39	25.18	12.51	42.30	27.1

[1] Trace.

AGRICULTURE

Prior to the first permanent settlement in 1871 the area now included in this county was occupied by Indians, trappers, and hunters, who subsisted largely on wild game, fish, and fruit. The earliest settlers located in the larger valleys, where fuel and water were

readily obtained and where the relief favored easy cultivation. During the first few years vegetables, corn, and spring wheat were grown. These food products were supplemented by milk, game, pork, and beef. As the settlements became more permanently established, the farmers began to break the land for the more extensive production of corn and wheat, together with some oats for feed. Cattle raising was not very extensive, but it became more important as the sandier sections were settled.

The steady increase in the acreage of both corn and oats is a result of a combination of agencies still existent in this general locality, including the value of both for feeding cattle and hogs, although numerous other important crops may be grown to insure a more stable income. The corn acreage is constantly held up to or even beyond the rotation ratio best calculated to conserve soil fertility. This is especially true on the more nearly level land and on small farms, where more intensive cropping is practiced. Oats remain in favor largely because the entire crop can be utilized on the farm for livestock, the raising of which is more profitable in years of low crop prices. The sandier soils produce better yields of oats than of wheat. Wheat, although adapted to most of the soils, has never been grown extensively. It is often damaged by the chinch bug and hessian fly, and the straw is not so valuable for feed as either oat or barley straw. Sorghum and rye are produced on many farms but are grown regularly by only a few farmers. All the crops grown are such as can be handled almost entirely by machinery.

No major enterprises other than agriculture exist in this county. In past years, however, a small quantity of silica was shipped out, but larger sources closer to centers of utilization have been discovered in other parts of Nebraska. A dam in the Cedar River at Spalding furnishes power for a local mill.

Practically no commercial fertilizer is used, as most of the soils, except the sandier types, contain sufficient plant nutrients for normal production of crops.

The hired laborers are white. Farm wages range from $15 to $25 a month, with room and board. Corn shuckers receive from 3 to 5 cents a bushel for harvesting the corn crop.

In 1935, owners and part owners occupied 47.8 percent of the farms, tenants 51.9 percent, and managers 0.3 percent. The proportion of tenant farmers has steadily increased since 1880, only 5.2 percent of the farms being operated by tenants in that year. Life-insurance companies, loan companies, and banks own most of the tenant-operated land. Cash or share rentals and a combination of the two are followed. In the valleys and on the better upland soils the landlord receives as his share two-fifths of the corn crop and one-third of the small-grain crop. He charges about $2 an acre rental for pasture land. On the rolling lands, one-third of all the grain is usually the landlord's share, and he receives from $1.50 to $2 an acre for pasture. When alfalfa land is rented for shares, the owner receives one-half of the crop. Four dollars an acre is the standard cash rent for alfalfa land. In the cultivable parts of the sand hills land rents for 25 to 50 cents an acre and one-third of the grain. The tenant furnishes the seed, labor, and machinery.

Ordinarily the farm buildings include a two-story house, a large barn for storing some of the straw and hay and housing the livestock,

a corncrib, an oat or barley bin, hog and poultry houses, and, on many farms, a dairy house. Most of the houses and barns are painted and kept in good condition. In the sand hills in the northwestern part of the county, smaller barns and houses are common.

The usual farm equipment includes harrows, mowing machines, two-row cultivators, disk plows, hayrakes, a hay loader, several farm wagons, a small-grain binder, and a cream separator. Many farms are equipped with a corn binder, corn shucker, and tractor, and there are a number of grain threshers and some combines and hay balers in the county. A large number of the farms have silos, some have modern heating plants, and some are equipped with electric-lighting systems.

Cattle and hogs provide the chief source of income. Most of the feeder cattle are raised locally, although some are purchased when 2 or 3 years old from ranchers in the more western counties of the State. Herefords comprise about 50 percent of the beef cattle. Most of the other cattle are mixtures of two or more of the following breeds: Shorthorn, Hereford, Polled Durham, and Holstein-Friesian. A section (640 acres) of pasture land on the heavier soils will support from 250 to 300 cattle during the grazing season—June to October, inclusive. On the sandy land, which supports a less luxuriant vegetation, from 80 to 100 cattle can be maintained on a section. Little attention is given the grazing cattle other than to furnish an adequate supply of water and salt. Cattle to be fattened for market are fed corn, alfalfa, and clover for a period ranging from 60 to 90 days.

No farm is devoted exclusively to dairying, although nearly every farmer milks a few cows, some of which are Shorthorns or other beef breeds. A number of dairy herds are kept, which supply the local towns with whole milk. The surplus cream is sold to local cream stations. The Holstein-Friesian is the most popular dairy cow, and a few farmers keep Jerseys and Guernseys.

Hogs for market are raised extensively on most farms, except those in the sand hills, where only a few hogs are kept for home consumption. The Federal census reported 15,756 hogs on the farms on January 1, 1935. Most of the hogs are fed corn and alfalfa, although barley and rye are frequently added to the ration. Most of the hogs are grades, and there are only a few purebred herds. Poland China, Duroc-Jersey, Hampshire, and Chester White are the favored breeds.

Horses of the Percheron draft type are popular in this section, although most of the horses are of mixed breeding. Purebred stallions are used extensively. A large number of mules are used as work animals.

Sheep raising receives little attention, but there are several flocks ranging in size from 200 to 300 sheep.

Poultry constitutes an important source of farm income. A small flock of chickens is kept on every farm. The local demand for poultry products is generally good, and poultry raising seems to be increasing in volume.

Agricultural practices in Greeley County are similar to those in other counties of central Nebraska. Most of the crops produced are used in raising and fattening livestock. Some, however, are sold for cash, especially the landlord's share of the corn and small grain. Part of these crops is sold locally to ranchers in the sand hills, who

do not produce enough corn and small grain on the sandy land to fatten their cattle.

Most of the corn is husked from the standing stalks in the fall, and the rest is pastured by cattle and horses in the field during the winter. Many farmers annually fence off a few acres of unhusked corn for hog range. That from a small acreage is cut for forage. On farms having silos, the corn from 15 to 20 acres is cut each year for silage. Very little attention is given to the improvement of the seed corn, although most of it is produced in the locality where it is to be planted. Silvermine, St. Charles White, and Reid Yellow Dent are the leading varieties. This crop is grown on all the soils except those in the more poorly drained parts of the flood plains, in rough broken areas, and on unstable sandy land.

Table 2 shows the acreage devoted to the principal crops, as reported by the Federal census for the years 1899, 1909, 1919, 1929, and 1934.

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

Crop	1899	1909	1919	1929	1934 [1]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Corn	52,748	76,941	70,694	86,566	18,072
Oats	13,046	23,943	23,034	30,340	175
Wheat	31,096	12,467	19,343	3,948	390
Rye	518	525	4,624	2,153	202
Barley	386	31	1,220	4,309	31
Potatoes	569	746	791	718	56
Hay	15,104	51,411	61,666	51,700	[2] 12,468
Wild grasses	12,852	35,181	35,737	29,804	
Alfalfa	167	14,108	22,789	19,101	7,127

[1] The number of acres harvested was abnormally reduced, owing to the spring and summer drought.
[2] All hay and sorghums for forage.

The area devoted to oats fluctuates greatly. This crop is planted in the spring. It is usually cut with a binder and either shocked or stacked for threshing. The grain is used largely as feed for horses, mules, and calves. The straw is fed to cattle and work animals and is often left in the field where it is accessible to both. Smut sometimes reduces oat yields during prolonged periods of rainy or cloudy weather. Injury from this source can be controlled by spraying the seed the day before planting with a solution of equal parts of formaldehyde and water. One quart of solution is sufficient for treating about 40 bushels of oats.[2] Dry weather, accompanied by hot southerly winds during the time the grain is filling has often prevented good yields of oats in this section of Nebraska.

Barley, like oats, is planted in the spring and is generally harvested with a binder. Most of the grain is used as hog feed, and the straw is fed to work animals and cattle. The common six-rowed smooth-bearded varieties are considered superior for Nebraska conditions.

The wheat grown is of the winter varieties, chiefly Turkey and Nebraska 60. Land to be used for this crop is plowed and harrowed in late summer. The seed is planted with a press drill late in Sep-

[2] STEWART, P. H., and GROSS, D. L. SMUT CONTROL IN CEREALS. Nebr. Agr. Col. Ext. Circ. 132. 13 pp., illus. 1929.

tember, in order to allow sufficient growth before cold weather begins. Wheat makes a good growth before heavy frost occurs and remains dormant during the winter. It is cut with a binder and is shocked or stacked for threshing. The hessian fly sometimes causes much damage to the wheat in this section. Stinking smut, which also does some damage, can be controlled by mixing copper carbonate with the seed at the rate of 2 or 3 ounces of powder to a bushel of grain.[3]

Alfalfa is the chief tame-hay crop, and the principal varieties grown are Grimm and Cossack. A good seedbed is needed for alfalfa to insure a good stand, and the soil should be moist when the seed is planted. Alfalfa is usually allowed to remain as long as it produces satisfactorily. Ordinarily three cuttings are made during the season, but the number of cuttings depends largely on the amount of moisture available during the growing season. On bottom lands, four cuttings are occasionally obtained. The common practice is to stack the hay in the field and haul it to the feed lots as needed. It is used as feed for cattle and hogs and is sometimes fed to horses and mules. Hogs are allowed to run in the fields during the summer. Cattle, however, are seldom grazed on green alfalfa as there is danger of bloating. Alfalfa is a good soil binder and is especially valuable wherever erosion is severe. It is adapted to all the soils in this county, except the sandy types and the poorly drained flood plains. Additions of lime to the more sandy soils used for alfalfa or sweetclover should prove profitable.

The acreage devoted to sweetclover has increased considerably during the last few years. This crop is valuable, not only for pasture and hay, but also for seed, for checking erosion, and for increasing the organic-matter content and maintaining the nitrogen supply of the soil. Sweetclover is generally sown between the corn rows in the fall, but some is planted in early spring. The crop is generally cut the first year for hay, before the growth becomes coarse or woody. The second year, the crop may be allowed to mature and reseed itself, or it may be cut with a binder and threshed for seed. Sweetclover is more satisfactory for soil improvement than alfalfa, as it is adapted to a wider range of soils, including the sandier ones, and it does not deplete the supply of soil moisture so deeply as does alfalfa.

Crop rotation is practiced to some extent on most of the farms, but no definite system is followed. The most common rotation is corn, followed by a small grain, as oats or barley. Some farmers plant corn for 2 years and follow with sweetclover for 2 years. On bottom lands and in depressions within the sand hills many farmers plant corn continuously for 6 or 7 years on the same land. On the more rolling land corn is usually followed by a small grain and sweetclover.

Practically no commercial fertilizer is used. A large quantity of manure is produced, most of which is hauled in the fall or spring and spread over the land to be used for corn.

SOILS AND CROPS

Approximately 55 percent of the land in Greeley County is under cultivation, and the remainder, including principally areas of hilly and broken land and extremely sandy soil, is used for grazing cattle

[3] STEWART, P. H., and GROSS, D. L. See footnote 2.

and the production of wild hay. The farming land is rather evenly distributed over the loessial section, and most farms include sufficient areas of pasture for grazing cattle.

About 65 percent of the soils have developed from loessial material. The loessial mantle, which is a light-gray floury and limy silt, has been deposited in the past to various depths over the southern and eastern parts of the county. The soils of these loessial areas are naturally productive, and the annual decay of grass roots has produced an abundance of black well-decomposed organic matter. The intensity of darkness and the depth to which the dark color has penetrated depend on relief, drainage, and the length of time the soils have lain in their present positions undisturbed by erosion. On the steeper slopes the organic matter has been removed almost as fast as it has formed, and the soils are light colored even on the surface. The decomposed vegetable matter is most abundant in the more level areas, where it has penetrated the soils most deeply. Between these topographic extremes the content and depth of organic matter varies inversely with the degree of slope. Slopes devoted to cultivated crops have a tendency to erode more readily than those left in pasture or some hay crop. In addition to their prevailingly dark color, the topsoils of most of the soils derived from loess are characterized by a crumblike or granular structure. A third fairly uniform characteristic of these soils is the occurrence of lime in sufficient quantities for crop needs, although few of the soils contain an abundance of lime in the surface layer and some have only a small amount in the subsoil. Approximately 85 percent of the soils which have developed from the loessial material can be readily cultivated. The rest are too steep or broken for tilled crops.

The three general characteristics of the loessial soils are valuable assets in connection with crop production. Organic matter is a strong absorbent of both heat and moisture, it increases the water-holding capacity of the soil, it is loose and mellow and promotes favorable tilth, and it is the chief source of nitrogen, an important plant nutrient. The granular or crumblike structure facilitates easy penetration of crop roots and allows free passage of air and water. Lime prevents the soil from becoming sour, or acid, and assists in preserving the supply of organic matter and the crumblike structure.

The valleys of North Loup and Cedar Rivers, in the southwestern and northeastern parts of the county, respectively, and some of the valleys along the smaller streams, as Freeman, Spring, Fish, and Wallace Creeks, are characterized by soils which have developed chiefly from alluvial sediments derived largely from the loessial uplands. A few, however, have developed on sand, especially those occupying the bottom lands along North Loup and Cedar Rivers. The almost total absence of erosion in the valleys has especially favored the accumulation of organic matter, and most of the soils have dark topsoils. Some of the more recent soils, that are developed on sands, contain little organic matter and are light colored from the surface downward.

The older soils of the bottom lands, most of which have developed from loess, are similar in their main characteristics to the soils in the less eroded parts of the loessial uplands, and they are used for

the same crops as those grown on the higher lying areas. Some of them are limy, whereas others, owing to their loose, porous character, have been leached of their lime.

The area of sandy land in the northwestern and north-central parts of the county comprises approximately 30 percent of the total area. High winds have been responsible for the transportation of this material, and only a very small part of the land surface has remained undisturbed. Over about half of this sandy area, wind has heaped the sand into dunes ranging in height from 20 to 75 feet, and most of the organic matter has been blown away as fast as it has formed. Here the soils are used almost entirely for grazing. Throughout the rest of the sandy uplands, the relief is undulating or rolling. In many places the sandy topsoil and subsoil have become more or less mixed with finer material blown from the nearby loessial uplands. Extensive weathering and the accumulation of organic matter have imparted to these soils a brown or dark grayish-brown surface layer. Such soils are suited to general farm crops including corn, oats, barley, and sweetclover. Those in the lower lying valleys, where the water table lies at a slight depth, are, in addition, adapted to alfalfa.

The general characteristics of the loess-derived soils favor the production of corn, small grains, and hay. All the soils, however, will produce one or another of these crops, and their intricate association on many farms necessitates using them for the crop to which they are best suited. Some soils have characteristics which, although favorable to one crop, may be decidedly unfavorable to another, and all the soils cannot be used with equal economy for all the crops.

Although the soils differ widely in their producing powers and adaptability to crops, they may be placed in groups, each of which includes soils that are fairly uniform in agricultural value and soil characteristics. Therefore, the soils are placed in three groups, on the basis of drainage conditions, as follows: (1) Well-drained soils, (2) excessively drained soils, and (3) poorly drained soils.

In the following pages, the individual soils are described in detail, and their agricultural relationships are discussed; the accompanying soil map shows their distribution in the county; and table 3 gives their acreage and proportionate extent.

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

Soil type	Acres	Percent	Soil type	Acres	Percent
Holdrege silt loam	79,552	21.8	Thurman loamy fine sand	4,992	1.4
Holdrege silt loam, colluvial phase	4,736	1.3	O'Neill fine sandy loam	8,704	2.4
Holdrege very fine sandy loam	4,800	1.3	O'Neill loamy fine sand	3,712	1.0
Hastings silt loam	6,208	1.7	Anselmo fine sandy loam	3,776	1.0
Marshall very fine sandy loam	6,208	1.7	Anselmo loamy fine sand	3,968	1.1
Hall silt loam	16,768	4.6	Valentine loamy fine sand	7,424	2.0
Waukesha silt loam	7,872	2.1	Valentine sand	27,072	7.4
Wabash silt loam	10,944	3.0	Dune sand	38,848	10.6
Lamoure silt loam	1,024	.3	Cass loam	3,136	.9
Lamoure very fine sandy loam	256	.1	Cass fine sandy loam	2,880	.8
Colby silt loam	82,368	22.5	Cass loamy fine sand	1,856	.5
Colby silt loam, broken phase	24,768	6.8	Cass silt loam	704	.2
Colby very fine sandy loam	6,016	1.6			
Thurman fine sandy loam	6,848	1.9	Total	365,440	

WELL-DRAINED SOILS

The soils of this group include most of those on the loessial uplands and the more productive soils of the terraces and bottom lands. One or another of them is in all sections of the county, except the northwestern part where dune sand prevails. The relief ranges from nearly level to rolling, and both surface and subsoil drainage are adequate. All the soils of the group have developed mostly or entirely from the gray limy flourlike loess which covers most of the county.

The topsoils, which are loose, mellow, and crumbly, are very dark grayish brown or almost black. They are prevailingly fine in texture, most of them ranging from very fine sandy loam to silt loam. The subsoils are, for the most part, friable, and none is so heavy and impervious as to retard drainage or so loose and porous as to be droughty. Control of acidity is not a problem on these soils, as they all contain calcium carbonate in sufficient quantities for general crop needs. The soils of the uplands are not quite so productive as the soils of the terraces and bottoms, mainly because the precipitation received by them is not supplemented by run-off from higher levels, as it is on the lower lying soils. The bottom-land soils and most of the soils developed on terraces are particularly well adapted to alfalfa where the water table is within reach of the roots.

Practically all the area occupied by these soils can be cultivated readily, and only small widely scattered fields remain in native grass. More small grain and alfalfa, in proportion to other crops, are grown on these soils than on the soils of the other groups.

Holdrege silt loam.—Holdrege silt loam is the most extensive soil of this group. It occupies much of the nearly level or gently rolling parts of the loessial upland, wherever erosion is not severe. Most of it is in the southern half of the county. The largest areas are on the divides between Fish, Wallace, and the two Timber Creeks and on the gentle slopes bordering these streams. The soil has developed from light-gray limy and silty loessial material, but in most places it lies considerably below the original surface of the loess plain. The relief is undulating or gently rolling.

The surface soil ranges from 6 to 20 inches in thickness, averaging about 12 inches. It consists of very dark grayish-brown mellow crumbly silt loam. The upper subsoil layer is grayish-brown, friable, and slightly granular or cloddy silty clay. The lower subsoil layer, which begins at a depth of about 32 inches, is light yellowish-gray floury silt containing some clay and numerous white spots of free lime. The surface soil and upper subsoil layer have been leached of lime, but this constituent is abundant in the lower part of the subsoil. The parent material, or original loess, which is light gray, floury, and limy, begins at a depth between about 4 and 4½ feet.

The depth and color of the surface soil varies with the topographic position. On the divides and near the bases of slopes adjoining streams, conditions have favored deep soil development and the accumulation of organic matter. Here the surface soil is very dark and in many places 20 inches thick. In places areas of a colluvial phase of Holdrege silt loam have formed. These areas, however, are too small to show on a small-scale map and are included with the typical soil. In the more rolling areas, especially in the vicinity of

the Colby soils, where the relief has allowed more rapid run-off, erosion has somewhat thinned the topsoil, and lime lies a little nearer the surface of the ground than in the more nearly level areas.

A few small bodies of Hastings silt loam are included with mapped areas of Holdrege silt loam. These are along the Wheeler County line. In that county the occurrence of the Hastings soils is too slight to justify their separation.

Holdrege silt loam is one of the most productive upland soils in Greeley County and ranks among the most productive soils for wheat in the central prairie States. It is adapted to all crops suited to the climate. Alfalfa, provided a good stand is obtained, returns good yields for 4 or 5 years, but subsequent yields decline, as the deeply stored moisture supply becomes exhausted. The normal rainfall is not adequate for continued large yields of alfalfa on any upland soil in this section. A publication by agronomists at the Nebraska Agricultural Experiment Station [4] shows that alfalfa, on soil receiving moisture from precipitation alone, as do most of the upland soils of Greeley County, can deplete the stored moisture to depths far beyond the reach of the roots of ordinary cereal crops within 2 years, and within 5 or 6 years can almost completely exhaust the available moisture in the lower part of the soil to a depth exceeding 25 feet. This publication indicates that alfalfa in Nebraska must depend almost entirely on the annual precipitation for its growth after the first 5 or 6 years, except in situations where the precipitation is supplemented by a favorable moisture supply from other sources.

Yields of all crops on Holdrege silt loam compare favorably with those grown on any other upland soil but, in most years, are a trifle below those obtained on the lower lying silty soils of the terraces and bottom lands. In seasons of normal precipitation, corn yields about 28 bushels an acre, oats 26 bushels, barley 30 bushels, wheat 14 bushels, and alfalfa about 2 tons from three cuttings. In dry seasons the yields of corn and alfalfa are rather low.

Control of erosion is important on the Holdrege soils. Where not controlled, the surface wash gradually depletes the organic matter, rendering the soil unproductive and subject to considerable gullying. Terracing the land for cultivation is a very efficient method of preventing loss by erosion. The use of more clover and alfalfa in the rotation would save some of the expense incurred in terracing.

Holdrege silt loam, colluvial phase.—Holdrege silt loam, colluvial phase, occupies small areas near the bases of slopes and narrow strips along the headwaters of small drainageways. It occurs in all parts of the county that are covered with the loessial material.

This soil, owing to its low position, which has favored the accumulation of considerable surface wash from higher levels, has a thicker topsoil than occurs in typical Holdrege silt loam. The topsoil ranges in thickness from 22 to 36 inches. It is friable and mellow and contains proportionately more organic matter than the corresponding layer in any other soil of the county, except, possibly, Wabash silt loam. The subsoil is variable. In most places it is friable, but in certain localities it becomes fairly heavy, owing to the presence of considerable clay. Generally, however, the material

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

in this layer is more friable than that in the corresponding layer of typical Holdrege silt loam and is not so well developed.

Athough the denseness of the upper part of the subsoil is rather variable, in no place does the material become too dense to prevent the free movement of roots, air, and moisture. In many places, especially at the heads of drains, the soil has been considerably modified by alluvial deposits. The relief, however, is more sloping than that of the soils of the terraces and bottom lands. The soil is not noticeably limy to a depth exceeding 4 feet.

This is the best upland soil of the county and is equal to any terrace soil in natural fertility. It is very retentive of moisture and, owing to its position, normally receives more water than the slopes above. Some of the run-off from the higher soils is absorbed by the more gentle slopes. Most of this colluvial soil is under cultivation, and it is especially suited to corn and alfalfa. As it has a large content of nitrogen, it is well adapted to crops that produce high yieds of forage. Alfalfa does well, especially where it is grown in positions low enough for the roots to reach the water table.

Holdrege very fine sandy loam.—Holdrege very fine sandy loam is not a very extensive soil. It occurs in small areas near the sand-hill section, in most places lying between the sand hills proper and the finer textured soils of the loessial uplands. The surface layer is a mixture of wind-blown sands, gray loessial material, and dark organic matter. The largest areas are near the center of the county. One body is about 2½ miles southeast of Greeley, one is 4 miles northeast of Greeley, and a smaller body lies 2 miles northeast of Horace.

The relief is similar to that of Holdrege silt loam, that is, undulating or gently rolling.

The 10- to 12-inch topsoil of Holdrege very fine sandy loam is mellow friable very fine sandy loam. The dark layer is generally somewhat thinner than in Holdrege silt loam and has a slightly lower content of organic matter. In a few small areas the texture is fine sandy loam. The lower layers are similar in all respects to those of Holdrege silt loam. They overlie the parent loess, a light-gray floury and limy silt.

Holdrege very fine sandy loam is highly retentive of moisture and is more readily cultivated than the silt loam. It is easily maintained in a mellow condition. The soil throughout is sufficiently porous to allow good aeration, easy root penetration, and the free movement of soil moisture. The lime in the subsoil is within easy reach of plant roots.

This is one of the most productive upland soils in central Nebraska, but, owing to its small extent, is of minor agricultural importance in Greeley County. Yields of oats are usually about the same as those obtained on Holdrege silt loam, and yields of other small grains and corn are slightly lower. Alfalfa yields from 1¾ to 2 tons an acre.

Hastings silt loam.—Hastings silt loam occurs chiefly in the south-central and southeastern parts of the county, and smaller tracts are in the western and northeastern parts. One of the largest developments is 2 miles northwest of the southeast corner and a large area is 7 miles west of Wolbach. Most of this soil is so nearly level that surface run-off is slow, but it includes small depressions, into which

the surplus surface moisture slowly drains. In areas of this soil that occur as remnants of old terraces, the surface slopes sufficiently for the run-off of excess water.

The topsoil of Hastings silt loam is very dark grayish-brown crumbly granular silt loam 16 or 18 inches thick. The upper part of the subsoil, to a depth of about 30 inches, is grayish-brown moderately compact silty clay loam, and the lower subsoil layer consists of light-gray loose floury silt. Lime is abundant below a depth of about 4 feet. This soil differs from Holdrege silt loam in that its topsoil averages a trifle thicker, its upper subsoil layer is more compact, and the layer in which lime is present lies at a greater depth. Although the subsoil of the Hastings soil is compact and heavy, it is easily penetrated by air, moisture, and plant roots.

Hastings silt loam is adapted to all crops common to the general area of its occurrence, and yields are slightly higher than on the sloping Holdrege soils, owing principally to the more nearly level surface of the Hastings soil, which is favorable for the retention of more water. This soil is valued at a higher price than the other upland soils. Its nearly even relief facilitates easy cultivation and prevents excessive erosion. Approximately 95 percent of the land is under cultivation. During normal years corn and small grains yield about 10 percent higher than on the Holdrege soils. Alfalfa and clover produce well, but crops following alfalfa produce lower yields than when they follow other crops. Owing to its freedom from erosion, it is advisable to use most of this soil for corn and small grains and to seed the sloping land to alfalfa and clover, where there is a tendency toward erosion.

The soils in the basinlike depressions are similar to Scott silt loam and Butler silt loam, mapped elsewhere in the State, but in this county they occupy such small patches that they are not separated from Hastings silt loam in mapping. Altogether they occupy a total area of only about 40 acres. The largest basin occupied by these included soils is in sec. 12, T. 20 N., R. 9 W., on the Boone County line. A smaller basin is near the southeast corner of sec. 26, T. 19 N., R. 12 W. Yields in these depressions are generally less than one-half of those obtained on the better drained Hastings silt loam. As water collects in the depressions, the soil is often too wet in the spring for tillage operations. It is subject to drought in the summer, owing to the claypan character of the subsoil.

Marshall very fine sandy loam.—Marshall very fine sandy loam is not an extensive soil. It occurs in small bodies, most of which are in the central and northern parts of the county—many of them in the upland between Freeman Creek and Cedar River. Few areas are more than 300 acres in extent.

The relief is similar to that of the Holdrege soils, that is, it is for the most part undulating or gently rolling. In this section the Marshall soil has developed over a wind-laid mixture of loess and sand, the former predominating.

The topsoil is very dark grayish-brown friable very fine sandy loam 10 or 12 inches thick, and it is well supplied with organic matter. The upper subsoil layer is light grayish-brown granular very fine sandy clay that is friable when moist but becomes moderately hard and cloddy when dry. It extends to a depth ranging from 20 to 24 inches.

The lower subsoil layer, in most places, is light-gray or yellowish-gray heavy brittle clay loam which breaks into angular clods when dry. It continues to a depth ranging from 36 to 40 inches. In most places this layer is underlain by pale yellowish-gray floury silt which is generally slightly calcareous below a depth of 5 feet. In many places the lower subsoil layer lies on sandy material that grades into almost pure fine sand at greater depths. The sand is lime-free, and the entire solum, although low in lime, contains sufficient calcium for the needs of crops.

All this soil is suitable for cultivation, and about 90 percent of it is farmed. It can be cultivated under a wider range of moisture conditions and is ordinarily better supplied with moisture than a silt loam. Yields of oats and corn are slightly higher in dry seasons than on Holdrege silt loam but do not average much higher over a period of years. Alfalfa, wheat, and barley yield a little less than they do on Holdrege silt loam or Holdrege very fine sandy loam. The average acre yield of corn is about 28 bushels, oats about 26 bushels, barley about 30 bushels, and alfalfa about 1¾ tons.

A few small areas included with this soil contain a larger percentage of fine sand in the surface soil than is typical. Some of these areas occupy flat basinlike depressions in the sand hills. Others have an undulating or gently rolling relief. One of the largest lies 3 miles northwest of Greeley. These included soils are suitable for cultivation, and the greater part of them is farmed. Yields are only slightly lower than those obtained on the typical soil. In seasons of normal rainfall the average acre yield of corn on the coarser textured Marshall soil is about 22 bushels, oats 24 bushels, alfalfa 1½ tons, and sweetclover 1 ton.

Another variation of Marshall very fine sandy loam occurs in very small areas. One of these is in the northwestern part of the county in the vicinity of School No. 66; another is 1 mile south of the same school, and a third is three-fourths mile southeast of Belfast. The subsoil in these areas is slightly plastic and contains gray mottlings.

Hall silt loam.—Hall silt loam is the most extensive valley soil in Greeley County. It occurs in long, almost continuous strips, or in bodies of various sizes and shapes in nearly all the larger valleys. The largest developments are along Cedar and North Loup Rivers, and smaller bodies lie along Wallace, Fish, and the two Spring Creeks. This soil has developed on light-gray limy silt which has been washed from the uplands and deposited on the valley floors when the streams were flowing at higher levels.

The relief ranges from nearly level to very gently undulating. The soil lies from 10 to 25 feet above the stream channels and is not subject to overflow. In several places, however, the water table is much lower than the stream channel, especially near the heads of streams, where many of the terraces begin. About 3 miles southwest of Spalding, in the vicinity of School No. 38, one of the terraces lies about 75 feet above Cedar River and the water table.

Hall silt loam, where typically developed, is similar to Hastings silt loam of the uplands, except that the subsoil is slightly less compact or dense, owing to a lower content of clay. The 12- to 16-inch surface soil consists of very dark grayish-brown silt loam rich in organic matter. The upper subsoil layer consists of lighter brown

more compact but crumbly silty clay which passes, at a depth of 22 inches, into light brownish-gray silty clay which is hard and brittle when dry and plastic when wet. At a depth ranging from 30 to 36 inches, the subsoil is underlain by floury loess that is spotted with lime at a depth of 3½ or 4 feet.

Hall silt loam includes more variations than the Hastings soil. In some places the dark layer is much thicker, and in a few places a second soil, similar in character to the one above, occurs at a depth ranging from 3 to 4 feet. Included also are several areas of poorly drained flats or depressions. Here the surface soil is more compact than typical, a little lighter in color, and contains more or less alkali. In the latter situations, the upper subsoil layer, which continues to an average depth of 30 inches, consists of dark-brown or grayish-brown extremely compact clay which is plastic when wet and hard and tough when dry. During dry weather, a white efflorescence occurs in spots on the surface of the ground. The largest of these poorly drained areas occurs 2 miles west of Scotia, in the southwest corner of sec. 6, T. 17 N., R. 12 W. A smaller area is along the county line about 2 miles northwest of Scotia in the southwestern part of sec. 31, T. 18 N., R. 12 W.

The same crops as are grown on Holdrege silt loam do well on Hall silt loam. Yields are from 10 to 20 percent higher than on the Holdrege soil and only slightly higher than on Hastings silt loam. A valuable asset of Hall silt loam is its smooth relief which facilitates cultivation. In normal years, corn yields about 32 bushels an acre, oats 32 bushels, barley 35 bushels, wheat 15 bushels, and alfalfa 3 tons of hay. The higher yields obtained on the Hall soil than on the Holdrege soil are due, for the most part, to a difference in the moisture supply of the two soils. The Hall soil naturally receives some water in the form of run-off from the higher lying Holdrege and Colby soils.

A small total area of Hall very fine sandy loam has been included on the soil map with Hall silt loam. This coarser soil is similar to the silt loam in all characteristics, except that it contains more very fine sand in the surface layer, and in most places has a more friable upper subsoil layer. This included soil occurs in small bodies on the terraces bordering North Loup and Cedar Rivers, North Branch Spring Creek, and Wallace Creek. Here the surface soil, to a depth of 10 or 12 inches, in most places is very dark grayish-brown friable very fine sandy loam containing an abundant supply of organic matter. The upper subsoil layer is grayish-brown crumbly very fine sandy clay containing some organic matter. The lower subsoil layer is similar to the corresponding layer of Hall silt loam, except in a few small areas, where it is slightly more friable. Yields of corn, oats, and alfalfa are practically the same as those obtained on typical Hall silt loam, but the yields of barley and wheat are slightly less. The topsoil of the Hall very fine sandy loam areas is loose and mellow and can be cultivated without injury under a wider range of moisture conditions than can the corresponding layer of the typical silt loam.

Included also with Hall silt loam are several small bodies of less than 10 acres each in depressions, where the surface soil is a trifle heavier and the subsoil, to a depth of 30 inches, is compact clay which is plastic when wet and very hard and tough when dry. The claypan-

like layer in the subsoil limits the storage of available moisture to the overlying layers and is not readily penetrated by roots. Here only shallow-rooted crops give satisfactory yields.

Within mapped areas of Hall silt loam are a few small bodies, in which the topsoil contains an unusually large quantity of fine sand, and the upper subsoil layer is very sandy. Were these bodies larger, they would have been indicated on the soil map as Hall fine sandy loam. The largest area of this kind lies along the county line on the Cedar River terrace in sec. 3, T. 20 N., R. 11 W. A smaller area is in the southwestern part of the same section.

Waukesha silt loam.—Among the terrace soils, Waukesha silt loam ranks in area next to Hall silt loam. It occurs in strips of various sizes bordering the larger streams. The principal developments occupy low terraces along North Loup River and Freeman, Fish, North Branch Spring, and South Branch Spring Creeks. In several places the soil occupies high terraces along the smaller streams, where it lies from 40 to 60 feet above the water table. The largest area on a high terrace is in the vicinity of School No. 38.

The relief of Waukesha silt loam is similar to that of Hall silt loam, that is, almost level with a gentle slope down the valley and toward the stream. Both surface and internal drainage are sufficient for good growth of all crops.

The surface soil is very dark grayish-brown friable silt loam to an average depth of 14 inches. The upper subsoil layer is grayish-brown friable crumbly silty clay of fine-granular structure. Below a depth of 30 inches the soil material grades into light grayish-brown friable silt loam. In most places the subsoil resembles that of Marshall very fine sandy loam. Lime is reached within a depth of 5 feet in only a few places.

Along its outer margins, where this soil joins the upland, and bordering some of the smaller drains on the terrace, the surface soil has been slightly thickened by the addition of colluvial wash from the higher slopes. Here the soil is very dark grayish-brown mellow silt loam to a depth ranging from 20 to 24 inches, where it passes into moderately heavy silty clay, which continues to a depth of 3 feet. In these bodies the silty clay layer is thicker and slightly more plastic than the typical Waukesha subsoil. The largest area of this variation occurs about 3 miles southeast of Scotia and crosses the middle of section 23 from north to south.

Waukesha silt loam is naturally a fertile soil and ranks in agricultural value with the Hall soils. It is well suited to all the crops common to this section, and approximately 95 percent of the land is under cultivation. The general tendency is to use this soil mainly for corn and alfalfa. Alfalfa, particularly, is well adapted to the Waukesha soil on the lower terraces, where the water table can be reached by plant roots. Yields of corn, wheat, oats, and clover are about the same as on Hall silt loam. The soil is easily handled; its subsoil is porous and easily penetrated by roots.

Wabash silt loam.—Wabash silt loam is the most extensive bottom-land soil in the county. It occurs in scattered areas along most of the larger creeks, but the greater part is along Spring Creek and its branches.

The topsoil, to a depth ranging from 18 to 24 inches, is very dark grayish-brown or almost black friable silt loam containing an abun-

dant supply of organic matter. The subsoil is grayish-brown heavy silty clay loam which is moderately compact but does not attain the density of the subsoil layers of the silt loams on the terraces and upland. It is easily penetrated by moisture and plant roots. In some of the narrow strips of Wabash silt loam along the heads of small drains, the dark layer extends to a depth of 3 feet without perceptible change either in color or structure. The Wabash soils are composed mostly of material washed from the loessial uplands. Neither the topsoil nor the subsoil contains sufficient calcium carbonate to effervesce with hydrochloric acid. The soil, however, does not seem to be deficient in lime, so far as crop needs are concerned.

The relief of Wabash silt loam is prevailingly smooth, although in places it is broken by old stream channels. In many places small intermittent streams from the upland carry the run-off from large areas to the edge of the valley, where, on account of the decreased velocity of the current, the channels become filled with sediment and the water spreads over the surface.

As a rule drainage of this soil is good, although local areas occur in which frequent inundation prevents cultivation. About 90 percent of the land is farmed. Some bodies occur in such narrow strips or are so badly dissected by old drains that they are better suited for pasture land than for tilled crops. Most of the land is used in the production of corn, yields of which are about the same as those obtained from the Lamoure soils and slightly higher than those from any other soil in the county. Wabash silt loam is particularly adapted to alfalfa. Occasional inundation is apparently more beneficial than harmful to this crop. The alfalfa roots can readily reach the water table, and the soil is not left in a droughty condition, as are the upland and high-terrace soils after remaining in alfalfa for 3 or 4 years. The yield of alfalfa is about 3½ tons to the acre. Several minor crops, including potatoes and clover, yield exceptionally well. Small grains are not grown on this soil, owing to the danger from overflow in the spring and early summer. These suffer more damage from high water than do most of the other general farm crops common to this section. Where well drained and occurring in bodies of sufficient size to warrant cultivation, this soil is regarded as one of the most valuable soils in the county for corn and alfalfa.

Small areas mapped as Wabash silt loam along streams that originate in the sandier parts of the county have a soil that differs from typical Wabash silt loam, in that it has more very fine sand and fine sand in the surface soil and upper part of the subsoil. The largest body of this included soil is in the vicinity of O'Connor on North Branch Spring Creek. In all these areas the surface slope and subsoil drainage are adequate for crop production. Corn yields are about the same as on typical Wabash silt loam, but yields of clover and alfalfa are ordinarily slightly less. Owing to their higher sand content these included soils can be cultivated sooner after rains than the typical Wabash silt loam, and good tilth is more easily maintained.

Lamoure silt loam.—Lamoure silt loam is a soil of the first bottoms. It is sufficiently well drained to be classed in the group of well-drained soils, although some areas of it lie only 3 or 4 feet above the water table.

This soil occupies only a small total area and is of minor agricultural importance. Most of it occurs as strips in the flood plains along Cedar and North Loup Rivers. Small bodies of a few acres each are along North Branch Spring Creek.

The topsoil, which ranges in thickness from 10 to 18 inches, is almost black friable silt loam containing an abundance of organic matter. The subsoil is light grayish-brown or grayish-yellow silty clay splotched with white concretions of lime and a few rusty-brown spots. The soil is very limy in most places. Ordinarily the subsoil is heavier than the topsoil, but it is not tough or plastic and is readily penetrated by plant roots and moisture.

About 90 percent of this soil lies from 3 to 4 feet above the other bottom soils and is subject to overflow only rarely. Most of the remaining 10 percent is too wet for cultivation and is left in pasture. A small poorly drained area about 3 miles east of O'Connor in section 25 has developed an alkali claypan. Another poorly drained area is in section 5, 1 mile northwest of Scotia.

The Lamoure soil ranks with the Wabash soil as one of the most productive in the county for corn and alfalfa, and the cultivated areas are used chiefly for these crops. It also produces high yields of clover and is one of the best soils for potatoes. During dry seasons the roots of all the crops mentioned reach the water table more readily than do the roots of small grains. Yields of small grains, however, are large on the Lamoure soils.

Owing to its high content of silt and clay, this soil cannot be cultivated under so wide a range of moisture conditions as the very fine sandy loams and other coarse-textured soils of the county.

The average acre yield of corn is about 35 bushels, wheat 15 bushels, alfalfa 3½ tons, and clover 1½ tons.

Lamoure very fine sandy loam.—Lamoure very fine sandy loam is similar to Lamoure silt loam in all characteristics, except the texture of the topsoil, which is modified by a larger content of very fine sand and fine sand. The upper part of the subsoil is generally slightly more sandy in the very fine sandy loam. The sand facilitates tillage operations, and the soil can be cultivated under a wider range of moisture conditions than can the silt loam.

The relief is almost level, but the slopes are sufficient for adequate drainage, except in a few small areas. This soil, like the silt loam, occurs as low benches several feet above the other bottom-land soils and is rarely subject to inundation. Nevertheless, it has not developed distinct horizons so characteristic of well-drained soils.

This soil occurs in small patches along Cedar and North Loup Rivers. About 90 percent of the land is cultivated and is used for the same crops as are grown on the finer textured Lamoure soils. Yields of small grains are slightly less than on the silt loam, but yields of other crops are about the same.

EXCESSIVELY DRAINED SOILS

Within the group of excessively drained soils are those which have a low water-holding capacity, owing to the porous character of their subsoil layers or their inability to receive water, the latter on account of the steepness of the slopes on which they occur. The O'Neill soils occur on terraces and the others on the rolling to hilly uplands.

The Colby soils, which occupy the more steeply rolling and hilly parts of the uplands, have developed from loess. The soils of the other series represented in the group are composed chiefly of loose sands and have very porous subsoils. The sand soils occur mainly in the north-central and northern parts of the county, although the O'Neill soils are also in the southwestern part in the North Loup River Valley.

The Thurman and O'Neill soils have dark topsoils, owing to an abundance of organic matter, and the rest of the soils of the group are characterized by light-colored surface soils with a low content of organic matter. Either because of the steepness of the slopes or because of the porous character of the subsoil material, the soils of this group are unable to retain for crop purposes as much of the moisture which falls on the land as is retained by any of the well-drained soils of the uplands and terraces.

The cultivated land of the Colby soils is confined to some of the more gradual slopes, where the topsoils have accumulated the largest quantity of organic matter. Yields of grain and tame hay on these soils, however, are lower than those on any of the well-drained soils of the uplands or valleys, because less of the precipitation sinks into the ground for crop use. The prevention of erosion is an important factor on these soils. All the crops commonly grown in the county are produced on them, but not extensively.

Some of the sandy soils of this group have rather incoherent topsoils which are subject to drifting during dry windy weather. Only about 15 percent of the land occupied by them is cultivated, and the rest is used for pasture and hay land.

Corn is the principal crop on the excessively drained soils and covers about 75 percent of the cultivated area. Other important crops are oats, sweetclover, rye, and alfalfa. Yields are noticeably lower on all the soils of this group than those on any well-drained soil.

The Colby soils are characterized by a high lime content, whereas the other soils of the group are low but not deficient in this constituent.

Colby silt loam.—Colby silt loam is the most extensive soil in the county. It occurs in all parts of the loessial uplands wherever erosion has thinned or entirely removed the dark topsoil.

This soil lies from a few feet to several hundred feet below the remnants of the old loess plain on which the Hastings soil is developed. It occupies numerous elongated bodies of irregular outline on the higher and lower divides and slopes.

The topsoil, which in most places is 6 inches or less in thickness, is dark grayish-brown or very dark grayish-brown friable silt loam. In most places the material in the topmost 2- or 3-inch layer is darkest, owing to a larger percentage of organic matter. The organic material, however, decreases rapidly with depth and is practically absent below a depth of 12 or 14 inches. The subsoil is light-gray or grayish-yellow floury silt, which grades at a depth of about 20 inches into the very light gray or almost white parent loess. The subsoil, and in many places the topsoil, are very limy. The lime occurs in finely divided form and is evenly distributed throughout the soil mass. In many places, where areas of this soil lie adjacent to areas of Holdrege silt loam, and also in small local spots within areas of the typical soil, the topsoil is thicker—in places 8 or 10 inches thick. In other small

bodies on the rounded shoulders of hills and steep slopes the dark surface soils have been greatly thinned or entirely removed. These variations are too small and scattered to warrant separate mapping.

The agricultural importance of Colby silt loam in this county is greatly impaired by its unfavorable relief and shallow topsoil. About 50 percent of the land is under cultivation, and the rest supports a good growth of nutritious pasture grasses, including big bluestem, grama, and buffalo grass. The native grasses, when pastured, will support more cattle or sheep than those on the sandier soils. Corn, oats, barley, alfalfa, and sweetclover are the most important cultivated crops. Yields are controlled largely by moisture conditions and the care used in cultivation. In general, crop yields are about 25 percent lower than on Holdrege silt loam. Corn averages about 20 bushels an acre; oats, 20 bushels; barley, 22 bushels; and alfalfa, 1½ tons. In dry years corn yields are almost as high as on the more level upland soils. The low proportion of nitrogen to potash, calcium, and phosphorus in Colby silt loam is conducive to a comparatively small stalk growth in proportion to grain. The subsoil is slightly less compact and heavy than the subsoils of the Holdrege and Hastings soils, consequently more of the moisture supply is available for plant growth during dry seasons.

It is an advantage to use every practical means to conserve and increase the supply of organic matter in this soil and to prevent erosion. Alfalfa and sweetclover are valuable crops for this soil and should be grown more extensively than on the more nearly level areas of the upland. Stands of both crops are easily obtained, owing partly to the high content of lime near the surface.

Colby silt loam, broken phase.—Colby silt loam, broken phase, includes the rougher and more severely eroded areas of loessial upland. The surface material has been removed by erosion to such an extent that the ash-gray loose calcareous silt of the unweathered loess is exposed in many places. A small quantity of organic matter gives the shallow surface soil of this phase a darker color than the subsoil, but the light-gray limy loess is nearly everywhere within a depth of 10 inches.

This soil occurs extensively throughout the uplands wherever stream erosion has prevented the accumulation of much organic matter on the loessial deposits. Most of the soil occupies narrow irregular-shaped strips on steep slopes along short intermittent drainageways and on sharp crestlike divides. Soil slipping is common, and the steeper slopes present a succession of short vertical exposures locally known as catsteps.

This land as a whole is too rough for cultivation. It supports a good growth of nutritious pasture grasses, including big bluestem, little bluestem, grama, and buffalo grass, which will support from 125 to 150 head of cattle to a section (640 acres) during a normal grazing season. The number of animals should be kept well within the carrying capacity of the range, as heavy grazing destroys the protective covering of grass and results in excessive erosion. About 2 percent of the land is under cultivation, mainly to corn, sorghum, and alfalfa. Yields are lower than on the less eroded Colby soils, and cultivation is difficult, owing to the steepness of the slopes.

Colby very fine sandy loam.—Colby very fine sandy loam occupies only a small total area. It occurs mostly near the edge of the

loessial uplands in the central and northwestern parts of the county. Scattered areas are north of Horace. One of the largest developments is about 5 miles southwest of Spalding.

This soil is similar to Colby silt loam, although the surface soil and upper part of the subsoil contain more very fine sand and fine sand.

A few small areas of Colby fine sandy loam are included with this soil. These were too small and scattered to justify making a separation on the soil map, particularly as they do not change the agricultural value of the land. In a few places, the subsoil of Colby very fine sandy loam contains a larger quantity of sandy material than is typical, and lime is not present within a depth of 30 inches. This soil has about the same type of relief as the silt loam. About 40 percent of the land is cultivated. Alfalfa and small grains yield slightly less than on Colby silt loam, but corn and oats give almost the same yields. Owing to its coarser textured surface soil, the very fine sandy loam can be cultivated under a wider range of moisture conditions than the finer textured soils.

Erosion is a serious problem on this soil, and more of the land should be left in pasture or sown to alfalfa and sweetclover, which also would increase the organic-matter and nitrogen content and retard soil washing.

Thurman fine sandy loam.—Thurman fine sandy loam has a sandy texture throughout. The 8- to 12-inch topsoil is very dark grayish-brown friable fine sandy loam containing much organic matter. Below this, and continuing to a depth of 30 inches, the material is grayish-yellow moderately coherent loamy fine sand or fine sandy loam. This is underlain by loose fine sand or loamy fine sand. In no place is the subsoil heavier than fine sandy loam. In a few places, the surface soil is very fine sandy loam and locally the organic matter, which produces the dark color, extends downward to a depth of about 14 inches.

Thurman fine sandy loam is scattered throughout the sandier sections of the county, but it occurs only sparsely in the two northwest townships. Most of the bodies lie between the typical sand hills and the loessial uplands. The soil occurs in close association with areas of Anselmo and Valentine soils. The largest body is 2 miles southwest of Belfast.

Areas of this soil are slightly undulating or gently rolling. The soil has developed mostly from fine sand which has lain in its present position long enough to have accumulated an abundance of organic matter which produces the pronounced dark color in the surface layer. Most of the precipitation is rapidly absorbed by the organic matter in the topsoil and the porous sand of the entire soil mass.

About 60 percent of the land is under cultivation. Yields of crops are considerably lower than on soils of the well-drained group and slightly lower than on Colby silt loam, Colby very fine sandy loam, and O'Neill fine sandy loam. The soil, however, warms up early in the spring, is easy to manage and may be used advantageously for truck crops for which early maturity is desired. Areas occurring in association with Valentine sand are used principally for the production of corn, as cattle ranchers use an abundance of grain feed to supplement the hay ration for cattle during the winter.

Acre yields of corn are about 16 bushels, oats about 16 bushels, and sweetclover about 1 ton. Alfalfa, wheat, and barley are not adapted to the soil, and yields are poor.

The chief problem in managing this soil is conservation of moisture and organic matter. Additions of barnyard manure and the growing of sweetclover will, to some extent, solve these problems. Sweetclover grows better than alfalfa on this sandy land and is more beneficial as a soil builder.

Thurman loamy fine sand.—Thurman loamy fine sand is similar to Thurman fine sandy loam, but it has a larger content of fine sand and contains less organic matter in the upper part of the profile, and is generally slightly more porous and sandy in the lower part.

The 7- to 10-inch surface layer is very dark grayish-brown friable loamy fine sand. The material becomes lighter in color with depth, but the texture continues as loamy fine sand to a depth of about 30 inches, where it changes to loose sand.

The relief is about the same as that of Thurman fine sandy loam which is closely associated with this soil. The loamy fine sand occurs in small bodies scattered throughout the sandier northern part of the county. One of the largest areas is about 1½ miles southwest of Belfast.

Drainage is excessive, owing to the porous character of the subsoil. The land is considered too droughty to be of much agricultural importance and is subject to considerable drifting when cultivated. This is considered good grazing and wild-hay land, as it supports a fairly dense growth of grasses. About 120 head of cattle can be pastured on a section during the summer grazing season—June to October, inclusive.

About 45 percent of the land is cultivated, mainly to corn. Yields are about 10 percent lower than those on Thurman fine sandy loam and slightly higher than those on the Anselmo or Valentine loamy fine sands. Corn averages about 14 bushels an acre, oats 14 bushels, and sweetclover three-quarters of a ton. Vegetables do fairly well in normal seasons, but yields are not so high as on the fine sandy loam soils.

O'Neill fine sandy loam.—O'Neill fine sandy loam occurs in small irregularly shaped bodies or strips on terraces in nearly all of the stream valleys. The largest developments are along North Loup River and North Branch Spring Creek. Smaller, more scattered, areas lie along Wallace and Freeman Creeks, Cedar River, and a few of their larger tributaries. The largest body is about 1 mile southwest of Greeley. This soil has developed on sands washed down from the adjoining sandy uplands and from sandy areas to the northwest and deposited on the valley floors when the streams were flowing at higher levels.

O'Neill fine sandy loam is similar to Thurman fine sandy loam of the rolling uplands in color and structure. The topsoil, to a depth of 10 or 12 inches, is very dark grayish-brown fine sandy loam containing an abundance of organic matter. The subsoil in most places is light grayish-yellow slightly coherent loamy fine sand, but in some places it is friable coherent fine sandy loam. The fine mineral material and the organic matter in the topsoil gives that layer considerable stability and prevents it from drifting badly under cultivation.

The relief is nearly level or gently undulating. Surface drainage is not established, as all excess water is rapidly absorbed by the porous subsoil. The soil is able, however, to retain considerable moisture and is less droughty than the other sandy soils.

O'Neill fine sandy loam is a fair farming soil and is easily maintained in good tilth. About 65 percent of it is cultivated and the rest is used for pasture and hay land. Of the cultivated crops, corn, alfalfa, oats, and sweetclover are the most important. Yields are somewhat lower than those obtained on Waukesha silt loam and slightly better than those on Anselmo fine sandy loam. Owing to its more nearly level relief, the soil ranks in value slightly above Thurman fine sandy loam. The average yield of corn is about 17 bushels an acre; oats, 18 bushels; and alfalfa, 1½ tons. Alfalfa does best in places where the water table is within reach of its roots; that is, within a depth ranging from 15 to 20 feet. O'Neill fine sandy loam is well adapted to vegetables, particularly in places where the land is irrigated. Wheat and barley do better on heavier textured soils.

Included with mapped areas of O'Neill fine sandy loam are small scattered bodies of O'Neill very fine sandy loam, aggregating less than 320 acres. Had this soil been more extensive, it would have been described separately. One of the largest bodies occurs along Freeman Creek in the south-central part of sec. 12, T. 19 N., R. 10 W. An area is in the west-central part of section 34, about 2 miles southeast of Spalding. Smaller bodies are along North Branch Spring Creek, and in the valleys of North Loup and Cedar Rivers. This soil is essentially the same as O'Neill fine sandy loam, but it has finer textured topsoil and upper subsoil layers and the material is somewhat more coherent. The textural difference, however, causes only a slight difference in crop yields in favor of the very fine sandy loam. The included soil is somewhat more retentive of moisture, and crops suffer less from drought during dry seasons.

Other areas of O'Neill very fine sandy loam, which are included with O'Neill fine sandy loam in mapping, occur on the terraces of North Loup River, Freeman Creek, North Branch Spring Creek, Wallace Creek, and Cedar River, and on the high terrace from 2 to 5 miles southwest of Spalding. The surface soil in these areas is similar to that of typical O'Neill fine sandy loam, except that it contains a larger proportion of very fine sand. The subsoil in most places is fine sandy loam and is heavier than the corresponding layer of the typical soil. It is nearly everywhere underlain by loamy sand. The greater part of this soil is more productive than typical O'Neill fine sandy loam. In normal seasons corn yields 30 bushels to the acre; oats, 32 bushels; wheat, 14 bushels; and alfalfa, 2½ tons.

A fine sandy loam with a subsoil somewhat heavier than that of typical O'Neill fine sandy loam occupies a few small areas on the terrace southwest of Spalding. It is underlain by a sandy substratum. This soil is not so productive as the very fine sandy loam, but yields of crops are somewhat higher than on typical O'Neill fine sandy loam.

O'Neill loamy fine sand.—O'Neill loamy fine sand is similar to O'Neill fine sandy loam, except that it has a larger proportion of sand and fine sand and a smaller proportion of organic matter in its upper layers. Like the other terrace soils, it has developed from alluvial

material carried down and deposited by the streams when they were flowing at higher levels. The relief of both the high and the low terraces ranges from almost level to gently undulating.

This soil is mapped along the larger streams, including North Loup and Cedar Rivers and Freeman, Wallace, and North Branch Spring Creeks. The largest body includes the town of Greeley. An area comprising more than a square mile lies 1 mile west of Greeley.

The 8- or 10-inch topsoil of O'Neill loamy fine sand is dark and contains a good supply of organic matter. The subsoil is incoherent sand or loamy fine sand. It it light grayish brown in the upper 5- or 6-inch layer and yellowish gray in the lower part. The soil is not retentive of moisture and when cultivated has a slight tendency to drift.

About 50 percent of the land is under cultivation, principally to corn. Small grains do poorly on account of the incoherent character, low water-retaining power, and lack of stability of the soil. Some oats, rye, sweetclover, and alfalfa, however, are grown, mostly in the lower lying and more protected situations. Yields of all crops are low in comparison with those on other terrace soils. Corn averages about 12 bushels to the acre, oats 12 bushels, alfalfa 1¼ tons, and sweetclover three-quarters of a ton. Vegetables mature early on this soil, and yields are good if the soil is irrigated. Pasture grasses are not so luxuriant as those on the finer textured soils, and only about 120 or 130 head of cattle can be supported on a section (640 acres) of land during the grazing season.

The chief problems in managing this soil are the conservation of moisture and the prevention of wind erosion. Listing the corn and applications of barnyard manure will partly solve these problems.

A sandier and less productive phase of O'Neill loamy fine sand occurs in small bodies along Cedar River and Freeman Creek and in one narrow strip west of Greeley on North Branch Spring Creek. These areas are too small to indicate separately on the soil map. The soil in them has developed largely from alluvial sands deposited on former flood plains of streams which are now flowing at lower levels. Surface wash from some of the surrounding soils has also contributed to its formation. The 8- to 10-inch topsoil is grayish-brown loose incoherent sand, the upper 4 inches of which are slightly darker than the lower part, owing to the presence of a small quantity of organic matter. There is not enough organic material, however, to prevent the soil from drifting. The upper part of the subsoil consists of light grayish-brown loose sand which is practically devoid of organic matter, and the rest of the soil is incoherent gray sand. The relief is almost level or gently undulating and is modified in a few places by low rounded hummocks and ridges of sand. Internal drainage is rapid, owing to the loose porous character of the soil to a depth exceeding 4 feet.

This included soil is a poor farming soil, owing to its low moisture-retaining power and its tendency to drift when cultivated. About 10 percent of it is cultivated, and the rest supports a fair growth of sandgrass and grama. The cultivated land is used principally for corn, which yields from 5 to 10 bushels an acre. Some cantaloups and watermelons are grown, and yields are fair in seasons of good rainfall.

Anselmo fine sandy loam.—Anselmo fine sandy loam occupies only a small total area. It occurs as small irregular-shaped bodies throughout the sandy upland. The largest lie between the loessial uplands and the sand hills.

This soil is closely associated with the Thurman and the Marshall soils. It differs from the former in having a lighter colored topsoil that is less abundant in organic matter. The 6- to 8-inch topsoil is light grayish-brown coherent fine sandy loam containing some organic matter. The upper subsoil layer is light grayish-yellow loose fine sandy loam practically devoid of organic matter. The lower subsoil layer, to a depth of 36 inches, is pale grayish-yellow friable fine sandy loam containing some silt. The silt in this layer is presumably Peorian loess which has blown in from nearby loessial deposits. The material below a depth of 36 inches is loose gray sand similar to that beneath the Valentine soils.

Included in mapped areas of Anselmo fine sandy loam are several bodies of Valentine loamy fine sand, which are too small to separate on a small-scale map. The relief ranges from gently undulating to gently rolling and is characterized by slight depressions and low rounded ridges produced by recent wind action. Drainage is good. The porous surface soil and subsoil readily absorb the surplus moisture.

About 55 percent of Anselmo fine sandy loam is cultivated, and the rest is used for pasture and wild hay. This soil is slightly less productive than Thurman fine sandy loam, as the organic matter and silt are not sufficiently abundant to prevent the sand, of which the soil is largely composed, from drifting, especially during prolonged periods of dry, windy weather. Corn is the most important crop and yields from 12 to 18 bushels an acre. The average yield of oats is about 14 bushels and that of sweetclover three-quarters of a ton. Small grains do not make good returns, on account of the loose sandy character of the seedbed and the impaired stands caused by exposure of the roots through soil drifting.

This soil is greatly in need of organic matter and nitrogen, in order to increase its productiveness and water-holding capacity. Manures and legumes are the logical and only practical means of supplying the greater part of these necessary materials, and they should be relied on largely for this purpose. A system of livestock farming, with plenty of sweetclover in the crop rotation, would tend to improve the land.

Anselmo loamy fine sand.—Anselmo loamy fine sand resembles Anselmo fine sandy loam, although its surface soil and upper subsoil layer contain a smaller proportion of the finer soil materials and slightly less organic matter. The subsoils, below a depth of 20 inches, are very similar in both soils.

Anselmo loamy fine sand occurs in small bodies throughout the sandy uplands in the northern half of the county, but it is less extensive in the high sand-hill areas than in the lower lying sandy belt bordering the loessial upland. It has about the same relief as Anselmo fine sandy loam, but it offers less resistance to wind erosion and, in places, is slightly more hummocky.

About 40 percent of the land is under cultivation. It is rather droughty, and low yields of crops are obtained unless the rainfall is above normal during the growing season. In most years, crops yield

about 25 percent less than they do on Anselmo fine sandy loam or Thurman fine sandy loam.

The content of organic matter has been depleted largely through cropping. The cultivated land is in need of clovers and manure, in order to restore the humus. More of this soil should be left in pasture, in order to prevent soil blowing.

Valentine loamy fine sand.—Valentine loamy fine sand occupies only a small total area and is of minor agricultural importance. Widely scattered small bodies occur throughout the sandy uplands. The largest areas are northwest of Greeley.

This soil differs from Valentine sand in that it contains a larger quantity of organic matter and more fine-textured material in the topsoil. The 8- to 10-inch surface soil is grayish-brown or dark grayish-brown rather incoherent sand or loamy fine sand, which contains sufficient organic matter to give it a loamy character. It does not contain enough of this material, however, to prevent the soil from drifting where not protected by a cover of vegetation. The subsoil is light grayish-brown or grayish-yellow incoherent sand. In many places it contains sufficient fine material to be a loamy sand. The mass may be slightly sticky when wet.

The relief as a whole ranges from slightly undulating to rolling, and in places it is hummocky or slightly choppy. Some areas have a smooth, almost level surface, especially those in small valleys or depressions within areas of Valentine sand. Drainage is entirely subterranean, as the loose porous sands afford ample outlet for all surplus water.

This is a better soil for cultivated crops than is Valentine sand. About 25 percent of it is under cultivation, and the rest supports a fair growth of grass, consisting chiefly of sandgrass and needlegrass. This soil has about the same value for grazing and for the production of hay as the loamy fine sands of the Anselmo and the Thurman series, and it is a better soil for farming, pasture, or hay land than O'Neill loamy fine sand or Valentine sand. Corn is the leading cultivated crop and is followed in importance by oats and sweetclover. The average yield of corn is about 10 bushels an acre and of oats 8 or 9 bushels. Wheat and barley are not adapted to this sandy soil, owing to the sandy unstable character of the seedbed.

Large quantities of barnyard manure should prove very beneficial in building up the organic-matter content and stability of this soil. It is advisable not to disturb the soil until ready to plant, as it should not be left unprotected longer than absolutely necessary.

Valentine sand.—Valentine sand is extensively developed in this county. It occurs in bodies of various sizes scattered throughout the northwestern and central parts. The largest body, which comprises nearly 50 percent of the total area, extends from a point 2 miles north of Belfast to a point within 1 mile of Greeley. Small bodies of other soils occur within this area.

The surface soil of Valentine sand consists of loose incoherent grayish-brown sand to a depth of 8 or 10 inches. The upper 4-inch layer is, in most places, slightly darker than the lower part, owing to a larger content of organic matter. The subsoil consists of loose incoherent gray sand which extends to a depth exceeding 5 feet. The color and depth of the surface soil vary with the topographic position. On the more level areas and in shallow depressions, where

conditions have been most favorable for the growth and decay of vegetation, the topsoil is somewhat darker and deeper than elsewhere. On the crests of the low rounded knolls and ridges the organic matter has largely been removed by the wind, leaving the soil shallow and of a prevailingly light color.

In general, the relief is undulating or rolling, but it is modified in many places by a pronounced hummocky topography. There is no surface run-off, as the precipitation rapidly percolates into the porous sand. The soil has been entirely leached of lime.

Valentine sand is of little value for crop production, on account of its low water-retaining capacity, low content of organic matter, and unstable character. Not more than 10 percent of it is under cultivation. A few of the favorably situated areas in depressions, where crops can receive some moisture through seepage, are used for the production of corn. Sweetclover does fairly well, provided a stand can be obtained in the loose seedbed. Small grain is seldom grown, and yields are very low. Corn yields from 6 to 10 bushels an acre, except in the more favorable areas mentioned, where yields may range from 15 to 20 bushels.

Most of this land remains with its original covering of grasses and is used for grazing cattle and the production of wild hay. The grasses do not grow so luxuriantly as the grasses on the finer textured soils, and only about 100 head of cattle can be supported on a section of land.

Dune sand.—Dune sand occupies a large total area. Most of it occurs as one large body which covers about 75 percent of the two northern townships in the western half of the county and extends east into adjoining territory.

Dune sand is not a soil. It consists of gray or grayish-brown incoherent fine sand or medium sand, which extends to a depth of 3 feet or more, with no marked change in texture, color, or structure. The material in the surface layer contains practically no organic matter, aside from that in undecomposed plant remains and the living grass roots.

The topographic features of dune sand are the result of wind action. The relief is sharply rolling or hilly. The sand is ridged and heaped into dunes ranging in height from 15 to 60 feet. Steep slopes abound. Numerous small hummocks, hollows, and blow-outs vary the otherwise billowy appearance of the landscape.

Dune sand has no value for farming. Isolated patches have been cultivated, but the material is so subject to blowing that removal of the native vegetation ruins the land. The land is used mostly for pasture, although the grasses from some small depressions and smoother areas are cut for hay. The native vegetation consists chiefly of a sparse growth of *Redfieldia*, needlegrass, and sandgrass. This land supports only 75 or 100 head of cattle on a section during the summer grazing season. When the grass is cut for hay, yields of about one-quarter of a ton an acre are obtained.

The preservation of the native grasses is essential to the utilization of this land. On patches or slashes along old roads and near watering tanks, where the wind has had an opportunity to work, the bare surface plainly shows the disastrous effects of disturbing the soil-binding roots. Care must be taken to control fires which burn off the protective covering of grasses.

POORLY DRAINED SOILS

The poorly drained soils comprise only a small total area. The group consists almost entirely of soils of the Cass series. There are a few poorly drained soils aside from the Cass soils, but they are of such small extent that they are not indicated on the soil map. Most of them have been described with the soils with which they are associated.

The Cass soils have developed from recently deposited sandy alluvium. The coarser textured members have developed almost entirely from sands, and the finer textured soils from sandy material containing small quantities of silt and clay. These soils occur most extensively along North Loup and Cedar Rivers and in scattered narrow strips along all the larger streams that rise in the sandier parts of the county.

The relief is nearly level, except where the land is traversed by old and present stream channels or modified by slight elevations and shallow depressions. These soils are subject to overflow from the main streams, but the flood waters soon drain off.

The water table lies within 10 feet of the surface, and in most areas along Cedar and North Loup Rivers, it is within a depth of 5 feet. In the latter areas, only shallow-rooted crops are grown successfully. The subsoil is kept well supplied with moisture, even during the driest years. In places where the water table is unusually high, the land remains too wet for optimum growth of grain and alfalfa.

The moist condition prevailing in the bottom lands has been conducive to the accumulation of organic matter. In many places, however, the dark organic layer is thin and disappears rapidly under cultivation, especially in the more sandy soils. Less than 10 percent of the Cass soils along North Loup and Cedar Rivers is cultivated, but about 35 percent of the area occupied by them along the smaller streams is under cultivation. The water table lies deepest in the latter areas.

Corn occupies most of the cultivated land. Alfalfa is adapted to these soils, wherever the water table is more than 5 feet below the surface of the ground. Small grains grow rapidly, but, owing to the abundant moisture supply, they have a tendency to produce long weak stems at the expense of the grain, and yields are lower than on the soils lying at higher elevations. The chief obstacles in the management of these soils are lack of drainage and the danger of damage from flooding. Some of the areas could be artificially drained. These soils are especially suited for pasture and hay land, as a luxuriant growth of nutritious grasses covers the uncultivated areas. A few narrow strips of woodland border the channels of the larger streams.

Most areas of the Cass soils are limy, especially those along North Loup and Cedar Rivers.

Cass loam.—Cass loam is the most extensive poorly drained soil. It occurs mainly along Cedar and North Loup Rivers and less extensively along smaller streams. This soil has developed from water-laid deposits consisting largely of sands and silt, which have been stationary long enough to have accumulated an abundance of dark, almost black, organic matter in the surface soil.

The land is nearly level, and surface drainage is generally adequate for crops, except in the lower situations which for the most part are places where the water table is within a depth of 2 or 3 feet.

The topsoil is very dark grayish-brown or almost black friable mellow loam to an average depth of about 9 inches. The subsoil is composed of loose gray or grayish-brown fine sand which is slightly loamy in the upper part, owing mainly to a small content of organic matter. The subsoil is generally limy.

About 20 percent of the land is cultivated, and the rest, including the more poorly drained bodies and those on which trees interfere with cultivation, is used for pasture and hay land. Corn is the leading cultivated crop, and alfalfa and sweetclover rank next. Yields are generally higher than those obtained on the well-drained upland soils, but they are slightly lower than those on the better drained terraces or bottom lands. The average yield of corn during normal years is about 30 or 35 bushels an acre, and of alfalfa 2 or 2½ tons. Only rarely is a crop badly damaged by flood waters.

Cass loam is one of the best pasture soils in the county. It is excelled for this purpose only by the Wabash and Lamoure soils which are not, however, left in pasture to a great extent. From 75 to 100 head of cattle can be supported on a quarter section during the grazing season. Wild hay yields from three-fourths to 1 ton an acre. Small grains grow well, but they usually produce a rank straw growth at the expense of the grain.

The higher lying areas of Cass loam can be cultivated without injury under a wide range of moisture conditions. The land warms up early in the spring and is particularly well suited to potatoes and truck crops.

Cass fine sandy loam.—Cass fine sandy loam occurs in small strips along Cedar and North Loup Rivers and to less extent along all the larger streams that have their origin in the sandier parts of the county.

This soil is similar to Cass loam, but its surface soil contains a larger proportion of fine sand and slightly less organic matter. The 7- to 10-inch topsoil is very dark grayish-brown friable fine sandy loam, and the subsoil is loose almost incoherent gray or grayish-brown fine sand or loamy fine sand. The subsoil is in general limy, except where the soil occurs along small streams, where it may be practically devoid of lime. In the latter situations the subsoil generally consists of fine sandy loam with considerable organic matter.

Cass fine sandy loam has the same smooth relief as Cass loam, and when farmed it is handled in the same manner. About 20 percent of the land is cultivated. Corn is the chief crop and occupies about 75 percent of the farmed area. Yields of all crops are from 5 to 10 percent lower than on Cass loam. Like the other Cass soils, the fine sandy loam is especially adapted to pasture and will support approximately 75 head of cattle on a quarter section of land. The native vegetation includes a great variety of prairie and water-loving grasses, together with some volunteer clover. Narrow strips of woodland border the stream channels.

Cass loamy fine sand.—Cass loamy fine sand occurs principally along Cedar River, North Loup River, and the larger streams that head in sandy sections. The largest body of this soil is in Cedar River Valley in the northern part of the county.

The topsoil is very dark grayish-brown friable loamy fine sand to a depth ranging from 6 to 10 inches. It contains considerable organic matter but less than the other Cass soils. The subsoil is loose almost incoherent gray sand containing scattered rusty-brown splotches.

The relief in general is smooth but is modified in places by slight depressions and abandoned channels. Drainage over most of this soil along the smaller streams is sufficient for crop cultivation in normal years, but along the rivers the water table is generally within 4 feet of the surface.

Only 12 or 15 percent of this soil is farmed. The same crops are grown as on Cass loam, but yields are about 15 percent lower. The land is best suited to pasture and wild hay, although slightly more luxuriant stands of grass grow on the other Cass soils.

Cass silt loam.—Cass silt loam is the least extensive poorly drained soil. Practically all of it occurs along Cedar and North Loup Rivers. This soil differs from Cass loam in the finer texture of its surface soil and upper subsoil layers. In places the surface soil is silty clay or silty clay loam, which may continue to a depth of 24 inches, where it gradually gives way to gray loamy fine sand or sand.

The land occupied by this soil is nearly level, and drainage is poorer than in the other Cass soils. In some places the soil is in shallow depressions, where the water table lies almost on a level with the surface of the ground.

This is an unimportant soil agriculturally, and only about 10 percent of it is cultivated. Yields on the better drained areas compare favorably with those obtained on the coarser textured poorly drained soils, and in dry years may be greater. As a whole, however, this soil is not considered so productive as Cass loam or Cass fine sandy loam for general farm crops, owing to its poor drainage and to the closeness of the water table to the surface. About 90 percent of the land is in pasture, for which it is best suited.

MORPHOLOGY AND GENESIS OF SOILS

Greeley County is in the Chernozem region of central United States. The climate, which is continental and temperate, together with a mean annual precipitation of 25.18 inches, has favored the annual growth and decay of a luxuriant grass vegetation. All the soils, except those on the steeper slopes or the most recently deposited or unstable sands, have accumulated much black well-decomposed organic material from the decaying grass vegetation and have developed dark, in many places almost black, topsoils. The moderate precipitation has not been sufficient entirely to leach the soils of their readily soluble salts, except over areas where it has been supplemented by run-off or in areas where the soils are unusually sandy and porous. In the normally developed soils, the soluble salts, chiefly calcium carbonate, have been leached only from the topsoils and have accumulated in the subsoils, producing a layer of higher lime content than occurs in any other part of the soil profile.

The parent materials of the soils of this county were derived from two principal sources. Peorian loess, a remarkably uniform light-gray calcareous silt, at one time probably covered the entire region. West of this county a vast area of sand was deposited by wind. Out-

liers of the sand hills enter the county and wind-driven sands have been deposited in greater or less quantity over the loess-covered plain. Nearly every soil in the county has had its surface layer modified to a greater or less degree by sand. In places the silt has also been moved by the wind and has formed strata in the sand or has become intermixed with it.

The principal soil-forming agencies, climate and vegetation, have, in most places, considerably altered the topmost part of the loess and the sand or gravel, as the case may be, and have produced the present soils. The effectiveness of the climate and vegetation in transforming the geological materials into soils in a particular locality has depended not only on the character of these materials but also on the relief and drainage conditions under which they have developed and on the length of time they have been subjected to undisturbed weathering. Most of the local differences in the soils are the results of differences in the surface features, which control the quantity of water entering the soil and the rapidity of the surface run-off. Especially is this true in all soils developed from the same geological formations. A few soil differences, however, particularly marked differences in the texture, coherence, and lime content of the subsoils, are largely the results of differences in the geological materials from which the soils have developed.

The soils in level or depressed situations, where surface drainage is slow or absent, have been subjected to the largest quantities of water and show well-marked characteristics, chief among which are more or less advanced stages of leaching, especially in the topsoils, and unless composed largely of sand or gravel, a large accumulation of clay in the subsoils. On strongly rolling or hilly areas, leaching and the accumulation of clay are negligible, but the rapidity of the surface run-off has greatly thinned or otherwise modified the topsoils through erosion, especially on strongly rolling or hilly areas of the more silty soils. The soils developed from sands or gravels are rather thoroughly leached, regardless of their relief. The sandy soils, however, show little accumulation of clay in their subsoils, partly because the quartzitic sands are extremely resistant to weathering and the formation of clay and partly because the soils are so porous that practically all fine material can pass through them in the underdrainage.

On undulating or moderately rolling areas the silty soils show neither excessive leaching and the accumulation of clay nor evidence of more than normal erosion. Practically all of them, except in stream bottoms, show evidence of having developed under good drainage and of having lain in their present position, undisturbed by severe erosion or excessive leaching, for a long time. They have accumulated an abundance of organic matter and have thick dark topsoils. They have also developed well-defined horizontal layers, or horizons, which occur in a definite order of succession and which differ from one another in one or more easily discernible characteristics, such as color, texture, structure, lime content, and coherence. These soils have been formed under the most favorable conditions for soil development afforded by the region. They have received the full impress of the regional climate and vegetation and may be regarded as fully developed soils of the Chernozem group.

All the rest of the soils have obviously formed under the same general climatic environment as the fully developed soils, and most of them have some of the characteristics common to those soils. One or more of the other environmental factors in soil development, however, such as resistance to alteration, duration of weathering of the parent geological materials, relief, drainage, and density of grass cover, have not been so favorable to soil formation as in the fully developed soils. One or more of the soil horizons is absent or poorly defined, and the soils are regarded as imperfectly developed.

The well-developed soils include the areas occupied by members of the Holdrege, Hastings, Waukesha, Hall, and O'Neill series.

A typical profile of one of the well-drained soils, which has reached a stage of development that may be regarded as mature, is given in the following description of Holdrege silt loam. This profile was observed three-eighths mile north of the southeast corner of sec. 1, T. 17 N., R. 11 W.

0 to 12 inches, very dark grayish-brown friable crumbly silt loam rich in organic matter. The color is almost black when wet. The lower part of the layer is made up of granules less than one-fourth inch in diameter. The organic matter, to a depth of 8 or 10 inches, is mixed through the soil material, but below this depth it forms a thin coating on the structure particles.

12 to 19 inches, yellowish-brown or grayish-brown slightly compact granular silty clay.

19 to 34 inches, grayish-yellow somewhat compact silty clay loam. The material has a cloddy or poorly developed prismatic form and is denser than that in the layers above and below.

34 to 54 inches, light grayish-brown floury structureless silty clay splotched with white spots, or concretions of lime.

54 inches +, grayish-yellow floury silt of the Peorian loess formation, in which lime is abundant in finely divided form and in scattered concretions.

Aside from slight differences in the texture, thickness, or compaction of some of their layers, most of the fully developed soils have profiles very similar to the one described. In the Hastings soils which have, as a rule, nearly level surfaces, more of the precipitation sinks into the ground than in the gently rolling Holdrege soils. Consequently, a greater translocation of clay downward has taken place, and the upper subsoil layers of the Hastings soils are considerably more compact than the corresponding layers of the Holdrege soils, but they nowhere attain the density of a claypan.

The Hall soils are very similar to the Hastings soils in all characteristics except topographic position. They occur on well-drained terraces.

The Marshall soils have developed from loessial material and resemble the Holdrege and Hall soils, especially in their upper soil horizons. The loessial material, which is unusually thin, however, in the Marshall soils, rests on sand above the depth of moisture penetration, and the soil material has been leached of lime.

The Colby soils are relatively immature. They have developed from loess of considerable thickness, but they occupy steep slopes, where run-off is rapid, and they have accumulated very little organic matter. The topsoil in most places is fairly dark but ordinarily does not exceed 5 or 6 inches in thickness and generally rests directly upon unweathered or only slightly weathered limy loess. In many spots the topsoil is very thin, and the almost white parent loess is exposed.

The other soils of the uplands and terraces are composed largely of sand, from which all lime has been leached. The O'Neill and Thurman soils, which are fairly stable, have reached rather advanced stages of development. Their thin topsoils are dark, owing to an abundance of organic matter, and they have well-oxidized grayish-brown upper subsoil layers. The lower part of the subsoil consists of loose gray sand. The Thurman soils are in the uplands, and the O'Neill soils are on the terraces.

The Anselmo and Valentine soils are low in organic matter and light in color from the surface downward. They consist mainly of sand, but the Anselmo soils contain sufficient silt to make them fairly coherent. The Valentine soils are very unstable and show no definite layers or horizons of true soil development.

None of the soils of the bottom land is old enough to have made much progress in soil development. They have, owing to the rank growth and rapid decay of water-loving grasses, accumulated much organic matter in their surface layers, and they have very dark topsoils. The subsoils have not developed definite soil horizons, or layers of distinct soil character.

The Wabash and Lamoure soils have developed from fine-textured sediments, largely silts. The coarse-textured flood-plain sediments, which consist largely of sand, have developed into the Cass soils. The Cass soils may or may not contain lime. In places where they do contain lime, the carbonates are in finely divided form and evenly distributed in the soil material. The topsoils, as well as the subsoils, in many places are limy. The Wabash soils are in general slightly acid and do not contain free lime, and the Lamoure soils contain an abundance of lime both in concretionary and disseminated form throughout most of the profile.

Table 4 gives the results of mechanical analyses of four soil profiles in this county.

TABLE 4.—*Mechanical analyses of four soil profiles in Greeley County, Nebr.*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Holdrege silt loam:								
377305	0–12	0.0	0.1	0.2	0.7	29.0	44.3	25.6
377306	12–19	.0	.1	.1	.3	25.6	43.0	30.8
377307	19–34	.0	.2	.2	.6	22.3	48.0	28.6
377308	34–54	.1	.2	.2	.7	25.7	50.4	22.6
377309	54–70+	.0	.3	.2	.7	29.0	47.6	22.2
Hastings silt loam:								
377310	0–16	.1	.1	.0	.6	17.0	50.6	31.5
377311	16–30	.0	.2	.1	.3	16.1	46.6	36.6
377312	30–50	.1	.2	.2	.7	18.2	48.4	32.2
377313	50–65	.2	.3	.2	.8	18.4	55.0	25.1
377314	65–80+	.0	.3	.3	.6	23.2	50.0	25.5
Marshall very fine sandy loam:								
377342	0–12	.0	.4	3.1	23.0	27.5	30.7	15.3
377343	12–22	.0	.4	3.3	20.6	25.0	29.7	21.0
377344	22–36	.0	.2	1.9	15.0	20.3	35.8	26.7
377345	36+	.0	.8	7.4	58.4	24.0	2.6	6.8
Wabash silt loam:								
377346	0– 1	.1	.2	.3	.5	10.8	53.6	34.5
377347	1– 8	.0	.2	.1	.5	18.2	54.9	26.1
377348	8–20	.0	.3	.2	.5	22.2	52.4	24.5
377349	20–30	.0	.3	.2	.5	21.0	47.0	31.0
377350	30–40	.0	.3	.2	.7	18.5	53.3	26.9
377351	40+	.0	.1	.1	.3	3.6	53.7	42.2

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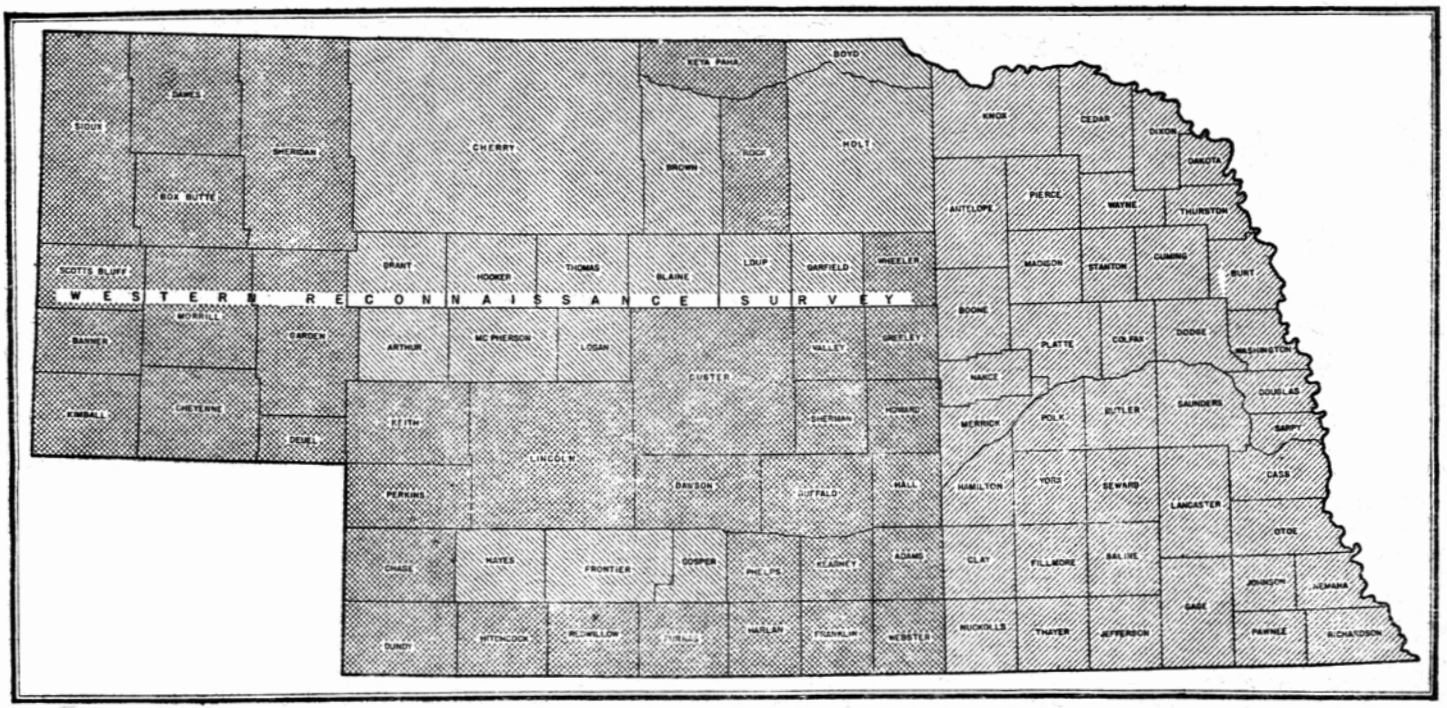
There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than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



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

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