

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF NEBRASKA,
G. E. CONDRA, DIRECTOR, NEBRASKA SOIL SURVEY.

SOIL SURVEY OF PHELPS COUNTY,
NEBRASKA.

BY

B. W. TILLMAN, OF THE U. S. DEPARTMENT OF AGRICULTURE,
IN CHARGE, AND B. F. HENSEL, OF THE
NEBRASKA SOIL SURVEY.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]



WASHINGTON:
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1919.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., May 31, 1918.

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of Phelps County, Nebraska, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1917, as authorized by law. This work was done in cooperation with the University of Nebraska.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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MAP.

Soil map, Phelps County sheet, Nebraska.

SOIL SURVEY OF PHELPS COUNTY, NEBRASKA.

By B. W. TILLMAN, of the U. S. Department of Agriculture, In Charge, and B. F. HENSEL, of the Nebraska Soil Survey.—Area Inspected by THOMAS D. RICE.

DESCRIPTION OF THE AREA.

Phelps County, Nebraska, lies in the south-central part of the State, in the second tier of counties north of the Kansas State line. It is bounded on the east by Kearney County, on the south by Harlan County, on the west by Gosper County, and on the north by the Platte River, which separates it from Dawson and Buffalo Counties. It is roughly rectangular, with an area of 538 square miles or 344,320 acres.

Phelps County is part of a vast plain upon which minor relief has been produced by stream erosion and by wind action. The less eroded section has a covering of silty materials and, on account of this, is known as the loess plain. It comprises about four-fifths of the area of the county, extending in a general northwest-southeast direction across the central part, forming the highest land in the county. The elevation along the Gosper County line varies from about 2,450 to 2,500 feet above sea level, while the elevation along the Kearney County line is approximately 2,250 feet. The general slope of the plain southeastward is about 8 feet per mile. This plain varies from flat to gently undulating. In places there are numerous narrow ridges 10 to 15 feet above the general level, and the surface is also modified by poorly drained depressions called basins. The basins are extremely variable in form, depth, and size. Some are only a few feet deep and 25 to 50 feet wide; others are 15 to 20 feet deep and cover 250 to 300 acres. During rainy seasons these depressions hold water, but even the deepest and largest of them dry out during the summer. The slopes from the plain to the stream terraces and first bottoms are gradual and everywhere cultivable, except in the southwestern part and the extreme northwestern part of the county, where they are abrupt.

Two areas of the upland have a more broken topography, the sandhill area in the northeastern part of the county, and the canyon

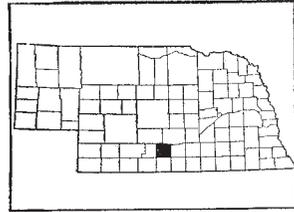


FIG. 1.—Sketch map showing location of the Phelps County area, Nebraska.

area in the southwestern part. The dune belt is 1 to 3 miles wide and extends along the southern border of the Platte Valley from a point 14 miles north of Holdrege to the Kearney County line. The slopes are rounded and the form of the hills is suggestive of wind action. There is no well-defined system of surface drainage. The few streams that exist gradually become obliterated, and many small basins receive the surface water and form ponds during rainy spells.

The canyon area extends along the Gosper County line from a point one-half mile south of Bertrand to Harlan County and east to within a few miles of Atlanta. Another small, inconspicuous area lies 4 miles south of Holdrege, extending south to Harlan County. The total area of this kind of land is approximately 38 square miles. It is thoroughly dissected by an intricate network of deeply-trenched ravines which have reduced the surface to steep, abrupt slopes, leaving only blocklike flats of the original plain. Small landslides are a prominent feature of this region. The depth of the dissection varies from 75 to 100 feet or more. Cultivation of the greater part of this land is difficult.

The alluvial land in Phelps County consists mainly of flood plains, or first bottom, with less extensive terrace or second-bottom areas. The terrace forms a continuous narrow strip in the northwestern part of the county bordering the Platte Valley on the south. It lies about 25 feet above the first bottom and 20 to 25 feet below the adjoining upland. The surface is flat or slopes toward the valley. The slope both to the first bottom and to the upland is generally gradual, though in places it is rather abrupt.

The first-bottom land, which is subject to overflow or lies only slightly above the flood level, forms a belt 1 to 2 miles wide along the Platte River. It is flat except where broken by sandy ridges and overflow channels. The elevation of the bottom land along the Kearney County line, according to the United States Geological Survey, is 2,180 feet above sea level and along the Gosper County line 2,380 feet, showing an average fall of approximately 8 feet per mile.

The upland is estimated to be about 75 to 100 feet above the first bottom. The highest point in the county is given as 2,500 feet, which is the elevation of the loess plain about 4 miles northeast of Bertrand, and marks the summit of the divide between the Platte and Republican Rivers. This divide extends southeastward from the western county line 4 miles north of Bertrand, passing just north of Holdrege and out of the county southeast of Funk.

The Platte River, which borders the county on the north, is a broad shallow stream overburdened with sediment. It rarely causes damage by floods, although overflows do occur at times. Only the

north part of the county drains into this stream. On account of the limited rainfall all parts of the county except the basins of the upland plain may be said to be adequately drained, and drainage in the canyon area is excessive. The drainage of most of the southeastern part of the county is intermittent. The streams issue into basins from which the water evaporates during the summer.

Phelps County was formed in 1873. The early settlers came largely from eastern States. The population is made up largely of Swedes, Norwegians, Danes, and Germans. The total population in 1910 was 10,451, all but 3,030 of which is outside the city of Holdrege and is classed as rural, averaging 13.8 persons to the square mile. The population is evenly distributed, except that it is sparser in the sandhill and the canyon regions.

Holdrege, the county seat, is situated in the southeastern part of the county on the main line of the Chicago, Burlington & Quincy Railroad. It is the chief distributing center of the county. Loomis and Bertrand are thriving towns with populations of 500 to 700. Atlanta and Funk are other small railroad towns.

Transportation facilities are good. Lines of the Chicago, Burlington & Quincy Railroad cross the county in several directions and the main line of the Union Pacific Railroad, which passes through the adjoining county on the north bank of the Platte River, supplies shipping facilities for the northern part of the county. The various lines afford direct connections with such points as Denver, Cheyenne, Lincoln, Omaha, St. Joseph, and Kansas City, which form the principal markets for the products of the county. Holdrege furnishes a good local market for dairy products, poultry, and wheat.

The public roads of Phelps County follow section lines. Nearly every section line has a road except in the canyon and sandhill belts, where roads are hard to maintain. The Omaha-Lincoln-Denver Highway traverses the county through Funk, Holdrege, and Atlanta. The Lincoln Highway, a transcontinental road, parallels the Platte River just across the county border. None of the roads have been surfaced, but are constructed of the materials they traverse. The more important ones, including the main roads to Elm Creek, Loomis, and Bertrand, are well graded and are dragged after rains, but the minor roads are not well maintained. There is a minimum of washing on account of the low rainfall and the soils are extremely favorable in structure and texture for road building. Only a few bridges and culverts are needed.

CLIMATE.

The climate of Phelps County, like that of all south-central Nebraska, is well suited to the production of certain grain crops and alfalfa and to live-stock farming. The following table gives the

normal monthly, seasonal, and annual temperature and precipitation as compiled from the records of the Weather Bureau station at Holdrege:

Normal monthly, seasonal, and annual temperature and precipitation at Holdrege.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1914).	Total amount for the wettest year (1915).
	° F.	° F.	° F.	Inches.	Inches.	Inches.
December.....	28.2	65	-18	0.68	0.76	0.35
January.....	25.4	70	-26	.42	T.	.59
February.....	26.9	78	-43	.89	.40	1.15
Winter.....	26.8	78	-43	1.99	1.16	2.09
March.....	36.9	92	-9	1.02	.84	1.76
April.....	51.0	101	10	2.79	.95	3.63
May.....	60.7	102	-19	4.26	2.29	6.99
Spring.....	49.5	102	-9	8.07	4.08	12.38
June.....	71.4	106	38	3.99	2.21	9.13
July.....	76.6	110	42	3.32	2.87	7.48
August.....	74.9	108	42	3.37	2.45	6.20
Summer.....	74.3	110	38	10.68	7.53	22.81
September.....	67.0	115	25	2.02	1.44	2.60
October.....	52.8	96	7	1.53	2.05	.50
November.....	38.6	88	-8	.60	0.00	.35
Fall.....	52.8	115	-8	4.15	3.49	3.45
Year.....	50.9	115	-43	24.89	16.26	40.73

The mean annual precipitation is 24.89 inches, of which 14.94 inches or 60 per cent falls during May, June, July, and August, which constitutes the main growing season. The mean annual precipitation for the driest year on record (1914) was 16.26 inches as compared with 40.73 inches for the wettest. The driest months of the year are November, December, January, and February, which have a normal precipitation of approximately one-half to three-fourths of an inch. May and June have the heaviest precipitation. The rain usually comes in the form of thundershowers, during which the precipitation is usually heavy in short periods of time, but normally there is little loss of moisture through rapid run-off on account of the level topography and the absorptive capacity of the soils. Droughts rarely occur during May and June, but during July and August the rainfall is frequently light and of unfavorable distribution, which results in long dry periods. Unfortunately the greatest

degree of uncertainty as to summer rainfall is during July, when a deficiency is likely to affect the corn crop injuriously.

The mean annual temperature is 50.9° F. The hottest month is July, with a maximum of 110 F. The mean temperature for the summer months of June, July, and August is 74.3° F. December, January, and February have a mean temperature of 26.8° F. The coldest temperature recorded is -43° F., in February.

The average date of the first killing frost in the fall is October 6 and of the last in the spring May 2, making an average growing season of 155 days. The earliest killing frost in the fall on record occurred September 11 and the latest in the spring on May 18.

Periods of excessive heat accompanied by hot winds during the summer season occasionally cause injury to corn and pastures. Hailstorms, although uncommon, sometimes do damage.

AGRICULTURE.

Phelps County is essentially agricultural. Grazing was the principal occupation in the early days. As early as 1865 there were two small settlements in the northern part of the county, on the old freight and emigrant road. Following the construction of the Union Pacific Railroad along the north bank of the Platte River in 1866, the overland road in Phelps County fell into disuse and the settlements were abandoned, and for a few years after there was no settlement in the county. The first settlers cultivated only a few acres of crops to supply domestic needs. In 1872 there was a second influx of settlers in the northern part of the county and the following year witnessed the arrival of quite a number of pioneers. From about 1876 to 1880 the cultivation of wheat, corn, and other cereals began. Wheat was the money crop from the beginning, and its cultivation increased almost as fast as the prairies could be broken up. Flax and barley were quite extensively grown in the years 1878 to 1885, but the acreage devoted to these crops soon declined after more favorable areas farther west were reached by railway. Many varieties of winter wheat were tried during the period from 1880 to 1888, but they were not entirely successful and spring wheat became the main money crop. It was never entirely satisfactory, however, and its acreage greatly decreased before a hardy winter variety was obtained. In the meantime corn was grown in increasing quantities and in 1889 surpassed wheat in acreage, occupying 62,234 acres, as against 32,764 acres for wheat. About this time the growing of winter wheat received a great impetus, through the introduction by the Nebraska experiment station of a variety known as Turkey Red, which was originally imported from Russia. The remarkable growth of the winter-wheat industry from that date is shown in the increase

in acreage of this crop from 32,764 acres in 1889 to 77,433 acres in 1909. The acreage in corn has also shown constant increase. Alfalfa was first grown about 1900, and has steadily increased in importance. The area in oats showed little change from 1890 to 1910, but since then the production has decreased largely, on account of uncertain yields. Enough oats, however, are usually grown to supply the local demands. The production of hay is still an important industry, but the acreage has decreased rapidly since 1885 as more grain has been grown. Wild hay is being displaced by alfalfa and other tame grasses.

At the present time grain growing is the chief type of farming, with the raising of beef cattle and hogs as an important adjunct. The value of all cereals produced in 1909 was \$2,085,728, as compared with \$1,182,929 worth of live stock sold or slaughtered and \$216,285 worth of dairy products, poultry, and eggs sold. According to the Nebraska State Board of Agriculture, the value of the corn, wheat, and oats produced in 1916 was \$3,823,287.

Wheat has always been the leading cash crop. At the present time winter wheat is grown practically to the exclusion of spring wheat, the acreage devoted to winter wheat in 1916 being 95,294 acres as against 88 acres of spring wheat. The average yield of winter wheat was 21 bushels per acre. The acreage in 1917 was probably larger than in 1916, owing to the higher prices. Turkey Red winter wheat continues to be the main variety. It is much more profitable than spring wheat ever was. This variety is being kept pure by the more progressive farmers, but on many farms it has been mixed with other strains. Wheat is usually thrashed from the shock, and most of the grain is sold direct from the machine, but there is a tendency in some neighborhoods to store the grain for advanced prices. About 130,000 bushels, or approximately 7 per cent of the total wheat produced, is ground into flour at two local roller mills. About 85 per cent of this flour is sold in the State of Nebraska.

Next to wheat, corn is the most important crop in Phelps County. In 1916, according to the State board of agriculture, the area in corn was 88,120 acres, yielding 23.9 bushels per acre or a total of 2,106,068 bushels, valued at \$1,263,641. On a large number of farms corn is a cash crop, but it is also extensively fed to live stock, principally beef cattle and hogs. The general tendency is to feed more of the crop as the acreage in alfalfa increases. Silage is receiving increased attention in connection with the raising of beef cattle, but as yet the number of silos in the county is too small. That part of the corn crop not used for silage is cut for fodder or husked in the field.

Moisture is the limiting factor in corn production in Phelps County. In years of adequate rainfall yields are easily double those of normal years. In general, the excess of rainfall in July above normal almost determines the increase in yield over the average. Tillage also is an

important factor. Corn is grown on all the soils of Phelps County except Dunesand. Both yellow and white varieties are grown. The best yields are obtained from the quick-maturing varieties. An early strain of Reid's Yellow Dent is extensively planted, but white corn is generally regarded as very early maturing and is grown on a large area. A local strain of corn called "calico" is extensively grown north of Loomis and in the vicinity of Bertrand. It is regarded as earlier than Reid's Yellow Dent and just as early as the white strains, and the opinion is held in this neighborhood that it has a higher feeding value than the other varieties.

Oats are not very extensively grown. The area devoted to this crop in 1916, according to the State board of agriculture, was 9,605 acres, and the yield was 36.3 bushels per acre. The average yield per acre during the three years 1914, 1915, 1916, was 28.3 bushels. It is generally considered that oats are not very profitable; the crop is grown because it is needed as feed for horses and in rotations. Red Rustproof seems to be the leading variety. Very little effort is made to control smut in oats, although yields are appreciably lower on account of this disease. As a rule oats follow corn in the rotation, the crop being seldom grown twice in succession. The crop is usually cut with the binder and thrashed from the shock. The straw is used for roughage, very little being baled or shipped. Nearly all the grain is fed to horses on the farm. Seed oats are frequently imported from other sections, as the opinion prevails that local seed deteriorates.

Following oats, barley is the most extensive grain crop. In 1916 there were 1,281 acres in barley, yielding 38.7 bushels per acre or a total of 49,575 bushels. In the vicinity of Loomis one farmer has grown barley mixed with oats as feed for hogs, and the mixture is preferred to either of the grains alone. Barley is regarded as much more drought resistant than oats.

Hay has been an important crop in Phelps County from the earliest days of settlement. The area in wild hay has steadily decreased until in 1916 it amounted to only 9,594 acres, and all of the land in Phelps County except the Dunesand and the broken phase of the Colby silt loam and the Scott clay probably will ultimately be devoted to grain or cultivated grasses. The yields of wild hay vary from 1 to 2 tons per acre. The crop is stacked in the field and either baled when placed on the market or hauled to the stock as needed. The usual price of wild hay is \$6 to \$10 a ton, depending on the quality and demand. The principal wild grasses are wheat grass, grama, little blue-stem, or bunch grass, and buffalo grass. The hay is of excellent quality.

Alfalfa is the principal leguminous crop that is adapted to this region, and on account of its value for stock feeding it promises to become the most important forage crop. The area in

alfalfa in 1916 was 9,406 acres, and the yield averaged 3.2 tons per acre. The yield varies greatly with the rainfall. In the driest seasons only one good cutting is obtained, but in seasons of sufficient rainfall three crops and sometimes four are harvested.. Even in very dry years the stand quickly revives after rains. Alfalfa growing is not well understood by most farmers, and there is some difficulty in obtaining a stand. On this account the stand when once obtained is usually left for a number of years, which minimizes the beneficial effect of growing the crop in rotations. Alfalfa is usually seeded in August, at the rate of 15 pounds per acre. Fall seeding is regarded as much more successful than spring seeding, provided there is sufficient soil moisture to give the plants a good start. Where grass abounds fall seeding is always best. The hay is of the finest quality, and there is little difficulty in curing all the cuttings. Some alfalfa seed is grown, but seed production is not extensively developed, and little is produced in the Platte Valley. About the same time is required to grow one seed crop as two hay crops. In general, the dry seasons are best suited for seed production, and the seed crop is not as profitable as the hay in seasons of adequate rainfall.

Sorghum was grown on 2,049 acres in 1916. Formerly sorghum was grown for sirup and seed, but as the market has become uncertain this crop is now grown exclusively for fodder. The largest fields are probably not over 25 acres in extent. Sorghum is usually planted in somewhat closer rows than corn, and is cultivated in the same way. It is cut with a corn binder, and is fed from the shock as needed. On some farms it is sown broadcast or drilled with a grain drill, which gives a finer fodder. Sorghum produces a large amount of feed, and is regarded as very drought resistant and extremely productive. It is usually allowed to ripen before cutting. The poisonous character of the green aftermath in the fall is well understood by farmers and there are few losses from carelessness in turning out stock to graze upon the cane.

Among the crops of minor importance are rye, grown on 306 acres in 1916; potatoes, grown on 607 acres; kafir, on 130 acres; and emmer, on 20 acres. Sudan grass, which is grown to a small extent, seems to give good results and apparently could well be used more extensively for forage.

There are two small apple orchards in the Platte Valley, and the trees seem well adapted to local conditions. The demand for fruit is not supplied, and it would seem that the production of fruit on the Platte Valley soils could be profitably extended. Trees usually do not do so well on the upland on account of scarcity of moisture, which is largely offset in the Platte Valley by the nearness of the water table to the surface. A species of wild plum is very plentiful and its fruit is used extensively.

As a source of income the live-stock industry of Phelps County holds a very prominent place. In 1916, according to the State Board of Agriculture, the value of all live stock in the county was \$2,177,248. There are several large herds of purebred beef cattle, and many purebred bulls have been introduced in recent years to improve the quality of the grade stock. The Hereford, Shorthorn, Angus, and Galloway breeds predominate in the order named. Many beef cattle are fed for market, but probably the majority are sold as stockers and feeders. The quality of beef cattle is generally very good. There are only a few purebred dairy cows in the county, and dairying receives practically no attention as an exclusive industry. Many farmers milk grade beef cows and sell the cream locally. There are 801 cream separators in the county. As far as known no records are kept of the amount and cost per cow of butter-fat production. The greater use of purebred dairy bulls is necessary before much development in the dairy industry can result.

Hog raising is a very important industry. Nearly all the farmers fatten 25 to 40 hogs annually. Large numbers are handled in combination with beef cattle. There are several purebred herds, and the quality of the hogs in general is excellent. Duroc-Jersey and Poland-China seem to be the most popular breeds, although the Chester White, Hampshire, and Berkshire also are raised. All the hogs are fattened on the farms, and usually at a very good profit. The use of alfalfa pastures for hogs is becoming more general, as it has been found one of the most successful methods of producing pork. Cholera vaccination is receiving attention, although cholera is not very prevalent. There is a growing appreciation of the value of sanitary measures in preventing hog diseases.

There are only a few flocks of sheep in this county, and sheep raising does not receive the attention it deserves. Sheep could profitably be produced on many farms, but farmers prefer to raise hogs and cattle. The State board of agriculture reports only 164 sheep in the county in 1916.

Draft horses are bred on nearly all farms. Only a few mules are raised, and the local demand for mules is not supplied. The quality of the farm work horses is good. The Percheron is probably the most popular breed. The greatest improvement in the quality of the horses has been made within the last 10 years, following the introduction of purebred stallions.

Poultry is an important source of income on all farms, the total revenue from poultry and eggs in 1909 being \$41,265. There is a steady demand for poultry products, and increased attention is being given to the improvement of the poultry. The Leghorn, Barred Rock, Rhode Island Red, Orpington, and Wyandotte are

the most popular breeds of chickens. There are apparently no highly specialized poultry farms in the county.

In general, the crops grown in Phelps County are well adapted to the soils and climatic conditions. The topography of the canyon area and the droughtiness of the soil of the dune region make the growing of crops in these sections difficult, and the farming activities here are confined largely to the grazing of cattle, though some corn and wheat are produced in the canyon area. The Cass silt loam and the Cass very fine sandy loam of the first bottoms are regarded as the best soils for alfalfa and corn. Considerable alfalfa is grown on the Holdrege silt loam and the Colby silt loam, but the latter soils are devoted extensively to winter wheat and corn, for which they are regarded as well adapted. Corn and wheat are also grown indiscriminately on the Colby very fine sandy loam and fine sandy loam. In seasons of adequate rainfall the yields on the sandy soils are as high as on the silt loams, but the heavier soils in general are regarded as more drought resistant. The growing of the staple crops indiscriminately on the various soils is due to the fact that no other crops yield larger profits.

Comparatively few farmers follow a definite rotation; in fact, on account of the occasional extremely dry seasons, adherence to a definite rotation is practically impossible. There is little appreciation of the beneficial effects of changing crops. Probably the most common rotation is to change from two or three years of corn to wheat and then to pasture, varying this with an occasional crop of alfalfa. Alfalfa is not grown systematically in the rotation, as there is a tendency to keep the stand as long as it is profitable, often seven or eight years. On many farms corn and wheat are grown in succession until yields decline, after which the land is pastured a few years. The most successful rotation is one including alfalfa and in which corn is not grown longer than two years in succession. Where alfalfa fails to make a stand, the rotation is seriously impaired by losing the only available legume.

The importance of proper cultural methods and soil fertilization is not appreciated. Wheat stubble is frequently disked regardless of a rank growth of weeds, and land is usually plowed late in the summer just before seeding, so that there is little time for proper aeration and mellowing of the soil. A few farmers take advantage of heavy rains to plow deep and mulch with a roller and harrow to retain moisture, after which corn is listed in the spring or wheat is seeded in the fall, according to the time of rainfall. Deep plowing, especially in dry years, is not regarded with favor by most farmers, who give as their reason the tendency of the soil to dry out subsequently, and this is very probably the case where no effort is made to compact the seed bed after plowing.

Wheat is often drilled between the rows of corn. Both single and double disk drills are used. The corn stalks are usually harrowed down in the spring except in seasons of scarcity in roughage, when the crop is cut for fodder. Where wheat follows wheat, a common practice, especially in dry seasons, is to disk the stubble and seed with a disk drill. When the rainfall is adequate much of the old wheat land is plowed in late summer and harrowed before seeding. The yields obtained are said to be about the same as on plowed land. The prevailing time of seeding is from September 15 to 25, but in dry periods the crop is sometimes sown as late as October 15 after rains so as to insure proper germination. Some damage is done by smut, but there are apparently no extended efforts to control the disease.

In growing corn not many farmers plow in the fall. Most of the crop is listed, as it is thought to withstand droughts better than where check rowed. The single-row lister is ordinarily used. During the present season (1917) several cases were reported in which fall-plowed wheat land listed to corn had yielded 15 to 20 bushels per acre over the yields on land not fall plowed, but the opinions held by farmers regarding fall plowing for corn are quite variable. Probably a majority do not favor the practice, owing to the danger of the soil not withstanding the dry summers. Some farmers say that it is advisable to fall-plow corn land only when the ground is well supplied with moisture, and this is not often the case. As a rule thinly planted corn gives the largest yield, a good distance being one stalk for every 24 to 26 inches in the row. Generally the interval is only 15 to 18 inches. Systematic seed selection is not practiced over all the county, and the yields could be greatly increased by careful work along this line. On many farms corn is grown 5 or 6 years in succession on the same land, despite the fact that better yields are obtained when the crop is rotated with alfalfa and the small grains.

As more live stock is kept the amount of manure increases and the supply generally is carefully preserved. The more progressive farmers use up the manure about twice a year, applying it to wheat and sometimes to corn land. The plowing under of green crops is not practiced, and commercial fertilizers are not used to any appreciable extent.

As a rule, the farms are well improved. A few farms have a gravity water system for the house and other buildings. The houses and barns are usually painted and kept in good repair, and there is a general appearance of prosperity. The most up-to-date machinery is generally used. Four-horse gang plows are common, and reports by farmers show that 50 farm tractors are in use in the county. The work stock is usually heavy draft horses, although

there are a few lighter teams. There is a general effort to economize on manual labor by the increased use of machinery. Automobiles are in general use.

Farm labor is hard to get. It is composed mostly of native Americans, although there are a few foreigners, including Swedes, Danes, and Norwegians. There are no negro farm laborers. Wages vary from \$30 to \$50 a month, with room and board. Day labor is paid from \$2.50 to \$3 a day, with board. Harvest hands are frequently paid \$4 a day and board. Many farmers find it advantageous to hire men by the year so as to keep them at rush periods. Wages are abnormally high at the present time, owing to economic conditions, and the range of prices as stated above is about the maximum that farmers are willing to pay.

All the area of Phelps County is classed as improved land by the State board of agriculture. The average size of farms is 224.8 acres. In 1880, according to the census, the average size was 144 acres, of which 43 acres were improved land. In 1916 only 41 per cent of the farms were operated by owners, the remainder being tenanted. The prevailing lease is on the share basis, but a few farms are rented for cash, usually at the rate of \$5 to \$5.50 an acre. Under the usual agreement the owner gets one-third of the crop, the renter furnishing implements, work stock, seed, and labor. In some cases the owner's share is one-third of the corn and one-half of the wheat, the owner paying for the seed wheat, half the thrashing bill, and half the binder twine. In all cases the tenant delivers the owner's share of the grain at the elevator. Special provision is made for pasture, which is usually rented at the rate of \$1.50 to \$2.25 an acre.

The value of all farm property in 1910, according to the census, was \$16,610 per farm, of which land constituted 78.3 per cent, buildings 10.4 per cent, implements 2.3 per cent, and live stock 9 per cent. The selling price of land in 1916 ranged from \$25 to \$90 an acre, depending on the location, kind of soil, and improvements. Probably the average price, excluding the canyon and dune areas, would be \$70 an acre.

SOILS.

The soil materials of Phelps County may be classified on the basis of origin and method of formation into four general groups: Loessial material; unconsolidated deposits, mainly sands of probable Tertiary age; eolian material, consisting principally of Dunesand; and alluvial material composed of sediments brought from various formations and deposited over river flood plains or in basinlike depressions in the upland.

Originally the silt or loess formation covered the greater part of the county, but much of the material has been washed away until at

the present time the original constructional surface is confined to the broad loess plain extending from northwest to southeast through the central part of the county. The mode of formation of this deposit is open to some doubt. Silt deposits of corresponding stratigraphic positions in the eastern part of Nebraska along the Missouri River have been classed as loess, the geological evidence indicating that the wind is an important agent of distribution, but the great distance of the Phelps County deposit from the river does not favor the hypothesis of a derivation of this material from the same source as the river bluff loess. It is believed from our present knowledge of soil-forming processes that soil material derived from deposits of various kinds may, through the long-continued action of physical and chemical forces, develop true loessial characteristics, so that loessial character is meaningless as far as determining the origin of the material is concerned, as in the case of the extensive terrace soils, or so-called valley loess, of Dodge County, Nebr., and other areas of the State. The general evidence in Phelps County seems to warrant a tentative conclusion that these silt deposits were brought to their present position by slowly moving water at the time of a glacial invasion of eastern Nebraska. They are classed as loess, but as loess made by sluggish streams during glacial time and not loess of glacial development. Loess is not uniform in all its physical and chemical properties, but there are physical qualities which characterize all loessial deposits.

In general, loess in its unweathered condition is an even-textured material composed largely of silt particles. It is characterized by its tendency to split into vertical planes, producing perpendicular bluffs along watercourses and roads and in other places subject to erosion. Subjected to the complex factors which act together to produce soils, loess deposits, like all other soil materials of rather uniform original characteristics, may be converted into soils which differ widely in their soil characteristics. The climatic forces which have acted on the widely distributed loessial soils of Nebraska vary greatly in their character and the strength of their action. This has resulted in the development of at least three belts of soils which are crossed successively in traversing the State from the Missouri River to Phelps County. They may be designated as the Marshall, Grundy, and Holdredge belts, the first one extending from the river westward to the general longitude of the western line of Lancaster, Saunders, and Wayne Counties, the second to the longitude of Hastings, and the third to Holdredge and beyond, the western boundary of which has not yet been determined. These belts are well developed only in the southern part of the State, the Sandhills interrupting them in the northern part. The profile of the predominant upland soil of Phelps County, the Holdredge silt loam, consists of a dark-brown to

very dark brown rather coarse silty horizon about 17 inches thick. It is loose, friable, and granular, free from the floury surface layer and the compact columnar subsurface horizon characteristic of the prevailing upland soil in the extreme western part of the State. This is underlain by a somewhat more compact but friable light-colored horizon, mainly light yellowish brown, which extends to a depth of about 30 inches. At this depth the material becomes looser, floury, and yellow in color, but downward becomes somewhat grayish and at from 36 to 48 inches becomes highly calcareous. There is no horizon of marked carbonate accumulation, the calcareous material seeming to be merely the unleached, unweathered parent loess.

Of the various factors which may have caused the differences between the loess soils of Phelps County and those of the eastern part of the State the dominant one is apparently climate, particularly the difference in rainfall. This difference accounts for the great contrast in depth of the weathered soil zone. It has also materially affected the character of the vegetation, and the resultant decomposition products have in turn exercised a strong influence on the decomposition of the soil minerals, producing important changes in the chemical properties. The average depth of the dark-colored oxidized layer in Phelps County is about 18 inches. The dark color is due to organic matter resulting from the decay of grasses and small plants of the prairie. The dark color extends to greater depths in depressional areas of the smooth table land, and is least developed in eroded areas where the run-off has hastened the leaching of the organic compounds. There is some concentration of clay particles, due to percolation, between 15 and 18 inches, giving the subsurface soil a heavier texture and more compact structure. Lime concretions occur much nearer the surface than in areas of the original loess plain in eastern Nebraska, showing that there has been less leaching of the soluble compounds.

The loess formation or silt deposit is the most important soil-forming material in the county, because of its extensive area and the productiveness of the soil derived from it. The productiveness is probably mainly due to the texture and structure of the soil and subsoil, to the high content of organic matter and abundant unleached mineral material, and to freedom from alkali. These features, as a whole, are due more to the climate under which it has developed than to the character of the original soil material. The loess gives rise to the extensively developed Holdrege silt loam, the Colby silt loam, the Wabash silt loam, basin phase, and Scott clay, besides contributing to the material of all the other types except Dunesand. The loessial soils cover about four-fifths of the total area of the county.

Underlying the loess is a deposit of sand, the exact geological relationship of which is not clearly understood. It outcrops southeast of Holdrege and in the northern part of the county adjoining the area of Dunesand, and is reached by well borings in the upland. It consists largely of brown to yellowish-gray sand except in places where the surface material has been mixed with the overlying silt deposit. The Dunesand is doubtless in large part a wind modification of the sand deposit. The material of the sand plain is largely Rocky Mountain débris, principally decayed granite. This plain may be of late Tertiary age or of early Pleistocene, and it is generally regarded now as being of the latter age. It underlies the loess and is the chief source of the water supply of the upland wells.

The cutting down of the Platte Valley through the silt deposit has exposed the underlying sandy material on the slopes in the north-central part of the county. The sand is not exposed in the northwestern and southwestern parts of the loess plain, but this is due simply to the creeping of the overlying silt down the slope, since well records show that the sand deposit underlies all the area. The cutting down of the streams in the southwestern part of the county extends to the Ogallala formation, which here apparently lies immediately below the silt deposit. The soil derived from the sand deposit has been classed as the Colby very fine sandy loam and fine sandy loam.

According to State surveys the underlying basal rocks of Phelps County consist of alternating beds of shale, limestone, and sandstone of Cretaceous and Tertiary age. Tertiary rocks outcrop at a few places in the extreme southwestern part of the county, a typical outcrop of the Ogallala formation of Tertiary age occurring in sec. 2, T. 5 N., R. 20 W. This formation is thought to underlie all the upland, and it has been identified in disconnected outcrops southeastward along the Republican River in Harlan County. The Cretaceous formations, such as the Pierre shale, Niobrara chalk, and lower divisions, outcrop near the southern border of the county and are thought to underlie the entire area. These rocks have not contributed directly to the soils.

The present stream alluvium consists both of sediments washed from the local upland and of heterogeneous material brought down by the Platte River from more distant soil provinces. Small areas of alluvial soils along small streams in the southwestern part of the county are derived exclusively from the surrounding upland. The first-bottom soils are classed in the Sarpy, Cass, and Lamoure series. The terrace or second-bottom soil is of minor importance in Phelps County. It consists of reassorted upland material which has been deposited at the former flood level of the Platte River. The terrace soil is classed as the Bearden silt loam.

The Holdrege soils are dark brown to nearly black, the dark-colored layer being 12 to 16 inches thick. The color gradually becomes lighter downward, merging into the pale grayish yellow of the parent material, though a distinct brown continues to about 30 inches. The subsoil is somewhat heavier than the soil, but there is no suggestion of a claypan.

The Colby series has light-brown surface soils grading abruptly into gray, light-gray, or white, floury subsoils. The subsurface layer and substrata are highly calcareous.

The Scott soils are black to dark brown, with gray subsoils. The materials have been eroded from the higher lying Holdrege and Colby soils and deposited by sheet surface water in temporary lakes or ponds occupying depressions. The Scott soils are poorly drained.

The Bearden series is characterized by dark-brown to black surface soils underlain by gray to light-gray, calcareous subsoils. It is derived from water assorted upland material deposited as former flood plains of the Platte River. The topography is flat.

The Wabash series includes dark-brown to black soils, high in organic content, with dark-drab to gray, heavy subsoils. Both soils and subsoils have a low lime content. The Wabash soils are alluvial, the parent material being derived principally from glacial and loessial deposits. In this area the Wabash has been mapped in former basins, now traversed and drained. This is not typical Wabash material in all respects, but this correlation is advisable on account of the similarity of the soil material to the Wabash mapped along streams farther east.

The Lamoure soils are black to a depth of 12 to 18 inches. The subsoils are dark brown and heavier in texture than the soil. The lower subsoil may be a light-brown or light-gray silty clay. The subsoils and often the soils are highly calcareous. These soils are derived from the alluvium of streams that drain calcareous soils. Drainage is usually deficient.

The Sarpy series is distinguished from the Cass by the light-brown to grayish-brown color of the surface soil. It differs from the Lamoure series in having loose, silty, or fine sandy loam subsoils distinctly lighter in texture than the surface material. The topography is flat except where modified by slight ridges and depressions.

The Cass soils consist of alluvium brought down by the Platte River. They are black in the surface portion, with brownish-gray to gray, porous subsoils. Drainage is somewhat deficient on account of the low topographic position.

The following table gives the name and actual and relative extent of each type of soil mapped in Phelps County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Holdrege silt loam.....	206,848	60.1	Cass silt loam.....	4,992	1.5
Colby silt loam.....	22,592	14.1	Scott clay.....	3,904	1.1
Broken phase.....	25,920		Sarpy fine sand.....	3,712	1.1
Wabash silt loam, basin phase.....	30,336	8.8	Bearden silt loam.....	3,520	1.0
Dunesand.....	14,080	4.1	Colby fine sandy loam.....	1,024	0.3
Colby very fine sandy loam.....	10,304	3.0			
Cass very fine sandy loam.....	9,408	2.7			
Lamoure silt loam.....	7,680	2.2	Total.....	344,320

HOLDREGE SILT LOAM.

The soil of the Holdrege silt loam is a dark-brown to black, friable silt loam, 15 to 18 inches deep. To a depth of 28 inches the subsurface material grades through a dark-brown to brown, friable granular silty clay loam to silty clay. This is underlain by a floury silt loam of light-gray color, which continues below the 3-foot section. The subsoil below 33 inches usually is calcareous, but in some places no calcareous material is encountered above 37 to 40 inches. The granular structure of the subsurface material is due to the concentration of clay particles by percolation.

The type presents several variations. In some places the gray subsoil material is not encountered above a depth of 32 to 34 inches. This variation occurs most extensively to the north and east of Funk, but is also encountered in small irregular areas in other parts of the county, notably north of Loomis.

In one or two small areas the Holdrege silt loam as mapped approaches in physical characteristics the Marshall silt loam or dark-colored loess soil of eastern Nebraska, the surface 20 inches being a friable, black silt loam underlain by a compact, brown silty clay loam to silty clay which becomes more friable at 30 inches. At 36 to 38 inches the typical light-gray, calcareous subsoil material is encountered.

In places there are small ridges or elevations in which the light-gray subsoil lies at depths of 18 to 24 inches, the surface soil being typical. Here the material usually is highly calcareous below 28 inches, and the lower 3-inch stratum of the subsoil is extremely friable or floury in structure. These ridges are suggestive of slowly moving water during deposition of the material. The present tendency is toward the leveling of such areas through washing and other physical action. The soil is less drought resistant than in the typical smooth areas, doubtless owing more to rapid run-off than to any deficiency in water-retaining power.

In a few places the surface soil of the higher lying situations and stream slopes is distinctly lighter in color than typical, being a brown

silt loam to 10 inches and underlain by a silty clay loam to 15 or 16 inches, below which the light-gray, calcareous material is encountered. This is a variation toward the Colby silt loam, but on account of its occurrence in small irregular areas it is included in the Holdrege silt loam. The Holdrege silt loam differs from the Colby silt loam not only in its darker color but in its higher organic content and smoother surface.

That part of the soil area lying 7 miles northeast of Bertrand resembles a broad valley, lying about 20 feet below the surrounding upland and the same height above the terrace or second bottom. The line of demarcation of this valley area is marked by a sharp slope. Apparently the material is a reassorted waterlaid deposit of the original upland, but on account of its nearness in age to the parent upland material no changes have been produced in its physical characteristics, the soil profile being typical of the Holdrege silt loam in every detail.

The Holdrege silt loam is the most important soil type in the county. It extends in a belt 6 to 12 miles wide across the county in a general southeasterly direction. It occupies the highest positions, representing the original constructional surface of the loess plain. The surface is prevailingly flat to gently undulating, relieved principally by small irregular ridges and occasional slopes of 10 to 15 feet, which mark the gradation from one broad plain into another. Scattered throughout the type are small depressions, occupied by the Scott and Wabash soils. The slopes of the marginal areas of the type along the Platte River in the northwestern part of the county are steep. In the southwestern part the surface is interrupted by the canyon area, which is occupied by the broken phase of the Colby silt loam. Here the drop from the level Holdrege silt loam is often a steep precipice with little or no sloping approach.

Drainage of the Holdrege silt loam is generally by means of intermittent streams which empty into depressions. On account of the relatively low rainfall, drainage in general is adequate.

About 85 per cent of the type is in cultivation, the rest being pasture. In natural productiveness it equals the Marshall silt loam and other leading upland soils of the Mississippi Valley, but the yields are probably not more than half those obtained on soils receiving ample rainfall. In seasons of adequate precipitation the yields of corn and alfalfa are twice those of normal seasons, indicating the vast possibilities of increasing the production under irrigation. On account of its high water-retaining power and favorable topography this soil, like the Colby silt loam, is ideally suited to irrigation. Several years ago an irrigation project was surveyed to include most of this soil in Phelps County and adjoining areas in Gosper and Kearney Counties, but no definite steps toward the prosecution of this work have been

undertaken. Probably few areas of equal size with such extremely favorable land features and soil characteristics for irrigation exist elsewhere in the United States.

The Holdrege silt loam originally supported a thick growth of grasses and was extensively used for grazing. Until 1885 only a small part of it was plowed, but by 1895 probably 60 per cent had been broken up. There are still many small tracts of the original prairie sod. The grass consists of a mixture of grama, little bluestem, buffalo grass, wheat grass, and other species, all of which supply excellent grazing and hay. The hay of wheat grass is held in very high esteem. This grass seems to be more abundant in the southeastern part of the soil area. The pastures are at their best in June. The grasses become harder in August and if dry weather continues often become poor, but they continue to support stock until November or later. The pasturing of cattle on dead grasses in winter has given way to the production of roughage for feed. Winter wheat is the most important crop, followed by corn, with normally about two-thirds the acreage. Wheat yields from 10 to 40 bushels per acre, the average for a period of years probably being about 22 bushels. The range in the corn yield is equally as great as in wheat. The average is probably about 30 bushels per acre, but maximum yields of 65 bushels are obtained under favorable rainfall conditions. Moisture controls the yield on this type.

Beef cattle and hogs are raised as an important adjunct to grain production. Only a part of the cattle are fattened on the farms, the remainder being sold as feeders. The hogs are fattened either alone or in conjunction with cattle. The most successful and the prevailing method is to force them on the market under 1 year of age.

Alfalfa is receiving increased attention on this soil, but as yet the crop is not grown systematically in rotations. As with the grain crop, the yields are extremely variable on account of the frequency of dry years. During seasons of favorable rainfall three cuttings, each of 1 to 1½ tons per acre, are obtained. The first cutting is always of excellent quality and is easily saved. The second and third cuttings sometimes fail on account of drought, but the crop usually supplies excellent fall pasture for pigs even with unfavorable dry weather. New seedings of alfalfa sometimes fail to catch, and there is more or less complaint regarding the difficulty of obtaining a stand on account of dry weather.

Barley and oats are of secondary importance, largely because the other grains are more profitable. These crops are used as feed for stock. Sorghum is grown for forage and gives excellent yields. Practically all the hay produced is fed to live stock. Pastures, of which the acreage is small, are principally of native grasses. The obtaining of suitable tame grasses to take the place of the native species is one

of the most difficult problems in the management of this soil and has received little or no attention. All the prairie sod will in a few years have been planted to grain, after which the problem of including pasture in rotations will be even more acute.

Corn on this soil is listed. A few farmers plow corn land in the fall. Corn frequently succeeds itself for five or six years, when it is usually followed by oats, although wheat is often drilled in corn land. Wheat stubble is plowed in the late summer if sufficient moisture is present; otherwise the stubble is disked and the wheat drilled without plowing. During the present season (1917) very little wheat land was plowed. Alfalfa is kept on the same land until the stand deteriorates. The 4-horse disk is commonly used in tillage operations, and farm tractors are being introduced.

Owing to its extremely favorable physical structure, the Holdrege silt loam can be cultivated under a wide range of moisture conditions and is easily handled. It retains moisture well, but is very seldom too wet for cultural operations. Where properly tilled it resists drought for long periods. Little or no commercial fertilizer is used, but barnyard manure is applied by the more progressive farmers, usually to wheat land.

This land sells at \$70 to \$90 an acre, depending on the improvements and the location with respect to towns and transportation lines.

Under the present system of extensive grain growing this type is rapidly depreciating in productiveness. On account of its poor adaptation to leguminous crops suited to short-time rotations the problem of maintaining the organic-matter and nitrogen supply is exceedingly difficult. Under the present system alfalfa is grown on only about 1 acre in 50; the proportion should be at least 3 acres in 50. The alfalfa land should be broken up every six years and the various grain crops rotated. Sweet clover should be introduced as a leguminous pasture crop, as it has been found very successful in other areas under similar climatic conditions. As a permanent pasture crop brome grass should be encouraged, as it is not only one of the very best pasture grasses but produces excellent hay and on rich land gives a heavy yield. With the keeping of more live stock greater quantities of manure would be produced, and this should be carefully returned to the land. If steps are not taken to maintain the soil productiveness it will ultimately be necessary to purchase plant food in commercial forms, which is costly and to be discouraged in a good live-stock community.

COLBY FINE SANDY LOAM.

The surface 12 inches of the Colby fine sandy loam is a brown to dark-brown fine sandy loam, underlain to 17 inches by a light-brown to yellowish-brown fine sandy loam. Between 17 and 36 inches the

subsoil grades through a very fine sandy loam into a light-brown to yellowish or grayish-brown loam. The fine sandy loam material frequently extends as deep as 27 inches before the heavier loam subsoil is encountered, although in places the loam appears at 18 inches. There are also small areas where the subsoil below 30 inches passes into a light-gray silt loam stratum similar to that underlying the Holdrege silt loam. Occasionally the lower 6 inches of the subsoil is a grayish loose fine sand.

The type as mapped includes a small area on the Harlan County line, one-half mile from the southeastern corner of the county, in which the surface 15 inches is a brown loam and the subsoil a lighter brown or grayish-brown loam to a depth of 25 inches. This grades into a subsoil of grayish fine sand of loose, incoherent structure, which continues throughout the 3-foot section. This area is virtually the Colby loam.

The boundary between the Colby fine sandy loam and very fine sandy loam in the northeastern part of the county is difficult to determine; also between it and adjoining areas of Dunesand, as in the southern part of the area of Dunesand along the Kearney County line.

The main body of Colby fine sandy loam lies in the northeastern part of the county. Several small areas occur southeast of Holdrege near the Harlan County line. The topography is undulating to rolling and drainage is adequate.

The Colby fine sandy loam is of minor agricultural importance. It covers only about 4 square miles. The type is used principally for corn and wheat. It is less productive than the silt loams of the upland, largely on account of its sandy composition, which renders it less drought resistant. Corn yields 15 to 45 bushels and wheat 10 to 35 bushels per acre, depending on the season. Little if any alfalfa is grown. In general the type is inclined to be droughty, and crops suffer quickly in dry periods. The lower lying areas, such as the basinlike depressions occurring within the main body of the type, are much more productive than the average, owing largely to the advantageous positions they occupy with respect to surface accumulation of moisture.

The Colby fine sandy loam is too irregular in distribution to have a separate selling value. In general it reduces the value of farms on the Colby silt loam and the Holdrege silt loam, but is much more valuable than the Dunesand.

This soil deteriorates rapidly in productiveness under a system of exclusive grain farming, and provision should be made to maintain the supply of organic matter by incorporating manure and such crops as sweet clover and alfalfa. Truck crops, particularly potatoes, could be made a profitable side line to the main business of grain growing and live-stock production.

COLBY VERY FINE SANDY LOAM.

The surface 10 inches of the Colby very fine sandy loam is a dark-brown very fine sandy loam grading below, to a depth of 16 inches, into a brown very fine sandy loam. From 16 to 30 inches the material consists of a grayish-brown very fine sandy loam, changing to a gray fine sand between 30 and 36 inches.

The type presents several variations in texture and color, ranging from a loam to a fine sand and from dark-brown to grayish brown. These variations are too irregular in distribution to be shown on the map. Where the sand stratum is at or near the surface the soil is a light grayish brown loamy sand and is subject to drifting. This variation occurs in marginal areas adjoining the associated Dunesand. Where the texture is a loam, as in the lower lying situations, the soil is deeper and darker than typical and the sand stratum is usually not reached in the 3-foot section. Even where the texture is a typical very fine sandy loam these variations in color and texture of the substratum occur. The type is free from gravel, but it carries considerable coarse sand. The content of organic matter varies with the color, the darker colored areas containing an adequate supply of organic matter.

The Colby very fine sandy loam lies between the Platte Valley and the upland loess plain. It occupies about 14 square miles, extending in an almost continuous belt along the northern border of the Holdrege silt loam and the Colby silt loam from a point 12 miles north of Holdrege to the vicinity of the Kearney County line. The topography is gently sloping to undulating and in places slightly rolling. The type always lies lower than the original constructional surface of the Holdrege and Colby silt loams. It is thoroughly drained. The soil is normally much more retentive of moisture than the Colby fine sandy loam, owing to its higher content of silt and organic matter, but where it is low in these constituents it is less drought resistant.

This land was originally covered with prairie grasses, but practically all the original sod has been broken. About 75 per cent of the type is now devoted to wheat and corn. Oats and alfalfa are of secondary importance. Corn yields 15 to 45 bushels, wheat 12 to 30 bushels, and oats 20 to 35 bushels per acre, depending upon the rainfall. Alfalfa does well and yields about 1 ton per acre at each cutting. The number of cuttings depends upon the season. In dry years only one crop is obtained, while in seasons of adequate rainfall three is the rule. On the light-colored sand spots yields are very low. The soil responds quickly to manure, which increases yields from 25 to 35 per cent for several years after application, but the supply is insufficient to cover all the type. Truck crops, particularly melons and potatoes, do well, but are grown only for home consumption. Corn and wheat are grown in rotation, varied with an occasional crop

of oats. Alfalfa is left as long as the stand is profitable. Wheat is usually drilled in the corn except where it succeeds itself, in which case the stubble is usually disked in late summer and the seed put in later with a disk drill. Fall listing for corn is not done on account of the danger of drifting.

The ordinary selling price of this land is probably \$45 to \$60 an acre, depending on the improvements. Few farms are composed entirely of the Colby very fine sandy loam.

COLBY SILT LOAM.

To an average depth of 8 inches the Colby silt loam consists of a brown to grayish silt loam. This grades abruptly into a grayish-brown silt loam which continues to 15 inches. Below this lies a gray to whitish-gray, floury silt loam which continues throughout the 3-foot section, becoming almost white in the lower 6-inch stratum. The material below a depth of 18 inches is calcareous.

There are a few variations from typical. In places the soil grades through a light-brown silty clay loam between 10 and 15 inches, the subsoil being typical. The marginal areas of the type adjoining the Holdrege silt loam are prevailing darker in surface color than typical, representing an extreme variation toward the Holdrege silt loam. In other small irregular areas the surface soil is a yellowish-gray silt loam grading abruptly at 10 inches into the characteristic light-gray, calcareous subsoil. The lime is usually in the form of very minute concretions, although the subsoil material itself effervesces, showing a rather uniform distribution of calcium carbonate through the soil mass. The marginal areas of the type adjoining the sandy soils show considerable variation in texture, grading through a loam into a very fine sandy loam.

An area of about 80 acres in sec. 14, T. 7, R. 17, consists of an alluvial phase of the type, the soil being a brown silt loam to 27 inches at which depth it rests on a gray silt loam. It lies about 15 feet above the channel of the small stream along which it is developed. Practically all this area is in alfalfa, and the crop during the present season was above the average in yield.

The Colby silt loam occurs in the northeast-central part of the county, extending from a point 8 miles north of Holdrege to the Kearney County line. It lies between the Holdrege silt loam and the underlying plain and is apparently derived from the lower stratum of the silt deposit, erosion having washed away the higher lying black soil or Holdrege silt loam. As the depth of erosion increases towards the Platte Valley the underlying sand plain is exposed. The surface of the Colby silt loam is billowy to gently undulating. In places there are many small knolls rising 3 to 4 feet above the surrounding level. The surface soil here is lighter in color than

typical and that of the intervening depressions is darker, being a dark-brown silt loam to 15 inches and underlain by the typical light-gray subsoil. Areas along the northern border of the type are rather steeply sloping to rolling. Both surface and subsoil drainage of the type are adequate.

In extent the Colby silt loam, including its broken phase, ranks second in Phelps County. All of the type is in cultivation. Wheat and corn are the principal crops, with alfalfa, oats, and barley of secondary importance. Only a small part of the type is left in native grass and used for pasture and hay. Wheat yields 35 to 40 bushels per acre in the best years, but the average for a series of years is probably not over 20 bushels. Turkey Red is the leading variety. Corn yields from 20 to 60 bushels per acre, depending upon the rainfall, the average yield being probably about 30 bushels. The type locally is considered somewhat better for corn than the Holdrege silt loam. The yield of corn the present season (1917) was 5 to 8 bushels per acre above the upland average, but this was due to favorable situation with respect to rainfall rather than to any soil difference.

Live-stock production, including beef cattle and hogs, is quite an important adjunct to grain growing. Some of the cattle are fattened on the farms, but most of them are sold as feeders. This is due, in part at least, to the large number of feeder cattle on the adjoining areas of Dunesand on which no crops are grown, thus giving a surplus of cattle as compared to the feed produced. The hogs are generally fattened on the farms and marketed at the age of 9 to 10 months. Alfalfa is receiving increased attention on account of the demand for nitrogenous feeds for live stock. The present acreage, however, is much too small to maintain an adequate supply of organic matter in the soil. Sorghum is grown in numerous small fields for fodder. It is generally planted and cultivated like corn, except that the rows are placed closer together. In a few cases the crop is sown broadcast. A few fields are devoted to millet, usually of a small variety, probably the Siberian. Millet is a very early and sure crop and produces a good quality of hay for cattle. It is not fed to horses.

Land of this type can be bought for \$65 to \$75 an acre, depending on the improvements.

For its improvement the Colby silt loam needs more organic matter, which can be supplied by growing more alfalfa and by the introduction of sweet clover.

A method of preparing land for corn, used with considerable success in adjoining areas, consists of fall listing and relisting in the spring by splitting the old ridge. This method could profitably be followed on the Colby and Holdrege silt loams in this county to counteract the

injurious effects of droughts. The selection of seed corn with a view to developing high-yielding and drought-resistant strains should be undertaken.

Colby silt loam, broken phase.—The broken phase of the Colby silt loam typically consists of 6 inches of light-brown to brownish-gray silt loam, underlain by gray silt loam which becomes white at 20 to 36 inches. In places the higher lying Holdrege silt loam has contributed to the surface soil, forming a dark-brown silt loam to 15 inches underlain by a light-gray subsoil, which continues throughout the 3-foot section and below.

This phase occupies the canyon area in the southwestern part of Phelps County, covering approximately 38 square miles. The main body of this soil lies west of Atlanta. A small area lies just south of Holdrege along the Harlan County line. The numerous ravines form the headwaters of Spring Creek and Elm Creek, which empty into the Republican River outside of Phelps County. The surface consists of an intricate succession of steep ravines, 75 to 100 feet deep. Landslides are a prominent feature, and the slopes often present a succession of steps due to the sliding action. The streams are still actively eroding, and drainage is excessive.

Only a few small areas of this soil are in cultivation. Tillage is difficult or impossible over most of the phase, and practically all of it is in pasture. It affords excellent grazing. Buffalo grass and species of grama constitute the principal growth. During the best seasons about 2 acres are required for a cow, and the average requirement probably is near $3\frac{1}{2}$ to 4 acres.

SCOTT CLAY.

To a depth of 12 inches the Scott clay is a dark-gray to black clay, underlain by a plastic, sticky clay to 18 inches. Below this the subsoil is a drab, plastic clay which extends without change to 36 inches or more. In places the subsoil below 30 inches is an impervious clay approaching a hardpan.

In texture the larger areas of the type are usually typical, but many small irregularly distributed areas have black silty clay loam in the surface 15 inches, the subsoil being typical. Such areas represent the Scott silty clay loam. Another variation occurs in which the subsoil below 30 inches changes from a clay to a light-brown or grayish-brown, friable silty clay loam. In these areas the impervious substratum is entirely absent.

The Scott clay occupies, in close association with the Wabash silt loam, basin phase, the depressions which exist throughout the loess plain. The largest area lies southeast of Holdrege near the Harlan County line, but there are a few rather extensive areas in the vicinity of Loomis. The few larger areas vary in size from 60 to 100 acres;

the rest are less than 30 acres in extent. The soil material has been derived from the higher lying Holdrege silt loam through the action of surface water. The silt particles have been first deposited, giving rise to the Wabash soil, and the clay particles have been carried in suspension to the center of the depressions, giving rise to this type. In places it receives the waters of small intermittent streams, and the water may stand on the surface for weeks before it evaporates. On this account, and owing to the plastic character of the soil, drainage is very deficient. The type occupies the lowest part of the upland depressions, locally called "lagoons." During seasons of abnormally high rainfall the water spreads over the entire type and parts of the surrounding Wabash soil.

The small cultivated patches of the type are really Scott silty clay, and are confined entirely to the smaller depressions. Cultivation of the larger areas is impossible under the present poorly drained conditions. Adequate drainage can be established only through the construction of ditches from one area to another and into the natural drainage ways, and this is not practical for most of the type under present economic conditions. There are, however, numerous small areas into which only a small amount of water drains. These could be ditched and the water collected in ponds at the lowest point in the depression, leaving the larger part available for cultivation or for use as improved pasture land. Under present conditions the Scott clay is valuable only for the limited grazing it affords during the summer and fall. Most of the type is overgrown with species of smartweed and affords little or no pasture.

WABASH SILT LOAM, BASIN PHASE.

As mapped in Phelps County the Wabash silt loam, basin phase, prevailingly consists of 18 inches of dark grayish brown to black silt loam grading into a dark-brown silty clay loam to 25 inches, below which lies a light-brown, friable silt loam. This becomes lighter in color below 30 inches. In a few places the subsoil is a brownish, compact to impervious silty clay below 25 to 30 inches. This impervious layer where present is encountered within the 3-foot section.

The Wabash silt loam, basin phase, occupies depressions in the loess plain. The soil has been deposited from shallow waters standing over or flowing into the depressions. In some cases drainage has been established, and these areas are now parts of stream valleys. The black silt loam layer is usually deeper toward the center of the depressions, frequently extending down to 24 inches, below which the light-brownish subsoil is encountered. The soil near the center of the depressions is frequently a heavy silt loam to silty clay loam. The boundary line between this type and the Holdrege silt loam is

usually marked by a sharp slope, and the soil near the border of the depressions frequently represents an extreme variation toward the Holdrege silt loam, consisting of a black silt loam to 20 inches grading through a brownish silty clay loam into a light-brown to gray silt loam at 30 to 33 inches. In mapping the soil here an effort has been made to place the boundary in agreement with the slope from the higher lying plain, but in some places the soil throughout the entire small depression shows no variation from the typical Holdrege silt loam and has, therefore, been included with that type, regardless of its depressional position.

As mapped, Wabash silt loam, basin phase, includes several large valley depressions, the soil of which probably is largely alluvial. The streams are intermittent and usually issue into lower depressional areas of Scott clay. A typical occurrence of such soil is mapped about 7 miles southeast of Holdrege, near Sacramento. Two other small areas occur 10 miles north of Holdrege, another 7 miles northeast of Holdrege, and one in the vicinity of Atlanta. A typical soil profile consists of 18 to 20 inches of black, friable silt loam grading into a compact, brownish silty clay loam, which continues throughout the 3-foot section, becoming somewhat more friable and lighter in color with increasing depth.

Drainage of the Wabash silt loam, basin phase, is adequate except during seasons of unusually heavy rainfall. There are generally a few poorly drained acres in the center of the depressions in which the water collects during rains. Nearly all the poorly drained land can readily be improved by ditching.

The Wabash silt loam, basin phase, occurs in small bodies throughout the Holdrege silt loam. The largest single areas lie southeast of Holdrege. Only a few areas exceed 200 acres in extent, and most of them cover less than 75 acres. The material has been derived from the higher lying Holdrege silt loam through the action of surface water during rains. Excluding the larger valleylike areas, there are few intermittent streams that flow from one area of this soil to another.

All of the type is in cultivation. It constitutes some of the most productive land in the county. Owing to its low position it receives run-off from the higher lying soils, and on this account crops rarely suffer as quickly during summer droughts as on the other types. Wheat and corn are the principal crops, the acreage being about equal. Yields of both crops are slightly above the average for the county. The average yield of wheat for a period of years is probably near 26 bushels an acre, and that of corn 33 bushels.

Wheat usually follows corn, being drilled between the rows as on the other types. Wheat, however, as well as corn, frequently succeeds itself for several years. Oats and alfalfa are of secondary im-

portance, but more attention is being given to alfalfa as more live stock is kept and the need of forage to take the place of the wild grasses is felt. The soil is well supplied with organic matter, and yields have depreciated little if any since it has been brought into cultivation. As on the other types, the yields of grain crops can be maintained indefinitely only by increasing the acreage in alfalfa, sweet clover, and other leguminous crops, the hay to be carefully fed on the land.

On account of its irregular occurrence in generally small areas, much of the Wabash silt loam, basin phase, is held in conjunction with other soils, the value of which it slightly enhances. The larger areas probably can be bought for \$80 to \$95 an acre, depending on the improvements.

BEARDEN SILT LOAM.

As most prominently developed the Bearden silt loam is a black to dark-brown silt loam to a depth of 15 inches, grading below this into brown, compact silt loam to silty clay loam. Below about 27 inches the subsoil grades quickly into a brownish-gray to light-gray, floury silt loam which continues without change throughout the 3-foot section and below. The light-gray subsoil stratum varies considerably in position, being encountered in some places at depths of 22 inches and in others as deep as 30 inches. There is a slight concentration of clay particles in the subsurface layer, imparting a granular structure. The lower portion of the 3-foot stratum is calcareous. The soil profile resembles that of the Holdrege silt loam.

An important variation occurs in which the surface material is a dark-brown loam to loamy silt loam, grading into the typical subsoil. The areas of textural variation are of irregular occurrence throughout the main body of the type, but in general the extreme eastern part of the type in secs. 21, 22, and 23, T. 8 N., R. 19 W., is more uniformly a loam than the remainder. This is probably due to the washing down of sand particles from the associated sandy soils.

The Bearden silt loam covers about 5 square miles in the northwestern part of the county, extending in a continuous belt from sec. 16, T. 8 N., R. 20 W., along the southern border of the Platte Valley soils to sec. 23, T. 8 N., R. 19 W. It occupies a terrace lying about 15 feet above the first bottom and 15 to 20 feet below the upland. It is marked by a sharp slope to both the bottom and the upland. The surface is flat or slopes gently toward the valley, only a small inconspicuous area along the slope showing erosion. The type is well drained, but its favorable physical texture makes it very drought resistant.

This soil originally was prairie and supported the same species of grasses as the upland Holdrege silt loam and Colby silt loam. Practically all of the type is now under cultivation, all the staple

farm crops of the area being grown. About three-fourths of it is devoted to corn and wheat, the acreage in these crops being about equal. Yields are extremely variable on account of the variation in rainfall, but the average yield of corn is probably about 25 bushels per acre and that of wheat 22 bushels. Oats and alfalfa are important crops. Oats yield from 18 to 40 bushels per acre, probably averaging about 30 bushels. Alfalfa gives 1 to 3 cuttings per season, depending upon the rainfall. During the present dry season (1917) only one cutting was obtained, but the crop supplied excellent fall pasture for hogs.

Corn and wheat are usually grown in a two-year succession varied occasionally by oats. Corn is prevailingly listed. Wheat is frequently drilled between the rows of corn. Alfalfa is left on the same land for 7 or 8 years, or until the stand deteriorates. A proper cropping system is difficult to follow on account of the lack of leguminous crops suited to short-time rotations. The general tendency now is to grow more wheat and less corn. Manure is applied usually to wheat land, but the supply is inadequate. Stubble land for wheat is either plowed or disked in late summer, depending upon the moisture conditions. If the season is dry it is disked. The general aim in preparing the seed bed for corn is to have the bed firm and fairly compact, with about 3 inches of fairly fine, moist mulch. Deep plowing, 8 to 10 inches, is done only during wet periods.

The productive capacity of the Bearden silt loam in general is being impaired by the continuous growing of grain. More alfalfa and sweet clover should be grown in the rotation, to enable the keeping of more live stock and to supply more manure. In general the type compares very favorably with the Holdrege and Colby silt loams, and it has the same selling price.

CASS VERY FINE SANDY LOAM.

To a depth of 12 to 20 inches the Cass very fine sandy loam consists of a dark-brown to black very fine sandy loam. This is underlain to 28 inches by a dark-brown very fine sandy loam, below which to 36 inches the material usually is a brown very fine sand to fine sand. In some places the lower 3 inches is a coarse, gray to almost white sand, a pure quartz or river sand. In other places the subsoil below 30 inches is mottled strongly with brown and gray. In another variation the type as mapped consists of alternating areas of silt, very fine sandy loam, and very fine sand in the lower subsoil. Calcium-carbonate concretions occur in the heavy subsoil layers but are entirely absent in the lighter-textured material. The type varies considerably in texture and in some areas may be a loam.

The Cass very fine sandy loam occupies a strip of the Platte River lowland extending from sec. 12, T. 8 N., R. 19 W., eastward to the

Kearney County line. An area of about 3 square miles lies south of Elm Creek Bridge. It is one-half to three-fourths of a mile wide and extends nearly 7 miles along the south bank of the river. The color of this soil in this area is black rather than dark brown. The type occupies approximately 12 square miles. It is alluvial, the material having been deposited by flood waters of the Platte River.

The topography is flat except for small ridges and sloughs. Drainage is good, except in part of the area south of Elm Creek Bridge, which lies near the river and drains slowly after overflows. Only about 50 per cent of this area is in cultivation.

All the higher land, except small areas temporarily in pasture, is in cultivation. Grain is the principal agricultural industry. Some cattle and hogs are raised, mainly on farms where some of the less desirable soils are included and can be used for pasture. Sheep are kept on a few farms, and sheep raising is reported to be very profitable. The industry could well be extended on this type, as on nearly all the soils of the county, on account of the good natural grazing and the extremely favorable climatic conditions. There are some small apple orchards on the Cass very fine sandy loam. These are in very thrifty condition and gave a very profitable crop the present season. It is reported that not more than 1 crop of apples in 5 is lost on account of cold winters. The success of these orchards suggests the advisability of increasing the production of apples, as there is a strong local demand for all kinds of fruit. There are few fungous diseases of the apple in this section, but insects are somewhat troublesome, so that spraying is necessary for the successful production of apples. The trees seem to be well pruned and show unusual thriftiness. The greater success of fruit trees in the first bottoms than on the upland is ascribed to the nearness of the water table to the surface in the former situation. As a rule, the moisture supply in the upland soils is not sufficient for the best development of fruit trees. The wild plum is indigenous on this type, as on the other soils of the county, and the trees bear heavily. Cherries can be grown with profit, but the climate is not adapted to peaches.

Yields of corn on the Cass very fine sandy loam vary from 25 to 65 bushels per acre, depending on the season. The average yield is probably near 35 bushels. Both yellow and white varieties are grown. Wheat yields 20 to 40 bushels per acre, with an average of about 25 bushels. Turkey Red is the principal variety. Oats yield 20 to 35 bushels per acre. Alfalfa gives from 1 to 3 cuttings, each of 1 to 1½ tons per acre. The acreage of alfalfa is increasing, but is yet far too low. More cattle and hogs are kept on farms producing alfalfa. All the crop is cut for hay, except in a few cases where the late growth is pastured with hogs. No attempt is made to grow alfalfa in rotation, although it is the only leguminous crop available for hay except

sweet clover, which is not grown to any extent. The grain crops are usually grown in some form of succession, but it is not unusual to grow corn on the same land 3 or 4 years. Corn is generally listed, as the extremely favorable structure of the soil and the dry atmospheric conditions make this method most practical. The soil can be cultivated almost immediately after rains. Heavy draft teams are in general use. The type is ideally suited to the production of small fruits and vegetables, especially potatoes, but very little attention is given to these crops. It is not quite as drought resistant as the Cass silt loam, but crops generally suffer less from lack of moisture than on the upland types. Yields of all crops are above the average for the county. Like the Cass silt loam, the type is greatly benefited by the growing of alfalfa, and with an increase in the acreage of this crop, coupled with the occasional growing of sweet clover, its productive capacity can be maintained indefinitely.

Land values on the Cass very fine sandy loam range from \$60 to \$85 an acre, depending on the improvements.

CASS SILT LOAM.

The Cass silt loam includes three distinct layers. The surface stratum consists of a dark-brown to dark-gray, mellow silt loam, usually 12 to 14 inches deep. The subsurface layer extends 20 to 22 inches and is a dark yellowish brown to brown silt loam. In some areas the subsurface material approaches a silty clay loam in texture, while in others it is slightly lighter than the surface soil. The subsoil grades through a very fine sandy loam of brownish-gray color into a very fine sand which is encountered below about 30 inches.

Although these layers are subject to considerable variation in different areas, they are fairly uniform in any one body of the type. There are places where the silt loam grades abruptly into a very fine sandy loam subsurface layer which continues without change throughout the 3-foot section. There are also included small areas having a billowy surface in which the crests of the slight ridges are frequently a very fine sandy loam. Such areas are too irregular in occurrence and too small to be shown separately on the map, and at any rate it is probable that with cultivation the very fine sandy loam layers will be mixed with the heavy silt loam to form nearly typical silt loam. The gradational zone of the type adjoining the Cass very fine sandy loam is very wide. The soil here is slightly coarser and loamier than typical.

The Cass silt loam occupies a continuous strip in the Platte Valley, extending from the Gosper County line in the northwestern part of the county to sec. 15, T. 8 N., R. 18 W. Two small areas occur east of the main body. The subsoil probably represents former sandbars laid down along the river and the surface soil a later covering of river-

borne silt. The decay of the vegetation, which grows luxuriantly, has added organic matter to the surface soil, increasing the difference between it and the subsoil. The material is retentive of moisture and crop failures are rare, notwithstanding the occasional droughts. The topography is flat, except for an occasional ridge or deserted stream channel. Both surface and subsoil drainage are adequate.

The Cass silt loam is one of the more important types of the Platte River Valley. It is the strongest corn soil in the county and stands continuous cropping to corn better than any other soil. Most of the type is very rich in organic matter, which in part accounts for its productiveness. Fertilizers are not used and are not needed under proper management. Corn and wheat are the principal crops, with alfalfa and oats of secondary importance. Corn yields ordinarily 35 to 40 bushels and wheat 20 to 30 bushels per acre. In favorable seasons corn has yielded 65 bushels and wheat 40 bushels per acre. Corn is generally listed. Both white and yellow varieties are grown. A strain of Turkey Red winter wheat is grown almost exclusively. Oats yield from 20 to 45 bushels per acre. Alfalfa generally gives three cuttings of 1 to 1½ tons per acre each, but occasionally only two cuttings are obtained in years of drought. This is the best alfalfa soil in the county. Most of the alfalfa is cut for hay and fed to cattle and work stock, but some is pastured with hogs, and this has been found a very profitable use of the crop.

Hogs and beef cattle are raised on this soil in considerable numbers. They are generally fattened on the farms. Many farmers pasture the associated Dunesand soils and fatten the stock on the corn and alfalfa grown on the Cass silt loam. In this way large quantities of manure are produced, and manuring results in increased yields for several seasons.

The Cass silt loam is easily handled on account of its favorable texture and thoroughly drained condition. It is well suited to plowing with tractors, and these are being increasingly used on this and associated soils.

Land of the Cass silt loam is valued at \$85 to \$90 an acre. Very few farms are composed entirely of this soil.

The acreage in grain is far too great and that in alfalfa too small for a well-balanced system of farming. This is largely due to the ease with which grain crops could be grown in the past and the great natural productiveness of this soil. There is evidence, however, that part of the type is becoming deficient in organic matter, and in places light-colored, unproductive spots are appearing. This condition can be remedied by a wider use of alfalfa, the fields to be plowed under every four or five years as conditions permit. Sweet clover also is well suited to this soil and could be used in pastures, but on account of the abundant grazing on the associated types there seems

to be little demand for permanent pasture on this type. Alfalfa, therefore, more nearly suits the requirement for leguminous forage than sweet clover. One-fourth or at least one-fifth of the land should be seeded to alfalfa and the fields changed about every five years, in order to give the grain crops the benefit of the increased nitrogen supply. Yields of corn can be materially increased by careful selection of seed to develop high-yielding strains.

SARPY FINE SAND.

The Sarpy fine sand consists of a brown fine sand with a depth of 3 feet or more. Below 20 inches the subsoil is somewhat coarser, consisting of a loose, incoherent fine sand. There is present in places from 1 to 3 per cent of gravel, and in areas of one-half to 1 acre enough gravel may be present to impart a decidedly gravelly texture.

The type includes small inconspicuous areas in which the soil grades through a loam into a very fine sandy loam extending to 12 inches, the subsoil being typical. It lies 2 to 4 feet higher than the Cass very fine sandy loam, and in some places is separated from that type by a distinct slope, but usually there is only a gradual rise in elevation.

The Sarpy fine sand occurs on the outer edge of the Platte River Valley, characteristically between the Dunesand and the Cass very fine sandy loam. Areas adjacent to the Dunesand contain an admixture of sandy material brought down from the higher lying Dunesand areas. In places the soil has drifted slightly, giving rise to areas which resemble the Dunesand except that the dunes are much lower, seldom more than 3 or 4 feet high. The general topography is flat to slightly billowy or gently sloping. The rise to the Dunesand area is usually a sharp slope 30 to 50 feet high. The type occupies approximately 5 square miles, extending in a narrow strip from a point about 3 miles southwest of the Elm Creek bridge eastward to the Kearney County line. Drainage is adequate for both soil and subsoil on account of the extremely porous structure. The type is of little importance, as only a few small areas are in cultivation. These are planted to corn. Except in seasons of excessive rainfall the yields are low, on account of the poor moisture-retaining power of the soil. Usually yields are higher during the first few years of cultivation than thereafter, as the rapid exhaustion of the organic-matter supply renders the soil extremely droughty. In its natural state the type supports a good growth of the usual pasture grasses, which afford splendid grazing or may be cut for hay. The average yield of hay is not over 1½ tons per acre. The grasses are largely little bluestem, grama, and buffalo grass, and are very nutritious. In general the type affords better grazing than the adjoining Dunesand. Its best use under present conditions is for grazing, as

the soil quickly deteriorates under cultivation. It is too droughty for alfalfa to do well.

Land of this type is usually held in conjunction with the Cass very fine sandy loam, the value of which it depreciates.

LAMOURE SILT LOAM.

The typical Lamoure silt loam consists of a dark-gray to black silt loam to a depth 14 or 16 inches, changing gradually to a dark-brown silt loam to silty clay loam, which continues to 25 inches. Below this the subsoil is a compact, brownish-gray silty clay loam to silty clay, which becomes lighter in color until at 30 to 32 inches a light-gray silty clay is encountered. The soil and subsoil are highly calcareous, although very few concretions are present. In places the subsoil below 25 inches consists of alternating strata of black clay and gray silty clay. Frequently the lower section is a white, floury silt loam immediately overlying a dark-colored silty clay. Another subsoil variation consists of a heavy, brownish clay loam below 34 inches. The sand particles which impart the loamy structure are extremely coarse.

The type as mapped includes a few areas, 1 to 3 acres in extent, in which the surface 18 inches is a black silty clay, underlain by grayish, calcareous clay or alternating strata of gray and dark brownish drab clay. Such areas virtually represent the Lamoure silty clay. A typical area occurs one-half mile south of Elm Creek bridge.

Another variation occurs in the southwestern part of the county where a narrow strip of the type is developed along a small creek. Here the surface soil is a black silt loam to 15 inches, grading into a lighter colored silty clay loam which continues to 20 inches. Below this the subsoil grades into a light-gray calcareous silt loam to silty clay loam.

The two most extensive areas of Lamoure silt loam occur in the extreme northwestern part of the county, extending along the Platte River to a point about 2 miles west of the Elm Creek bridge. Two small areas occur just east of the main body of the type, and a small area is mapped in the southwestern part of the county. The topography is flat. Surface drainage varies from place to place, but subsoil drainage is somewhat deficient, although the higher lying situations usually are adequately drained. Drainage of the area in the southwestern part of the county is good. The surface in places is modified by ridges 1 to 2 feet high or by deserted stream channels.

The Lamoure silt loam differs from the Sarpy and Cass soils in having a heavy, calcareous subsoil, which accounts for its poorer drainage. It is an important soil, although the total area does not exceed 11 square miles. About 65 per cent of the type is in cultivation, the rest being devoted to grazing and hay production. Corn

and wheat are grown most extensively. Oats occupy a minor position. Yields of all crops compare favorably with those obtained on the upland, but are somewhat below those obtained on the Cass silt loam. Corn averages about 35 bushels and wheat 22 bushels per acre. The poorly drained areas of the type are regarded as better for corn than for wheat. Strains of Reid's Yellow Dent and white corn are grown. Turkey Red is the main variety of wheat.

As on the other soil types, corn is usually listed and this method seems well adapted to the soil. Little alfalfa is grown; its acreage could well be extended. Sweet clover also might be grown. Poorly drained areas need to have the drainage remedied by ditching or tiling in order to grow alfalfa successfully. Under present conditions such areas supply excellent grazing and wild hay, which can be used to balance the rich nitrogenous hay of the better drained land. With adequate drainage the type should be as productive as the Cass silt loam, needing only good farming methods to keep it so permanently.

A few inconspicuous saline spots are developing on this soil and tend to depreciate its agricultural value. When dry these areas have a white crust on the surface. The accumulation of the salt is due to the capillary movement of the water to the surface, where it evaporates. When present in sufficient quantities the salt becomes toxic to plants. To remedy the saline condition the soil must be adequately drained, after which the salts will gradually leach out in the soil solution. The reclamation may be aided by applying barnyard manure. Experience has shown that systematic treatment by manuring alone will sometimes suffice where the drainage is fairly good.

Land of the Lamoure silt loam sells for \$50 to \$75 an acre, depending upon the drainage and the improvements.

DUNESAND.

The areas mapped as Dunesand consists of brown fine sand to 8 inches, underlain by yellowish-brown fine sand to 36 inches. The material is very uniform except in the small depressions and in small valley areas, where the soil is variable, being a dark-brown loamy sand to fine sand in the surface 12 inches, though the subsoil is typical. Frequently in depressional areas 1 or 2 acres in extent the soil grades through a dark-brown fine sandy loam in the surface 18 inches into a gray loamy sand in the subsoil. The heavier texture in such places is due to the "silting in" of the fine particles of these wind deposits, and the soil is virtually the Colby fine sandy loam.

Dunesand occurs in the northern part of the county, extending in an almost continuous belt along the southern border of the Platte Valley from a point 14 miles north of Holdrege to the Kearney County

line. It is a wind modification of the material of the sand plain which underlies the loess. Drifting is still going on in places where vegetation is removed. Where sufficient silt from the original Holdrege silt loam and Colby silt loam is mixed with the sand, areas of the Colby very fine sandy loam and fine sandy loam have been formed, the texture here being sufficiently heavy to prevent drifting of the underlying sand strata.

On account of the extremely porous nature of the Dunesand drainage is largely underground. There are only a few small streams that do not lose themselves in these sand areas. The land forms are dunes, basins, and blowouts. Some of the dunes are 40 to 45 feet high.

None of the Dunesand is in cultivation. It supports a good growth of buffalo and grama grasses, and is used exclusively for grazing. From 5 to 6 acres are usually needed per cow. The live stock is of excellent quality, leading beef breeds such as the Hereford and Shorthorn predominating. There are some purebred herds. The grazing season usually extends from May to November. Where the land is not grazed wild hay is cut at the rate of 1 to 1½ tons per acre. The hay is of excellent quality, and practically all of it is fed on adjoining farms. Grazing is the best use that can be made of this soil. It should not be plowed on account of its tendency to drift. It is too low in plant food to produce profitable crops without heavy manuring or heavy applications of fertilizer.

Land of this type can be bought for \$20 to \$25 an acre.

SUMMARY.

Phelps County, Nebr., lies in the southern part of the State, in the second tier of counties from the Kansas line. It has an area of 538 square miles, or 344,320 acres.

The upland is a broad area of level to gently undulating table-land, representing the loess plain. It covers about four-fifths of the area of the county. Besides the loess plain the upland includes a small belt of dunes in the southeastern part of the county and a comparatively inextensive canyon area in the southwestern part, both of comparatively rough topography.

The lowland of Phelps County borders the Platte River along the northern county line. It is flat except where modified by low ridges and deserted stream channels. The lowland includes, in the northwestern part of the county, a small strip of terrace lying from 15 to 20 feet above the first bottom.

The elevation of the bottom land along the Kearney County line is from 2,180 to 2,380 feet above sea level. The upland lies 75 to 100 feet above the first bottom. The highest point in the county is 2,500 feet, which is the elevation of the loess plain north of Bertrand.

Drainage is adequate except in some depressions of the upland loess plain. Much of this is drained by small intermittent streams which issue into depressions. The Platte River drains the northern part of the county and the Republican River the southern part. The Platte River is the only main drainage way touching the county.

Phelps County was organized in 1873. About 75 per cent of the people are of native birth. The total population in 1910 was 10,451, 71 per cent of which is classed as rural, an average of 13.8 persons to the square mile. Holdrege is the county seat, with a population of 3,030 in 1910.

Transportation facilities are good and afford direct connection with the excellent markets of Cheyenne, Denver, Lincoln, Omaha, St. Joseph, and Kansas City. The main highways are well graded and in excellent condition. The Omaha-Lincoln-Denver Highway traverses the county. The Lincoln Highway, a transcontinental road, parallels the Platte River just north of the border.

The climate of Phelps County is well suited to general grain farming and live-stock production. The mean temperature for the winter is 26.8° F. and for the summer 74.3°. The mean annual precipitation is 24.89 inches, of which 10.68 inches falls during the three summer months. Rainfall is the limiting factor in crop production.

Phelps County is essentially agricultural. The prevailing type of farming consists of grain growing, with the raising of beef cattle and hogs as important adjuncts. The principal crops are corn, wheat, alfalfa, and wild hay, with oats, barley, and sorghum of minor importance. Wheat is a cash crop. The acreage in corn is about two-thirds that of wheat. Most of the corn is fed to live stock, but some is sold at the elevators. Alfalfa is grown for hay, little seed being produced. The combined value of the wheat and corn crops of 1916 was \$3,701,256. The crops in general are well suited to the soils.

The upland covers about four-fifths of the county. It is represented by seven soil types, the Holdrege silt loam, the Wabash silt loam, basin phase, the Scott clay, the Colby silt loam, the Colby very fine sandy loam, the Colby fine sandy loam, and Dunesand. The silt loam soils of the upland are classed as loessial, but the origin of the sandy types is not clearly understood. Excepting the Scott clay, the soils are well drained. They are extremely productive, with the exception of Dunesand and the Sarpy fine sand. The introduction of permanent pasture grasses and leguminous crops in rotation with the grains is the principal need of these soils in general. Dunesand is devoted to grazing, which is its best use, on account of its tendency to drift when cultivated.

The bottom soils occur in the northern part of the county bordering the Platte Valley. They comprise the Bearden silt loam of the

terraces and the Cass very fine sandy loam and silt loam, Sarpy fine sand, and Lamoure silt loam of the first bottoms. The bottom soils comprise some of the best land in Phelps County. Only small areas of the Lamoure silt loam and Cass very fine sandy loam are deficient in drainage.

The present system of farming in general is unbalanced, too much grain being grown in proportion to the leguminous crops and the number of live stock kept. The productiveness of the soils is gradually being impaired. Alfalfa and sweet clover are the only legumes available for increasing the organic matter and nitrogen supplies of the soils. As yet sweet clover is not grown, and alfalfa is grown on only about 1 acre to 50 acres of grain crops. The proportion should be at least 1 acre of the legume to 10 or 15 of grain, the sod to be plowed under every 5 years, and the grain crops rotated during the interval. When this system is combined with live-stock raising the leguminous hay crops can be fed and the manure returned to the land. For permanent pasture, the need of which is great, brome grass should be introduced.



[PUBLIC RESOLUTION--No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for 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 area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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