

SOIL SURVEY OF LANCASTER COUNTY, NEBRASKA.

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DESCRIPTION OF THE AREA.

Lancaster County is situated in the southeastern part of the State of Nebraska, approximately 50 miles west of the Missouri River and about halfway between the Platte River and the north boundary line of Kansas. Meridians of longitude $96^{\circ} 40'$ west and latitude $40^{\circ} 50'$ north intersect near Lincoln, which is located near the center of the county. The county is bounded on the north by Saunders County, on the east by Butler, Saunders, Cass, and Otoe counties, on the south by Gage, and on the west by Saline and Seward counties.

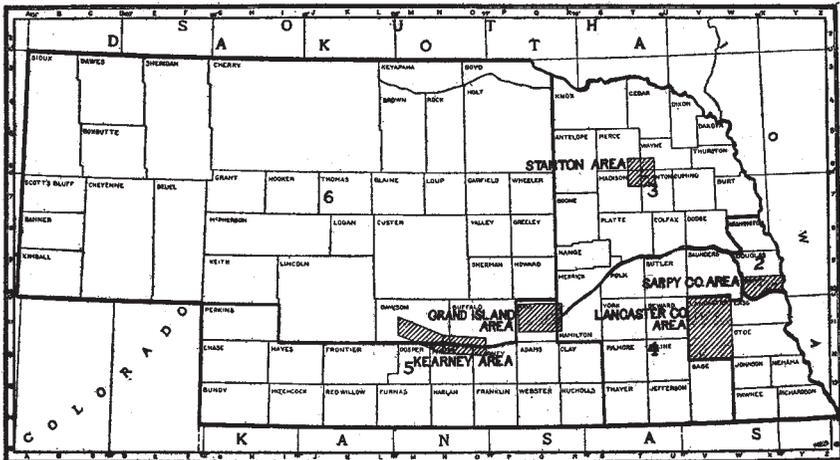


FIG. 32.—Sketch map showing location of the Lancaster County area, Nebraska.

The surface of Lancaster County varies from gently rolling to rough and hilly. While the county lies wholly within the boundary of the Kansan drift, the glacial material is more pronounced in determining the surface configurations in the west half of the area, where glacial action and subsequent erosion have developed a broken topography. It is quite noticeable that the most irregular surface is found on the south sides of streams flowing east. An exception is found in the case of the main channel of Salt Creek northeast of Lincoln, where the higher hills are on the north. The lowest point in the county is found where Salt Creek passes into Cass County, where the elevation is about 1,100 feet above sea level. From this point the

surface rises north, west, and south, finally reaching an altitude of 1,500 feet in the southwestern part of the county along the divide between the Salt Creek basin and the valley of the Big Blue River. The general elevation of the county is about 1,200 feet above tide.

Beginning in the southwest part of the county, at a point 1,500 feet high, there opens out toward the north and northeast an elliptical basin, with an average depth of probably 200 feet. This basin makes a broad curve near Lincoln, turns to the northeast, and leaves the county a few miles east of Waverly. It is traversed throughout by Salt Creek and its tributaries, the most important of which are Rock Creek, Little Salt Creek, Oak Creek, Middle Creek, Haines Branch, Antelope Creek, Stevens Creek, and Dead Mans Run. Near Roca the main channel of Salt Creek divides into the south and west forks. A part of the drainage in the southern part of the county finds its way into Big Blue and Nemaha rivers, but the greater part is carried by Salt Creek into the Platte River.

The population of the county is practically all white and mostly native born, though a large percentage of the people, particularly in the rural communities, is of foreign extraction. The early settlers came to this country from Iowa, Illinois, Indiana, and from various eastern States. The first settlement was made in 1856 on Salt Creek, about 15 miles south of where Lincoln now stands. The county was organized in 1859, and the State capital was removed from Omaha to Lincoln in 1867.

The rural population is grouped roughly into settlements representing various nationalities. In the southern part of the county are the Germans, in the southeastern part the Hollanders, in the northeastern part the Swedes, and in the northwestern part the Irish. Except in the rough country around the headwaters of some of the western tributaries of Salt Creek, the rural population is fairly dense.

Lincoln, the most important city and the best immediate market in the county, is situated near the center of Salt Creek basin, and is one of the most important railroad centers in the State. There are a number of small towns in the county. These are composed generally of farmers who have collected together for church and educational advantages. These small places also serve as shipping points for the farmers. Crete, a town of 3,000 or 4,000 inhabitants, is located only a short distance across the west boundary line of the county and affords a limited market for the farmers in the southwest section of the area.

The transportation facilities are excellent. The Burlington, the Union Pacific, the Rock Island, the Missouri Pacific, and the Northwestern railroad companies operate lines through the county and place it in direct connection with Omaha, Chicago, Kansas City, Denver, and other large cities.

CLIMATE.

Lancaster County is situated wholly within the rain belt of the Mississippi Valley and has a moderately humid climate. The normal annual temperature is 50° F., the normal monthly temperature ranging from 22° F. in January to 76° F. in July. The average annual rainfall is about 27 inches, most of which occurs during the growing season, from March to October.

While this area possesses a mild climate for about eight months in the year and a rainfall well distributed throughout the season of plant growth, still it is subject to those occasional extremes of temperature that may be expected to pass over the upper Mississippi Valley, especially the western part, once in every five or ten years. The winters sometimes become so severe that the less hardy perennials are frozen, while, on the other hand, the crops may fail now and then from drought, accompanied by hot, dry, southwesterly winds. The years 1894 and 1901 were noted for continued and destructive droughts. During July and August of these years the soil became greatly heated, being more than 72° F. at a depth of 36 inches below the surface. While these years were most destructive of crops, it frequently happens that some part of the growing season has insufficient rainfall. The corn crop may be injured during the early summer, or the wheat, and especially the oat crop, may be cut short by prolonged dry periods during the spring, as in 1906. In any case the damaging effects of deficient rainfall in this area may be largely offset by improved cultural methods, which will be discussed later in this report.

The following tables, compiled from the U. S. Weather Bureau records at Lincoln, show the normal monthly and annual temperature and precipitation and the dates of the last and first killing frosts. It will be seen from the latter that the growing season lasts from April 21 to October 15, a period of about six months.

Normal monthly and annual temperature and precipitation.

Month.	Lincoln.		Month.	Lincoln.	
	Tempera- ture.	Precipi- tation.		Tempera- ture.	Precipi- tation.
	° F.	Inches.		° F.	Inches.
January	22.1	0.66	August	78.9	3.26
February	25.2	.92	September	65.2	2.04
March	36.1	1.37	October	53.7	2.03
April	51.0	2.62	November	37.5	.68
May	61.5	4.38	December	27.5	.75
June	70.8	4.23	Year	50.0	26.76
July	76.0	3.82			

Dates of last and first killing frosts.

	Lincoln.			Lincoln.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1897.....	Apr. 19.	Oct. 29	1903.....	Apr. 30	Oct. 27
1898.....	Apr. 26	Oct. 17	1904.....	Apr. 17	Oct. 25
1899.....	Apr. 21	Sept. 29	1905.....	Apr. 17	Oct. 20
1900.....	Apr. 18	Oct. 17	Average.....	Apr. 21	Oct. 15
1902.....	Apr. 23	Sept. 12			

AGRICULTURE.

The first settlers came to this part of the State in 1856, when the area within the present limits of the county was all virgin prairie. They were molested by the Indians until 1864, when the Government succeeded in confining the latter to their respective reservations.

The first settlement was small and quite isolated, but in 1859 the overland trail from the East to the West was changed from Ashland to a more direct route through this territory. The colony was thus brought into more prominence, and the population increased rapidly.

It was not thought at first that spring wheat would be profitable or that winter wheat would stand the climate in this latitude, consequently only corn and flax were grown prior to 1870. Corn was and has since remained the principal crop in the county. Flax was found to be quite a remunerative crop on virgin soil, but when the land became older the yields were small, and finally, in the early eighties, the land became so infested with noxious weeds that the cultivation of this crop in any quantity was abandoned.

In 1870 an agricultural society was organized "for the development of agriculture along all lines suited to this latitude" and for the development of mechanic arts. It was about this time that the farmers began to test the possibility of wheat production. The first variety tested was known as "tea" wheat, so called from having been found in a package of tea imported from China. This was grown for several years as a spring wheat, but was finally superseded by another called "grass" wheat. This "grass" wheat was grown for a number of years also as a spring wheat, but about 1888 the farmers by accident discovered that this could be grown as winter wheat, and from that date the growing of winter wheat gained some importance. The production of winter wheat in this area, however, received its greatest impetus when the State experiment station demonstrated the value of certain varieties from Russia and Turkey. From 1890 to 1898 hemp was grown in the bottom lands along Salt Creek, its discontinuance being due to a change of ownership of the lands on which it was grown,

The only serious difficulties the farmers of this area have encountered were the grasshopper pest in 1874 and the droughts that occurred in 1894 and 1901.

The implements used in the early agriculture were those for breaking and pulverizing the sod. Then came the check-row corn planter, the gang plow, the disk harrow, and other modern implements suited to the agriculture of the area, the lister being introduced in the later eighties. This implement plows the land and plants the corn in one operation, and its labor-saving merits at once recommended it to the farmers, especially to those who were tenants and desired to farm very extensively. Not only among the tenants, but also among those farmers who own the land, has the use of the lister become quite general. Recently, however, the more progressive landowners have begun to doubt the efficiency of the lister on the soils of this county, recognizing that while it may save much labor it frequently causes a shortage in crop yields and is always prejudicial to the maintenance of productiveness, thus decreasing the intrinsic value of their lands. All the implements used are such as are suited to general agriculture. There is little or no intensive farming done and only a very limited number of stock raised, the principal products being corn, wheat, and oats.

The following table shows the crops grown in this county and the dates of sowing and reaping:

Principal crops and dates of sowing and harvesting.

Crop.	Date of planting.	Date of harvesting.
Corn.....	May 1-20.....	October.
Wheat.....	September 1-20.....	June 20-July 15.
Oats.....	April 1-15.....	July 20-31.
Spelt.....	April 1-15.....	July 1-20.
Sugar beets.....	April 10-20.....	October 20-November 20.
Clover.....	April.....	
Alfalfa.....	August and September.....	
Timothy.....	September.....	

It will be seen from the above table that corn, oats, emmer (sometimes incorrectly called "spelt"), and sugar beets are planted in April and May, a period during which a relatively large proportion of the rainfall is likely to occur. This rainfall coming when the land is without vegetation is usually attended with serious washing, especially on rolling fields where a series of trenches has been made by the lister in planting the corn crop. Indeed, all the soils in the area except that found in the bottoms are very susceptible to erosion, and during the season of planting care should be taken to put the

soil in a condition to hold the utmost amount of moisture. This is important both for future plant growth and for protecting the soil.

The crops are harvested from July to October. Those harvested in July are likely to suffer some damage from heavy rains, while those harvested in October and November are not generally in danger from too much moisture.

General grain farming has always absorbed the interest of the farmer in this county. Corn is the most important crop and, until recent years, when the experiment station made an effort to introduce some diversification in the farm practice of the State, corn was practically the only money crop grown. Corn and wheat are now both put on the market, but oats are not considered in the present economy except for home consumption. Nearly all the grain is sold from the farm, only a very limited number of hogs and cattle being fed for market. There is a large acreage in wild grass, the amount of land devoted to this kind of forage ranking next to that seeded to oats. The acreages in alfalfa and clover are about equal. The millets are grown to some extent. Sugar beets, macaroni wheat, and emmer are comparatively new crops in this area. Sugar beets and emmer are worthy of extended cultivation.

While practically all the staple crops of the area are grown on every farm regardless of soil type, the farmers, nevertheless, recognize that the soils in the eastern half of the county are richer and better adapted to corn and wheat than the soils in the western half, where the glacial drift affects both the topography and soil composition. In the western half of the county as a general rule the lands are in wild grasses, while little or no land is in virgin sod in the eastern half, except in close proximity to some of the streams. The heavy soil in the east half of the county is well suited to clover and alfalfa, as well as to the cultivated grasses.

Perhaps the necessity of crop rotation receives the least attention of any factor entering into the economy of farm practice in this area. The present system of cropping follows corn with oats, and oats with wheat when any rotation at all is practiced, but on many farms corn follows corn for years in succession. When a change is made oats are sown in the spring on "stalk" land, and the oat stubble is plowed in the fall for the succeeding winter-wheat crop. Clover and alfalfa fields are seldom seen in the area, hence no rotation looking to the maintenance of soil fertility is practiced in general. The barnyard manure is frequently wasted, notwithstanding the soil is often in serious need of it.

The soils and the climatic and market conditions in this area suggest certain specific methods of farm practice which no farmer in the county can afford to ignore. The soils have such physical qualities that moisture enters slowly and escapes by evaporation very

rapidly during the hot summer months. The farmers in general do not plow the land deeply, and hence limit the amount of moisture the soil can hold. The surface is generally quite rolling, sometimes hilly, and requires deep plowing and, in certain places, terracing to prevent erosion; but the general rule is to put the corn crop in with the lister, and by so doing reduce the surface of these rolling fields to a series of ditches, while the space between the rows is rarely broken deeper than the tooth of the cultivator runs. By this method of listing the surface soil is rapidly decreasing in depth because of erosion. The nature of the soil and the climatic conditions make it imperative that every effort should be made to conserve moisture, yet the methods of soil management allow great quantities of the annual precipitation to escape by evaporation. By listing the land about 25 per cent more surface is exposed to the sun's rays than would be exposed should this surface remain level; moreover, the use of the lister precludes the possibility of surface mulching, which is of extreme importance early in the spring, when the seed is germinating and when a few days of drought may greatly reduce the stand.

Most of the labor is performed by the farmer and his family. Some of the farmers employ one or two hired men, but the price of labor is high, owing to the demand for laborers in the city and on the railroads. Farmers say they can afford to pay as much as \$25 a month the year round for good men, but there seems to be no supply at this rate.

According to the census of 1900, of 555,520 acres of land in this county about 92 per cent is in farms and about 80 per cent of the entire area is improved. According to the same authority not more than 39 per cent of the farms are operated by the owners, the other 61 per cent being farmed by tenants. The tenant system is thus seen to play an important part in the agricultural practice of this area.

By reason of the location near the principal city of the State, the land in the county brings a high price. Land is generally worth more in the east than in the west half of the area owing to the differences in agricultural value. The prices range from \$50 to \$150 an acre. The prevailing practice of letting the farms to tenants, who can have only a temporary interest in the land, is said to be rapidly reducing the value of the farms. There is a serious need for a definite agreement between the landlord and tenant by which the tenant could be assured of remaining on the farm for a definite number of years and thus be able to plan his operations for some years ahead. This agreement should secure to the landlord a certain method of farm practice by his tenant, through which the productiveness of the soil would be maintained or increased.

At present leguminous crops are grown only to a very limited extent, while the character of the soil throughout the county is such

as to make their use imperative. The conditions in the area suggest the importance of an increased interest in dairying and in the production of live stock. The productivity of the soils should be carefully maintained by the use of farm manure, which at present is frequently allowed to go to waste. The use of the lister, except where land has first been plowed, should be abandoned. Plowing should always be done with a view of conserving the rainfall and preventing soil erosion. The present rotation on many of the farms should be changed. Wheat should follow corn, and oats should follow wheat, in order to get larger yields of each crop. In every system of farming the rotation should include some leguminous crop, and on every farm at least a limited number of stock should be kept to make use of the forage and to increase the supply of barnyard manure.

SOILS.

There are four distinct superficial geological formations in Lancaster County, and each gives rise to a distinct type of soil. In the order of their areal extent these formations are the loess of the Middle Pleistocene period, the Kansan drift belonging to the early Pleistocene period, the most recent alluvium occupying the lower levels along the streams, and the Dakota formation, a ferruginous sandstone outcropping around the base of some of the steeper slopes.

The Kansan drift underlies the surface of the county generally and has a marked influence on the soils. This material is being gradually uncovered by erosion, and in the west half of the county the soil type derived from it covers a large percentage of the area. In the east half this glacial material is deeply covered and comes to the surface only occasionally, being found in ravines and in the vicinity of some of the larger streams. The loessial material appears at one time to have covered the surface of the whole county, but the agencies of erosion have removed the greater part of it from the surface in the western part of the county, where at present it is found capping knolls, skirting the bases of slopes, and occupying the crests of stream divides. The great body of the loess is found in the east half of the area, where, though eroded badly, the stratum is seldom cut through to the glacial material below. The loessial deposit and the Kansan drift merge into each other and sometimes make it difficult to define the boundaries of the resulting soil types.

The Dakota formation is found in the deeper ravines and in places where the overlying formations have been removed by erosion. Here is exposed almost pure gray sand, which is usually cemented on the immediate surface by ferruginous material, while below this the sand is in a semiconsolidated condition and is easily broken down between the thumb and finger. This material comes to the surface

over a very limited area and affects only a small percentage of the soils.

The recent alluvium is found along the streams throughout the county and gives rise to one of the most important soil types in the area. In areal extent it ranks next to the Kansan drift.

All the soils of the area have a brown to dark-brown color, and are generally productive, the least valuable being that derived from the Dakota sandstone. The upland soils contain a comparatively large amount of humus at present, but this element is rapidly decreasing, owing to general grain farming and the limited use of farm manures.

As stated, the surface material of this area has been classified into four distinct types of soil. In the order of their extent these are: The Marshall silt loam, Marshall loam, Wabash silt loam, and the Lancaster fine sandy loam. The first two belong to the Marshall series of soils, so widely developed in this and other Middle and Northwestern States. The Wabash silt loam belongs to the Wabash series of soils, which have a large development in the Mississippi and Missouri bottoms.

The Marshall soils are derived from transported loessial and drift material; the Lancaster fine sandy loam has been formed in place from the weathering of the underlying sandstone, and the Wabash silt loam represents the alluvium which is derived from the wash of the surrounding higher lands.

The actual and relative extent of each soil type is given in the following table:

Areas of different soils.

Soil.	Acres.	Percent.
Marshall silt loam	362,240	66.0
Marshall loam	96,576	17.6
Wabash silt loam	87,616	16.0
Lancaster fine sandy loam	2,368	.4
Total.....	548,800	.....

MARSHALL SILT LOAM.

The Marshall silt loam is the most important soil type in the area. The soil is variable in depth, ranging usually from 10 to 15 and sometimes having a depth of 20 inches, depending on the topographic position. The more shallow places are found where the land has been under cultivation for several years and erosion has removed much of the surface soil to lower levels. Where the surface has remained unbroken and covered with vegetation, the soil is quite as deep on the slopes as on the more level areas. The color of the soil varies, but is prevailingly brown to dark brown, the shade depending on the quantity of organic matter present. The color gradually becomes

lighter the longer the soil is cultivated without the addition of farm manures. This soil is composed largely of silt, with varying amounts of clay and very fine sand. In its original state the particles are so arranged, being influenced by the content of humus, lime, and soluble salts, as to give the soil, when plowed, a rather open and porous structure. By reason of this structure the type is easily cultivated and may be kept in good tilth at comparatively small cost. Only when plowed too wet does this soil puddle. Where this takes place it may require the process of weathering for a whole year to regain a proper physical condition.

The subsoil of the Marshall silt loam may be discussed in two divisions. Immediately beneath the soil is a dark-brown stratum, varying from 8 to 15 inches in thickness, which carries a percentage of clay sufficient to give the texture of a heavy silty clay. Below this heavy material the subsoil becomes relatively light in texture and has a yellow color. Throughout the deeper subsoil small lime concretions are much in evidence, and sections exposed in excavations reveal vertical fissures and numerous small holes through which plant roots have grown. The deeper subsoil of this type is thus seen to be quite porous and comparatively dry, and has been affected very little by weathering. The whole geological body from which this type is derived is proverbially dry and all wells sunk in it must penetrate the light sandy stratum below before water is reached.

The Marshall silt loam is derived from the weathering of the loess. During the process of weathering some of the finer particles, such as the fine silt and clay, have been carried in suspension from the surface and deposited at lower levels, and thus the surface soil has become gradually lighter. This type carries small quantities of soluble salts near the base of slopes and at other points where water accumulates and where capillarity and evaporation combine to concentrate these salts.

The greater part of this type is located in the east half of the county, where it is the dominant soil. There is quite an important area in the southern and southwestern parts of the survey, and at various other points there are small patches and narrow strips around the base of slopes and along the interstream divides.

The surface of the type is gently to heavily rolling. In the extreme southern part of the county there are several square miles that are nearly level. This is along the main divide between the Big Blue River Valley and the Salt Creek basin. There are other level areas at various places in the Salt Creek basin, but with these exceptions all the type has sufficient relief for excellent drainage.

There is a phase of the Marshall silt loam developed in ravines and on some of the slopes where the soil is quite shallow, having been eroded away. The heavy subsoil comes near the surface and causes

trouble in the preparation of the seed bed and the subsequent cultivation of the crops. The farmers find that when the surrounding soil is in prime condition for plowing these heavy spots are too wet, and if plowed at such times they puddle and remain out of condition all the growing season. On the other hand, when these heavy spots are in good condition for plowing, the surrounding soil is much too dry. These heavy spots are called "gumbo spots" by the farmers. Their low productiveness is thought to be due to the presence of alkali salts, but chemical analysis shows no appreciable excess. The lack of humus, therefore, and the poor physical condition appear to be mainly responsible for the poor crop yields obtained. Deep plowing, subsoiling, and heavy manuring will eventually ameliorate these conditions. It would be a good practice for the farmers to place straw on these heavy spots and allow it to rot down and then plow it under deeply.

The native vegetation peculiar to the Marshall silt loam includes the usual grasses of the prairie, together with various herbaceous plants, many of which belong to the family Leguminosæ. Under cultivation this type is productive for corn and wheat. It is the great upland corn soil of the Mississippi Valley. It is also well adapted to sugar beets and other root crops. In growing these deep-rooted annuals subsoiling will be found necessary in the preparation of the seed bed, in order to secure the most satisfactory yields. This soil is also well suited to the production of alfalfa, clover, and many of the tame grasses, such as timothy, orchard, brome, blue, fescue, and other species that thrive on a medium heavy soil. Oats and emmer do well when arranged in rotation with corn, wheat, and clover.

The crops grown at present are corn, wheat, and oats, the most important of which is corn. The yield of corn may vary from 15 to 50 bushels, depending on the season and methods of farming. A general average would be about 30 bushels per acre. Wheat yields from 10 to 35 bushels, with a general average of about 12 bushels per acre. Oats run about the same as wheat. The relative low yield of the latter is due in part to sowing in the spring when there is very likely to be a few weeks of drought, which cuts the crop short or sometimes even destroys it. Clover and alfalfa make fair yields, and the grasses do well.

The Marshall silt loam is capable, under proper management, of holding a very large supply of water, and the annual precipitation is generally sufficient for crop production. Yet it frequently happens that the crops are cut short by drought, although the annual rainfall has been ample. An examination of the topographic and mechanical features of this soil reveals some of the causes of crop failure and indicates why the yields on this type, as at present managed, are not as large as would be expected from a study of this soil in other areas. First, the surface is rolling to hilly and rain water soon finds its way

into the streams. Second, the subsoil carries a heavy stratum just beneath the soil which retards or prevents the percolation of the rain water to the lower subsoil. Third, the soil is of such color that it absorbs heat readily and the moisture is lost very rapidly by evaporation. The latter tendency is very much accelerated by the hot, dry winds from the southwest that frequently come just after a rain and rapidly reduce the inadequate supply of moisture retained by the soil. The crops thus need rain every few days during the growing season to prevent injury from drought. The usual practice is to plow shallow, say to a depth of 2 or 3 inches, or else to put the corn crop in with the lister and not plow the land at all, but reduce the fields to a series of ridges and ditches, thus exposing more surface to evaporation and increasing the tendency to erosion, as well as quickening the drainage of the surface water to the lowlands.

In view of these conditions it is of more than ordinary importance that special care be taken to catch and retain as much of the rainfall as possible in the subsoil for use of the crops during periods of dryness. Deeper plowing, in some cases subsoiling, during the fall season, followed in the early spring and as often during the summer as practicable by surface mulching, will be found to better the moisture conditions materially. This surface mulching is very important in the production of wheat. The wheat fields should be thoroughly harrowed early in the spring, provided the plants have stooled out well in the fall, and this should be repeated as often as necessary, the condition of the plants permitting, to keep a crust from forming. The land intended for oats should be fall plowed and disked early in the spring as long as possible before the crop is put in. After the crop is planted and before it comes up the land may be mulched again if moisture conditions warrant it.

Perhaps the best rotation for this type of soil in this area is that suggested by Hunt for similar soils in this latitude; namely, corn two years, wheat one year, and clover and timothy three years. It is thought that such a rotation would minimize the losses due to the "cornstalk disease" in cattle grazed in the stalk fields.

The Marshall silt loam is the highest priced soil in the county and has a greater crop value than any of the other upland soils.

The following table gives the average results of mechanical analyses of samples of this type of soil:

Mechanical analyses of Marshall silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>				
14945, 15952	Soil	0.0	0.4	0.4	1.3	6.7	68.9	22.5
14946, 15953	Subsoil .....	.0	.4	.5	1.6	3.5	65.5	29.1

MARSHALL LOAM.

The Marshall loam is second in area of the upland soils. The texture of the surface soil is loamy. Material of all grades from clay to gravel and pebbles enters into its composition. Lime concretions are usually plentiful and huge bowlders are of frequent occurrence. The soil is generally open in structure, but, like the Marshall silt loam, it has a heavy substratum that must be broken up before the best physical conditions can be secured. The color of the soil is usually brown to dark brown or with occasionally an area that is dark reddish brown, and in general the longer a field is cultivated the lighter the color of the soil becomes. In depth it ranges from 10 to 15 inches, with a general average of about 12 inches, though in local areas the surface is washed so badly that nearly all the soil has been removed. The composition of the subsoil is generally quite variable. Sometimes it is a mass of sand and gravel; again it may be composed of heavy bowlder clay. The color of the subsoil is generally yellow to reddish yellow and gray. This type, on the whole, because of its more open structure of subsoil, has a relatively lower water-holding capacity than the Marshall silt loam.

On account of its heterogeneous composition, the Marshall loam is not always easily cultivated. Sometimes the heavy subsoil comes near the surface and gives rise to what the farmers term "gumbo." Many fields must be cleared of stones before machinery can be used. A large percentage of the type, however, is clear of rocks of objectionable size and can be farmed with comparative ease.

The greater part of this type is found in the west half of the county, and it is typically developed around the headwaters of Salt Creek and its principal tributaries. It generally occupies the high rolling lands south of these streams, and the areas generally slope to the north. A notable exception to this rule is found east and north of Raymond, where the slope is to the south, agreeing with the direction of the drainage channels. This soil is nearly always found on the lower slopes, and occupies a position between the crests of the divides and the bottom lands along the streams. There is a large development of the type southwest of Lincoln, in the neighborhood of Sprague, Denton, and Berks. There is another large area north and east of Raymond. Other but smaller areas are scattered here and there over the county, following lines of greatest erosive action.

The surface of this type is heavily rolling to rough and hilly, and is so badly dissected in places, notably south of Sprague, Denton, and near Raymond, as to render it worthless except for pasture and meadow. The drainage is very good.

The Marshall loam is derived from the weathering of glacial material belonging to the Kansan epoch. The surface 10 to 12 inches has been changed through weathering to a material of lighter composition than the substratum. The color has been changed by oxidation and plant growth from a buff to a dark-brown color. This drift material is quite old, as shown by the weathered condition of the glacial boulders found in it. These boulders are fragments of granite, gneiss, trap, and Sioux quartzite. All but the last named are in an advanced stage of weathering, many of the granite boulders now falling to pieces.

The native vegetation of the Marshall loam consists almost entirely of grasses and herbaceous plants. There appear to be more leguminous plants on this than on any other soil in the area. Among the more important may be mentioned the wild licorice (*Glycyrrhiza lepidata*),^a the beggar tick (*Mibomia illinoiensis*), the partridge pea or wild senna (*Cassia chamæcrista*), the white thimble weed (*Psoralea argophylla*), the wild indigo (*Baptisia bractata*), and *Parasela delea*. There are more than 30 species of leguminous plants growing wild in this area and perhaps two-thirds of them are indigenous to this type of soil.

The Marshall loam produces good yields of corn, wheat, and oats, but in all probability it is better adapted to the production of oats, emmer, and some of the durum wheats. The soil is generally too light and droughty for the best yields of winter wheat. A large percentage of this type would be more remunerative if seeded to alfalfa and clover and stock raising introduced to take place of grain farming. A large proportion of it will never be valuable for general agricultural purposes. The average yield of corn is about 20 bushels and of wheat about 10 bushels per acre. The yields frequently run very low, owing partly to climatic and partly to cultural conditions.

Shallow plowing and listing are generally practiced on this type. These methods increase erosion and limit the amount of water in the soil reservoir, and the crop yields are affected accordingly. The lister is especially out of place on this soil, since the surface washes badly even under the best methods of soil management. The farmers who own this land are beginning to realize this and are using the lister less than formerly. These rolling lands when cultivated at all should be plowed deeply, so that the heavy rains, instead of running off the surface, may soak down into the subsoil. All the draws should be left to grass over and, where the liability to erosion is very great, terracing would be advisable to direct the surplus waters into the grassy draws. Much of this land should be left in permanent meadows or plowed up and put in alfalfa.

^a Identified by Dr. Charles E. Bessey.

This type of soil is of less intrinsic value and brings a lower price in the market than the Marshall silt loam. It ranges in price from about \$25 to \$50 an acre, depending on location and improvements.

The following table shows the average results of mechanical analyses of the fine earth of this type of soil:

Mechanical analyses of Marshall loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>				
14947, 15950	Soil	1.9	3.8	4.5	13.8	10.1	39.4	26.6
14948, 15951	Subsoil .....	.8	4.3	4.6	12.7	8.1	39.8	29.9

WABASH SILT LOAM.

The texture of the soil of the Wabash silt loam varies considerably. In some places where the Marshall loam is the adjacent type it is rather sandy, and again where deposition has occurred from comparatively still water the proportion of clay is greater. The soil is stratified, and silty, clayey, and sandy layers are found to occur alternately. It contains much organic matter, which renders its structure open and porous, except where clayey material predominates. It is generally dark brown to black in color, with here and there a gray phase, due sometimes to the presence of alkali. The surface soil is very deep, ranging from 15 to 40 inches, with a general average of about 20 inches. It is generally easy to cultivate, the worst trouble being the rapidity with which weeds and grasses grow.

The Wabash silt loam forms the bottoms along the principal streams, occurring in areas from a few rods to more than 2 miles in width. The surface is generally level, but some depressed areas are found along Salt Creek. There are some small islandlike areas of Marshall silt loam rising above the lowlands northeast of Lincoln. These mesalike elevations appear to have been caused by the shifting of the stream channel and by the general wearing down of the Salt Creek basin; areas better protected by vegetation or position with relation to currents have resisted leveling by erosion.

The whole of this type has a general slope of perhaps 10 feet to the mile, except that found along Rock Creek, where the slope is not so great. This rapid fall has caused both Salt Creek and its tributaries to cut their channels several feet below the surrounding bottom land, which when the streams are normal lies from 10 to 20 feet or more above water level. Nevertheless the streams tend to wind in their courses and loops, oxbows, and abandoned channels are of frequent occurrence.

Salt Creek and its tributaries drain not only most of the area of Lancaster County, but a vast area outside of the county to the west and northwest. All of this drainage, except that carried by Rock Creek, enters the main channel of Salt Creek near the city of Lincoln. Here sometimes the water accumulates in such floods that all the bottom land is submerged, as, for instance, during the present year (1906), and boats take the place of vehicles. During these freshets much farm and some city property is destroyed. There appears to be no practicable way of controlling these flood waters, though in some cases diking might be found worth while. With the exception of the floods most of this soil is very well drained, and much of it is under cultivation. There are some flat areas near Lincoln and, generally, where the larger tributaries enter Salt Creek that require tiling and in some cases open ditches. The drainage of these areas is feasible, since the stream channels are all deep enough to allow a sufficient fall in the drains.

The Wabash silt loam is alluvial in origin and is composed of the wash from the surrounding soil types. Little or no weathering is required to make this soil productive, since it is not only composed of the most available plant-food materials of the upland soils, but it receives a new and fresh supply of these at every flood. This type carries a small amount of alkali. The native vegetation consists of various lowland grasses, herbaceous plants, and trees. The most important trees are the willow, box elder, walnut, ash, and cottonwood. The trees usually are found near the streams.

The Wabash silt loam is the best corn and wheat soil in the county. Its water table is generally less than 10 feet below the surface, and capillarity works very advantageously in bringing the moisture within the zone of root action. Barring the liability to floods, this soil is well adapted to the production of sugar beets, clover, alfalfa, and the tame grasses, though alfalfa should not be expected to do well where the water table is less than 5 or 6 feet from the surface. Corn is not so likely to be damaged by floods if planted early, and wheat should be seeded early enough in the fall to give it a good start and hasten its maturity in the spring. The crops grown are corn and wheat. The former yields from 30 to 60 bushels, with a general average of about 40 bushels per acre. Wheat will generally produce from 20 to 40 bushels, with an average of about 25 bushels per acre.

There is perhaps less necessity for care in the conservation of moisture in the cultivation of this soil than with any other type in the county, but even in this rich alluvium moderately deep plowing and surface mulching are necessary for the best results. The various weeds and grasses grow with great rapidity, and frequent mulching not only conserves moisture, but serves to destroy germinating weeds and grasses. These troublesome weeds must be dealt with each year,

since the seeds are brought down by the floods and scattered over the farms, and the highest yields of corn and other cultivated crops can be secured only at the expense of much labor. Though this soil is subject to annual inundation, its crop value is so great in favorable seasons that its market price is always high, generally ranging from \$50 to over \$100 an acre.

The following table gives the average results of mechanical analyses of this type of soil:

Mechanical analyses of Wabash silt loam.

Number.	Description.	Fine gravel.	Coarse sand	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>				
14949, 15954.....	Soil.....	0.0	0.1	0.3	1.0	12.2	61.9	24.2
14950, 15955.....	Subsoil.....	.0	.5	.4	1.1	4.7	67.8	25.7

LANCASTER FINE SANDY LOAM.

This type is the least extensive found in the county. The soil is quite sandy, being composed of medium to fine sand with a slight admixture of silt blown over it from the surrounding heavier types. The structure is open and porous. The soil is generally of a dark-brown color, from 10 to 15 inches deep, with a general average of about 12 inches, and is very easily cultivated. The subsoil is composed of medium to fine sand or sandy loam of a yellow to gray color. At a depth of about 25 inches there is sometimes found a stratum of rather heavy silty material about 5 inches in thickness that aids in the conservation of soil moisture.

The Lancaster fine sandy loam is found in various parts of the northern half of the county. A small area skirts the bluffs along Salt Creek south of Lincoln, another larger area occurs 2 or 3 miles north of the city, and at several other points in the northeastern part of the county are found small patches of this sandy material. The surface of this type is rolling and sometimes quite precipitous. It is always well drained.

The Lancaster fine sandy loam is derived for the most part from weathered sandstone of the Dakota group. This material outcrops in some of the deeper ravines where the overlying formations have been removed from the surface. There is one place just north of Lincoln where the sandy material appears to have been an outwash from the glacier, but with this doubtful exception there can be no mistake concerning the origin of the type. The sandstone, when found in the ledge, has a brown to gray color and is only loosely consolidated, breaking down easily between the thumb and finger.

After it has been weathered for some time the color changes to a reddish-brown and there results a ferruginous sandy soil.

The limited extent of the type in this area and its occurrence in spots and patches make it difficult to determine its relative crop value. It is, however, much below that of any of the other types for general crops. Where favorably located it would be well to grow early vegetables on it, because its sandy, loose nature makes it more suitable to truck than to general farm crops.

The following table gives the results of mechanical analyses of this soil:

Mechanical analyses of Lancaster fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	Per ct.	Per ct.	Per ct.	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
15948	Soil	0.0	2.6	12.8	43.7	5.4	21.8	13.2
15949	Subsoil .....	.0	5.0	17.5	40.3	3.1	23.7	10.7

ALKALI.

The farmers of this area frequently find in their fields local spots and patches of heavy gray to dark-gray material that gives them much trouble in the cultivation of their crops. These local areas are called "gumbo," and are caused by the subsoil coming to the surface in badly eroded places. The cause of these spots is lack of humus and poor physical condition, but there is a popular notion that their refractory nature is due to an excess of soluble salts or alkali. In order to substantiate or disprove this theory, some of the worst places were sampled and chemical analyses made to determine the salt content.

These analyses did not show enough water soluble salts to justify a complete chemical analysis, slightly more than one-half of 1 per cent magnesium oxide, the salt which is thought to cause the trouble in these upland soils. So small a quantity is not enough to injure crops or markedly to affect the physical condition of the soil. These spots are generally found in the Marshall silt loam and the Marshall loam, and in the latter type they may sometimes carry an excess of salts, but the probability is that no serious trouble has ever arisen from this cause. As has been stated elsewhere, these heavy areas may be improved by heavy applications of coarse manure and deep plowing.

While little or no alkali is found in the upland soils, there is a considerable quantity in the Wabash silt loam, mainly compounds of sodium, magnesium, potassium, and calcium. The most prominent

alkali areas in this bottom-land soil are found near the junction of Little Salt, Oak, Middle, and Haines creeks with the main channel of Salt Creek. These areas are at once recognized either by the white incrustations of alkali or the otherwise barren surface, or by the well-known salt grass that thrives in soils saturated with alkaline solutions. These areas are generally low and too wet for cultivation.

As stated, these alkali spots occur wherever the large tributaries enter Salt Creek. It is notable that the tributaries mentioned are fed by waters that either leach out of or pass over the largest area of the glacial drift in the western and northern parts of the county. It is quite probable, therefore, that most of these soluble salts have come from the leachings from this ground-up glacial drift.

A small percentage of the Wabash silt loam is abandoned because of the alkali, and these small areas are outlined and designated as "salt flats" on the soil map, because the conditions did not justify the preparation of a separate alkali map. As elsewhere explained, the conditions of the streams make drainage in these bottom lands quite feasible, and drainage will in all probability reclaim these flats from their alkali condition.

SUMMARY.

Lancaster County is situated in the southeastern part of the State. The surface is rolling to rough and hilly, with a general elevation of 1,200 feet above sea level. The general slope is to the northeast, and the drainage is effected through Salt Creek and its tributaries.

The area has a moderately humid climate, but is subject occasionally to severe droughts. It has excellent railroad facilities, and good markets are within easy reach of all parts of the county.

The agriculture of the area dates from 1856 and has almost always been along the line of general grain farming. Stock is raised only in a very limited way, and most of the grain is sold from the farm. There is serious need of a mixed husbandry in which leguminous crops are grown and special attention directed to stock raising, especially hogs, and to dairying.

The principal crops grown are corn, wheat, and oats, and these have been the most important since about 1888, prior to which date flax constituted a principal crop. The tenant system is an important factor in the farm practice in this area, and this, together with a too general use of the lister, has caused the productiveness of farm lands to deteriorate.

There are four types of soil found in this area. The Marshall silt loam and the Marshall loam represent the Marshall series, and the Wabash silt loam the Wabash series. The Lancaster fine sandy loam

is associated with the Marshall series, but is not yet referred to any series.

The Marshall silt loam is well adapted to corn, wheat, oats, sugar beets, alfalfa, clover, and the grasses, while the Marshall loam is a heavier soil and is probably better suited to the production of durum wheats, oats, alfalfa, and some of the wild grasses. The Wabash silt loam is a very good corn and wheat soil, but is subject to annual inundations. The Lancaster fine sandy loam is too limited in extent to permit of a very detailed study, but where favorably situated will produce early truck better than any other type in the county. In the cultivation of the Marshall soils the conservation of moisture is a prime requisite to successful agriculture. In the Marshall soils there occurs a phase here and there known as "gumbo" that gives trouble in cultivating the farms, but by deep plowing and applying coarse manures these heavy spots can be made to disappear.

The adaptation of the Marshall silt loam to the production of sugar beets justifies a more extended interest in the beet-sugar industry in this county. More alfalfa should be grown, and a definite rotation of crops should supersede the present method of planting the same fields to corn for years in succession. Finally, the use of the lister should be largely abandoned, and the plowing of the land should be insisted upon by every landowner in the area.

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