SOIL SURVEY OF BARNES COUNTY, NORTH DAKOTA.

By L. C. HOLMES and J. E. DUNN, of the United States Department of Agriculture, and HERBERT A. HARD, A. C. ANDERSON, WM. ROMMEL, and A. C. BOUCHER, of the Agricultural and Economic Geological Survey of North Dakota.

DESCRIPTION OF THE AREA.

Barnes County is located in the eastern part of North Dakota, about 140 miles south of the Canadian line. It is bounded on the north by Griggs and Steele Counties, on the east by Cass County, on the south by Ransom and Lamoure Counties, and on the west by Stutsman County. The county is rectangular in shape, being 36 miles wide by 42 miles long. It comprises an area of 1,501 square miles, or 960,640 acres.

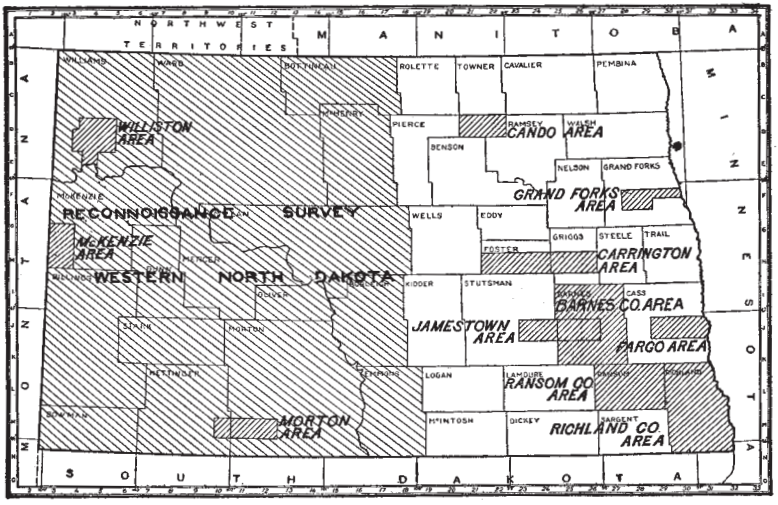

FIG. 52.—Sketch map showing areas surveyed in North Dakota.

Barnes County comprises two distinct topographic divisions. The first and by far the most extensive comprises the elevated treeless plains, while the second includes the deeply trenched Sheyenne Valley system. The prairie region is quite typical of a great part of eastern North Dakota. It is an extensive level or gently undulating to

rolling plain of extremely monotonous outline. Being within the glaciated zone, it has all the more minute features of a drift-covered plain. Low ridges and flattened, choppy hills or isolated knobs are common, but the apparent variations in elevation are magnified by the level intervening stretches. The morainal hills are sometimes closely set, rough, and stony, giving their localities the most uneven topography of the plains. A belt of such hills occurs south and southeast of Sanborn, with maximum elevations of about 100 feet above the prairie. Other groups are found in the western part of Baldwin and Grand Prairie Townships, in portions of Sibley Township, and elsewhere. Segments of several terminal moraines having more than local significance are encountered. An extended ridge known as Alta Ridge follows a north and south course through the eastern part of the county. It is several miles wide and attains elevations of 200 feet above the surrounding plains. Its base is thought to be of preglacial formation, with a thick covering of glacial material.

Most of the prairie region has no surface drainage other than that afforded by numerous potholes, small lakes, and swales, which serve as collecting places for the run-off. The largest depressions are often disjoined valley sections marking the location of streamways which existed prior to the last ice advance. The lakes in the western part of the county occupy old blocked valleys. Some of the largest of the lakes are at times merely mud flats. Various systems of connected swales and small channels traverse the prairie and unite to form extended minor valleys. These were avenues by which the water from the melting ice escaped, and at the present time they are insignificant in appearance and unimportant as drainageways. In some instances, as along Stony Slough and the Sand Prairie region, they serve to modify the otherwise level to undulating prairie topography, but do not greatly alter the general surface, except where they approach the deep Sheyenne Valley. The depressions and ridges largely merge to form a billowy skyline. The elevations above sea level in this upland plain region range from approximately 1,200 to 1,500 feet.

In places the typical prairie till surface merges imperceptibly into a slightly lower, flat series of terraces along the Sheyenne Valley. These uniformly surfaced terraces are easily observed from a distant elevation, while the more deeply cut valley may be invisible.

The Sheyenne River occupies a huge trough following a north to south course through the county a little east of its center. The stream is about 200 feet below the level of the prairie, and the slope from the upland is precipitous. The distance across the valley from one prairie rim to the other varies from 1 to 3 miles or more.

The largest local tributary of Sheyenne River is Bald Hill Creek, in the northern part of the county. This stream is similar to the Sheyenne River in having a deep channel and eroded sides, but is of smaller proportions. In addition, many coulées[1] or gulched washes dissect the prairie along its valley margin. These are largely intermittent waterways draining a territory not much greater than their own side slopes, which merge quickly into the prairie topography.[2]

In 1870 the population of the entire State of North Dakota was only 2,405. This region was at that time held in low esteem for agriculture. The building of the Northern Pacific Railway in the early seventies stimulated settlement. The vast extent of the new country and the transitory habits of the first settlers retarded organization and development. Barnes County was not organized until August, 1878. In 1880 the population of the county was 1,585. The next decade was marked by a great influx of settlers, and by 1890 the population had increased to 7,045. It was 13,159 in 1900 and 18,066 in 1910.

The county ranks eighth in population among the counties of the State. The 1910 census reports 12 inhabitants per square mile, as compared with 8.2 for the State and 30.9 for the United States. The farmers of Barnes County have since its early settlement been predominantly of foreign birth. Of the 1,751 farmers in the county 943 are foreign born, mainly Swedes, Norwegians, Germans, and Danes. Most of the native-born farmers came from the North Central and Central States, and some from the North Atlantic and New England States.

Barnes County has about 155 miles of railroad. The main line of the Northern Pacific bisects the county from east to west. The Minneapolis, St. Paul & Sault Ste. Marie Railway (the Soo Line) crosses the county diagonally from southeast to northwest. A line of the Great Northern Railway has recently been constructed across the extreme northeastern corner of the county. In addition to its main lines, the Northern Pacific has two feeders, the Cooperstown branch, which extends northward from Sanborn, crossing the Soo Line at Roger, and the Casselton branch, extending into the southern part of the county. The railroads are quite well located to best serve market and distributing requirements, yet the haul to shipping points is too great in some instances. Of the 1,501 square miles in the county, 1,011 square miles lie within 6 miles of a shipping point, 327 square miles lie within 6 to 9 miles, while 163 square miles have

[1] The word "coulée" is here used as locally understood.

[2] A description of the main topographic features, geology, and water supply of southern Barnes County is found in the Jamestown-Tower Folio, No. 168, of the Geologic Atlas of the United States.

a haul of more than 9 miles. Southwestern Grand Prairie and northwestern Svea Townships and adjacent areas are farthest from a railroad, with a maximum haul of 12 to 14 miles.

Valley City is the county seat and the largest town of Barnes County. It has a population of 4,606, and is known as one of the most admirably located towns in the State. Its sheltered position in the deep Sheyenne Valley presents a marked contrast with other towns of the State, most of which are located upon the prairie. It is the site of a State Normal School, which, together with local schools, affords advanced educational advantages for the county. In addition, Valley City is a good business center and the sixth city of the State in size. Its location at the intersection of the Northern Pacific and the Soo Line gives it good railroad facilities. Wimbledon, on the Soo Line, with 571 inhabitants; Litchville, on the Casselton branch, with 484; and Sanborn, on the Northern Pacific, with 390, are next in size. Other towns are Dazey, Nome, Oriska, Fingal, Roger, Kathryn, Leal, Eckelson, Hastings, Eastedge, Lucca, and Pillsbury.

Schools are good and well managed. More attention could be paid to the betterment of rural-school surroundings, but this will follow thicker settlement of the farming sections.

The county roads are receiving increased attention, the automobile being a stimulating factor. There are very few heavy grades besides those leading from the valley region to the prairies, and even here care in the location of the valley exits has eliminated serious grades. All of the roads except those in the valley region follow section lines with remarkable regularity. Nearly all section lines are open and occupied by usable roads. In most instances these are "prairie" roads, unmodified from nature except by the construction of dirt fills in swale bottoms and slight cuts on ridge crests. Each year sees substantial additions made to the graded roads and to the number of bridges in the county. Short stretches of road are graveled, especially on grades and across sticky, low-lying soils. The fact that the soils dry quickly and become smooth after rains is a contributing factor in the maintenance of good roads. Snow drifts into the road cuts during winter, but in general few communities have better natural conditions for moving farm products and farm machinery.

The telephone is in use throughout the county, and every section is reached by the rural free delivery of mail.

CLIMATE.

Barnes County is characterized by short, cool summers and long, cold winters. Occasionally in July and August a temperature of 100° F. is reached. During midsummer the nights are cool and some-

times even chilly. The region is noted for its severe winters, but, owing to the dry air, the cold is not so penetrating as in more humid sections. The winters set in suddenly as a rule and immediately stop all outside work except grain hauling. A frost penetration of 4 to 6 feet is common, since the snow covering is rarely thick and is drifted continuously by strong winds. Occasionally very low temperatures continue for long periods.

The following data, taken from the records of the Weather Bureau station at Berlin, Lamoure County, are typical of the region in which Barnes County is situated:

Normal monthly, seasonal, and annual temperature and precipitation.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	13	55	−36	0.6	0.7	0.6	6.6
January	8	65	−38	0.6	0.6	0.6	5.6
February	6	54	−44	0.9	1.0	1.9	8.7
Winter	9			2.1	2.3	3.1	20.9
March	22	68	−41	1.4	1.3	1.4	13.5
April	42	85	−18	2.3	2.9	5.1	3.8
May	52	99	20	1.8	0.7	4.0	Trace.
Spring	39			5.5	4.9	10.5	17.3
June	62	101	23	3.7	1.5	3.2	0.0
July	67	104	36	2.7	1.5	1.3	0.0
August	66	102	29	3.6	0.7	4.6	0.0
Summer	65			10.0	3.7	9.1	0.0
September	56	99	8	1.3	0.3	0.9	Trace.
October	44	89	−21	1.2	0.7	2.0	2.1
November	26	71	−31	0.7	0.2	3.2	2.1
Fall	42			3.2	1.2	6.1	4.2
Year	39	104	−44	20.8	12.1	28.8	42.4

The table shows this to be a region of comparatively light rainfall, but the scant supply is offset, so far as agriculture is concerned, by the manner of its distribution. Normally 75 per cent or more of the precipitation comes during the growing season. For this reason crops thrive as well as in some sections of much greater annual rainfall, but not so favorably distributed.

The average date of the last killing frost in the spring is June 2, and of the first in autumn, September 12. The date of the earliest

killing frost recorded in the fall is August 31, and of the last in spring, June 21. Light frosts occasionally occur in midsummer, but these are rarely damaging.

The growing season averages about 102 days, being slightly longer in the southern than in the northern part of the county. The general region about Barnes County and northward to the Canadian line has a shorter growing season than any other part of the United States of equal or less elevation, but this limitation may be largely overcome by the adaptation of crops through seed selection.

The prevailing winds from October to March are from the northwest, during April and May from the north, and during the summer months from the south. The most damage results from the hot, withering winds from the south and southwest, but their occurrence is rare, and they are not so destructive here as in most parts of the Great Plains region. Hail is of sufficiently frequent occurrence to warrant its being commonly provided against by insurance, but records of losses are surprisingly low. Blizzards, though of infrequent occurrence, are usually severe.

AGRICULTURE.

The agricultural development of Barnes County was begun in a desultory way by its first settlers early in the seventies. The possibilities of the region were little appreciated and the crops and methods adapted to it were not well known. It was natural that the pioneer farmers should be attracted by the protected situations along the Sheyenne River, and the first homesteads were located in such places near the newly constructed Northern Pacific Railway. The relatively inextensive tillable valley soils were soon occupied. The prairie lands near the railroad were next taken, and in this manner the country was gradually settled.

It was several years before agriculture had made much headway. Breaking the tough virgin sod was the first operation on the prevailing prairie soils. Poor equipment, scanty provisions, and all the delays and discouragements incident to pioneering sometimes so hampered this work that placing a 160-acre tract under cultivation required several years' work.

Some oats and barley were grown in the early days for horse feed to supplement the prairie hay. From the very first spring wheat was the money crop. The good yields secured constituted one of the greatest inducements to prospective settlers, so that the population increased rapidly, and by 1890 agriculture had become permanently established. The county had become noted for the high quality of its wheat and other crops, particularly flax and barley. Shortly after 1890, however, a period of depression was caused by

two successive crop failures followed by the nation-wide financial depression. Owing to scarcity of money and failure of credit, many fine farms were sacrificed. Agriculture thus received a severe setback, but with the return of national prosperity farming again became profitable and the progress initiated then has continued to the present time.

Spring wheat has consistently been the principal money crop of the county, and owing to natural conditions the tendency has been toward a one-crop system. Sowing wheat continuously for many years upon the same soil was the rule and was scarcely avoidable, owing to the meager crop range permissible under the limited methods and climate of the region. In the earlier years Scotch Fife was the principal variety grown. Varieties of the blue-stem class soon became dominant and have so continued, but the durum varieties, a later introduction, have become important. According to the census of 1910, 150,701 acres were devoted to durum wheat in 1909 and 198,804 acres to other varieties. Durum yields exceeded those of other varieties for a time, but the difference has grown less, and it is now perhaps no more profitable, with a prevailingly lower price. Velvet Chaff yields well, but seems to be more subject to rust, shatters badly in windy weather, and deteriorates faster when wet, because of its open husk. With wheat, as with other crops, seed selection is highly important.

Wheat, being the slowest-maturing grain crop grown, is the first sown in the spring, usually between April 15 and May 15. In order to minimize disease and insure early planting, farmers do as much fall plowing as possible. Probably 90 per cent of the plowing for this and other crops is done with 14-inch gang plows, triple gangs being commonly used on the larger farms and sulkies on the smaller. The common practice is to use five horses on a 14-inch gang, seven on a triple gang, and three on a sulky, plowing an average of a little over an acre per day for each animal used. Under the extensive system now in vogue, the walking plow is unusual. The soil is ordinarily turned to a depth of 4 or 5 inches, but the benefits of deeper plowing and subsurface packing are gaining recognition. Gas tractors for drawing plows are sometimes used, but are comparatively new and not in common use because of the expense involved in their operation. Most of the wheat land, as well as that devoted to other grain crops, is harrowed twice before seeding and once after. All grain is drilled in rows 6 inches apart at the rate of 5 pecks per acre of ordinary wheat and 6 pecks of durum.

Harvesting begins early in August, the wheat being cut with binders and shocked immediately without capping to stand until thrashed. During the season of 1912 much of the grain was badly

damaged in the shock, and stacking will no doubt eventually become the rule when grain farming on a large scale gives way to more diversified forms. Thrashing is done with portable machines drawn from field to field by steam traction engines, using coal and straw for fuel, although gas engines are becoming common. An average machine will thrash about 1,600 to 2,000 bushels per day and will serve several farmers of a locality during a season. The balance between available machines and grain demanding attention is never very well maintained and small machines for restricted use are becoming popular. The standard thrashing price paid for thrashing the wheat is about 10 cents per bushel. Probably 90 per cent of the straw is immediately burned. This constitutes one of the greatest wastes incidental to grain growing, but one which may be eliminated by the raising of large numbers of live stock.

The average yield of wheat in Barnes County is about 13 bushels per acre, but this is subject to wide variation from season to season. The extreme range in yields extends from complete failure to a maximum of 38 to 40 bushels. The season of 1912, with an average yield of about 16 or 17 bushels per acre, probably represents the greatest total crop and the highest average acre yield in the county's history. This is in strong contrast with the years 1910 and 1911, when scarcely half this average was produced. The quality of the hard wheat of North Dakota has a world-wide reputation, and this crop will always be an important one in Barnes County. Diversification may reduce the acreage, but will probably cause an increase in the average yields even beyond the figures for 1912. Most of the wheat produced in Barnes County is shipped to Duluth and the milling centers of the country. A mill with a flour capacity of 1,800 barrels per day is located at Valley City.

The growing of wheat in Barnes County, as elsewhere, has been accompanied by losses from rust and smut. Smut has been decreased by the formaldehyde treatment of seed grain, but "black rust" is still disastrous at times.

The oat crop is probably next to wheat in point of acreage and has been grown in the county since its early settlement. This crop constitutes the principal grain feed for horses and the area devoted to it is roughly calculated to meet local needs, only small quantities being shipped. The White Russian variety seems to be best adapted to the soils and climate, and is the prevailing variety grown. It has a grain of heavy quality. Average yields are about 28 bushels per acre, but maximum yields of 75 bushels are occasionally secured.

Barley did not become an important crop until some years after the county was settled. It is a short-season crop and can be planted later than either wheat or oats. It is an excellent crop for fields infested with weeds, since the soil can be plowed late in the spring,

thereby destroying the sprouted weeds. The quality of grain is good, being much in demand for brewing purposes when not damaged in the shock. When so injured it is used locally or shipped for feed. Yields average about 17 or 18 bushels per acre.

Flax was introduced many years ago and was extensively grown, at one time even approaching wheat in acreage. It was the first crop sown on newly broken land and was often grown for several successive years. The advent of the disease known as "flax wilt" resulted in a decreased acreage. At present it is not considered safe to grow flax on the same land at intervals of less than 5 to 7 years. It is produced entirely for its seed by the growing of what is known as "common flax seed," which is in reality a mongrel mixture of strains, or even varieties. The Agricultural College of North Dakota has conducted experiments with this crop and its diseases in an effort to retain the crop in the region. Some individual strains known as "wilt resistant" have been developed, which succumb less easily to the disease. By seed selection, seed treatment, and careful attention to the main facts already known of the disease the flax crop can be retained as a valuable factor in the agriculture of Barnes County. The present yields average about 7 bushels per acre. Fields entirely free of wilt are rare.

Corn will probably become an important crop. The production of a sure yield of mature corn has been generally thought to be impossible until very recently. Patchy fields were planted for fodder and there was little concern as to whether mature corn was produced. At present, however, this crop is receiving increasing attention. As measured by the well-known corn States, Barnes County has not a climate suitable for corn production. The farmers of the county, however, with the aid of specialists in seed selection, are making an effort to produce varieties which are adapted to the region. The past practice has been to import seed corn and the poor results have spread pessimistic views. Corn breeders are progressively shortening the maturing period of the corn plant and will probably perfect varieties that can mature in the short season of Barnes County. The Northwestern Dent, Minnesota 13, and Minnesota 23 are the most promising varieties.

Potatoes are grown for local use and moderate quantities for shipment. Although the quality of the potatoes is good it is difficult to place them on the market profitably. Average yields approximate 75 or 80 bushels per acre. The Early Ohio is the most popular variety.

The growing of winter rye is increasing, not so much because of the direct profits derived from its production as of the opportunity it affords to free the land of obnoxious weeds. Spring rye does not

have this advantage, and offers no other inducement for its growth. Rye yields average about 15 bushels per acre.

Millet or Hungarian grass is grown to a small extent, with average yields of about 2 tons per acre. The acreage devoted to timothy is not increasing. It produces but little hay and its place as a pasture grass is better filled by brome grass, which, however, is not a heavy producer of hay.

At present no legume is grown as a regular crop. Red clover is not suited to the climate, but Canada field peas seem to do well and may become popular in the county. Alfalfa has been tried with varying degrees of success, the Grimm variety apparently being best suited to local conditions. The winters are rather severe for this crop, as for all perennials, and it is believed that fair trials will show it to be poorly adapted to the county. Inoculation of the soil is usually necessary.

The trucking industry has never been developed in the county, and owing to unfavorable climatic conditions this branch of agriculture could hardly be made profitable. Beans, onions, radishes, lettuce, cabbage, asparagus, celery, tomatoes, sweet corn, squashes, pumpkins, and other hardy vegetables are grown for local use.

The climate is unfavorable for the commercial production of fruit. Some tree and bush fruits are grown, however, for home use. Only the most hardy sorts should be planted. The young trees and plants require considerable attention.

The average size of the farms in Barnes County, as given by the 1910 census, is 517.9 acres. It was 444.8 acres in 1900 and 268 acres in 1890. The number of farms in 1910 is given as 1,751. In 1910 there were 128 farms of over 1,000 acres, 512 between 500 and 999 acres, 800 between 260 and 499 acres, 281 between 100 and 259 acres, and 30 of less than 100 acres. The number of farms operated by owners is given as 1,170, by tenants 549, and by managers 32. A little more than half the whole number are mortgaged. Better results would probably follow a reduction in the size of the farms to about 320 acres.

Under the general system of tenure in Barnes County the owner and tenant share the grain crop equally, the tenant furnishes all machinery, and horses and labor for tillage and harvesting, while the owner furnishes seed. The tenants usually remain on one place for only a few years. Poorer farming is generally practiced on tenanted land than on the farms operated by the owners.

As a rule there is great difficulty in securing efficient labor. Nearly all of the farmers hire labor from April to November, at the rate of $35 per month. When hired by the year farm laborers are paid about $32 per month. The greater part of the work is done by day laborers, who are paid about $1.25 per day with board during spring and mid-

summer to $2 or possibly $2.50 or more during the harvest season. The difficulty in securing reliable labor is greatest during the harvesting and thrashing season.

Land values have advanced steadily since about 1895. The present average value is about $37.50 an acre, with an extreme range from about $15 for nonagricultural land to $60 or $65 an acre for the best and most advantageously located farms.

At present agriculture in Barnes County consists almost entirely of the production of grain for a cash market. The farmers, however, are beginning to appreciate the necessity for a greater diversification of crops and the desirability of mixed farming.

Very little of the land is fenced. The fields are in many cases overrun by obnoxious weeds, such as pigeon grass, wild oats, and mustard, which can only be eliminated through the production of intertilled crops. The systematic rotation of crops has never been practiced, but must be considered in connection with any readjustment of the present methods of farming. It is impracticable to suggest any exact system of farming without a study of the individual requirements of the farmer and experimentation. The belief is prevalent that the soils of the county are exhausted. It is probable, however, that improper soil management rather than the exhaustion of the soil is responsible for the decline in yields.

The raising of live stock and dairying should receive greater attention. The 1910 census reports 19,830 head of cattle, 20,735 horses, 97 mules, 11,765 hogs, and 1,336 sheep in the county. In view of the possibilities these numbers are extremely small. The heavy Percheron breed of horses long ago supplanted the range stock of the early settlers. The Duroc-Jersey is the most popular breed of hogs.

Dairying should prove a profitable industry. There are several creameries in the county, and this branch of agriculture is receiving more attention. While the winters are severe, feed can be provided cheaply by the use of the silo. In general the farmhouses and outbuildings are good, but greater attention should be paid to the protection of farm machinery and live stock.

SOILS.

In origin the soils of Barnes County are similar to those of a vast surrounding region. They were formed during the glacial period by the great continental ice sheet which advanced and retreated across this region, carrying materials from the north and east. In its work the ice was assisted by the unusual volumes of water which were, of course, released as the ice disappeared. These foreign materials were ground up and mixed with the underlying local material, and the entire mass deposited as a mantle which varied in thickness

from 30 to 100 feet. This mantle was subsequently modified by the waters from the melting ice, which effected extensive erosion and redeposition along irregular stream courses.

The soils which escaped alteration after being deposited by the ice are known as glacial or drift soils. These are by far the most extensive in Barnes County. They were classified as the Carrington series, with two types, the Carrington silty clay loam and Carrington loam. This series of soils is widely distributed throughout the northern part of the central prairie States from middle Iowa northward to the Canadian line. The Carrington soils are easily tilled and are excellent for general farming. They are commonly known as "black prairie soils," are very high in organic matter, and in Barnes County usually carry large percentages of calcium carbonate. Nearly all of the products of eastern North Dakota outside of the Red River Valley are grown upon the Carrington soils. Minor bodies of other good soils are associated with this series, but their areas are relatively small.

The Sioux fine sandy loam and Pierce gravelly loam were formed as marginal deposits along the front of the ice sheet or by gorged streams running through the glacier. In origin they are somewhat different from the Carrington series. These soils are inextensive, and as a result of the water action by which they were formed their subsoils consist of an assorted mass of coarse material.

While the ice sheet reduced the originally rough surface to a comparatively smooth plain it left a large number of lakes, minor inclosed depressions, and sags. These areas of deficient drainage occur throughout the undulating plain occupied by soils of the Carrington series and possess soil characteristics sufficiently different to warrant their classification into several types, and they are mapped as the Rogers silty clay, Fargo silty clay, Meadow, and Beach gravel. These soils are largely nonagricultural. Alkali spots have been formed in places by the accumulation of the salts in areas of poor drainage.

The types owing their origin to the activities of escaping water from the melting ice comprise terrace or temporary lake soils which vary widely in crop value and other features. The Bearden silty clay loam and the Sioux fine sandy loam, heavy phase, are soils deposited by the Sheyenne River when it occupied its highest level, represented by Getchell Prairie. The Sioux gravelly loam, Sioux fine sandy loam, valley phase, and the Lidgerwood clay in part were represented by Getchell Prairie. The Sioux gravelly loam, Sioux sandy loam, Maple clay loam, and Bearden loam were laid down along glacial stream courses. All of these soils except the Bearden loam have gravelly subsoils. They were formed within temporary lakes.

The Wabash clay occupies the flat bottom of the Sheyenne River, while the Rough broken land covers the blufflike slopes of the valley. The Pierre clay as mapped is a residual soil derived from Pierre shale, but its total extent is small, and it is closely confined to the Sheyenne Valley.

The following table gives the names and extent of the soil types mapped in Barnes County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Carrington silty clay loam	391,296	40.7	Sioux fine sandy loam	5,952	
Carrington loam	338,752	35.3	Heavy phase	3,840	1.1
Bearden silty clay loam	55,936	5.8	Valley phase	640	
Rough broken land	35,968	3.8	Fargo silty clay	9,600	1.0
Rogers silty clay	20,288	2.1	Lidgerwood clay	6,080	.6
Sioux loam	18,368	1.9	Sioux gravelly loam	4,608	.5
Maple clay loam	17,536	1.8	Beach gravel	3,968	.4
Meadow	17,152	1.8	Pierre clay	2,816	.3
Bearden loam	13,184	1.4	Pierce gravelly loam	2,688	.3
Wabash clay	10,880	1.1	Sioux sandy loam	1,088	.1
			Total	960,640	

CARRINGTON SILTY CLAY LOAM.

The Carrington silty clay loam is fairly uniform in texture, varying from a silt loam to a rather silty clay loam, and having a smooth feel when moist. The high content of organic matter which has accumulated through the growth and decay of prairie grass gives the type a sufficiently dark color for it to be widely known as one of the "black" prairie soils. It varies from dark gray or brownish gray when dry to black or very dark brown when wet. The type is mellow and well granulated and is very easily tilled for a soil of its texture. When properly cultivated it seldom forms clods or becomes refractory and does not bake or crack when drying. Scattered glacial bowlders are rarely found over the type. Gravel, rock fragments, and other coarse materials are occasionally encountered, but never in quantities sufficient to interfere with tillage. The soil is very retentive of rainfall. At from 14 to 24 inches, the soil becomes lighter in color, grading into an ashy-gray or yellowish-gray subsoil. At 17 to 60 inches other variations in color occur. The texture of the subsoil is sometimes similar to that of the surface material. As a rule, however, the subsoil is more clayey and compact, in places consisting of a clay. It is without stratification, although it carries some gravel. High percentages of calcium carbonate characterize the subsoil, and in many places small limestone

gravel are abundant. The glacial till continues downward and forms the deeper underlying mass for a depth of many feet. Owing to its relative uniformity of depth and porosity the subsoil constitutes an excellent reservoir for the storage of ground water.

The boundaries between the Carrington silty clay loam and the Carrington loam are of necessity often arbitrary, since gradations in texture between the two types are common. Some of eastern Binghamton and southern Raritan Townships occur as ridged regions bearing resemblances in texture and topography to both types. Another notable variation of more than patchy extent was found in eastern Thordenskjold Township, where the type is more sticky and cracks slightly, and where it may occur as a heavy clay loam. Much of the type lying south and east of Roger is also more clayey than usual, but is otherwise similar to the typical soil.

The Carrington silty clay loam is extensively developed and constitutes the most important type of the county. It is widely distributed throughout the most even or gently undulating prairie section, as distinguished from the associated Carrington loam, which is found in the rougher, moraimic part of the county. It is in places marked by broad swells or gentle surface inequalities which may gradually become intensified until they assume outlines approaching the least rolling phases of the Carrington loam. The type includes some flattened elevations, where the soil is slightly more sandy and gravelly, with accompanying swales in which the material is more clayey than the average.

Surface drainage ways are poorly developed, and, though the type is well drained, probably 90 per cent of the rainfall upon it sinks beneath the surface instead of running off. While associated low-lying types are poorly drained, only a small proportion of the Carrington silty clay loam would be improved by artificial drainage. Its natural condition has been improved by cultivation which has increased its power of absorption until depressions previously untillable because of poor drainage are now under cultivation. Alkali has accumulated in only a few places. Some low, moist depressions in an elongated area just west of Fingal and limited areas in northwestern Weimer Township include alkali spots.

The Carrington silty clay loam is one of the soils formed directly by the invasion and retreat of the great continental ice sheet and comprises ground moraine material, as distinguished from lateral, terminal, or recessional moraines. The type consists in part of finely powdered rock flour derived from granite, limestone, gneiss, and other ice-carried rocks. These were ground and intermingled with large quantities of the underlying Cretaceous shales which constituted the floor across which the ice moved. The present small quantities of coarse material and the level topography indicate the formation of

the type beneath the ice by a long-continued grinding process. Its high content of calcium carbonate is beyond doubt due to limestone bowlders brought from the northeast. This glacial till is underlain by Pierre shale at depths varying from a few feet to over 100 feet. After its formation and particularly during the period of glacial recession, the type was modified somewhat in places by the waters from the melting ice. A further modification has resulted from the disintegration of surface limestone fragments in the presence of organic acids. In general, however, the soil is unchanged from its original condition and is merely unassorted and uneroded glacial till.

The Carrington silty clay loam is naturally very fertile. It originally supported a heavy growth of prairie grass. All of the type is in cultivation, and few soils anywhere are superior to it for general farming, as almost any crop which can be grown in the climate will give good yields. It is better adapted to general farming than to special crops. Its broad, even fields have encouraged extensive farming, and its present utilization is identical with that of the Carrington loam. Wheat continues as the main crop, with an average yield of about 14 bushels. Flax averages about 8 bushels, barley 20 bushels, oats 30 bushels, and winter rye 16 bushels. Maximum yields of 35 or 38 bushels of wheat are sometimes produced. Flax may yield nearly 20 bushels, barley 45 bushels or more, and oats as high as 75 bushels. The soil produces good potatoes of excellent shipping qualities. The yield averages about 80 bushels per acre. Timothy and brome grass are grown to a small extent for hay and pasture. Millet does well, yielding about 2 tons per acre. Vegetables and such bush fruits as can withstand the climate are grown for home use. Corn is becoming a more important crop. Alfalfa is being tried in a small way. Probably 80 per cent of the type is devoted to grain, but this acreage is being reduced with the increasing popularity of other crops.

The Carrington silty clay loam is held at an average price of about $42 an acre, and the range in price is strikingly narrow, from about $35 to $60.

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

Mechanical analyses of Carrington silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351220, 351228.....	Soil.....	0.7	2.9	3.3	8.0	11.5	45.6	28.0
351221, 351229.....	Subsoil.....	1.6	6.1	7.0	13.8	11.0	33.7	26.6

CARRINGTON LOAM.

The Carrington loam, because of its topography and method of formation, is subject to many minor variations in texture. Usually it consists of a brownish-gray to black loam or light clay loam extending to an average depth of 14 inches. Its color is usually a shade lighter than the Carrington silty clay loam, because of a somewhat lower content of organic matter, but presents the same desirable features of good tilth and uniformly good physical condition. The subsoil from 14 inches downward is gray to yellowish gray and very similar to that of the Carrington silty clay loam, except that it carries larger quantities of sand, gravel, and bowlders and is a little less compact. It retains water well, but is somewhat less retentive of moisture than the Carrington silty clay loam. It rather closely approaches the surface on some of the ridges and slopes, giving the surface material a lighter color than usual. The subsoil of much of the large body of Carrington loam in southwestern Getchell Township carries more sand and gravel than common. A fine sandy loam phase occurs in small patches on the west slope of Alta Ridge and elsewhere, and the soil in such places has drifted somewhat, but wind action has not affected the main type.

Changes in soil texture do not uniformly accompany changes in topography, but generally a more sandy, gravelly, and stony phase is encountered on the crests of elevations, the clayey texture increasing as the soil slopes toward the swale bottoms. Gravel and broken stone fragments, while always present, do not occur in large quantities, except on knoll tops. Bowlders, ranging in size up to 2 or 3 feet in diameter, occur in places on the surface. These are mainly granitic, with some limestone, and were transported and deposited by the ice sheets. They can be removed without difficulty and are frequently used for building purposes. Areas in which the bowlders have accumulated in quantities sufficient to interfere with cultivation are indicated on the map by a stone symbol. The rough topography of such areas also tends to prohibit agriculture.

The Carrington loam is one of the most extensive types of the county, and, together with the Carrington silty clay loam, makes up the main body of the prairie region of this and adjoining counties. It occupies higher elevations than associated types, except where it occurs as eroded slopes between the Carrington silty clay loam and the Sheyenne Valley edge, or as bordering slope fringes between the Carrington silty clay loam and the Maple clay loam. It is a terminal moraine type and has the surface inequalities typical of such a soil. Often it is developed in separate bodies over single ridges or low hills, but usually it occupies aggregations of these so closely set that a rather choppy surface exists over most of its extent. Many regions are quite rough, as in northern Green and

southern Hobart Townships, where the scattered groups of hills have slopes too uneven or steep for agriculture, but even here, however, a very small proportion of the soil is untillable. A phase approaching the Carrington silty clay loam occurs where earlier deposits were overridden by successive forward movements of the ice. The type is free from alkali. It includes numerous depressions which receive the drainage from bordering slopes.

The Carrington loam is of glacial origin and has been little modified since deposition. It was formed where the glacier edge remained stationary through the ice melting as rapidly as the glacier pressed forward. Quantities of stone embedded in the ice were thus abnormally concentrated. This process indicates that this type and the Carrington silty clay loam were formed in a manner so similar that the resultant soils include approaching phases of similar agricultural value.

The native vegetation was characteristic of the prairie, with a sod less dense than on the smoother portions of heavier soils. This soil is somewhat less desirable than the Carrington silty clay loam. There is little waste land, yet more than on the latter type. The Carrington loam is not quite so easily cultivated, because of its rougher topography. It is a good agricultural soil, however, and produces average yields of 12 bushels of wheat, 7 bushels of flax, 16 bushels of barley, 26 bushels of oats, 15 bushels of winter rye, and about 75 bushels of potatoes per acre. Yields of nearly all crops are somewhat lower than those on the Carrington silty clay loam. Corn, being an intertilled crop, is perhaps as well adapted to one type as to the other, for whatever the Carrington loam loses through its lower water-holding capacity is made up by its warmer, quicker nature. Lands of this type are held at an average price of about $36 an acre.

The results of mechanical analyses of samples of the soil and subsoil of the Carrington loam are given in the following table:

Mechanical analyses of Carrington loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351218	Soil	2.1	4.3	5.0	14.6	14.9	36.6	22.3
351219	Subsoil	1.9	7.0	7.2	17.5	15.2	27.4	23.9

PIERCE GRAVELLY LOAM.

The Pierce gravelly loam is extremely variable in texture. It ranges from a sandy loam to a light loam. It has a grayish-brown color, becoming almost black when moist, and extends to a depth of

about 14 inches. The structure is loose and incoherent and cultivation would be easy if it were not for the large quantities of gravel present. The gravel consists of rounded pebbles of all sizes up to about 2 inches in diameter. A high percentage of the coarse material is calcium carbonate. At depths below 14 inches are found beds of partially stratified gravel or layers of irregularly assorted clay, gravel, and sand, usually of a yellowish-gray color. These gravelly beds probably average about 15 feet in depth. Gravel is commonly scattered over the surface and small bowlders occur in places. Owing to its loose structure the water-holding capacity of the soil is poor.

This soil type has a relatively small extent. It occurs in small bodies throughout the county, but most of the soil is included in two bodies, one extending northeast from sections 7 and 8, Uxbridge Township, and one in sections 14 and 23, Svea Township. A large number of scattered bodies of this type are too small to be shown on the map.

The Pierce gravelly loam is confined entirely to kamelike knolls, ridges, and eskers and the topography is generally hilly or hummocky. Owing to the rough topography, high elevation, and porous nature of the soil drainage is always excessive.

The type supports a fairly good growth of native grass. The native vegetation comprises the ordinary prairie grasses of the region, with some patches of sand grass occupying the most sandy phases.

Only about 60 per cent of the type is cultivated. At times it is used with contiguous types to preserve the regularity of the fields. The crops grown are those common to the county, but, owing to the droughty nature of the soil, the yields are much below the average on other types. The soil is probably better suited to pasture than to cultivated crops. If farmed it should be devoted to intertilled crops. Wheat produces from 4 to 18 bushels, with an average of about 8 bushels per acre. Corn and potatoes, when well cultivated, are not so apt to suffer from drought as other crops.

The Pierce gravelly loam is valued at $10 to $25 an acre, the average being about $18. This is very low as compared with the price of other lands in the county.

ROGERS SILTY CLAY.

The soil of the Rogers silty clay usually consists of 12 to 36 inches of medium gray to dark-gray heavy clay loam or clay. Typically it is one of the lightest colored soils of the survey. Its texture is always clayey and it is subject to only a few minor variations. Coarse material such as sand, gravel, or bowlders is entirely absent, except in a few patches where bowlders occur and render the type much like the stony phase. The soil is in a very poor condition. It becomes sticky and puddled when wet and cracks on drying. Owing

to the low organic-matter content and the generally soggy condition of the type it does not granulate readily and tillage is difficult. In places more than average quantities of organic matter have accumulated, giving the soil a darker color. In such instances the type may rank as a black soil, but even here it gains little in value owing to unfavorable drainage conditions.

The soil gradually merges at about 30 inches into a subsoil which is lighter in color, heavier, and of closer structure than the surface material. An ashy-gray layer about 10 to 16 inches thick, very high in finely powdered calcium carbonate, often occurs between the soil and the subsoil. Gravelly layers are very rarely found within 5 feet. In general, the soil is tight and refractory and is known locally as "gumbo."

The Rogers silty clay occurs as small, scattered areas over the entire county, usually surrounded by soils of the Carrington series. In relative location and distribution the type is comparable with Meadow. Its irregular bodies sometimes attain a size of 1 square mile, but are commonly smaller. It is one of the minor types of the county, yet it has a rather large total area. The surface of the type is flat and depressed. The general topography suggests the site of former small lakes or ponds, segments along sluggish drainage ways, or dried-up marshes and ponds. Sharp outlines define the type along its outer edges. The surface may rise rather abruptly into the Carrington series or gentle slopes may mark the change. Such a marked differentiation, however, does not separate this type from such other low-lying types as may occur with it in the same depressed region. Varying phases sometimes occur between this soil and Meadow or the Fargo silty clay.

The drainage of all the Rogers silty clay is poor. These low areas usually receive the run-off or seepage from the surrounding slopes of Carrington types. In some bodies drainage outlets have never been developed. When the region was settled these "pot holes" or "sloughs" were much wetter than now. Some of them were small, shallow lakes and others had a marshy character similar to that of the areas now classified as Meadow. The cultivation of the prairie has so diminished run-off that most of the type is now only water logged by seepage or forms the collecting place for decreased quantities of water. The old drainage ways have grown more indistinct and in many instances are farmed. Marshy spots are frequently found, but most of the type is simply saturated within a few inches of the surface. Conditions have favored the accumulation of alkali, and probably 90 per cent of the type has been ruined in this way. The presence of alkali is shown by white surface deposits, barren spots, and in numerous other ways. The percentage of alkali is large

enough to injure crops even if perfect drainage were provided. Thorough drainage will not usually be found practicable. No extended system could be used, on account of the widely separated areas requiring improvement, and in most cases the expense incident to securing an outlet for isolated bodies would be prohibitive.

The Rogers silty clay is the accumulated material laid down in low areas by the run-off from other soils. Its maximum depth is only a few feet, being underlain by typical glacial material. Some of the soil was deposited in minor lakes with steep sides, while much of it was deposited in localities of poor drainage. Its fine particles indicate its deposition in still water or in sluggish currents through marshy swales.

Not over 15 per cent of this type is cultivated, embracing the least water-logged portions, with the smallest accumulations of alkali. Some of the bodies of this type developed in very shallow depressions within the Carrington series can be farmed in exceptionally dry years. Flax is usually grown in such places. The yields of all crops grown are small. Heavy manuring would greatly benefit all tilled areas. By far the greater part of the type is nonagricultural, and there is little chance for much improvement. Some hay is cut where alkali does not preclude the growth of native grasses. Salt grass is the principal grass. The type is not well adapted to the tame grasses. Its best use is for pasture. As pasture land, when occurring as portions of farms otherwise composed of first-class tillable soil, the type has an average value of about $20 an acre.

A stony phase of this type is encountered principally in the northwestern part of the county. The phase carries large glacial bowlders, which are scattered over the surface or, more commonly, are buried within the soil mass. The surface is sometimes entirely covered with these bowlders. Such a body occurs in sections 15 and 22, Rogers Township. Over small areas, where drainage and alkali conditions are not too discouraging, the stones have been removed and the soil tilled. Like the typical soil, this stony phase occurs as slightly depressed bodies within the Carrington series, bounded by well-defined rims. The drainage is somewhat better and the interstitial soil material is slightly more sandy than in case of the typical Rogers silty clay. Alkali has not accumulated in so large quantities. This phase is largely utilized as pasture. Hay is cut where the stones are less numerous. The bowlders may be removed from some areas, which may then be tilled, but most of the phase is nonagricultural. Its general value is about equal to that of the typical Rogers silty clay.

In the following table the results of mechanical analyses of typical samples of the soil and subsoil of the Rogers silty clay are given:

Mechanical analyses of Rogers silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351234	Soil	0.4	2.8	3.4	9.7	4.8	44.2	34.3
351235	Subsoil	.6	.9	1.0	3.1	3.3	50.8	40.3

FARGO SILTY CLAY.

The Fargo silty clay to an average depth of 28 inches consists of a dark-gray or black clay loam to clay. It is often a silty clay loam. The organic-matter content is high. A rather granulated structure is developed where drainage is best, but the material is normally sticky and impervious, and tillage is difficult. It cracks badly on drying. There are no gravel or bowlders. The subsoil is generally ashy gray or yellowish gray and similar in texture to the surface soil. Layers of fine sand and mottled variations of the clayey subsoil are encountered below 48 inches. To a depth of 5 feet the soil is refractory, dense, and free from gravel beds.

This type, like Meadow and the Rogers silty clay, occupies depressed areas in the prairies. It is not extensively developed. The surface is flat, and it is separated from the Carrington soils by gentle rises or abrupt banks. Knolls of Carrington material are sometimes encountered within bodies of this type. Drainage is poor, but is much improved over conditions years ago before run-off was reduced and the absorption of surface water increased by cultivation. Even yet marshy or boggy places occur, and nearly all of the type is generally too soggy for good crop growth. Much of it can not be tilled at all.

The Fargo silty clay is of glacial origin. The soil was deposited by sluggish streams or in shallow minor lakes and ice-blocked preglacial valleys. It does not occupy minor flats, as does the Rogers silty clay, but only the deepest sags and old valley remnants. It differs from the Rogers silty clay also in color and texture and is practically free from alkali.

The type originally supported a rank growth of vegetation, which persists in uncultivated areas. The tendency has been to utilize the bodies of this soil best adapted to grass for the production of hay, but with deterioration in the quality of the hay and improvement in drainage the land is being broken for crop production. About 50 per cent of the type is now cultivated. Flax and barley seem to do best, although the other grain crops do well. Corn is poorly suited to this soil on account of its cold nature, and the drainage is unfavor-

able for alfalfa. Nearly all of the type would be benefited by artificial drainage, but the practicability of draining the different areas of it varies, depending upon cost, acreage affected, and available outlets. This soil requires careful handling in order to avoid injuring its physical condition. It is naturally fertile, its best-drained portions being equal to the Carrington silty clay loam in productiveness. The average yields are perhaps a little below those for the county as a whole.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Fargo silty clay:

Mechanical analyses of Fargo silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351206	Soil	0.0	0.1	0.4	1.8	6.9	46.1	44.5
351207	Subsoil	.2	.0	.2	.8	2.0	51.6	45.0

BEARDEN SILTY CLAY LOAM.

The Bearden silty clay loam to a depth of 12 to 26 inches is a dark-brown or grayish-brown silty clay loam, entirely free from stone or gravel. In places the soil varies from a loam to a silty clay loam, but it is always very friable and in excellent physical condition. It has a smooth texture, like that of the most silty phase of the Carrington silty clay loam, and it also resembles the latter type in having a high percentage of organic matter. The type ranks as a "black prairie soil," but is distinctly more brownish than the soils of the Carrington series. The subsoil occurs at an average depth of 18 inches, and is typically a yellow silt loam, friable and free from gravel, bowlders, or leachy coarse layers. It normally extends to depths much greater than 6 feet, but below 30 inches it occasionally grades through layers of fine sand, while below 50 inches a few small, waterworn gravel may occur. Both soil and subsoil are retentive of moisture, being equal to the Carrington silty clay loam in this particular. The soil and subsoil are a little coarser in texture where the type merges with the Sioux fine sandy loam and with inclosed bodies of Carrington loam. This condition also exists on slopes and along areas of Rough broken land, where sand and gravel may occur in quantities sufficient to modify slightly the agricultural value of the type. On a few slight swells within the type the soil is a little more sandy than usual, and a few "gumbo" spots occur, but these variations are of very little importance.

The Bearden silty clay loam is one of the most extensive types of the county. Its largest development is the body lying east of Valley City and occupying the level prairie between Alta Ridge and the broken slopes of the Sheyenne Valley, where it extends north and south for about 18 miles, with a width varying from a mile to several miles. Much of this region is locally known as "Getchell Prairie." Other bodies border the valley and the lower course of Bald Hill Creek.

This type was formed as flood-plains by the Sheyenne River when that stream occupied a general level about 200 feet higher than at present and was receiving enormous quantities of water from melting ice. The Getchell Prairie portion was undoubtedly formed largely by the water flowing southward from the northeast corner of Getchell Township. The original surface of the type was almost level and in places it extended entirely across the region of the present Sheyenne Valley, which was subsequently cut to its present depth. Although the type includes scattered knobs of Carrington loam, and deeply eroded coulées mark the edges of the main bodies, continuing at times as gentle swales for some distance, the general topography is favorable for tillage. The irregular body lying in sections 31 and 32, Valley Township, and sections 5, 8, and 17 of Marsh Township is much less clearly defined and has a more uneven surface than any other body of the type. This is near the maximum elevation attained by the well-developed terraces, which ordinarily ranges from 1,380 to 1,420 feet above sea level in this locality. The soil is free from alkali, except in minor included depressions occupied by the Rogers silty clay, but too small to be separated as such on the map. The type is drained mainly by subsoil percolation, but there is some run-off along courses which lead to the valley and also into low-lying inclosed soils. Some of these depressions are remnants of former stream courses.

The native vegetation of the Bearden silty clay loam was the same as that of the Carrington silty clay loam, the sod in places having been even heavier. The Bearden silty clay loam is one of the best soils of the county and includes very little waste land. Practically all of the type has been farmed for years. Grain is the most important crop grown, but the diversification of crops and more intensive cultivation offer exceptional opportunities on this type. It is an excellent soil for general farming and is well suited to all crops common to the region.

Average yields are approximately the same as those obtained on the Carrington silty clay loam. That part of the type lying within a few miles of Valley City is held at $55 or $60 an acre, but average values do not exceed those of the Carrington silty clay loam.

The results of mechanical analyses of samples of the soil and subsoil of the Bearden silty clay loam are given in the following table:

Mechanical analyses of Bearden silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351216	Soil	0.1	0.3	0.5	1.6	4.4	61.9	31.2
351217	Subsoil	.1	.7	.8	2.7	6.1	61.5	28.1

BEARDEN LOAM.

The soil of the Bearden loam varies from a light loam or silt loam to a light clay loam, with an average depth of 18 inches. It is dark grayish brown in color when dry, but becomes black when wet. A small quantity of gravel is usually present, but no bowlders occur. The material carries a high percentage of silt, making the texture smooth and sometimes slightly sticky, yet farm implements scour well. The soil is easily tilled. With cultivation it becomes powdery when dry and neither bakes nor cracks. In the most sandy areas the soil drifts somewhat when carelessly handled. The organic-matter content is nearly or perhaps fully as high as in the Carrington silty clay loam.

The subsoil is subject to some variation. For the most part it consists of beds of material ranging from clay loam to silty clay. A number of such beds may occur between 18 and 60 inches. The subsoil mass varies widely in color, the average being brownish yellow. Seams of fine sandy texture and others of sandy clay with embedded gravel are common. The subsoil as a whole is a little more permeable to water and somewhat more granular than the subsoil of the Carrington silty clay loam. Both soil and subsoil are retentive of moisture and the type is well adapted to farming. At a minimum depth of about 40 inches gravelly beds sometimes occur. Probably the deep subsoil is always rather porous and coarse.

The Bearden loam is developed mainly in the eastern tier of townships, with scattered bodies elsewhere in the county. The surface is level to gently sloping. The type occupies depressed areas. In general the drainage is adequate, and there are no accumulations of alkali. In small bodies, however, such as that in section 35, Springvale Township, drainage is poorer than usual and there is some alkali present in the soil. Along the boundaries of the Bearden loam the surface rises slightly and gradually passes into the less even topography of the Carrington series.

This type is always associated with actual or abandoned stream courses which had their maximum development during glacial times.

Most of the soil was deposited by complex and varying methods. There is an intricate system of waterways in the eastern part of the county, the main axis of which extends southward from the Goose Lake region, in Baldwin Township, for a distance of about 36 miles, leaving the county in southeastern Binghamton Township. A rather well-developed trough extends throughout this distance, crossing the Northern Pacific Railway at Brackett. It is in this elongated depression that most of the Bearden loam is found. This old valley has a low gradient. It was progressively developed as the ice retreated northeastward, aided by water from the east face of Alta Ridge. Its lower segments were from time to time abandoned as the melting ice barrier permitted easier escapes for the water to the eastward. These features are evidenced by the numerous eastward channels which were made at a time when the old southward channel was unable to prevent the ponding of water along the ice front. The Bearden loam is therefore an irregular product of sluggish stream and temporary lake deposition. It consists partly of reworked material of the Carrington series. Some of its bodies are rather typical terraces.

The native vegetation of the Bearden loam is similar to that of the Carrington silty clay loam. The soil is naturally fertile, and, with the exception of small areas where drainage is poor and alkali has accumulated, it constitutes an excellent agricultural type. Where typically developed it is one of the most productive soils of the county. It is a good soil for tilled crops, as well as for the dominant grain crops. The yields, value, and general utilization of the type approximate those of the Carrington silty clay loam. Good water is available at shallow depths.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Bearden loam:

Mechanical analyses of Bearden loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351238	Soil	2.2	4.9	5.3	19.8	14.1	32.3	21.0
351239	Subsoil	3.4	5.2	5.6	20.9	15.0	27.8	21.6

SIOUX FINE SANDY LOAM.

The Sioux fine sandy loam ranges from a fine sandy loam to a light loam in texture. It varies considerably, but is locally known as a rather light sandy soil. Small quantities of gravel are occasionally encountered, but bowlders are absent. The soil is always

very friable, and sometimes very loose in structure. The content of organic matter is not so high as in the Carrington or Bearden soils, and the color of the soil is a shade lighter, being brownish gray. It is sometimes wind drifted, but drifting is never serious except over small sandy areas. The depth to the subsoil and the character of material are subject to wide variation. Usually the soil grades at 12 to 20 inches into porous layers or masses containing relatively high percentages of sand and gravel. As a rule this material is irregularly stratified. In places the subsoil may be a gravelly sandy loam, a coarse sandy loam, or even a coarse loamy sand. It is at all times too coarse for best moisture conditions.

One body of the Sioux fine sandy loam was mapped, extending in a north and south direction for several miles through the western part of Noltimier, Alta, and Cuba Townships. It occurs as a sloping to nearly level plain between the Bearden silty clay loam slopes of Alta Ridge. Its upper margin is poorly defined. Gradation zones likewise prevail along the lower edge, where the characteristic slope imperceptibly flattens into the vast terrace occupied by the Bearden series. The drainage is ample, both by reason of the topography and the porous structure of the soil.

The Sioux fine sandy loam is composed of irregularly assorted beds, pockets, and deltas of alluvium which were deposited at the western foot of Alta Ridge. The soil is composed largely of material which was transported down the moraine slopes by glacial water when the edge of the ice occupied Alta Ridge during its retreat eastward. The type also includes some reworked lower slopes of the moraine. A few small bodies are developed along the foot of other moraines in the county. These are too small and poorly defined to be shown on the map. Such a body borders the Sioux loam in sections 26, 27, and 28, Oakhill Township.

This type is all farmed with associated soils. The yields are variable even in single fields. The productive capacity of the soil varies with its power to hold water, the crop yields being highest when the soil and subsoil are heaviest in texture, but always materially lower than those of the Carrington loam, Carrington silty clay loam, or the Bearden silty clay loam. The soil is not quite so desirable as the Sioux loam. Its texture approaches the sandy limits for good crop production under this climate. Its use may be made more profitable by the exercise of greater care in the production of tilled crops, and by the addition of manure.

Sioux fine sandy loam, heavy phase.—The surface soil of the Sioux fine sandy loam, heavy phase, to a depth of about 18 inches, varies from a fine sandy loam to a light silty loam. The soil is very friable, and in places contains small quantities of gravel. It is not so high in organic matter as the main type, and is generally a poorer

soil. The subsoil is usually a grayish-yellow fine sandy loam or sandy loam, becoming coarser and carrying larger quantities of gravel with increase in depth. In some places a coarse loamy sand extends from 18 inches downward, and in others this is displaced at shallow depths by a silty loam. Some of the phase is not injured by leachy subsoils, but none of it has as good water-holding capacity as the Bearden silty clay loam.

The phase is very inextensive. One of the principal bodies lies a short distance southeast of Valley City. It usually occupies positions slightly higher than the Bearden silty clay loam, yet not high enough to have retained the original character of the glacial till. Exception is made of those bodies in T. 142 N., R. 58 W., where they in part at least are lower than the Bearden silty clay loam and owe their origin to water assortment of the latter type. The phase is farmed with adjoining soils and has a crop value about equal to that of the main type.

Sioux fine sandy loam, valley phase.—The Sioux fine sandy loam, valley phase, is typically a fine sandy loam or light loam of very friable structure and dark-gray to light-brown color. It usually carries a few waterworn gravel, but no bowlders. It is loose, porous, and contains a moderate quantity of organic matter. At about 18 inches it becomes a little more clayey and normally passes into a loam mixed with gravel. The deeper materials, from 36 inches downward, consist of gravel and sand.

The type has a small total area, and is confined to the Sheyenne Valley near the center of the county. It occurs as narrow, sloping fringes along the valley's edge, flattening into the Wabash clay on its lower edge and merging into Rough broken land on the upper.

It is composed largely of small deltas of material laid down at the mouths of minor washes through the Rough broken land. It may in part occur as poorly defined or eroded minor terraces of low elevation deposited at another stage of the river's history. Such a body occurs just south of Valley City.

The Sioux fine sandy loam, valley phase, is too sandy to give sure returns under the rainfall typical of the region. It is not retentive of water. Most of the phase is farmed, however, together with the bordering Wabash clay. Wheat, flax, and corn are grown, with yields below the county averages. Intertilled crops should do fairly well, especially where the soil is heavily manured and carefully handled.

SIOUX LOAM.

The Sioux loam is a fairly uniform type, with several striking characteristics. It is a loam in texture and is free from gravel or bowlders. It is easily tilled and does not puddle, bake, or crack,

even when handled in a wet condition, except in the patches of gumbo soil found interspersed with patches of gravelly soil in some of the areas. The texture in some localities is rather silty, while in some small areas it approaches a heavy sandy loam. A small amount of damage results from wind action on areas of the latter character, but in no place does marked drifting occur, as only a surface film at most is loosened. The slight range in texture is scarcely sufficient to influence crops. The soil is dark brown to dark brownish gray when moist, being dark enough to rank popularly as a "black" soil. The organic-matter content is large, but not so large as in the two major types of the Carrington series. The average depth of this soil is about 14 inches, the top 6 inches being darkest in color and highest in organic matter A few inches of ashen-gray, silty material high in calcium carbonate is sometimes found below the surface soil, but the tendency is to grade directly into incoherent, leachy masses of gray, coarse material ranging from sand to waterworn gravel the size of small marbles. Quantities of shale particles are common, and through disintegration these have given in places a slightly sticky character to the subsoil. Its water-holding capacity is low. The gravelly tendency increases with depth. A depth of 30 to 36 inches is sometimes reached before anything coarser than very fine gravel is encountered, but the type as a whole is noted for its poor, loosely structured subsoil.

The most uniform body of the Sioux loam, locally known as "Sand Prairie," lies in the southern part of Oakhill and Spring Creek Townships. It covers about 11 or 12 square miles in this locality, and continues into Ransom County, where it occupies a considerably greater area. The surface is level to flat, even slight irregularities being rare. Slight swells so common in even the flattest phases of the Carrington silty clay loam are noticeably absent in the Sand Prairie region. The northern and western margins of this even-surfaced plain are very plainly defined by sharp changes in topography and a rising elevation, which leads into some of the rougher moraine hills of the Carrington loam. In section 35, Oakhill Township, the type extends to the rim of the Rough broken land marking the descent into the Sheyenne River bottom. Other relatively large areas occur in Heman, Svea, Skandia, and Meadow Lake Townships, and smaller areas scattered over the county along minor drainage ways.

The Sand Prairie area of the type in the main area of its occurrence is excessively drained. Much water percolates through the surface loam and is lost for plant use in the coarse subsoil. Boggy, marshy, or alkali spots are not developed. There is no run-off, drainage being exclusively into subsurface layers. Drainage conditions are somewhat better in the other important areas, the coarse subsoil often

lying at greater depth or in some cases being more retentive of moisture.

The Sioux loam is composed of reworked and redeposited glacial material mixed with varying amounts of disintegrated local shale. The large area in Oakhill and Spring Creek Townships was probably laid down partly as a shallow lake deposit, but largely as the flood-plain product of a broad, shallow stream whose changing course resulted in the even distribution of fine gravel and sand debris. It is probable that the waters of Stony Slough formed this area at a time when they flowed southward from section 18, Oakhill Township, the present outlet of this stream to the east from this point having been developed at a later date. The surface loam constituting the present soil of the type was formed by the deposition of material by more gentle currents and to some extent by surface weathering of the softer materials. Glacial till here forms the deep substratum underlying the stratified gravel and sand at 10 to 50 feet.

Native growth on the Sioux loam is characteristic of the region, being without trees or shrubs. The type was originally covered with a heavy sod of prairie grasses. This has been gradually broken since first settlement on the type, a little over 30 years ago. It is now all utilized, there being practically no waste land. The porous, unretentive subsoil is unfavorable for agriculture, yet the surface loam is naturally fertile and the type is productive. It is free from rocks or rough places, and it is possible to secure the maximum efficiency from farm machinery. The natural deficiencies of the soil are largely overcome by the uniformity of the fields. Wheat, barley, oats, flax, and millet are the principal crops, the varieties and methods used being those common to the county. The yields are slightly less than the county averages. Minimum rainfall or protracted dry spells are injurious to crops. In the years of excessive rainfall or very evenly distributed precipitation the yields on the Sioux loam exceed the average yields for the county and approach those obtained on the Carrington silty clay loam. With an adequate rainfall potatoes do well. Timothy is less well adapted to this soil than brome grass. Under ordinary conditions of rainfall the growing of alfalfa is probably impossible. Winter rye, as elsewhere in the county, is becoming more common. The increasing use of corn as a tilled crop is apparent on this type as elsewhere. All crops come to maturity rather quickly, owing to the early date at which the soil can be handled in the spring and to its warm porous nature. The grain crops produce a relatively smaller quantity of straw than on the Carrington types. Crop yields seem to be decreasing slightly. The Sioux loam has an average value of about $35 an acre.

An abundant supply of good water may be obtained from the reservoir of sand and gravel which underlies the type at 4 to 20 feet, the depth being slightly greater along the top of the escarpment descending to Sheyenne Valley. Conditions are favorable for the development of an intensive irrigation system, either by the use of individual or community pumping plants. Such systems have been established under similar conditions throughout the arid west, although in this locality the crop range is so restricted by the climate that the production of high-priced products such as are grown elsewhere by pumped irrigation water is impracticable, and it is problematical whether such irrigation would prove profitable. Electrical power for pump operation is not available at reasonable rates, and the fuel expense would perhaps be prohibitive. Texturally the soil is especially adapted to canning products, such as peas, sweet corn, tomatoes, etc. Potatoes and alfalfa would give maximum yields for the region with irrigation and sugar beets would also probably do well.

SIOUX SANDY LOAM.

The Sioux sandy loam to a depth of 8 to 14 inches usually consists of a dark brownish gray sandy loam. The soil is very loose in structure and carries varying quantities of waterworn gravel. Bowlders are sometimes encountered. At about 10 inches the soil becomes coarser and passes directly into a very poor subsoil, which is more open and incoherent than the subsoil of the Sioux loam. While moderately coherent clayey seams or layers of fine sand are sometimes present, the subsoil is commonly made up of beds of sand and gravel, the whole mass usually being grayish in color or occasionally mottled with brown or red.

The Sioux sandy loam consists of old alluvial deposits along glacial waterways. The areas of this type are usually smaller than those of the Sioux loam and occur at slightly higher elevations. The soil is rarely found in extensive bodies, usually being developed in relatively narrow areas bordering the streamways. While it is typically flat and terracelike, in places the surface is made quite uneven by the presence of channels of abandoned waterways. Some of the bodies of this type are merely sandy bars which were formed at the junction or divergence of old streams. These are the most sandy areas of the type. The drainage is excessive. The rainfall escapes by percolation rather than run-off and very little is retained for plant use.

Owing to its droughty nature, the agricultural value of the type is low. Its use is restricted, too, by its irregular distribution and lack of natural fertility. While quite a large part of the type is pastured and a small part is devoted to hay, the greater proportion of it is at

present uncultivated. Most of the tilled areas are farmed in connection with better soils. It has an average value of about $15 an acre. Even with liberal applications of manure it would not produce heavy yields.

SIOUX GRAVELLY LOAM.

The Sioux gravelly loam is a brown loam or sandy loam which carries a small amount of gravel and extends to a depth of about 14 inches. The coarse material is sufficient to loosen the structure, so that tools scour well. The soil contains moderate quantities of organic matter, and no large glacial bowlders occur. In places the surface soil is underlain by a thin layer of gray silty material, but usually it grades directly into waterworn gravel mixed with small quantities of finer materials. Coarse sand and very fine gravel occasionally predominate, but the gravelly beds are mainly composed of pebbles averaging about 1½ inches in diameter. The subsoil is not retentive of moisture, and most of the water supply for plants must come from the shallow surface covering.

The Sioux gravelly loam is confined to a few small bodies along the margin of the Sheyenne Valley. It occurs as old terraces intermediate in elevation between the present river bottom and the general level of the prairies. The surface is level, sloping, or uneven where modified by erosion, as in eastern Sibley and western Thordenskjold Townships. Gentle slopes or strips of Rough broken land separate the type from the higher Carrington soils. The most elevated bodies are bordered by rough slopes leading to the river soils. At times the descent is by a succession of well-marked terraces, as in the body at Valley City. The drainage is excessive.

The Sioux gravelly loam is a coarse alluvial product of the Sheyenne River, deposited when that stream occupied an elevation midway between its present flood plain and the higher terrace on which the Bearden series is developed. The bodies of this soil are but remnants left at inner bends of the river course. The area lying north of Kathryn is a veneer of gravelly loam overlying Pierre clay. That in northeastern Nelson Township carries a high percentage of fine sand and is somewhat dissected by erosion.

Only a part of the type is farmed. The large body in sections 3, 10, and 15, T. 142 N., R. 58 W., and another in section 25, Sibley Township, are perhaps the most productive areas of the type, but even here the yields are relatively low in dry seasons. Its agricultural value is much lower than that of the Carrington loam and silty clay loam. The crops common to the county are grown. Farming is fairly profitable on some parts of the type. The soil is warm, easily tilled, and susceptible of much improvement through the growing of intertilled crops, such as corn, with heavy applications of manure.

MAPLE CLAY LOAM.

The Maple clay loam consists of a rather smooth heavy silt loam or clay loam to a silty clay loam. Gravel is not usually found in the surface soil. The soil is sticky and plastic when wet, and has a puddled, refractory structure, largely due to poor drainage and excessive accumulations of alkali. The color is usually dark gray and under prevailing moisture conditions the type has the appearance of a black soil. The soil is generally well supplied with organic matter. The subsoil is encountered at an average depth of about 18 inches. It varies in color from brownish gray to ashen gray, mottled effects being common. The texture corresponds with that of the surface soil. It has a somewhat more friable structure and usually carries greater quantities of intermingled coarse sand and water-worn gravel. Distinct beds of gravel, sand, and coarse alluvium are nearly always encountered at 24 to 36 inches. In exceptional instances the subsoil is free of gravel to a depth of 60 inches, while in other places it assumes only a gravelly or sandy phase within this depth. It normally grades sharply into the gravel beds at an average depth of 30 inches. Below this depth limestone gravel, fragments of shale and other rocks common to the region, and coarse sand are intermingled with varying quantities of clayey material to constitute the deeper subsurface layers of the type. With the exception of the practically gravel-free phase, the subsoil is porous and unable to retain moisture. The droughty conditions caused by the loose subsoil are modified, however, by the naturally low position of the type.

The Maple clay loam is widely distributed over the county, yet its total area is small. The long, narrow, converging swales of the Maple River tributaries in the southeastern part of the county comprise much of the type. Many typical elongated bodies are also found in the southwestern part of the county. In all cases the type occupies flat-bottomed swales or the lowest parts of minor valleys, which continue perhaps for miles to join others of a similar nature. In most cases the strips are less than one-eighth mile wide for long distances. The most important development of this soil occurs through Svea, Skandia, and Spring Creek Townships, where a maximum width of almost one-half mile is reached. In this locality the type carries a great quantity of the largest glacial bowlders found in the county.

All of the bodies of Maple clay loam in the county have a characteristic topography. The greatest variation of surface is afforded by the shallow, winding stream course which traverses the type. In many places this old channel is all but obliterated, is typically choked

with vegetation, and because of the low gradient and present small run-off is incapable of causing either marked erosion or deposition. At times considerable water escapes along such courses and bridging is necessary at all road crossings. Some overflow occurs. Rather marked channels with steep banks are sometimes found at junctions of adjoining channels or along locations of greatest fall, as where the drainage way approaches the main valley of the Sheyenne River. In such instances the accompanying flat area of Maple clay loam is not found. The type usually extends from this dim waterway for short distances and then mounts by sharp banks or distinct slopes into the high prairie types of the Carrington series. In places it is bordered by the Sioux loam or the Bearden loam, a rather distinct low terrace intervening before the level, slightly elevated, surface of these types is reached.

The drainage of the entire type is very poor. The permanent water table is usually encountered within a depth of 2 or 3 feet and often less. The type is normally waterlogged almost to the surface. Throughout its extent the Maple clay loam, with the meandering channel which traverses the type, forms the avenue along which most drainage water escapes. While the run-off from neighboring types is relatively slight, the surface and percolating waters together form large quantities, which seek the lower levels of the Maple clay loam. In this manner the porous subsoil is kept saturated with water containing a high percentage of soluble material, with a consequent evaporation from the surface sufficient to accumulate alkali. Practically all of the type has been injured by alkali to such an extent that its reclamation, even with the establishment of perfect drainage, would require many years. The natural features of the type, including its gravelly subsoil, the alkali content, its irregular, narrow bodies, and its present utilization tend to discourage any attempt toward improvement except possibly the relatively inexpensive and superficial drainage of the marshy spots.

The type is alluvial in origin. The depressions occupied by it were once occupied by torrential streams deriving their water from near-by melting ice. The gravelly layers underneath the type are swift-water materials deposited by early streams. The heavier, sticky surface soil is a later deposit made by slowly moving waters. The edges of the Maple clay loam strips have been slightly influenced by colluvial wash from the slopes of bordering types. In a few cases where the bordering slopes are gentle the type is farmed with the predominant types which it traverses. Such use is possible only on the best phases. It is most often fenced off with the rougher nonagricultural slopes of the Carrington series and used for pasture. The parts best adapted are used for the production of hay,

such areas resembling Meadow in the principal features. The hay yield averages perhaps 1 ton per acre and is locally known as "slough hay." The grass growth is fairly heavy except in the worst alkali areas; even here salt grass (*Distichlis spicata*) makes a fair pasture. Probably 90 per cent of the soil is unfit for tillage. The type has an average value of about $14 an acre.

WABASH CLAY.

The Wabash clay is normally a slightly brownish to dark-gray clay, wholly free from gravel and bowlders. A silty clay loam phase is occasionally encountered. While the organic-matter content is not so high as in the Carrington series, it is sufficient to aid in granulation. The soil is friable considering its class, yet rather hard to till. It cracks upon drying. Some areas are soggy and cold natured under poor drainage. The soil extends with little variation to 60 inches, but usually becomes lighter colored and more compact at 24 inches. A few limestone concretions may be found in the yellowish-gray subsoil from 40 inches downward. The soil to a depth of many feet is clayey, free from gravel, and retentive of water. Coarse alluvium of swift water deposition is always encountered at great depths. The type is known as "gumbo."

The Wabash clay is confined to the flat bottom of the Sheyenne Valley. It occurs as a narrow belt one-eighth to one-half mile wide along this river throughout the county. It occupies both banks, with no types intervening between it and the stream. The surface is level, except for old ox-bow remnants of abandoned channels, quite marked at times. The river meanders by sharp curves through this flat belt. The Wabash clay rarely attains an elevation of more than 30 feet above the bed of the river. The river's flood stages are not so high as formerly, owing to decreased run-off, so that overflow is confined to the lowest bends and ox-bow depressions, rarely covering even these places.

This type is an alluvial product of the Sheyenne River, and its sluggish current accounts for the absence of coarse material. Most of the soil has been transported long distances and thoroughly intermingled, so that the material is uniform. It is naturally fertile and fairly well drained. A few areas are wet and nonagricultural. These lie about the mouths of small lateral washes from which water flows over the type in irregular courses. Such localities, as well as certain old channels, require drainage. There are small accumulations of alkali in places.

The Wabash clay originally supported a more extensive forest growth than all the rest of the county combined. The timber consisted principally of box elder, ash, elm, and oak. These trees yet

border the river in a continuous fringe, and occupy the sharp bends which are poorly suited for fields.

The main crops are wheat, barley, oats, and flax. A few potatoes are grown. There is usually a narrow strip of untillable land along the river banks. Owing to the tortuous course of the river, the type is farmed in irregular, patchy fields. The soil requires more careful handling than the prairie types, but is perhaps a more certain producer whenever crops are planted under even moderately favorable conditions. Weeds are prevalent over the type. In general the type is more resistant to drought and hot winds, especially the latter, than the prairie soils. The average yields of grain on good fields are higher perhaps than on any other type in the county. Owing to the "gumbo" nature and patchy extent of the type, the prairie soils are usually preferred to it for farming. The river farms, however, are valued a little higher. The type is not segregated in valuation, but is nearly always transferred in farms consisting largely of poorer types. It no doubt has a higher value, separately, than any other soil in the county. Its productivity can be materially increased by manuring and the use of intertilled crops to lighten its structure and make cultivation easier. Increasing attention is being given to the production of corn. Alfalfa has been tried, and has given fair results in places, but the plant does not seem to develop a normal root system and crown. As a rule a more intensive and diversified system of farming is practiced on this soil than on other types in the county.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of the Wabash clay:

Mechanical analyses of Wabash clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351230	Soil	0.0	0.1	0.5	5.1	13.9	39.3	40.9
351231	Subsoil	.0	.1	.4	7.4	12.0	39.3	40.7

LIDGERWOOD CLAY.

The Lidgerwood clay rather uniformly occurs as a heavy clay loam or, in most instances, a clay. It carries very small quantities of sand and no gravel or bowlders. It is stiff and refractory, cracks on drying, and is known as "gumbo." The color is modified by varying proportions of organic matter, ranging from brownish gray to dark gray. The structure is usually poor. Tillage is difficult, but the soil is fairly well granulated in its darkest colored phases. The subsoil is encountered at 10 to 24 inches. It is a light-brown to

yellowish-brown clay of more compact, impervious structure than the surface soil, and in places contains small quantities of limestone concretions. Occasionally it becomes more sandy at about 4 feet. Both soil and subsoil have good water-holding capacity. Along Bald Hill Creek this type is a little lighter colored than usual, and the subsoil carries larger quantities of gravel.

The Lidgerwood clay is relatively inextensive. It is developed as marginal deposits along the Sheyenne River Valley and its major tributaries. Its typical occurrence is as smooth slopes between the Rough broken land and the flat river-bottom region of the Wabash clay. In some instances it occurs as flats or slopes about the mouths of small streams, sometimes extending up their courses for short distances. Along its higher margin it breaks sharply into Rough broken land, while the lower margin may merge gradually into the Wabash clay.

The type is alluvial in origin. It is the remnant of more extensive deposits made at a period when the river flowed at a higher general level. Some of the creek-mouth bodies consist largely of redeposited Pierre shale soils, while in the Sheyenne Valley the type contains more or less colluvial material largely washed down from areas of Pierre clay or where the shale outcrops in the Rough broken land. Some reasonable doubt exists as to the correctness of its correlation in the Lidgerwood series, and it is possible that further study will necessitate its reclassification. Alkali is not usually present except in that body lying at the mouth of Bald Hill Creek. The drainage is good.

This type supported a better growth of native grasses than the Pierre clay. It produces good yields, despite its sticky character. Some of its heaviest phases and irregular areas bounded by steep slopes or cut by stream ways have not been continuously farmed. Such typical areas as that around Daily have given consistently good yields. It is somewhat more productive than the Pierre clay, and a little poorer than the Wabash clay. Its value and agricultural possibilities are generally a little below those of the latter type, although the two soils are used for similar purposes.

The results of mechanical analyses of samples of the soil and subsoil of the Lidgerwood clay are given in the following table:

Mechanical analyses of Lidgerwood clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351212.....	Soil.....	0.1	0.3	0.2	0.7	2.0	22.7	73.9
351213.....	Subsoil.....	.1	.3	.2	.8	1.5	19.7	77.6

PIERRE CLAY.

The Pierre clay as developed in Barnes County closely resembles those broad areas of the same type encountered in South Dakota and Nebraska. The soil generally consists of 6 to 12 inches of light-brown, sticky, waxy clay. When wet it is adhesive, slippery, and has a greasy feel, owing to the very fine texture of the material and the absence of gritty particles. It is always spoken of as "gumbo." Upon drying it becomes hard and cracks freely. Tillage is difficult, and the soil is low in organic matter compared with the prairie types. At about 10 inches the soil becomes a little lighter in color and lower in organic matter and passes directly into a stiff, compact clay subsoil, varying in color from drab to gray or brownish gray. It is often mottled and iron stained. Both soil and subsoil are free from gravel or bowlders. Small quantities of dark brownish red fragments of ironstone are scattered over the surface and throughout the soil and subsoil. These are resistant to weathering. The original ironstone masses developed within the Pierre shale were of rounded form, but the broken particles are sharply angular. At an uncertain depth, probably averaging less than 60 inches, shale fragments become quite plentiful. A few inches more of partially softened shale then intervenes before the massive layers of unmodified rock are reached.

The Pierre clay is of small extent in Barnes County. It occupies small bodies and is confined to the Sheyenne Valley region, southward from Valley City. Its greatest development is in those eroded areas about the mouths or lower parts of lateral drainage ways. The surface is sloping, sharply rolling, or uneven. Small hills with varying slopes, ridges, and some slightly dissected gentle slopes make the surface rather varied. Drainage is adequate and is mainly through an intermittent stream which traverses the type. This stream was swollen with water during glacial times and is responsible for the uncovering of Pierre shale to develop the type. The soil is always bordered on its higher side by Rough broken land. Its lower edge usually gives way to the more gently sloping Lidgerwood clay or to Wabash clay.

The Pierre clay is residual in origin, being the weathered product of Pierre shale. It is slightly influenced by colluvial wash. There are numerous exposures of this shale on the bordering slopes of Rough broken land. It is also seen along road cuts and the steeper sides of minor hills within the type. The residuary clay product is variable in depth and is usually deepest on the gentle slopes. In places the soil has been removed from hillsides, leaving small areas of nonagricultural lands. In places small quantities of glacial material from the higher Rough broken land are mixed with the soil.

The Pierre shale underlying the type continues to a depth of hundreds of feet. Parts of the type are damaged by accumulations of alkali coming from the parent rock. The bases of hills or slopes and the ravine phase of the type have suffered most. The domestic water supply is generally impregnated with these undesirable salts.

The type is treeless, except for a brushy growth along the streams, and native grasses are not so luxuriant as on the plains. Slender wheat grass is one of the predominant varieties, while salt grass is found in the alkali areas. Most of the type is tilled, but some of the smaller bodies are used only for pasture. The fields are irregular in outline and variable in productiveness. Wheat, barley, oats, and flax are the principal crops grown, with low average yields. Some of the more uniform, less gumbolike portions of the fields produce fairly well, but rank distinctly lower than the even-surfaced, tillable Carrington soils. The soil is sticky when wet and becomes hard on drying, and its cultivation is difficult. More careful tillage and heavy manuring would result in improvement of the type. Lands of this type have an average value of about $27 an acre, although some bodies, such as the better ones in the Kathryn region, no doubt have a higher value.

ROUGH BROKEN LAND.

Rough broken land embraces the broken and precipitous slopes between the high prairie section and the deeply eroded Sheyenne River drainage system. It occurs as two ragged strips, one-eighth to a mile wide, bordering the Sheyenne River and includes the irregular bluffs of the Sheyenne River and its tributaries with their numerous forked coulées. The valleyward margins of these two strips are rather regular, forming the fairly even border of the valley soils along the river. The boundary along the higher side of the strips, however, is very irregular, since the prairie edge is cut by numerous coulées leading to the valley. From the lower to the upper side of the strips of this type there is a range in elevation of 60 to 200 feet. This constitutes the most prominent topographic feature of the county.

The Rough broken land comprises several classes of rock and soil material, which are often intermingled and poorly defined. Rather typical glacial material is usually found along the brow of the slope extending downward for about one-third of the distance. This may be the stony, coarse-textured residue of destructive erosion. The middle section is generally very blufflike and includes denuded slopes and dark exposures of Pierre shale, some small patches being covered by a mantle of till. The lower slopes have a deeper soil covering and often merge into certain types of lower elevation, such as the Pierre clay. The type is not now subject to severe erosion.

In the northern part of the county it often consists entirely of steep, eroded slopes without Pierre shale exposures. Old modified terraces, where nonagricultural, were also included. Small strips or pockets of alluvial material may also be found along some of the coulées. Heavy accumulations of bowlders occur, principally in the region several miles north of Valley City. The boundary of the type was extended in some instances to include very rough morainal hills where these are unsuitable for agriculture and merge with the Rough broken land. Such an area occurs in section 18, Sibley Township, and extends into Dazey Township.

The Rough broken land is practically nonagricultural. Over at least 85 per cent of the type the rough topography precludes tillage. Although a few patches are cultivated, nearly all of the type is pasture land and suited for nothing else. Hay is cut on even slopes and in coulée bottoms. It is quite a good native grass producer except on the barren Pierre shale exposures. Small wooded slopes may be found whenever moisture conditions, soil, and protected position are favorable, as at Valley City and Kathryn. Scrubby oak, box elder, ash, and elm are the principal trees. A fringe or clump of these trees, with a brushy undergrowth, borders some of the coulées. The type has an average value of about $18 an acre.

MEADOW.

The soils classified as Meadow have common conditions of stagnated drainage, but are not necessarily similar in texture, structure, or origin. Bodies of this type, ranging in size from about an acre to several hundred acres, are scattered throughout the county. Many bodies occur which are too small to be shown on the map. The most characteristic occurrence of Meadow is as low, wet bodies of soil developed in the troughs, potholes, and minor lake depressions of the Carrington series. These basinlike bodies are known as "sloughs." The driest bodies of Meadow may be plowed, in part at least, along with the surrounding types during a succession of dry years. The wettest bodies become shallow, marshy lakes, with successive seasons of maximum rainfall. All bodies are wettest in the spring from the accumulated snow water.

Certain general variations of soil accompany the different phases of Meadow. The typical rounded or oval kettle holes in the rougher Carrington soils slope gradually toward the center. In this phase some run-off water enters the depressions, which have no outlets, though much of the wet condition is due to seepage. The most depressed part of these bodies may be occupied continuously or periodically by a shallow marshy lake. Hay is cut where the soil is not too boggy. The soil in these developments of the type consists of about 16

inches of black silt loam or clay loam, free from gravel or bowlders, appreciably light in weight, and fluffy from its high content of organic matter. This phase is practically free from alkali. Its subsoil is generally similar to that of the Carrington series, but frequently it is more clayey. Deposits of finely powdered calcium carbonate often occur. All of these bodies mapped as Meadow were much wetter before the run-off entering them was reduced by cultivation.

The lake-bottom phase of Meadow covers the flat floors of old shallow lakes, now only marshy or even dry. This phase comprises some of the larger bodies. The soil is usually lighter colored and more sticky than in the potholes, averaging a silty clay loam in texture. Alkali is usually present, and the hay crop is patchy. The lowest part of the lake floor is usually occupied by shallow water. A coarse growth of marsh vegetation generally occurs. Such areas are shown on the map with a swamp symbol.

The Meadow type is nonagricultural, since, owing to the low position, it is nearly always too wet for cultivation. A large part of the hay crop of the county, however, is secured from these natural meadows, and this constitutes their only use. The hay is sometimes coarse and mixed with undesirable plants of recent introduction, such as foxtail, sometimes known as wild barley. Hay is cut from about 70 per cent of the type as mapped. Barren alkali spots and marshy areas restrict the utilization of the soil. The type averages about 1 ton of hay or a little more per acre. Drainage is hardly feasible or advisable in most cases. It is possible that some bodies such as that in sections 19 and 30, Baldwin Township, could be drained economically.

BEACH GRAVEL.

The Beach gravel is a nonagricultural type of very small extent, occurring as fringelike beaches bordering some of the larger lakes or dry lake bottoms. The material is rather variable in character, but is usually a gray or ashy-gray mass largely composed of sand and gravel. Great accumulations of large glacial bowlders are a feature of the type. These range upward to a ton or more in weight, and are either fully exposed or partly buried in the porous beach material. The bowlders are most numerous along the bank or slope on the landward margin of the beach, having been gradually crowded and wedged outward by the expansion of the ice during successive winters. The soil to a depth of 6 or 8 inches is sometimes dark gray in color and rather loamy in texture. The organic-matter content is normally low.

The subsoil carries higher percentages of clay and silt, but it also has a low water-holding capacity. Beds of unassorted gravel and sand usually occur within a depth of 60 inches, and no doubt con-

tinue to a depth of many feet. At best Beach gravel is entirely too porous and open for agricultural use. Its value per acre is very low.

SUMMARY.

Barnes County is located in the eastern part of North Dakota and has an area of 1,501 square miles, or 960,640 acres. It is one of the most prosperous counties of the State. Most of its surface consists of level to rolling prairies, broken by the valley of the Sheyenne River. Surface drainage is restricted, but usually sufficient when assisted by percolation into the subsoils. The population has increased from 1,585 in 1880 to 18,066 in 1910. Valley City is the largest town, with 4,606 inhabitants. More than half the farmers are foreign born and are largely Scandinavians. The Northern Pacific and the Minneapolis, St. Paul & Sault Ste. Marie are the main railroads. A total area of 1,011 square miles is within 6 miles of shipping points. The roads are good and are continually being improved.

The summer temperatures are comparatively low, and the winters are long and cold. The growing season averages about 102 days, commencing about June 2. Maximum temperatures occasionally exceed 100° F., and minimum temperatures of 40° below zero sometimes occur. The mean annual temperature is about 39° F. The average yearly rainfall is between 21 and 22 inches, with the heaviest precipitation in midsummer. Prevailing winds are from northerly directions in the fall and winter and from the south in the late spring and summer. The climate is not so severe as ordinarily believed, and is not perceptibly changing.

Agriculture was first practiced about 40 years ago. It developed slowly for a time, but with greater rapidity as population increased and cropping under the regional climate became better understood. A one-crop system of farming, with spring wheat as the main crop, has been followed from the start. Oats, barley, and flax are other crops of varying degrees of importance. Land holdings are large, but will probably decrease with the establishment of a more diversified system of agriculture. Stock raising probably offers greater possibilities than any other form of agriculture. Land has an average value of $37.50 an acre. The farm unit on the basis of utilization is 550 acres. It should be reduced to 320 acres.

Eighteen soil types were mapped in Barnes County. The Carrington silty clay loam is the most extensive and one of the best soils of the county. It is retentive of moisture, admirably adapted to general farming, and occupies the most level portions of the prairies. There is very little waste land, and the type has been used for grain

production for many years. Grain farming is giving way to mixed farming, and indications are that its present average value of $42.50 an acre will increase.

The Carrington loam is the second soil of the county in extent. It is rather more variable than the Carrington silty clay loam. It has a rougher topography and a slightly lower value. The utilization and future adaptations of the two types are quite similar.

The Pierce gravelly loam is of small extent. Its surface soil is too sandy and its subsoil much too gravelly for the best crop yields under the climatic restrictions. Its agricultural value is low.

The Rogers silty clay is largely a nonagricultural type of sticky soil which occupies the flat bottoms of depressions throughout the prairies. It is less wet than Meadow, but carries excessive accumulations of alkali. Small areas are cultivated with low yields. The stony phase of this type is lighter in texture and contains less alkali, but carries large quantities of embedded glacial bowlders.

The Fargo silty clay occupies similar depressions and old valley bottoms, but is better agriculturally and has less alkali than the Rogers silty clay. Limited areas of these types can be drained, but as a rule an outlet can be secured only with difficulty.

The Bearden silty clay loam is extensively developed and constitutes one of the best soils of the county. It has the same crop value as the Carrington silty clay loam.

The Sioux fine sandy loam is one of the most sandy soils of the county, and its coarse variable subsoil tends to lower its value. It is all farmed, however, with yields about equal to those obtained on the Sioux loam. The Sioux fine sandy loam, heavy phase, is of small extent. It has a light sandy surface soil grading into gravel and sand. As usual with soils of this description, under conditions of rainfall such as those prevailing in the county, this type gives low yields.

The greater part of the Sioux loam has a good surface soil, which is underlain by coarse sand, fine gravel, and broken shale at a shallow depth. It is surprisingly productive, in view of these latter features. It ranks below the Carrington silty clay loam. Some portions of the type are droughty and unproductive, owing to the gravelly subsoils being close to the surface.

The Sioux sandy loam occurs in small areas. Its agricultural value is low because of its droughty nature, irregular distribution, and its lack of natural fertility.

The Sioux gravelly loam occurs as a few small bodies, some parts of which are farmed. Its better areas are fairly productive, but the yields are limited by gravelly layers which underlie the soil from 14 inches downward.

The Maple clay loam is a nonagricultural type lying along the beds of glacial waterways. Its bodies are narrow, poorly drained, affected with alkali, and underlain with gravel.

The Bearden loam is one of the better agricultural types. It is easily tilled, naturally fertile, and has but small areas of waste land occasioned by poor drainage and alkali.

The Wabash clay occurs in the flat bottom of the Sheyenne Valley. Although the soil is sticky and tillage is difficult, the type is very productive.

The Lidgerwood clay is intermediate in character between the Pierre clay and Wabash clay. Its tillage is difficult, but a part of the type has been continuously farmed, with good yields.

The Pierre clay is derived from the weathering of Pierre shale, which underlies the entire county, but is exposed only along the side slopes of the Sheyenne River. It is gummy when wet and becomes hard when dry, but is responsive to careful tillage.

Rough broken land is nonagricultural because of its steep, broken topography. It occupies the bluff areas bordering the major stream courses and is good pasture land.

The Beach gravel is nonagricultural because of its alkali and stone content and poor texture. It has a small total area and is developed as fringelike beaches around the larger lakes of the county.

Meadow represents a wide range of soils which are classed together because of similar drainage conditions. The type is nonagricultural, but it has some value for the production of hay. The bodies are known locally as "sloughs."

NRCS Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.