



U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE NORTH DAKOTA AGRICULTURAL EXPERIMENT  
STATION, THOMAS P. COOPER, DIRECTOR. R. C. DONEGHUE,  
IN CHARGE SOIL SURVEY

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SOIL SURVEY OF BOTTINEAU COUNTY,  
NORTH DAKOTA.

BY

W. B. COBB, IN CHARGE, W. I. WATKINS, AND A. T. STRA-  
HORN, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND  
MURRAY E. STEBBINS, MELVIN THOMAS, AND  
A. C. ANDERSON, OF THE NORTH DAKOTA  
AGRICULTURAL EXPERIMENT STATION.

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THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

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[Advance Sheets—Field Operations of the Bureau of Soils, 1915.]



WASHINGTON:  
GOVERNMENT PRINTING OFFICE.

1917.

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## LETTER OF TRANSMITTAL

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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF SOILS,  
*Washington, D. C., October 4, 1916.*

SIR: During the field season of 1915 a soil survey was made of Bottineau County, North Dakota. This work was done in cooperation with the North Dakota Agricultural Experiment Station, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this area and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1915, as provided by law.

Respectfully,

MILTON WHITNEY,  
*Chief of Bureau.*

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

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### MAP.

Soil map, Bottineau County sheet, North Dakota.



## SOIL SURVEY OF BOTTINEAU COUNTY, NORTH DAKOTA.

By W. B. COBB, In Charge, W. I. WATKINS, and A. T. STRAHORN, of the U. S. Department of Agriculture, and MURRAY E. STEBBINS, MELVIN THOMAS, and A. C. ANDERSON, of the North Dakota Agricultural Experiment Station.—Area Inspected by THOMAS D. RICE.

### DESCRIPTION OF THE AREA.

Bottineau County is situated along the international boundary line in the north-central part of North Dakota. It is bounded on the east by Rolette County; on the south by Pierce, McHenry, and Renville Counties; on the west by Renville County; and on the north by the Dominion of Canada. The county is approximately rectangular in shape, its maximum dimensions being 60 miles from east to west and 31 miles from north to south. It embraces an area of 1,681 square miles, or 1,075,840 acres.

Physiographically, Bottineau County lies within the glaciated portion of the Great Plains. There are parts of two distinct topographic provinces within the county, the Turtle Mountains and the Prairie Plains. The Turtle Mountains, situated in the northeastern part of the county, are considered an outlying remnant of the Missouri Plateau, the nearest point of the main escarpment being 30 miles west of this area. By unequal erosion these hills have been left standing from 400 to 600 feet above the surrounding plain, and the general elevation of their summits is from 2,000 to 2,100 feet above sea level. Two of the higher elevations, Bear Butte and Butte St. Paul, are 2,200 and 2,300 feet above sea level, respectively. The topography of the Turtle Mountains is that of a very much eroded plateau remnant over which has been dumped a covering of glacial drift. The sides of the escarpment vary from gently sloping to fairly steep, with a few small areas too steep for agriculture. Above the outer slopes the surface of the greater part of the Turtle Mountains is irregular, being made up of numerous low hills, with intervening depressions. Many of the depressions are occupied by small lakes and others by grassy meadows and Muck areas which represent the beds of dried-up lakes and ponds.

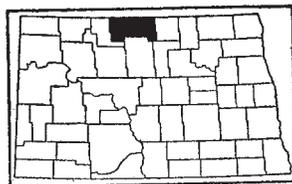


FIG. 1.—Sketch map showing location of the Bottineau County area, North Dakota.

The greater part of Bottineau County is situated within the Prairie Plains. The topography of this division is nearly level to undulating, with rolling areas in a few localities, usually along the courses of the larger streams. The more nearly level areas are supposed to be the remnants of extinct lakes and occur chiefly in the east and southeast-central parts of the county, with smaller areas scattered throughout the southeastern part. A strip 2 or 3 miles wide on each side of the Mouse River is nearly level, but is cut into frequently by drainage channels which approach the river.

The general slope of the greater part of the county is to the south and southeast, notwithstanding the fact that the Mouse River, which traverses the county, flows north. Bottineau, in the eastern part of the county, has an elevation of 1,644 feet above sea level, and Willow City, in the southeastern part, has an elevation of 1,478 feet. Souris and Westhope, which lie nearer the river, in the northern part of the county, have elevations of 1,520 and 1,506 feet, respectively, while Newburg and Deep, in the south-central part, have elevations of 1,472 and 1,458 feet, respectively. The western half of the county slopes eastward. Lansford, in the southwest corner of the county, is 1,613 feet above sea level, and Antler, in the northwest corner, has an elevation of 1,542 feet.

The drainage of the county is effected mainly through the Mouse River, known in Canada as the Souris River, which flows slightly west of a northerly direction and divides the county into two nearly equal parts, the eastern being somewhat the larger. The bottom of this stream lies about 50 feet below the immediately surrounding country and has many of the characteristics of a huge canal. The banks are quite precipitous and straight, with few draws cutting back into the prairies. The river has such a slight gradient that formerly it wandered back and forth across its flood plain without any well-defined channel. Recently, however, a new channel has been dredged, which has lowered the water level 3 or 4 feet, making the bottom lands available for agriculture. The main tributaries of the Mouse River are Willow, Oak, Boundary, Stone, South Antler, and Cut Bank Creeks, all of which are intermittent streams.

The southeastern corner of the county is drained by Willow Creek, which has a very slight gradient. Oak Creek has its source in the Turtle Mountains, and flows in a southerly direction, joining Willow Creek near the southern boundary of the county. Boundary and Stone Creeks also rise in the Turtle Mountains and flow southwest. South Antler Creek flows east along the international boundary for a short distance and then turns north, entering the river in Canada. Cut Bank Creek follows a southeasterly course into McHenry County and then turns north, entering the river just east of Deep. Owing

to the relatively light rainfall the drainage is generally sufficient, although it is far from complete. There are numerous depressions that have no outlets, and several large, flat areas that are only partially connected with the drainage system.

Bottineau County was first formed from Buffalo County, Dakota Territory, in 1873. It was definitely organized and local government established in January, 1884, but four changes in the boundaries have been made since that time. Settlement began about 1883. In the east-central part of the county the first settlers were mainly French Canadians from Quebec and Scotch Canadians from west Ontario and Manitoba. Settlements were scattered over much of the eastern part of the county when the Great Northern Railroad was extended to Bottineau in 1887. The advent of this railroad marks the beginning of the real development of the region east of the Mouse River. By 1890 much of the land in this region was occupied. The population of the county was then 2,893. During the next decade the eastern half of the county was completely occupied and settlers were beginning to take up land west of the Mouse River, which was then inaccessible to railroads and isolated from the other half of the county owing to the lack of bridges across the river. The population in 1900 was 7,532. By 1910 it had increased to 17,295, or 129.6 per cent. This represents a density of 10.3 persons per square mile, as compared with 8.2 per square mile for the State and 30.8 for the United States. There has been a very slight increase since that time. The entire population is classed as rural.

The population of Bottineau County consists largely of persons of western European birth or extraction, a large proportion of them coming into the county from the west-central States. The northeast quarter of the county is occupied largely by Norwegians. French Canadians predominate in the region east of Bottineau and south of the Turtle Mountains, and Germans in the south-central part of the county. In other sections the population is mixed and includes a large number of Canadians.

Bottineau, situated in the east-central part of the county, is the county seat and largest town, having a population in 1910 of 1,331. Willow City, with a population of 623, is the second largest town and the most important trading center in the southeastern part of the county. Westhope, with a population of 592, and Lansford, with a population of 456, are important trading points in the northwestern and southwestern parts of the county, respectively. Other towns with railroad facilities are Antler, Omemee, Maxbass, Souris, Overly, Kramer, Newburg, Eckman, Landa, Roth, Carbury, Kuroki, Arnedo, Hurd, Dunning, Deep, Forfar, Truro, Belmar, Tasco, and White Siding.

The county as a whole has good transportation facilities, being served by a branch line of the Minneapolis, St. Paul & Sault Ste. Marie Railroad and three branches of the Great Northern Railroad.

The public roads, with the exception of some of those in the Turtle Mountains, are good. They consist largely of driven trails on the section lines, with dirt fills in the poorer drained places.

Outside the Turtle Mountains region, where there are a large number of springs, the domestic water supply is all obtained from wells. The wells vary in depth from 8 to 300 feet or more, those in the sandy areas being usually very shallow. Over much of the eastern part of the county a good supply of water can generally be obtained at a depth of about 80 feet, while in the western part it is often necessary to go down 300 feet or more. The deep-well water is in most cases slightly alkaline.

The common-school system compares favorably with that of any other section of the country. All rural schools are open seven months or more and town schools nine months in every year. Several rural consolidated schools have been established. Most town schools offer from two to four years of high-school work. The State school of forestry, which offers special training in forestry with academic school work, is located at Bottineau.

Most of the farmers have telephones. The residences and other buildings are generally good. In the best agricultural sections large modern houses and barns are quite numerous. Little attention is paid to the housing of farm machinery. There are many log houses in the mountains.

#### CLIMATE.

The climate of Bottineau County is subhumid, with comparatively long winters and short, cool summers. The mean annual temperature is 36.1° F., the mean for the winter months being 5.1°; for the spring, 36.4°; for the summer, 63.8°; and for the fall, 39.1°. The highest temperature recorded is 104°, in August, and the lowest -54°, in February. While the winters are rigorous, the dry atmosphere causes the cold to be less penetrating than in more humid regions.

The mean annual rainfall is 15.33 inches, 75 per cent of it falling during the growing season, enabling farmers to obtain as good crop yields as can be produced in regions whose precipitation is much greater but less favorably distributed. In some years crops suffer injury from droughts, but these usually are offset by other seasons having exceptionally favorable moisture conditions. The rainfall is said to be heavier in the Turtle Mountains than in the remainder of the county, and although no records for this section are available, the fact that crops rarely suffer from excessive drought there would seem to substantiate this opinion.

Hail occasionally injures crops and some of the farmers insure against it, although the damage usually is restricted to relatively small areas.

The average depth of snowfall is 22.3 inches. The ground frequently is bare for long periods in the winter and freezes to a depth of 4 to 6 feet.

The average date of the last killing frost in the spring at Willow City, in the southeastern part of the county, is May 30, and that of the first in the fall is September 11. The date of the latest killing frost recorded in the spring is June 14, while that of the first in the fall is August 20. In the northern part of the county the dates may vary somewhat from these. The average length of the growing season ranges from about 95 days in the more elevated, northern part of the county to about 104 days in the southern part.

The following data, taken from the records of the Weather Bureau station at Willow City, are typical of all of Bottineau County, except the northeast corner, occupied by the Turtle Mountains:

*Normal monthly, seasonal, and annual temperature and precipitation at Willow City.*

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1897).	Total amount for the wettest year (1908).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	10.0	50	-37	0.37	.....	0.46	3.4
January.....	1.7	48	-52	.37	T.	T.	1.8
February.....	3.7	56	-54	.42	.40	1.40	5.1
Winter.....	5.1	56	-54	1.16	.40	1.86	10.3
March.....	16.6	65	-45	.80	.85	.80	3
April.....	40.2	88	-22	.89	.66	1.60	1.6
May.....	52.3	95	10	1.87	.58	1.53	.....
Spring.....	36.4	95	-45	3.56	2.09	3.93	4.6
June.....	61.4	96	28	3.70	1.17	6.30	.....
July.....	65.9	101	30	2.21	2.77	2.50	.....
August.....	64.1	104	27	1.86	.45	3.10	.....
Summer.....	63.8	104	27	7.77	4.39	11.90	.....
September.....	54.3	101	11	1.73	.34	.58	1
October.....	42.2	87	- 2	.66	.52	.62	.5
November.....	20.7	75	-30	.45	.42	.47	5.9
Fall.....	39.1	101	-30	2.84	1.28	1.67	7.4
Year.....	36.1	104	-54	15.33	8.16	19.36	22.3

## AGRICULTURE.

Bottineau County is one of the more recently settled counties of North Dakota. Much of the eastern half was settled shortly after 1883, when there was a great influx of settlers into northern North Dakota. The agricultural development of the western half has taken place since 1900. Since the settlement of the county agriculture has been followed almost exclusively. The Turtle Mountains supported a forest from which wood for fuel and logs for building could be readily obtained, and for this reason many settlers were attracted to the bordering prairie region. Two successive forest fires killed most of the trees at about this time, but there was a great demand for the partly burned logs. People came a distance of 50 miles to get these logs and houses built of them still are scattered over the eastern part of the county. A relatively small proportion of the burned-over land is now covered by a second growth. Only about 25 per cent of the Turtle Mountains has been cleared.

Agriculture was retarded in the late eighties by two crop failures caused by droughts. Many farmers became discouraged and left the county and there was a great decline in land values. The financial depression following these crop failures continued until 1895. Beginning with that year there was a series of good crops and the county developed rapidly. A little later the Great Northern and the Minneapolis, St. Paul & Sault Ste. Marie Railroads extended their lines into the county and this gave added impetus to settlement and agricultural development. In 1909, according to the census, the value of all crops was \$7,398,656.

As in most of the prairie region of the State, the prevailing type of agriculture consists of grain farming, with wheat as the principal crop. The 1910 census reports 374,399 acres in wheat in 1909, from which 5,271,527 bushels were produced. This compares with an acreage of 30,439 and a production of 110,387 bushels in 1889, and 97,404 acres and 1,450,850 bushels in 1899. The varieties of wheat mostly grown are Scotch Fife, Bluestem, Durum or Macaroni, Velvet Chaff, and Marquis. Scotch Fife was the most common variety in the early years. Later Bluestem was introduced and the last-named variety, Marquis, was introduced about 1912, but has given large yields and is becoming a popular variety in the region. It is valued especially for its early maturity, which enables it often to escape damage by rust or hail, and also for its closed husk, which prevents shelling, though the latter makes it difficult to thrash. It has good milling qualities. Marquis wheat is especially suited to the richer, finer textured soils. It was originated by the Canadian Agricultural Experiment Station at Ottawa, Canada. Scotch Fife and Bluestem are so-called hard wheats. They are highly prized for their milling

qualities, and gave this region its enviable reputation for producing wheat of the highest quality. Durum wheat was first introduced into the United States in 1898 by the Department of Agriculture. It was discriminated against by millers for a long time, but during the last two years it has sold at about the same price as the other hard wheats. Durum wheat matures about six days earlier than Bluestem and Scotch Fife and usually gives somewhat higher yields. Some objection to it is caused by the fact that it is bearded, which makes it disagreeable to handle. Durum wheat usually is regarded as being better suited to sandy, coarse-textured soils than other varieties. It is resistant to rust. Velvet Chaff is not very extensively grown. Its open husk causes it to shell easily, which may greatly reduce the yield if the weather is hot and windy at harvest time. The average yield of wheat is about 13 bushels per acre.

Oats are grown mostly for home use, the surplus being sold. Most of the horses are fed little grain except oats. Practically every farmer grows some oats. The crop is most extensively grown on the sandy soils, to which it is better suited than other grain crops. Swedish Select and Sensation are two popular varieties. The 1910 census reported 94,880 acres in oats, with a production of 3,006,315 bushels. In 1890 the acreage reported was 3,126, and in 1900 it was 15,356.

Considerable barley is grown. It is used as a feed for hogs and cattle, and also shipped out of the county to be used for malting. Barley is a quick-maturing crop; it can be sown late in the spring, thus extending the seeding season, and is an excellent crop to grow for freeing land of weeds, as it matures earlier than most weeds. Both 2-rowed and 6-rowed varieties are grown, the latter being the more popular. The average yield is about 20 bushels per acre. In 1909, 35,202 acres were devoted to barley, producing 804,262 bushels.

Flax is still a common crop, although not so popular as it was several years ago. It is essentially a new-land crop, being liable to injury by wilt on old lands. The wilt has been overcome to some extent by growing resistant varieties and by crop rotation. Flax gives best results when sown in a moist, warm seed bed. It requires almost as long a time to mature as wheat, but can be sown about a month later. The seed may be sown in May and June, but best results are usually obtained from the late May seedings. The seed is sown at the rate of one-third to one-half bushel per acre, and covered lightly. In harvesting, flax is not usually bound like other grain crops, but is left on the ground in loose bundles until it is thrashed. Little use is made of the straw. Flax was introduced into the county about 1896. The yields vary greatly from year to year, the average yield being about 8 bushels per acre. In 1909 there were 27,734 acres devoted to this crop, from which 264,258 bushels of seed were obtained.

In 1909 the land in rye amounted to 766 acres. The acreage is increasing. Winter rye is mostly grown. As a rule, the grain is seeded on stubble land with very little preparation, except disking in some cases, as soon as the shocks are cleared away, which is sometimes as late as October 1. Best results usually are obtained by seeding late in August or early in September. In some cases the seed is sown on summer fallow. Rye matures earlier than many weeds, and is highly valued for eradicating them. It also is popular on account of the low cost of production. The average yield is about 14 bushels per acre. Most of the rye is used locally for feed. According to the last report of the State commissioner of agriculture and labor, only 80,000 pounds of rye were shipped out of the county during the year ending July 31, 1913, while 53,469 bushels (3,208,140 pounds) are reported as produced in 1912.

Considerable emmer, locally known as speltz or spelt, is grown. This crop requires about the same seasonal conditions as oats for best results. It is usually seeded at the rate of 2 bushels per acre. The crop is used almost entirely as feed, for which it is highly valued. The average yield is a little larger than that of barley.

The Hungarian, Siberian, and common millet are the most common varieties of millet grown. Millet is grown mostly as a feed for cattle. In recent years it has been superseded to some extent by perennial grasses. Yields vary greatly, the ordinary yield being 1 to 1½ tons per acre. The crop needs a good supply of moisture to make a luxuriant growth.

Considerable timothy is grown for hay. One crop is cut each season. The average yield is probably not over 1 ton of hay per acre. Brome grass yields about as much hay as timothy, and makes very good pasturage. Western rye grass gives about the same yields as timothy. It is not extensively grown. There were 6,645 acres devoted to tame grasses in 1909.

Alfalfa and sweet clover are the most promising legumes of those that have been tried in Bottineau County. Alfalfa has been grown with more or less success in all parts of the county, the best results being obtained in the Turtle Mountains. The principal variety grown is Montana, although considerable Grimm has been sown. The Grimm has given somewhat better results than the Montana, because it does not winterkill as badly. A good stand of alfalfa usually can not be obtained when it is seeded with a nurse crop. It has been found difficult to get a stand by sowing in close drills or broadcast. By preparing a finely pulverized and compact seed bed and by sowing thinly in rows about 30 inches apart and cultivating during the summer some very good stands have been obtained. This method is especially well adapted for growing seed. It is probable that alfalfa-seed production could be made a profitable industry.

Two cuttings of hay or one crop of hay and one of seed can be obtained in ordinary years. The second crop is the usual seed crop.

Outside the Turtle Mountains red clover has not been a success, but sweet clover has been tried in quite a number of places with favorable results. In the Turtle Mountains wild peas, which are relished by live stock, grow luxuriantly in cleared places.

Corn has been grown on an extensive scale only in the last three years, and has become one of the important crops of the county. It is grown not so much for the product as for the benefits that accrue to the soil from its cultivation, although the corn is usually a profitable crop itself if it is given the proper management. Owing to the rapid spread of weeds, an intertilled crop was needed to clean the land. Summer fallowing, which was formerly the general practice, had proved unsatisfactory, not only because the use of the land was lost for a year but because the unprotected surface soil was subject to serious drifting. The chief difficulty in growing corn is the short growing season. In most seasons corn should be planted as soon as possible after May 20. Most of it is check-rowed, but some is seeded in rows with an ordinary grain drill after stopping up some of the holes in the drill. Northwestern Dent is the most popular variety of corn, although quite a number of other varieties are grown.

Dakota White Flint and Gehu are early flint varieties which do very well here, maturing in most seasons. An objection to them is that the stalks are very short and the ears close to the ground, which makes them hard to cut with a corn binder and difficult to husk. This objection is met, however, by hogging them off, for which purpose they are very well suited. As a rule, most of the corn crop is utilized for fodder. In favorable seasons the greater part of the crop matures, when a part of it is husked and the remainder hogged off. One of the chief advantages of corn is that it frequently produces a good crop in dry years when other feed crops are light. Corn yields ordinarily from 20 to 40 bushels per acre. Maximum yields of nearly 100 bushels per acre have been produced in boys' corn-growing contests. Considering its benefit to the soil, corn is probably one of the most profitable crops grown. Many silos are being constructed, and by their use corn can be fed in the most efficient and economical form. The 1910 census reports 365 acres in corn, from which 8,023 bushels were produced.

Potatoes are grown largely for home use at present, although an increasing quantity is shipped out each succeeding year. The crop is easily grown and the tubers are of excellent quality. Potatoes are especially well suited to the fine sandy soils, on which they are beginning to be grown on a commercial scale. Early Ohio is the most popular variety. Potato diseases have done very little damage, but

the potato beetle causes considerable loss. This could be prevented by spraying. A yield of 400 bushels per acre has been reported, but the ordinary yield is about 100 bushels. The yield could be greatly increased by better cultivation, by a rotation of crops which includes a legume, and by the use of manure. In 1909, 1,292 acres were devoted to potatoes, producing 112,915 bushels.

Garden vegetables are very easily grown, but lack of markets makes their production on a large scale unprofitable. Small fruits are successfully grown for home use.

The value of animals sold or slaughtered in 1910, as reported by the census, was \$412,530. Dairy products, excluding those consumed in the homes, were valued at \$148,629 and poultry and eggs at \$177,613. These figures show a considerable increase over those for 1900, in which year the value of animals sold and slaughtered was \$67,255; of dairy products, excluding home use, \$9,240; and of poultry raised, \$8,757. Most farmers have a fair grade of cattle. Some have bred up their herds to a high standard. Shorthorns are the most popular breed of cattle.

The raising of hogs for market has greatly increased in the last three years, the number having probably trebled since 1910. This is partly accounted for by the large increase in the production of corn.

A very good grade of draft horses is found in the county. Most farmers take pride in breeding their horses to a high standard. Pure-bred sires are used almost entirely. Percheron horses are most common.

Except in the Turtle Mountains, few native trees are found in the county. There are many small poplar groves in the region southeast of Bottineau, and a belt of trees occurs along Antler Creek in the northwestern part of the county. Groves have been planted on a large number of farms, especially in the longest settled parts of the county. These are useful as a protection against wind, as well as in relieving the monotonous prairie landscape. The School of Forestry at Bottineau is doing much good work in encouraging the growing of trees.

Practically the same method is used in growing all the spring grains. Farmers plow as much as possible in the fall. Plowing often has been done as late as the last of October or later. All the land to be devoted to wheat ordinarily is plowed in the fall. In the spring the land usually is harrowed twice before seeding and often once after seeding. Harrowing after the grain is up has been carried on to some extent and has sometimes given good results with wheat and oats. The sandy soils can not be harrowed much, as destructive drifting may result.

The small grains are seeded in drills 6 inches apart. Double and single disk and shoe drills are used, the double disk being the most

common. Broadcast seeders are scarce. Weedy plowed land often is disked before seeding, especially for the late crops. In backward seasons some farmers double disk instead of plowing the stubble. Most of the plowing is done with gang plows, using five or six horses. Considerable plowing is done with triple gangs, with which seven or eight horses are used. Tractors are used to some extent for plowing. Four to six horses are used with other field implements, except corn and haying machinery, with which two horses generally are used. Most of the grain is cut with 7 or 8 foot binders. Threshing is mostly done by large itinerant outfits owned and operated by farmers, who charge a stipulated price per bushel. Most of the grain is thrashed from the shock. Power is supplied by steam or gasoline engines.

The greatest need of the county is a system of crop rotation which shall include an intertilled crop and a legume. A sufficient quantity of live stock should be kept to consume the forage crops, and to convert the straw into manure to be returned to the land.

Much of the work on the farm is done by the farmer and by members of his family. Farm labor is mostly transitory. Men hired by the month are paid \$35 to \$40 or more for a period of 7 or 8 months. In the late summer and fall much higher wages are paid. Men who do chores in the winter usually are paid \$20 to \$25 a month. In the summer most of the laborers are hired by the day. Day wages range from \$1.25 in the spring to \$3.50 or more for unskilled labor during the thrashing season. Subsistence is always furnished to farm laborers.

In 1890 there were only 677 farms in the county, of an average size of 225 acres. The average value of farms, including land, fences, and buildings, implements and machinery, and domestic animals, was \$1,334, which indicates the extremely low price at which the land was held. By 1900 the number of farms had almost trebled, being 1,966, while the average size remained about the same, or 224 acres. Only 44.1 per cent of the farm land was improved, the small percentage probably being due in part to the large acreage which had but recently been homesteaded. The average value of the farms was \$2,529, of which 66.2 per cent was represented by the land. The decade between 1900 and 1910 was a period of great progress. The number of farms increased to 2,304 and their average size to 418.9 acres, of which 88.3 per cent was classed as improved. The large increase in the average size of the farms was due to the departure of many of the 160-acre homesteaders and the combining of small farms. The average value of the farms was \$15,357, having increased more than sixfold in 10 years.

In 1900, 3 per cent of the farms were operated by tenants; in 1910 the percentage had increased to 17.3. Under the common system of leasing, the owner and tenant share the grain crops equally, the tenant

furnishing horses, machinery, and labor and paying for twine and half the cost of thrashing, and the landlord furnishing the seed. Special arrangements are made for growing intertilled crops. At present in some cases the tenant gets free use of the land for a field of corn, as well as of pasture and hay land. The length of tenure usually is short, in most cases being only one year. As a rule poorer methods are followed on land farmed by tenants than on that farmed by owners.

In 1910, 66.19 per cent of the tenants were native-born and 33.81 per cent foreign-born white, while 43.87 per cent of the landowners were native born and 56.13 per cent foreign born. Of the farms operated by owners, 612 were reported as being free from mortgage debt and 1,283 as mortgaged, 6 not reporting. Only about half the mortgaged farms reported the amount of their indebtedness, which averaged \$2,850.75 per farm, or 22.6 per cent of the value of the land and buildings.

Land values range from \$5 to \$50 or more an acre. The average value is about \$28 an acre, as was found by consulting the county transfer records for alternate rows of townships across the county east and west and by personal inquiry among the farmers. It was found that the light sandy soils change ownership with greater frequency than the heavier types. This is especially true of the level Barnes types, which are as productive as the heavier types during wet years but are inferior to them in average or dry seasons. Farmers are loath to dispose of fine-textured soils, which they have found by experience to be more certain to produce profitable crops.

#### SOILS.

The soil materials of Bottineau County, with the exception of recent alluvium, were deposited during the glacial period by the great continental ice sheet, a part of which covered this part of the country. During its advance and recession the ice left a thick layer of drift or till composed of a great variety of material taken from the soils and rocks of the country to the north and northeast of the county. This drift in places was modified by the waters from the melting ice, which caused erosion and redeposition of the soil material along irregular stream courses and in shallow lakes.

The soils derived from materials which escaped modification by water after being deposited by the ice are known as glacial or drift soils. The pure drift soils occupy the northeastern part of the county, a north-and-south strip through the central part, and approximately the western fourth of the county. The surface of the area occupied by the drift soils ranges from nearly level to undulating or gently rolling, with some more sharply rolling areas, as in the extreme north-

eastern part of the county, occupied by the Turtle Mountains. The drift soils have been modified by weathering and by the addition of organic matter through the decaying of the roots of grasses and weeds. The lime content of the drift soils is high.

The soils that have been modified by the action of water occupy chiefly the bed of a supposed extinct glacial lake known to geologists as Lake Souris. The more nearly level areas, represented roughly by a northwest and southeast strip just east of the central part of the county, are occupied by the heavier types of lake-bottom soils. A large percentage of the lighter types of water-deposited soils are undulating in topography, and it is doubtful whether many of them were deposited in standing water.

Lake Souris has no distinct shore lines and probably existed only during a short period of time. The water probably was very shallow. On the east there is a rather distinct line of demarcation between the upland till soils and the supposed lake-bottom soils, but on the west the slope is very gradual and the boundary of the lake on that side was possibly formed by the receding ice. The sandy areas usually occur in association with streams, which probably had something to do with their sorting out and deposition. There are many small basins scattered over the county which at one time were undoubtedly filled with water.

Along the stream courses also have been deposited strips of alluvial soils of varying widths and different characteristics.

The drift soils of the county are included in the Barnes and Williams series, the lake-bottom and supposed lake-bottom soils in the Valentine, Fargo, and Rogers series, and the stream-deposited soils in the Sioux, Lamoure, and Maple series. In addition to the above-named series numerous small areas of Peat and Muck were mapped in the Turtle Mountain section.

The soils of the Barnes series are black to dark brown in color. The subsoils are grayish, yellowish, greenish yellow or brownish yellow in color and highly calcareous. The soils rarely effervesce in hydrochloric acid and in extreme cases the effervescence will not take place above 30 inches. Below that depth it always takes place and usually above it to within 18 inches of the surface. The lime may be uniformly distributed or may be collected in masses, but not usually in well-defined concretions. The soils are derived from glacial till, occur in regions that have been subjected to very little erosion or leaching, and have predominantly a constructional topography and are well drained. They occur most abundantly in regions of low to moderate rainfall. In Bottineau County this series is represented by the Barnes fine sandy loam, very fine sandy loam, loam, silt loam, clay loam, and clay.

The surface soils of the Williams series are dark gray to brown or dark brown in color and are generally underlain at a depth of 8 to 15 inches by lighter brown subsoils, which pass abruptly into light-gray or yellowish calcareous material, usually of fine and often of silty texture. These soils are derived from glacial drift composed of a great variety of rock materials ground by the ice into different grades of fineness. Rounded glacial boulders, cobbles, and gravel are usually present. The calcareous character of the subsoils is due to the presence of crushed limestone in varying degrees of disintegration. The Williams series is represented in Bottineau County by the gravelly loam, and by the rolling phases of two other types, the sandy loam and loam.

The surface soils of the Valentine series are brown to dark brown; the subsoils are light brown to brown and usually heavy. Below 3 feet they grade into loose sands. The soil material is of wind-laid origin, derived mainly from the sandy strata of the stream-outwash plain deposits of Tertiary age, and is associated with Dunesand. The soils of this series occupy level, terracelike areas. In some places the material has been modified by alluvial agencies. The topography ranges from almost level flats to dune-shaped hills. The members of this series usually are well drained, and in outlying areas the water table is encountered near the surface. The Valentine fine sand is the only type of this series mapped in Bottineau County.

The surface soils of the Fargo series are dark gray, brown, drab, or black in color, and the subsoils are gray to light yellowish brown. These soils contain a very high percentage of organic matter, in some cases enough to make them slightly mucky. There is also present, especially in the subsoil, a large percentage of lime. The topography is prevailingly level. Two types are mapped in this series, the silty clay loam and clay.

The Rogers series is characterized by gray to yellowish-gray or brownish surface soils and gray to brownish-gray subsoils. The Rogers soils occur in depressed areas and are generally poorly drained and of low agricultural value. The presence of alkali is characteristic. One type, the Rogers clay loam, is mapped in this county.

The soils of the Sioux series are dark brown to gray or dark gray in color and are generally underlain within 3 feet of the surface by beds of gravel and sand, which cause crops to suffer in times of drought. These soils occur as stream terraces and bottoms that are not subject to overflow. Three types, the gravelly loam, sandy loam, and loam, are mapped in Bottineau County.

The surface soils of the Lamoure series are typically dark brown or black in color. The subsoils are drab or gray. The members of this series occur in the first bottoms of streams in the glacial province.

Three types, the fine sandy loam, silt loam, and clay occur in this county.

The surface soils of the Maple series are gray to dark gray in color. The subsoil below 18 inches usually is light gray or drab, and may in rare instances be mottled with brown or yellow. Pockets or beds of sand or of sand and gravel occur at depths ranging from 18 to 36 inches. These soils occur along streams and in old drainage-way depressions. Owing to the high content of clay in the surface soil and the presence of clay layers in the subsoil, the soils of this series usually are poorly drained and contain alkali in spite of the porous nature of the subsoil. One type, the Maple clay loam, is mapped in the county.

Peat and Muck consists of partially decomposed vegetable matter mixed with varying quantities of soil material and fragments of shells. It occurs chiefly in old lake beds in the Turtle Mountains.

The following table gives the names and the actual and relative extent of the several soil types mapped in Bottineau County:

*Areas of different soils.*

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Barnes loam.....	300,032	32.5	Lamoure clay.....	13,824	1.3
Stone-free phase.....	27,328		Valentine fine sand.....	13,184	1.2
Heavy-subsoil phase.....	22,144		Maple clay loam.....	9,728	.9
Barnes very fine sandy loam..	73,152	22.0	Williams gravelly loam.....	9,600	.9
Stone-free phase.....	163,840		Peat and Muck.....	8,128	.8
Barnes fine sandy loam.....	74,816	11.6	Lamoure fine sandy loam.....	7,424	.7
Stone-free phase.....	49,856		Sioux gravelly loam.....	7,296	.7
Barnes silt loam.....	49,024	8.3	Rogers clay loam.....	3,008	.3
Stone-free phase.....	40,576		Williams sandy loam, rolling phase.....	2,560	.2
Fargo clay.....	59,648	5.5	Barnes clay.....	2,432	.2
Barnes clay loam.....	43,840	4.1	Lamoure silt loam.....	896	.1
Fargo silty clay loam.....	41,920	3.9			
Sioux loam.....	17,920	1.7			
Williams loam, rolling phase..	17,152	1.6			
Sioux sandy loam.....	16,512	1.5			
			Total.....	1,075,840	.....

BARNES FINE SANDY LOAM.

The Barnes fine sandy loam as mapped east of the Mouse River consists of a dark grayish brown fine sandy loam, 7 to 20 inches deep, underlain by a darker layer having an average thickness of about 8 inches, which grades through a light-brown into a yellowish-gray fine sandy loam. Gravel and boulders are common on the surface, and both soil and subsoil contain considerable coarse sand. In places the type approaches a sandy or gravelly loam in texture, and there are some small included areas of sandy loam. In the western part

of the county a variation of this type occurs in which the surface soil consists of a dark fine sandy loam, about 12 inches deep, underlain by a brown fine sandy loam, which grades at a depth of about 20 inches into a grayish-yellow fine sandy loam. This variation has a fair content of organic matter and is almost free from gravel and boulders. Much of it approaches in texture the lighter parts of the Barnes loam. The subsoil throughout this type is loose and incoherent in structure and highly calcareous.

This type has its largest developments in the eastern part of the county, around Souris, and in the western part south of Antler. There also are scattered areas in other parts of the county. In the eastern part of the county the topography is prevailingly gently rolling, and in the western part it is level to undulating. Most of the type is well drained, although there is practically no surface runoff. The subsoil is fairly retentive of moisture.

The Barnes fine sandy loam is inclined to be droughty, but in favorable seasons it produces very good yields. The more even textured portions have to be handled very carefully to prevent drifting. This soil is especially well suited to intertilled crops, but in the past the common crops of the region have been grown to the same relative extent as on other types, very little attention being paid to crop adaptation and rotation.

Wheat yields about 12 bushels, oats 30 bushels, barley 18 bushels, and potatoes 110 bushels per acre.<sup>1</sup>

The average value of the Barnes fine sandy loam is about \$25 an acre.

*Barnes fine sandy loam, stone-free phase.*—The surface soil of the Barnes fine sandy loam, stone-free phase, is a dark grayish brown to almost black fine sandy loam or light fine sandy loam, ranging from 8 to 20 inches in depth, with an average of about 14 inches. This passes gradually into a dark-gray to light-gray sandy loam. Below a depth of 30 inches the subsoil usually is a gray to drab heavy fine sandy loam. Fine gravel occurs in spots in some of the areas in the eastern part of the county and in those south of Maxbass, but the greater part of the phase is free from gravel and boulders. A few small areas of sandy loam were included with this phase as mapped. These occur near Lords Lake, in the eastern part of the county, southwest of Bottineau, and south of Maxbass.

The largest area of this phase occurs west and northwest of Westhope and the second largest area occurs south of Maxbass. There are a few areas in the eastern and southeastern parts of the county. The

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<sup>1</sup> Statements in this report in regard to yields are based on information obtained from farmers and on observations in the field. On the better managed farms the yields are somewhat larger than those given, which are intended to represent ordinary results.

topography varies from almost level to gently undulating. Owing to the level surface all the rainfall which does not evaporate sinks into the soil, and enough of it is retained to keep the soil in a good condition of moisture.

This soil is easily tilled and has about the same agricultural value as the Barnes very fine sandy loam, stone-free phase. About 90 per cent of it is in cultivation. The yields of wheat and oats are not so high as on the latter soil, but the yields of rye, corn, and flax are similar and those of potatoes are higher. Potatoes yield ordinarily about 110 bushels per acre, and in seasons of good rainfall as much as 200 bushels per acre has been obtained. The potato crop is harvested in the early fall and is mostly sold.

Land of the Barnes fine sandy loam, stone-free phase, sells for \$15 to \$50 an acre, depending upon location and improvements. The higher priced land is located near Westhope.

#### BARNES VERY FINE SANDY LOAM.

The surface soil of the Barnes very fine sandy loam is a dark grayish brown very fine sandy loam with an average depth of about 12 inches. It appears quite black when in a moist condition owing to the high content of organic matter. The subsoil is a calcareous very fine sandy loam, brown in the upper part and becoming grayish yellow or yellowish gray at a depth of about 20 inches. It is fairly compact and quite retentive of moisture. In many places the subsoil consists almost entirely of silt. Both soil and subsoil are very smooth and even textured, have a floury feel when dry, and become quite sticky when wet. Glacial gravel and boulders occur on the surface and throughout the soil section.

The Barnes very fine sandy loam is extensively developed and widely distributed. The largest area occurs in the northwest corner of the county near Antler, where it is the predominating type. Another large area lies northeast of Westhope, bordering the Mouse River bottom, and a number of areas border the river on the east. The topography generally is undulating and drainage is good.

The Barnes very fine sandy loam is a productive soil, being especially well suited to intertilled crops. In favorable seasons it produces yields which compare well with those obtained on any other soil type in the county, but crops are more likely to suffer from drought in extremely dry years than on the heavier types.

Wheat yields ordinarily about 13 bushels, flax 7 bushels, barley 20 bushels, oats 30 bushels, and potatoes 110 bushels per acre.

The price of land of this type ranges from \$20 to \$45 an acre, the average price being about \$25 or \$30 an acre.

*Barnes very fine sandy loam, stone-free phase.*—The Barnes very fine sandy loam, stone-free phase, consists of a dark grayish brown very fine sandy loam with an average depth of about 14 inches, underlain by a yellowish-gray very fine sandy loam, usually containing a high percentage of silt and extending to a depth of 36 inches or more. The dark-colored surface soil may be only 6 or 8 inches deep or it may continue to a depth of 2 feet or more. In some places the surface soil closely approaches a silt loam in texture. The subsoil is in places gray, especially where the surface soil is of maximum depth. Both soil and subsoil are free from gravel and bowlders. Frequently there is encountered just below the surface soil a gray layer which grades into a yellowish-gray or pale-yellow very fine sandy loam containing a high percentage of silt, in some instances the silt content being large enough to make the texture a silt loam. This yellowish subsoil usually becomes light gray on drying out. In some small areas southwest of Gardena the subsoil is brown. There are a few small depressions, mostly in the southeastern part of the county, in which the subsoil is a yellowish or brownish-gray very fine sandy clay or silty clay loam.

The Barnes very fine sandy loam, stone-free phase, is the second most extensive soil type in Bottineau County. It occupies a large proportion of the southeastern and south-central parts of the county and also occurs in numerous relatively small areas in the north-central and central parts. The topography is undulating to nearly level, some of the very small areas being flat. Drainage is sufficient, but is nowhere excessive. Practically all the rainfall is absorbed by the soil, the run-off being very slight, and both soil and subsoil are fairly retentive of moisture. In unusually dry growing seasons preceded by winters of more than average precipitation the phase frequently produces better yields than heavier members of the Fargo and Barnes series.

This phase is one of the most desirable soils in Bottineau County. It is easy to cultivate and the topography is sufficiently uniform to allow the cultivation of probably 95 per cent of it. Wheat, the principal crop grown, yields ordinarily about 13 bushels to the acre, while a maximum yield of more than 35 bushels per acre has been obtained. Oats yield ordinarily about 30 bushels, rye 15 bushels, barley 22 bushels, and flax 10 bushels to the acre. Corn, which is becoming an important crop on the phase, yields from 20 to 25 bushels per acre in favorable seasons. Comparatively little hay is grown, although favorable results usually are obtained. Timothy yields about a ton and alfalfa and sweet clover more than a ton per acre. Millet also does well. Where weeds are troublesome hay crops sometimes are grown for the purpose of cleaning the land.

Land of this phase usually sells for \$30 to \$40 an acre. A few farmers hold their land for as much as \$50 an acre.

#### BARNES LOAM.

The surface soil of the Barnes loam consists of a dark-brown, light loam to rather heavy silt loam, from 8 to 15 inches deep and having a high content of organic matter. In places it contains considerable very fine sand. The subsoil is a friable loam, light brown in the upper part and becoming gray to light yellow at a depth of about 20 inches. The subsoil is very calcareous and at a depth of 26 to 30 inches shows streaks of lime. It sometimes contains small reddish iron spots. Small bowlders and gravel occur on the surface and throughout the soil section.

In the northwestern corner of the county much of the type is rather light in texture, being closely associated with the Barnes very fine sandy loam. A variation occurs in Cut Bank Township in which the texture is finer than usual, and in much of the type in Scandia and Haram Townships there is an unusually large quantity of gravel.

The Barnes loam is the most extensive soil type in the county. The largest areas occur in the southwestern part of the county. The topography is prevailingly undulating, being almost level in places. One small area northwest of Carbury has a rolling surface. Drainage usually is sufficient.

This soil is easy to cultivate and does not bake or crack upon drying. Probably 90 per cent of it is under cultivation at present, and practically all of it can be cultivated. It is retentive of moisture and productive.

All the crops common to the region are successfully grown on this soil, but it is recognized as being particularly well suited to general farming crops. Wheat is the principal crop grown and yields ordinarily about 13 bushels per acre. Oats yield about 32 bushels, barley 22 bushels, and winter rye 15 bushels per acre. Corn generally is grown for forage. Alfalfa has been tried, and where the seed bed has been well prepared and hardy varieties sowed it has been a success. Millet, timothy, brome grass, and western rye grass are grown for hay with fair results, about a ton per acre usually being obtained.

Land of this type sells for \$15 to \$50 an acre, the average price being about \$30 an acre.

*Barnes loam, heavy-subsoil phase.*—The surface soil of the Barnes loam, heavy-subsoil phase, consists of a gray loam to silty loam from 5 to 10 inches deep. The subsoil is a yellowish-brown clay loam to clay, usually becoming lighter in texture and containing some fine gravel at a depth of about 26 inches. In many places the surface soil

is dark gray or dark brown in color, and in forested areas there is generally an inch or two of black loam overlying the gray material. In other places a layer of clay about 4 inches thick, containing a small quantity of gravel and sand, occurs below 26 inches. Some bowlders generally are scattered over the surface of the phase. The areas of this phase contain numerous depressions occupied by small lakes and swales. Where large enough the latter were mapped as Peat and Muck, but a number were too small to be separated on a map of the scale used and are therefore included with the phase.

This phase is confined to the Turtle Mountains. The topography is undulating to rolling and drainage is good. Only about 15 or 20 per cent of the phase is in cultivation at present, the remainder supporting a growth of small trees consisting mostly of poplar, with some birch, oak, wild cherry, and willow. The area of cleared and cultivated land is gradually being extended. Partly cleared areas usually support a luxuriant growth of wild peas.

Wheat, oats, and barley are the principal crops grown. Wheat yields ordinarily 15 to 20 bushels, oats 35 to 40 bushels, and barley about 25 bushels to the acre. A few fields of corn have been grown, and where the crop has not been killed by frost yields of 20 to 30 bushels per acre have been obtained. Some of the farmers have grown alfalfa, timothy, and clover with good results, the yield under ordinary conditions averaging a little more than a ton of hay to the acre. Potatoes do well, yielding a hundred bushels or more to the acre.

The average price of uncleared land of this phase is about \$10 an acre. Cleared land, when reasonably well located, brings about \$25 an acre.

*Barnes loam, stone-free phase.*—The surface soil of the Barnes loam, stone-free phase, is a dark grayish brown loam, 8 to 10 inches deep. The subsoil to a depth of 36 inches is a yellowish or brownish-gray light loam to silty loam. In slightly elevated, undulating areas the soil may contain a high percentage of very fine sand and should be described as a light loam, while in depressed areas it may be somewhat heavier. The more nearly level areas usually have a gray, silty subsoil. A few small depressed areas which receive seepage from higher lying soils have a dark-brown, rather compact, silty subsoil. The more elevated, undulating areas—those associated with the Barnes very fine sandy loam and the Barnes silt loam, stone-free phase—usually have a grayish-brown light loam subsoil. This phase is free from gravel and bowlders.

No very large areas of the Barnes loam, stone-free phase, were encountered. The largest areas mapped occur northeast of Willow City. Numerous smaller areas are scattered throughout almost the entire county. The topography is prevailingly gently undulating,

there being a few level areas. Drainage is good, except in a few depressions.

The greater part of this phase is in cultivation. It is devoted mainly to the production of small grains, although other crops, such as corn, potatoes, and hay also are grown. The yields are intermediate between those obtained on the Barnes silt loam, stone-free phase, and the Barnes very fine sandy loam, stone-free phase. Some of the depressed areas are used either as pasture or hay land. About a ton of native hay per acre is cut from such land. Very few farms are located exclusively on this phase, and its value depends somewhat on that of the soils with which it is associated. It ranges from \$25 to \$40 an acre.

#### BARNES SILT LOAM.

The surface soil of the Barnes silt loam is a dark-brown to nearly black, friable silt loam, 10 to 20 inches deep. It has a high content of organic matter. The subsoil consists of a light-brown silt loam, passing at a depth of 20 to 36 inches into a grayish-yellow silt loam to silty clay loam. The subsoil is highly calcareous. Where this type is associated with the Barnes very fine sandy loam the subsoil approaches a very fine sandy loam in texture. Gravel is scattered over the surface and throughout the soil and subsoil. There are also some boulders over most of the type, these being most numerous near the Mouse River in the Eidsvold Township region. Much of this stony land, as well as much of the type mapped east of it, closely approaches a silty clay loam in texture.

This type is most extensively developed in a large area in the center of the county, between Kramer, Landa, and Roth. There are also numerous small areas scattered over the county. Most of the type lies slightly lower than the Barnes loam.

The topography ranges from level to gently undulating, and is entirely constructional, being exactly as it was when the material was deposited at the close of the glacial period. The drainage usually is sufficient to take care of the small amount of rain that falls.

This is one of the most desirable soil types in the county, and practically all of it is cultivated. All crops common to the region do well on this type. Wheat yields about 14 bushels, oats 35 bushels, barley 25 bushels, and flax 10 bushels per acre.

Land of the Barnes silt loam sells for \$30 to \$50 an acre, the average price being about \$35 an acre.

*Barnes silt loam, stone-free phase.*—The Barnes silt loam, stone-free phase, where typically developed, consists of a dark grayish brown to black silt loam, 8 to 18 inches deep, underlain by a brownish or yellowish-gray, friable silt loam. There usually is considerable variation in the color and texture of the subsoil. The surface

soil frequently is slightly calcareous, and the subsoil is always markedly so. The phase is free from gravel and boulders.

The most extensive areas of this phase occur in Whitby Township, and other important areas are scattered throughout the southeastern, central, and south-central parts of the county. The topography is gently undulating and drainage is sufficient, although most of the rainfall sinks into the soil.

By far the greater part of the phase is in cultivation, and the crop yields equal those on any other prairie soil in the county. Wheat yields ordinarily 14 bushels, oats about 35 bushels, winter rye 15 bushels, barley 25 bushels, and flax 10 bushels per acre. Potatoes do well. Corn seems to do a little better on this phase than on any other soil in the county. Timothy and rye grass yield about 1½ tons of hay to the acre, while sweet clover and alfalfa probably yield a little more than this. The price of land of this phase ranges from \$30 to \$50 an acre.

#### BARNES CLAY LOAM.

The surface soil of the Barnes clay loam consists of a black or dark grayish brown clay loam, 6 to 18 inches deep, with an average depth of 10 inches, underlain by a brownish to yellowish-gray clay loam to clay. In places loamy or sandy pockets, and occasionally a distinct layer of loam, are encountered at about 26 inches. Boulders are common on the surface and gravel occurs throughout the 3-foot section. Some areas are almost free from gravel and entirely free from boulders, and in these both soil and subsoil are slightly heavier than usual.

The Barnes clay loam is the most extensive type within the Turtle Mountains, to which it is confined. It occupies numerous small elevations and depressions, and the topography is undulating to rolling. Many of the depressions are occupied by small lakes or peaty areas. The surplus rainfall drains into these depressions. The soil has a good moisture-holding capacity, however, owing to its high content of organic matter, and most of the rainfall is retained by it. Crop failures due to droughts seldom occur either on this type or on any of the other soils within the Turtle Mountains.

About 20 per cent of this type is under cultivation. Uncultivated areas support a forest growth consisting mainly of poplar, oak, birch, and willow, with an undergrowth of shrubs.

All crops common to the region do well on the Barnes clay loam. Wheat, the principal crop, ordinarily yields about 20 bushels to the acre, while yields of over 35 bushels have been obtained. Wheat grown on this soil, as well as on the other types in the Turtle Mountains, is a little softer than that grown on the drier prairie soils. This slight inferiority, however, is more than offset by the higher yields.

Oats yield ordinarily about 40 bushels; barley, 25 bushels; timothy, alfalfa, and clover, 1 or 2 tons of hay; flax, 10 to 12 bushels; and potatoes, 100 bushels per acre. Very little rye is grown. Alfalfa gives best results when planted in rows and cultivated.

Some dairying is carried on and some beef cattle are raised. These are pastured in the woods and on the peaty areas.

Uncleared land of this type sells for \$7 to \$15 an acre. Cleared and improved land brings \$25 to \$40 an acre, according to its location and the nature of the improvements. The development of this type is retarded by its inaccessibility.

#### BARNES CLAY.

The Barnes clay consists of a dark brownish drab to black clay, 6 to 10 inches deep, underlain by an olive-drab or brownish-gray, heavy, plastic clay. Some areas occur in which there is no variation in color or texture from the surface to a depth of 3 feet or more. This type is practically free from gravel and bowlders.

The Barnes clay is confined to the Turtle Mountains and is not very extensive, although several areas half a square mile or more in extent were mapped. The topography is generally slightly undulating, with some nearly level areas. Drainage is fair.

Between 40 and 50 per cent of this type is in cultivation. Uncultivated areas are forested, mainly with oak, differing in this respect from the associated types on which the principal tree is the poplar. Wheat is the most extensively grown crop, oats and barley ranking next. Some potatoes and vegetables are produced for home consumption. Yields are about the same as on the Barnes clay loam, as are also land values.

#### WILLIAMS GRAVELLY LOAM.

The Williams gravelly loam consists of a dark-grayish to brown loam or fine sandy loam, 6 to 10 inches deep, underlain by a yellowish or brownish-gray, rather friable loam or fine sandy loam, which extends to a depth of 3 feet or more. Gravel is present throughout the soil section, being most abundant in the lower subsoil. Streaks of white calcareous material are also present in the lower subsoil. The content of gravel is somewhat higher in the areas occurring along the border between the prairie and the Turtle Mountains, which have a more gently sloping topography than in other parts of the county, where the topography usually is rolling. Bowlders are common on the surface of the type. Where it occurs along streams this type represents areas of Williams loam or fine sandy loam which have been rather extensively eroded. The Williams gravelly loam is one of the least valuable soils of the Williams series.

The greater part of the type is used as pasture land. Some areas are cultivated, but crop yields are rather low and cultivation is difficult.

In the east-central part of the county there are included with this type a number of small areas consisting of dark grayish brown, gravelly fine sand, 4 or 5 inches deep, underlain by more or less stratified sand and gravel. The gravel is composed of granite, gneiss, limestone, sandstone, and quartzite. This material occurs on knobs and is a kame deposit. It has little agricultural value.

#### WILLIAMS SANDY LOAM, ROLLING PHASE.

The Williams sandy loam, rolling phase, consists of a gray to dark grayish brown sandy loam, about 10 inches deep, underlain by a yellowish or brownish-gray sandy loam containing some coarse sand and fine gravel. The subsoil frequently passes into a sticky sandy loam or sandy clay loam at about 20 to 26 inches. Boulders and gravel usually are present on the surface, and a small quantity of gravel may be encountered anywhere within the soil section.

This phase is confined to the Turtle Mountains. The topography is undulating to rolling. A part of the phase is cultivated, wheat, oats, rye, barley, and potatoes being grown. Uncultivated areas are forested. The soil is not considered quite so valuable as the associated Barnes clay loam and loam, as it is inclined to be a little leachy and crops may suffer for lack of moisture in dry periods.

#### WILLIAMS LOAM, ROLLING PHASE.

The surface soil of the rolling phase of the Williams loam consists of a grayish-brown to dark grayish brown loam, generally 8 to 12 inches deep, but only 5 or 6 inches where there is considerable erosion. The subsoil to a depth of 36 inches consists of a yellowish-gray to light yellowish gray very calcareous loam to silty loam, which usually contains a small percentage of gravel. Gravel is present throughout the soil section, and there are usually a few small boulders scattered over the surface. In places along the slopes of the Turtle Mountains there is a large percentage of glacial boulders scattered over the surface and throughout the soil section.

The largest areas of this phase are located along the outer edges of the Turtle Mountains. Smaller areas occur as eroded slopes in places along the Mouse River and some of its tributaries. The topography is rolling to hilly and drainage usually is excessive.

The Williams loam, rolling phase, is used almost exclusively for pasturage. It is not cultivated, on account of its hilly topography and excessive drainage. Clumps of scrub oak trees and wild rose bushes are common, especially along coulees and in depressed areas. Land of this phase is valued at \$9 or \$10 an acre.

## VALENTINE FINE SAND.

The Valentine fine sand to a depth of about 20 inches consists of a grayish-brown to brown fine sand or loamy fine sand. The dark color of the surface soil is due to the presence of organic matter. The organic-matter content, however, is not so high as in the sandy phases of the Barnes series. The subsoil to a depth of 3 feet or more varies from a grayish-brown to gray fine sand or loamy fine sand. In places there is little difference in color between the surface soil and subsoil. In depressions southeast of Eckman the surface soil is a fine sandy loam or very fine sandy loam, underlain at about 12 inches by a bright-yellowish fine sand or very fine sand. These areas were considered too small to map as a separate type. Two large and several small areas of this type were mapped. One of the former lies southeast of Willow City, extending into Pierce County, and the other southeast of Eckman and west of the Mouse River. The small areas are associated with the stone-free phases of the Barnes fine sandy loam and very fine sandy loam. Where the type borders the latter it is nearly a very fine sand in texture. The surface of the type is billowy, being characterized by numerous small, wind-formed hillocks. Owing to the light texture of the subsoil under-drainage is excessive.

Only about 30 per cent of this type is cultivated. Uncultivated areas have a characteristic growth of dwarf willows and numerous weeds and grasses. The Russian thistle is common. In some of the depressions there are clumps of larger willows and shrubs.

The agricultural value of this soil is seriously affected by its tendency to drift. The crops common to the region are grown, but the yields are somewhat below the average for the county. Some depressed areas in which drainage is less excessive than usual produce a fair quality of native hay.

Land of this type sells for about \$15 to \$50 an acre. The average value is about \$20 an acre.

## FARGO SILTY CLAY LOAM.

The Fargo silty clay loam consists of a dark grayish brown to black silty clay loam, 12 to 24 inches deep, underlain by a gray to dark grayish brown silty clay loam or clay. The surface soil is rich in organic matter and both soil and subsoil are calcareous. Several small areas in different parts of the county vary from the typical soil in that the surface 4 to 6 inches is a dark grayish brown to nearly black silt loam, underlain by a clay of the same color, which continues to a depth of 12 to 20 inches. In places the subsoil is a heavy silt loam. In the areas with a gray silty clay loam subsoil, which occur north of Kramer, closely associated with the

Barnes silt loam and loam, there may be a small percentage of gravel in the lower subsoil, but elsewhere the type is free from gravel. This type is closely associated with the Fargo clay, and it usually lies above the Fargo clay and lower than the stone-free phase of the Barnes silt loam. The topography is either level or very nearly so. Drainage is poor, but this defect is largely offset by the relatively slight rainfall.

Some small areas of this type and the Fargo clay are locally known under the name "gumbo." It is considered a lighter phase of "gumbo," however, as cultivation is easier than on the Fargo clay. The soil has about the same agricultural value as the Fargo clay. It is not naturally so strong as the latter soil, but on account of its less plastic nature and slightly higher position it produces better crops in wet seasons than that type. The greater part of the type, exclusive of numerous small depressions, is cultivated. Hay is cut from the less well drained depressions. The average price of land of this type with farm improvements is about \$35 an acre.

#### FARGO CLAY.

The surface soil of the Fargo clay consists of a dark grayish brown, drab or black, rather heavy, plastic clay, from 12 to 20 inches deep. The subsoil is a dark-gray or drab, heavy, compact clay, usually becoming lighter in color with depth. The surface soil has a high content of organic matter, and over areas that have never been cultivated there is usually a layer of dark-brown peat from one-half to 1 inch in thickness. Both soil and subsoil are highly calcareous. The type is free from gravel and bowlders. This type is much easier to cultivate than some other soils of the same texture. It does not clod when plowed nor crack badly during long dry periods. Instead, when properly cultivated, it granulates, forming a light mulch on the surface.

The surface soil varies somewhat even in areas of uniform topography. The texture is sometimes a silty clay. Such areas occur within the larger areas of the type near Souris. Small inclosed areas also occur in which the dark-colored surface soil is underlain at about 6 inches by a brownish-gray layer of clay which extends to a depth of 12 to 20 inches. In some areas east of Gardena there is a small quantity of alkali present on the surface. Alkali spots also occur within the large area of the type east of Willow City.

Frequently the subsoil is uniformly dark gray or drab in color to a depth of 3 feet or more. In some cases a silty clay is encountered at about 30 inches, and in the large area east of Willow City there are spots in which a layer of silt loam or very fine sandy loam occurs at a depth of 30 to 40 inches. This layer usually is

about 6 inches in thickness and is underlain by dark-gray or grayish-brown clay.

The topography of the Fargo clay is level, and as there are very few streams passing through areas of the type it is poorly drained. This, however, does not seriously affect the agricultural value of the soil, except in years of more than average rainfall, although in a number of cases it has been necessary to establish artificial drainage in order to make cultivation possible.

All the crops commonly grown in Bottineau County are produced on the Fargo clay. Good yields of most crops are obtained when the soil is thoroughly cultivated. Oats do as well as, if not better than, on any other type in the county, yielding ordinarily from 35 to 40 bushels per acre, and frequently much more. Wheat also does well, the average yield being about the same as on the Barnes loam. Very little rye is grown, and corn does not do quite so well as on some of the lighter types. Potatoes do not make as good yields as on lighter soils, and are usually grown only in small fields. Some seed potatoes are produced.

About 50 per cent of this type is in cultivation, the remainder being used mostly for cutting native hay and as pasture land. The smaller areas, which are usually lower and less well drained than the others, are used almost exclusively for the production of hay. Native grasses yield from 1 ton to 3 tons of hay to the acre.

The price of land of the Fargo clay ranges from \$20 an acre for unimproved land to about \$40 an acre where the improvements are of high grade, the average price being about \$30 an acre. The type is locally referred to as "gumbo."

#### ROGERS CLAY LOAM.

The Rogers clay loam consists of a light grayish brown clay loam or silty clay, from 8 to 15 inches deep, underlain by a light-gray, drab or yellowish-gray clay loam to clay, which is very plastic and sticky and very seldom dries out. Occasionally a very small percentage of coarse sand is present in the subsoil below 30 inches. The type contains a large quantity of alkali and in dry weather white bare spots can be seen on the surface.

The Rogers clay loam is very inextensive. It has its largest development in the eastern part of the county, several miles from Bottineau, where there are several small areas. The other areas are scattered.

The type occupies the beds of extinct lakes and ponds, in some of which the soil has been influenced by the addition of material washed from the higher lying surrounding soils. The drainage is rather poor and the type is seldom cultivated. Grains grown on this soil

have given poor results. The type is mostly in pasture. The price of the land is low.

A variation of the type occurs in the southeastern part of the county, mainly south of Willow City. This consists of a gray to brownish-gray very fine sandy loam to clay loam, 8 to 12 inches deep, underlain to a depth of 20 inches by a sandy clay. Below 20 inches the lower subsoil is a very fine sandy loam to fine sandy clay. When wet the subsoil appears to be very sandy, but upon drying it hardens into cementlike clods. This variation occurs in small depressions and is used only for hay and pasture.

#### SIoux GRAVELLY LOAM.

The surface soil of the Sioux gravelly loam, to a depth of about 10 inches, is a brown loam or sandy loam, containing considerable gravel. The subsoil consists of coarse alluvial sand and gravel, well stratified with fine material, and is very loose and porous. It is usually brown in the upper part and gradually becomes brownish gray or light yellowish brown, with many layers of a reddish-brown hue. A large number of very gravelly spots occur over the type where burrowing animals have thrown up the coarse subsoil.

This type is very inextensive and occurs in small, scattered areas, mostly in the west-central part of the county. It occupies level, elevated terraces bordering old watercourses, often at the junction of drainage channels. In places the type is somewhat dissected by erosion, giving it an undulating appearance.

Owing to its high content of gravel and its droughty nature, this soil is of little agricultural value. Only a very small part of it is cultivated. Alfalfa could probably be produced on those areas that have water fairly close to the surface and where tillage is practicable. Many fields that were formerly cultivated have been allowed to revert to grass. Most of the type is covered with a fair growth of native grass and makes good pasture land, for which it is largely utilized. It is also valued for the sand and gravel which it contains. The land is worth about \$10 an acre.

#### SIoux SANDY LOAM.

The surface soil of the Sioux sandy loam is a grayish-brown sandy loam, 7 to 20 inches deep, with an average depth of 12 inches. It becomes lighter in color with depth. At about 20 inches the subsoil contains considerable gravel and coarse sand, and in the lower part it consists of interbedded sand and gravel, the sand predominating, and is usually of a rusty brownish to rusty grayish yellow color. Both the soil and subsoil are loose and incoherent in structure. There are small included areas of fine sandy loam and fine sand.

The Sioux sandy loam is inextensive and occurs in small, scattered areas. It occupies minor stream bottoms or terraces which are more elevated than the ones on which the Sioux loam occurs and usually slightly lower than those on which the Sioux gravelly loam is found. A considerable proportion of the type occurs along Cut Bank Creek, mostly south of Maxbass. The soil does not drift badly, except in the included spots of fine sand. Owing to the porous nature of the subsoil, drainage is excessive.

The agricultural value of the type is rather low. Probably 60 per cent of it has been cultivated, but much of it has been allowed to revert to native grass. The soil is recognized as being best suited to inter-tilled crops, but heretofore the common crops of the region have been grown on it in the same proportion as on other soils. Oats seem to do better than any of the other small-grain crops. Wheat yields ordinarily about 9 bushels per acre, which is much below the average for the county. Water in some places stands 4 to 8 feet from the surface, and it is probable that in such areas fair yields of deep-rooted crops, like alfalfa, could be obtained. The price of land of this type ranges from \$15 to \$20 an acre.

#### SIoux LOAM.

The surface soil of the Sioux loam consists of a dark grayish brown to dark-brown loam, about 10 inches deep. In places the material varies from a light loam to a heavy silt loam. The subsoil to a depth of about 24 inches is generally finer in texture than the soil. At depths ranging from 16 to 36 inches or more occur stratified layers of coarse alluvial sand and gravel, with considerable interstitial material consisting of very fine sandy loam or gravelly loam. The subsoil varies greatly. Many small areas of alluvium along Cut Bank Creek in which the leachy subsoil does not appear within 36 inches of the surface were included with this type, as they were too small to warrant separation.

The Sioux loam is an inextensive type, and is developed mainly in rather straight, narrow strips through areas of the Barnes loam and very fine sandy loam in the western part of the county. It is largely confined to gently sloping terraces in swales bordering old drainage channels at elevations somewhat lower than the contiguous glacial types. Owing to this fact the water table is sometimes fairly close to the surface, so that crops are usually as well supplied with moisture as on some of the finer textured upland types.

About 75 per cent of the type is cultivated at present. Owing to its coarse texture its agricultural value is not nearly so high as that of the Barnes loam. The crops common to the region are grown. Wheat yields ordinarily about 11 or 12 bushels per acre and other crops relatively well.

The value of land of this type ranges from about \$15 to \$20 an acre. Owing to the narrow strips in which it occurs the type is never sold separately.

#### LAMOURE FINE SANDY LOAM.

The surface soil of the Lamoure fine sandy loam varies from a dark grayish brown fine sandy loam to very fine sandy loam or loam, from 10 to 18 inches deep. These variations may occur as separate areas or within the same area. The content of organic matter is high. The subsoil is a brownish gray or gray calcareous fine sandy loam to loam which extends to a depth of 3 feet or more. One or two small areas of silty clay loam occurring along Cut Bank Creek in the southwest part of the county have been included with this type.

The Lamoure fine sandy loam occurs as alluvial strips along intermittent streams. The most extensive areas lie along Oak, Willow, and Boundary Creeks, in the eastern part of the county, while several areas were mapped along Cut Bank Creek, in the western part, and near Antler, in the northwestern part. One small area occurs in the Turtle Mountains along the upper part of Oak Creek. The topography is nearly level, except where abandoned stream channels are numerous. Drainage usually is good, as most of the type lies 5 to 7 feet above the water level in the stream channels. The streams along which the type occurs seldom, if ever, overflow their banks.

The Lamoure fine sandy loam is a very productive soil, but owing to the relatively small areas in which it occurs it is used principally for pasturage and the production of hay. Occasional fields of the type are devoted to flax and barley, and some farmers plant their vegetable gardens on it. The strip of this soil along Oak Creek which passes through Bottineau is utilized for the production of vegetables. On account of its limited extent, areas of this type are sold only with other soil types.

#### LAMOURE SILT LOAM.

The Lamoure silt loam consists of a dark brownish gray or drab, heavy silt loam, about 8 inches deep, underlain by an olive-drab silt loam to heavy silt loam, which extends to a depth of 3 feet or more. Uncultivated areas usually have about an inch of brown or dark-brown peaty material on the surface. The Lamoure silt loam occurs as flat bottom land along South Antler Creek and the Mouse River. It is most extensively developed along South Antler Creek, lying about 8 or 10 feet above the level of the water in the creek. It is seldom overflowed and is fairly well drained.

About half of this type is in cultivation, the uncultivated part being covered with a growth of small trees and shrubs. Flax, wheat, and oats are grown, and the yields are similar to those on near-by

areas of the Barnes loam. Land of the Lamoure silt loam is valued at about \$30 an acre.

#### LAMOURE CLAY.

The Lamoure clay consists of a brownish-drab clay, about 18 inches deep, underlain by a somewhat lighter colored, compact, moderately tenacious clay. A black peaty layer 1 to 3 inches deep often covers the surface. Both soil and subsoil vary somewhat in color. Red iron specks and small pockets of crystals are sometimes encountered in the subsoil. The type is free from stone and gravel. It has a high percentage of lime and a fairly high content of organic matter and granulates well on drying. A slight accumulation of alkali occurs in spots, but there is never enough seriously to affect the value of the soil.

The Lamoure clay consists of alluvium deposited by the Mouse River along its low flood plain. It lies about 4 to 6 feet above the river level. Formerly the type was inundated much of the time, and its only agricultural value was in the heavy growth of marsh hay which it produced. In favorable seasons some patches yielded as much as 4 tons of hay per acre. Recently, owing to the deepening of the river channel by dredging, the water table has been lowered somewhat and the type has been more generally utilized, most of it being now either pastured or cut for hay every year. Hay yields ordinarily about  $1\frac{1}{2}$  tons per acre. A small proportion of the type is under cultivation, flax being the principal crop grown. Drainage is not very well established, and cultivated crops are apt to suffer from an excess of water in wet seasons.

The soil is naturally very strong and with thorough drainage and proper management is capable of producing good yields. Land of this type is valued at about \$24 an acre.

#### MAPLE CLAY LOAM.

The surface soil of the Maple clay loam consists of a gray, dark-gray or grayish-brown clay loam to silty clay loam 8 to 18 inches deep. There is usually alkali present in the surface soil, which makes it sticky, plastic, and refractory. The surface few inches is usually fairly well supplied with organic matter. The subsoil consists of a gray or light-drab clay loam to silty clay loam, in places containing a relatively high percentage of sand and some fine gravel. At depths ranging from 18 to 30 inches there is a substratum of sand or of sand and gravel. Occasionally the transition from the heavy subsoil to the sandy substratum is gradual, a sandy clay being first encountered, which gradually gives place to a sticky fine sandy loam or fine sand. Frequently lenses of gray clay are present in the sandy substratum. In some areas the subsoil passes into a gray and yellow

mottled very fine sandy loam instead of the coarser sandy material that is characteristic of the type. The subsoil and substratum frequently contain brown and yellow mottlings. Both soil and subsoil are highly calcareous.

The Maple clay loam is distributed throughout the county, but its total area is small. It occurs chiefly as narrow strips in small drainage-way depressions, and some areas occupy disconnected sloughs, which seem at one time to have been drainage channels. A few areas are evidently the remnants of dried-up ponds or small lakes. One such area occurs east of Souris.

Owing to the low-lying position of this type and the sticky character of the surface soil it is poorly drained.

None of the type is cultivated. It is generally used for pasturage and occasionally hay is cut from it. Alkali or salt grass is a characteristic growth.

#### PEAT AND MUCK.

The surface soil of Peat and Muck to a depth of about 20 inches consists of brown to dark-brown, partially decomposed vegetable matter mixed with varying quantities of soil material and fragments of shells. The subsoil is a brown, friable silty clay loam, containing a large percentage of organic matter. Bodies of Peat and Muck varying in size from 1 acre to 30 acres occur throughout the Turtle Mountains in old lake beds, and several areas also were mapped on the prairie. Numerous areas occur which are too small to be shown on the map. Some of the areas are marshy, but most of them are sufficiently dry to permit the cutting of hay. A few are pastured. The native grasses covering Muck and Peat make a hay of good quality, the percentage of weeds being small. Yields of 2 tons or more to the acre frequently are obtained, and the average yield is more than a ton and a half. None of this land is cultivated.

#### MANAGEMENT OF THE SOILS OF BOTTINEAU COUNTY.<sup>1</sup>

The great diversity of soil types in Bottineau County calls for considerable variation in management, but in this locality economy of soil moisture is probably the most important object of management on nearly all the types. In general there are four ways in which the available moisture can be conserved and used most economically: (1) By practicing such tillage methods as will enable the soil to absorb and retain as much of the rainfall as possible, within reach of crop roots; (2) by growing crops that will make the most economic use of the moisture supplied to them; (3) by growing crops in such succession that advantage may be taken of

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<sup>1</sup>This chapter was written by Prof. R. C. Doneghue, of the North Dakota Experiment Station.

the favorable soil moisture conditions created by the culture and growth of certain crops; and (4) by the elimination of weeds which rob the growing crops of large amounts of moisture.

The topography of the county, with the exception of the Turtle Mountains, is such that there is very little water lost in the run-off. In some of the sandy soil types, however, there is some loss of water through percolation into the lower soil layers. This can be prevented to some extent by keeping the soil as compact as possible and well supplied with organic matter. The rains have very little packing action on the soil in this region, so that it takes the soil some time to settle after plowing. Therefore the sandy soils, which have a tendency to become loose, should be stirred as little as the complete control of the weeds will permit. This is best accomplished by following a rotation which makes it unnecessary to plow every year. For example, in a simple rotation like corn one year, wheat one year, and grass one year it is necessary to plow but once. The land would be plowed for the corn and the wheat seeded on the corn stubble land without plowing, the grass being seeded with the wheat. While this rotation would probably not be suited to many farms in the county under present conditions, it illustrates a method of keeping the sandy soils in a compact condition.

Some of the sandy soils drift badly, especially when plowed in the fall. Drifting can be reduced to some extent by giving such lands a top-dressing of manure in the fall and winter. It can also be checked by covering the soil with straw.

Corn and alfalfa make about as good use of the available moisture as any crops suited to the region. The cultivation given the corn crop kills the weeds and keeps the soil in good condition to absorb and retain the moisture in the plowed layer where better use can be made of the available plant food. Alfalfa begins to use soil moisture early in the spring, and by means of its long roots uses it from the soil to a considerable depth as fast as it is supplied by the rainfall. Winter rye makes use of the early spring moisture to better advantage than spring-sown crops.

When spring wheat or other small grain follows corn fairly good use is made of the soil moisture, because the extra supply is used in producing a crop especially well suited to the climate of the region. In other words, the favorable soil conditions left by the corn crop offset a climatic deficiency and improve conditions for the growth of wheat, the uniformly compact structure of the seed bed making possible a more complete distribution of soil moisture through the zone occupied by the plant roots.

The elimination of weeds is absolutely essential if the best use is to be made of soil moisture. Where the growth in a wheat field is half wild oats only half the available moisture can be used in the pro-

duction of wheat. In case the available soil moisture is sufficient for a 30-bushel crop of wheat the demand upon that moisture by the wild oats would reduce the yield to 15 bushels. While fields containing such a large proportion of wild oats are unusual, many contain a large percentage. The growing of intertilled crops like corn and potatoes and the growing of alfalfa are the best means of controlling the annual weeds most common in the region. The growing of winter rye helps to keep certain weeds in check. Bare fallow if well tilled stores some moisture and is a good preparation for small grain, but no return is obtained from such land the year it is fallowed, while corn or potatoes will furnish some income.

The tilth of most of the soils of Bottineau County is very good, but certain extreme conditions demand special treatment. One of the serious problems is to prevent the drifting of the loose, coarser textured soils. The best way to improve these soils permanently is to increase their content of organic matter. After organic matter has reached a certain stage of decay it holds the coarser soil particles together and thereby has a tendency to retard drifting. Grass roots left in the soil after hay crops have been grown have a binding effect on loose soils. If large applications of organic manures are plowed under on light soils, the soil is apt to dry out rapidly. It is usually better practice in growing small grains to apply the fresh manure as a top-dressing on plowed land and disk it in, to plow it under for corn or to spread it on pasture land that is in the regular cropping system. Temporary measures may be adopted that will help to control drifting soils, such as covering the land with a coat of manure or straw. Drifting can be avoided to a great extent by planning the rotation so that it will not be necessary to leave the soil bare during the winter. The seeding of winter rye in the stubble and the practice of spring plowing keep the soil in such condition during the winter that it will not be as likely to drift. In a rotation of corn, barley, winter rye, wheat, and sweet clover the ground for the corn could be plowed in the spring, no plowing would be necessary for the barley, the winter rye could be "stubbled" in, and the land plowed in the spring for wheat. If the corn ground is inclined to drift, manure can be spread on it in the fall after the crop is removed. If one wishes to take advantage of the early plowing made possible by the early ripening of the winter rye, the ground could be plowed in mid-summer and covered with manure or straw during the winter. In some cases the soil drifts badly on newly seeded alfalfa. This can be prevented by giving it a light covering of manure. After alfalfa is well started it will control drifting soils very well.

Some of the finer textured "gumbo" soils are very hard to till, and if not properly handled it is difficult to work them into a good seed bed. The Fargo clay and Fargo silty clay loam belong to this

class of soils. If plowed when too wet they sometimes bake, and when an attempt is made to prepare a seed bed shortly after plowing the land works up cloddy. If plowed when too dry large lumps or clods are turned up and it is difficult to prepare a good seed bed. If these soils are plowed in the fall when the moisture content is as near right as possible, they mellow down during the winter and an excellent seed bed can be produced in the spring. The tilth of these fine-textured soils is injured by driving over the land when it is wet. When these clay soils are in good tilth the small soil particles are united into groups or granules and the soil is said to have a "crumb" structure. When this is fully developed they are mellow and in fine condition for the seeding and growth of crops. When fine-textured soils are handled wet the granules are broken up and the small particles run together and form large clods that are more or less impervious to water and air. The growing of legume and grass crops in the rotation promotes a granular condition in these fine-textured soils. The growing roots produce lines of cleavage between soil particles and when they decay open spaces are left. The application of farm manure has a similar effect upon clay and clay loam soils. Where small grains are grown exclusively there is a tendency for clay soils to become soggy and "dead." The application of manure or the growing of hay crops in the rotation makes such soils more mellow and friable. Drainage improves the structure of these soils materially.

While the county is in a comparatively new agricultural region and small grain has been the principal source of income on all farms, many of the farms of the county would be more profitable if forage crops had a more prominent place in the cropping system than at present. In the past the cropping has been much the same on all soil types. It is obvious, however, that the same cropping will not be equally well adapted to the Fargo clay and the Valentine fine sand. The finer textured soils, the clays, clay loams, silty clay loams, and silt loams, are the strongest soils in the county, and they will be able to support a cropping system containing a larger acreage of grain crops than the sandy loams. On the other hand, the sandy loams are warmer soils and corn will grow faster and be more likely to mature. For this reason corn should have a larger acreage in the cropping system on the light than on the heavier soils. Some of the coarser textured Sioux soils have water fairly close to the surface and no doubt some of these could be used more profitably in the production of alfalfa than in any other way.

The demonstration farms which are under the supervision of the experiment station have been established to show what can be accomplished by growing crops in rotation, by the return of farm manure to the land, and by using good seed in various localities in

the State. The farms consist of from four to seven fields, depending upon the length of the rotation. There are as many fields as there are years in the rotation, and all crops in the rotation are grown every year, one on each field. The crops follow each other on the various fields in regular order as the years advance. Manure is applied at the rate of 10 to 12 tons per acre for the corn. The yield of each crop is kept and the tillage and management of the crop are recorded. The records of these farms furnish information concerning the crop adaptation of the soil on which they are located, and are of service in ascertaining what can be accomplished by a fair system of soil management. Three of these farms are located in counties immediately adjacent to Bottineau, and furnish evidence concerning the use of certain soils in this county. The farm located west of Mohall is only a short distance from the county line. The results on this farm apply more directly to the soils in the western part of the county, especially the Barnes loam and Barnes silt loam. The results at Granville apply more especially to the coarse-textured sandy soils in the south-central part of the county, and those on the Rugby farm more especially to the Barnes very fine sandy loam. These farms are all situated fairly close to the county and the results apply to quite a large part of the county. Not all of the crops that are adapted to the soils of the county have been grown on these farms, but crops commonly grown in the region have been grown and the yields recorded, thereby furnishing definite information concerning these crops.

The Granville demonstration farm is situated on sandy soil similar to some of the coarser textured types of Bottineau County. During the 9-year period, 1906 to 1914, corn was planted on one field each year. In 1910, an extremely dry year, the corn as well as all other crops was a failure. Corn was planted in that year on one of the plots that is somewhat more sandy than the remainder of the farm. Corn matured in five years of the remaining eight. The yield of shelled corn was determined for three years of these five and the average yield was 33.75 bushels per acre. Calculated to a fodder basis for the eight years that crops were harvested the average yield was 1.45 tons per acre. In 1911 corn was the only crop that was not a failure.

Durum wheat has been seeded five times. The crop was a failure in 1910, and the average yield for the other four years was 13.34 bushels per acre. Bluestem wheat was seeded four years. It failed in 1911 and the average yield for the remaining three years was 16.28 bushels. The average yield for the nine years wheat was seeded, including the years in which it failed, was 11.34 bushels per acre. Oats and peas were seeded six times and failed in 1910 and 1911. The average yield of hay for the four remaining years was 1.72 tons

per acre. Barley has been seeded five times. It failed in 1910, and the average yield for the remaining four years was 17.16 bushels per acre. Flax was a failure one year out of four. The average yield for the three remaining years was 7.78 bushels per acre. Winter rye averaged 12.5 bushels per acre for the three years it was grown, and three crops of oats averaged 44.41 bushels per acre.

Corn has been the most consistent crop for the entire period, while oats and peas for hay have made a fairly good showing. The exceptionally good average yield of oats was partly due to the fact that they were grown in two favorable years, but when compared with other small grains grown the same year they have an advantage. Winter rye might prove profitable in favorable years if the cost of production were not too high.

The Mohall demonstration farm was established in 1910. This farm is situated for the most part on Barnes loam and Barnes silt loam. Corn matured three years of the five during the period of 1910 to 1914. The average yield of shelled corn for those years was 34.8 bushels per acre. The average yield of fodder for the other two years was 2.29 tons per acre. The average yields of the bluestem and durum wheats grown during this period have been 13.5 and 21.17 bushels per acre, respectively, when both were grown in the same year. Durum was grown in 1910, an unfavorable year. Its average yield for the five years was 15.43 bushels. Durum wheat, being seeded on corn ground, had a more favorable place in the rotation than bluestem, which no doubt accounts largely for its better yield. Oats and peas, grown three years, produced an average yield of 1.37 tons of hay per acre. Timothy and clover yielded a little over 1 ton per acre in 1913, and German millet about the same in 1914.

The rotation of this farm during the five-year period, 1910 to 1914, was corn, durum wheat, bluestem wheat, oats, and oats and peas. "During this period a net profit of \$3.26 per acre has been obtained from this farm, or a net profit of \$1,043 on a half section farm, with such a rotation after all expenses have been paid that are involved in producing farm crops."<sup>1</sup>

The Rugby demonstration farm is situated for the most part on Barnes very fine sandy loam, stone-free phase, and Barnes silt loam and is representative of quite a large area in Bottineau County. This farm was established in 1909. The rotation followed for the most part has been: Corn, wheat, barley, oats and peas, and wheat.

Mature corn has been produced three years of the six that the farm has been operated. The yield of grain was not determined in 1909; the fodder yield was 1.59 tons per acre. The average yield of

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<sup>1</sup>Ninth Annual Report North Dakota State Demonstration Farms, p. 30.

grain for 1913 and 1914 was 23.25 bushels per acre. The average yield of the fodder for the three years the corn did not mature was 1,833 pounds per acre. This included the extremely dry year of 1910, when all crops except wheat on corn ground were an entire failure.

The average yield of wheat during the six-year period has been 16.14 bushels per acre. Barley has averaged 27.07 bushels per acre, and oats and peas 1.65 tons of hay per acre.

The Langdon substation in Cavalier County is composed of a soil similar to the Barnes very fine sandy loam, so that the results at this station will apply in a large measure to this type. Where barnyard manure has been applied in the fall preceding the year in which corn is grown in a six-year rotation there has been an average increase of 1.23 tons per acre of fodder as an average of three years. Two years results with oats following this corn have shown an average annual increase of 5.09 bushels per acre due to the manuring of the corn. The manure has effected an increase of 3.89 bushels per acre for the wheat crop following the oats in such a rotation.

If the productive capacity of the soils of the county is to be maintained at its highest point, crops must be grown which are adapted to the respective soil types. These crops must be grown in a rotation that will provide for the control of weeds, the maintenance of good tilth, an adequate supply of decaying organic matter in the soil, and the economic use of soil moisture and plant food. In a well-balanced system of farming the necessary live stock will convert the forage crops and straw into manure. This should be returned to the soil with as little loss as possible. If applied to the right crops in the rotation it will produce a material increase in yield.

The foregoing results secured on the demonstration farms in this locality and at the substation at Langdon show that when attention is given to crop rotation and the use of farm manure fair yields will be obtained. If more forage is grown in the rotation and all the straw returned to the land in the form of manure more profitable yields will be obtained on the lands that are now cropped to small grain exclusively.

#### CHEMICAL COMPOSITION OF THE SOILS OF BOTTINEAU COUNTY.

Typical areas of the respective soil types were selected for analysis and samples were taken at three depths, the surface 7 inches representing the plowed layer, 7 to 18 inches the subsurface, and 18 to 40 inches the subsoil. Composite samples of each depth were made for each of the more important soil types and a single sample taken of some of the less extensive ones. The largest composite was made of samples of Barnes loam taken from 17 localities in the county. This

type is quite generally distributed and is associated with many of the other important types, so that its composition should furnish a general indication of the chemical composition of the soils of the county. The total amounts of nitrogen, phosphorus, potassium, calcium, and magnesium were determined according to approved methods.<sup>1</sup> The carbonates were determined by the cold dilute phosphoric acid method.<sup>2</sup> The following table shows the results of the chemical analysis of a composite of 17 samples of the Barnes loam in Bottineau County:

*Chemical composition of the Barnes loam in Bottineau County.*

Constituent.	Surface soil 0-7 inches.		Subsurface 7-18 inches.		Subsoil 18-40 inches.	
	Per cent.	Pounds per acre.	Per cent.	Pounds per acre.	Per cent.	Pounds per acre.
Total nitrogen.....	0.28	5,590	0.15	6,080	0.07	4,080
Total phosphorus.....	.06	1,194	.05	2,148	.05	3,048
Total potassium.....	1.91	38,200	1.76	70,320	1.67	100,200
Total calcium.....	1.40	27,880	4.41	176,600	6.91	414,600
Total magnesium.....	.93	18,500	1.46	58,320	2.28	136,800
Carbonate expressed as calcium carbonate (limestone).....	.46	9,282	7.74	309,400	15.20	911,820

In general the content of these elements in the Barnes loam is fairly high. This type compares very favorably with some of the most productive soils of the corn belt, containing about the same amount of nitrogen, phosphorus, and potassium, and considerably more calcium and magnesium. The subsurface furnishes some elements of plant food to crops and as the surface wears away additional portions of it are becoming mixed with the plowed layer, so that in considering the content of these constituents the figures should be taken only as an expression of the relative supply of the various elements. It is evident that nitrogen and phosphorus are relatively less abundant than potassium in the Barnes loam. Calcium and magnesium are present in larger quantities than potassium. The surface soil of an acre contains the equivalent of  $4\frac{1}{2}$  tons of calcium carbonate (limestone), the subsurface about 150 tons, and the subsoil about 450 tons. This high lime content is an important factor in the adaptability of this soil to alfalfa production.

<sup>1</sup> The total nitrogen was determined by the Kjeldahl method, and the total phosphorus by the magnesium-nitrate method. Bul. 107 (revised), Bureau of Chemistry, U. S. Dept. of Agr. The total potassium was determined by the J. Lawrence Smith method (modified); the total calcium and magnesium by fusion with alkali carbonates. (Bul. 261, Ohio Expt. Sta.) Results are stated as percentages on a moisture-free basis.

<sup>2</sup> Technical Bul. No. 1, Tenn. Agr. Expt. Sta.

The total nitrogen, phosphorus, and carbonate content of the more extensive types has been determined. Composite samples have been made of individual samples taken from representative areas of the more important types. In making these composites equal weights of the individual samples were taken and thoroughly mixed. The results of these analyses are shown in the following tables:

*The nitrogen, phosphorus, and calcium-carbonate content of the surface soils of Bottineau County.*

UPLAND SOILS—GLACIAL AND LOESSIAL PROVINCE.

Sample number.	Soil.	Location.	Total nitrogen.	Total phosphorus.	Calcium carbonate.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1295	Barnes silt loam.....	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 21, T. 162 N., R. 78 W.	0.40	0.07	0.04
1356	Barnes silt loam, stone-free phase.	SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 29, T. 161 N., R. 77 W.	.35	.06	.04
1268	Barnes clay loam.....	NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 28, T. 163 N., R. 75 W.	.45	.09	.10
1265	Barnes loam, heavy-subsoil phase.	NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 21, T. 163 N., R. 75 W.	.31	.05	.07
1283	Barnes very fine sandy loam.	SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 163 N., R. 82 W.	.30	.06	.28
1382	Barnes very fine sandy loam, stone-free phase.	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 36, T. 159 N., R. 75 W. NW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 22, T. 162 N., R. 77 W. NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 18, T. 160 N., R. 80 W.	.17	.05	1.67
1370	Barnes fine sandy loam.....	SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 18, T. 162 N., R. 82 W. NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 10, T. 163 N., R. 77 W.	.23	.05	.17
1373	Barnes fine sandy loam, stone-free phase.	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 13, T. 163 N., R. 81 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 27, T. 159 N., R. 75 W.	.19	.04	.05
1259	Williams sandy loam, rolling phase.	NE. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 6, T. 163 N., R. 75 W.	.09	.04	.13
1376	Barnes loam, east of Mouse River.	NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 162 N., R. 76 W. NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 8, T. 161 N., R. 75 W.	.28	.06	.07
1385	Barnes loam.....	SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 23, T. 161 N., R. 83 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 22, T. 161 N., R. 83 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 16, T. 161 N., R. 83 W. SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 161 N., R. 83 W.	.30	.06	.41

*The nitrogen, phosphorus, and calcium-carbonate content of the surface soils of Bottineau County—Continued.*

UPLAND SOILS—GLACIAL AND LOESSIAL PROVINCE—Continued.

Sample number.	Soil.	Location.	Total nitrogen.	Total phosphorus.	Calcium carbonate.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1367	Barnes loam, Lansford area.	NW. ¼ of NW. ¼ sec. 4, T. 159 N., R. 82 W. NW. ¼ of NW. ¼ sec. 35, T. 160 N., R. 82 W. NE. ¼ of SE. ¼ sec. 34, T. 160 N., R. 82 W. NW. ¼ of SE. ¼ sec. 34, T. 160 N., R. 83 W. NW. ¼ of NW. ¼ sec. 11, T. 160 N., R. 83 W. SE. ¼ of NE. ¼ sec. 15, T. 160, N., R. 83 W.	0.29	0.06	0.33

TERRACE AND LAKE-BOTTOM SOILS—GLACIAL LAKE AND RIVER TERRACE PROVINCE.

1379	Valentine fine sand.....	NW. ¼ of NW. ¼ sec. 33, T. 159 N., R. 74 W. NE. ¼ of NE. ¼ sec. 29, T. 160 N., R. 80 W.	0.13	0.04	0.06
1353	Fargo silty clay loam.....	SE. ¼ of NE. ¼ sec. 6, T. 169 N., R. 77 W.	.48	.09	.11
1298	Fargo clay.....	NE. ¼ of NW. ¼ sec. 36, T. 163 N., R. 78 W.	.36	.07	2.61
1338	.....do.....	SW. ¼ of SW. ¼ sec. 3, T. 160 N., R. 76 W.	.50	.06	2.65

BOTTOM-LAND SOILS—RIVER FLOOD PLAINS PROVINCE.

1292	Lamoure clay.....	NE. ¼ of NW. ¼ sec. 31, T. 163 N., R. 78 W.	0.38	0.07	8.24
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MISCELLANEOUS.

1262	Peat and Muck.....	NE. ¼ of NE. ¼ sec. 2, T. 163 N., R. 75 W.	1.59	0.09	1.39
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*The nitrogen, phosphorus, and calcium-carbonate content of the subsurface of the soils of Bottineau County.*

UPLAND SOILS—GLACIAL AND LOESSIAL PROVINCE.

Sample number.	Soil.	Location.	Total nitrogen.	Total phosphorus.	Calcium carbonate.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1296	Barnes silt loam .....	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 21, T. 162 N., R. 78 W.	0.19	0.04	0.10
1357	Barnes silt loam, stone-free phase.	SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 29, T. 161 N., R. 77 W.	.20	.06	4.65
1269	Barnes clay loam .....	NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 28, T. 163 N., R. 75 W.	.19	.05	.35
1266	Barnes loam, heavy-subsoil phase.	NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 21, T. 163 N., R. 75 W.	.11	.04	.04
1284	Barnes very fine sandy loam	SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 163 N., R. 82 W.	.20	.05	1.62
1353	Barnes very fine sandy loam, stone-free phase.	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 36, T. 159 N., R. 75 W. NW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 22, T. 162 N., R. 77 W. NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 18, T. 160 N., R. 80 W.	.10	.04	2.32
1371	Barnes fine sandy loam.....	SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 18, T. 162 N., R. 82 W. NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 10, T. 163 N., R. 77 W.	.10	.04	5.00
1374	Barnes fine sandy loam, stone-free phase.	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 13, T. 163 N., R. 81 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 27, T. 159 N., R. 75 W.	.13	.04	.21
1260	Williams sandy loam, rolling phase.	NE. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 8, T. 163 N., R. 75 W.	.04	.04	.15
1377	Barnes loam, east of Mouse River.	NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 162 N., R. 76 W. NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 8, T. 161 N., R. 75 W.	.16	.05	3.71
1386	Barnes loam.....	SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 23, T. 161 N., R. 83 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 22, T. 161 N., R. 83 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 16, T. 161 N., R. 83 W. SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 161 N., R. 83 W.	.15	.06	7.64
1368	Barnes loam, Lansford area.	NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 4, T. 159 N., R. 82 W. NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 35, T. 160 N., R. 82 W. NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 34, T. 160 N., R. 82 W. NW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 34, T. 160 N., R. 83 W. NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 11, T. 160 N., R. 83 W. SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 15, T. 160 N., R. 83 W.	.13	.05	12.65

*The nitrogen, phosphorus, and calcium-carbonate content of the subsurface of the soils of Bottineau County—Continued.*

TERRACE AND LAKE-BOTTOM SOILS—GLACIAL LAKE AND RIVER TERRACE PROVINCE.

Sample number.	Soil.	Location.	Total nitrogen.	Total phosphorus.	Calcium carbonate.
1380	Valentine fine sand.....	NW. ¼ of NW. ¼ sec. 23, T. 159 N., R. 74 W. NE. ¼ of NE. ¼ sec. 29, T. 160 N., R. 80 W.	<i>Per cent.</i> 0.07	<i>Per cent.</i> 0.63	<i>Per cent.</i> 0.30
1354	Fargo silty clay loam.....	SE. ¼ of NE. ¼ sec. 6, T. 169 N., R. 77 W.	.27	.07	4.06
1299	Fargo clay.....	NE. ¼ of NW. ¼ sec. 36, T. 163 N., R. 78 W.	.23	.07	5.57
1339	Fargo clay.....	SW. ¼ of SW. ¼ sec. 3, T. 160 N., R. 76 W.	.22	.06	7.30

BOTTOM-LAND SOILS—RIVER FLOOD PLAINS PROVINCE.

1293	Lamoure clay .....	NE. ¼ of NW. ¼ sec. 31, T. 163 N., R. 73 W.	0.29	0.97	10.76
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MISCELLANEOUS.

1263	Peat and Muck.....	NE. ¼ of NE. ¼ sec. 2, T. 163 N., R. 75 W.	0.97	0.97	5.97
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*The nitrogen, phosphorus, and calcium-carbonate content of the subsoils of Bottineau County.*

UPLAND SOILS—GLACIAL AND LOESSIAL PROVINCE.

Sample number.	Soil.	Location.	Total nitrogen.	Total phosphorus.	Calcium carbonate.
1297	Barnes silt loam.....	NW. ¼ of NE. ¼ sec. 21, T. 162 N., R. 78 W.	<i>Per cent.</i> 0.09	<i>Per cent.</i> 0.05	<i>Per cent.</i> 12.38
1358	Barnes silt loam, stone-free phase.	SW. ¼ of NW. ¼ sec. 29, T. 161 N., R. 77 W.	.11	.06	11.33
1270	Barnes clay loam.....	NE. ¼ of NE. ¼ sec. 28, T. 163 N., R. 75 W.	.18	.06	5.48
1267	Barnes loam, heavy-subsoil phase.	NE. ¼ of SE. ¼ sec. 21, T. 163 N., R. 75 W.	.09	.05	8.12
1285	Barnes very fine sandy loam.	SE. ¼ of NE. ¼ sec. 17, T. 163 N., R. 82 W.	.08	.05	16.40
1384	Barnes very fine sandy loam, stone-free phase.	NW. ¼ of NE. ¼ sec. 36, T. 159 N., R. 76 W. NW. ¼ of SW. ¼ sec. 22, T. 162 N., R. 77 W. NW. ¼ of NE. ¼ sec. 18, T. 160 N., R. 80 W.	.05	.04	6.80

The nitrogen, phosphorus, and calcium-carbonate content of the subsoils of  
Bottineau County—Continued.

UPLAND SOILS—GLACIAL AND LOESSIAL PROVINCE—Continued.

Sample number.	Soil.	Location.	Total nitrogen.	Total phosphorus.	Calcium carbonate.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1372	Barnes fine sandy loam.....	SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 18, T. 162 N., R. 82 W. NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 10, T. 163 N., R. 77 W.	0.06	0.01	8.30
1375	Barnes fine sandy loam, stone-free phase.	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 13, T. 163 N., R. 81 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 27, T. 159 N., R. 75 W.	.06	.01	9.60
1261	Williams sandy loam, roll- ing phase.	NE. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 8, T. 163 N., R. 75 W.	.03	.04	1.81
1378	Barnes loam, east of Mouse River.	NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 162 N., R. 76 W. NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 8, T. 161 N., R. 75 W.	.08	.05	33.92
1387	Barnes loam.....	SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 23, T. 161 N., R. 83 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 22, T. 161 N., R. 83 W. SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 16, T. 161 N., R. 83 W. SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 17, T. 161 N., R. 83 W.	.15	.06	7.64
1369	Barnes loam, Lansford area.	NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 4, T. 159 N., R. 82 W. NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 35, T. 160 N., R. 82 W. NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 34, T. 160 N., R. 82 W. NW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 34, T. 160 N., R. 83 W. NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 11, T. 160 N., R. 83 W. SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 15, T. 160 N., R. 83 W.	.05	.05	14.40

TERRACE AND LAKE-BOTTOM SOILS—GLACIAL LAKE AND RIVER TERRACE  
PROVINCE.

1381	Valentine fine sand.....	NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 33, T. 159 N., R. 74 W. NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 29, T. 160 N., R. 80 W.	00.05	00.03	0.84
1355	Fargo silty clay loam.....	SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 6, T. 161 N., R. 77 W.	.10	.05	13.79
1300	Fargo clay.....	NE. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 36, T. 163 N., R. 78 W.	.12	.06	10.10
1340	.....do.....	SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ sec. 3, T. 160 N., R. 76 W.	.10	.05	9.30

*The nitrogen, phosphorus, and calcium-carbonate content of the subsoils of Bottineau County—Continued.*

BOTTOM-LAND SOILS—RIVER FLOOD PLAINS PROVINCE.

Sample num-ber.	Soil.	Location.	Total nitrogen.	Total phos-phorus.	Calcium carbo-nate.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1294	Lamoure clay .....	NE. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 31, T. 163 N., R. 79 W.	0.15	0.08	12.15
MISCELLANEOUS.					
1264	Peat and Muck .....	NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 21, T. 163 N., R. 75 W	0.37	0.05	6.44

The nitrogen content of the surface soils of the classified types varies from 0.09 per cent in the Williams sandy loam, rolling phase, to 0.50 per cent in the Fargo clay. The Valentine fine sand is low in nitrogen and the Fargo silty clay loam and Barnes clay loam are quite high. In general the nitrogen content of the surface of the fine-textured soils is higher than that of the coarse-textured ones. The nitrogen content of the subsurface of the Williams sandy loam, rolling phase, is but 0.04 per cent, being the lowest of those analyzed. The Fargo silty clay loam shows 0.27 per cent and the Lamoure clay 0.29 per cent, which is the highest of the subsurface samples. The subsurface of the Valentine fine sand contains 0.07 per cent of nitrogen, which is the lowest of any type except the rolling phase of the Williams sandy loam. The Fargo clay, Barnes silt loam, Barnes clay loam, and Barnes very fine sandy loam all have a fairly high nitrogen content. As in the case with the surface soils, the subsoils of the heavier types contain a little more nitrogen than the lighter ones. The nitrogen content of the subsoil of the Williams sandy loam, rolling phase, is the lowest and that of the Barnes clay loam the highest of the soils examined. The Lamoure clay, Fargo clay, and Barnes loam all contain fair amounts. The average of all nitrogen determinations made of the surface soil is 0.31 per cent, the subsurface 0.16 per cent, and the subsoil 0.09 per cent. These averages do not include the determinations made of Peat and Muck. The areas of this type are relatively small and the aggregate area in the county is not great. They are quite different from the other soil types of the county. The analysis is significant inasmuch as it indicates the relation of large deposits of organic matter to the nitrogen content of the soil. The surface consists largely of partially decayed organic matter and its nitrogen content is five times that of the average of the upland soils in the county. The subsurface and subsoil also show proportionally larger amounts of nitrogen than the corresponding strata of the upland soils.

The phosphorus content of the surface soils varies from 0.04 per cent in the stone-free phase of the Barnes fine sandy loam, the rolling phase of the Williams sandy loam, and the Valentine fine sand to 0.09 per cent in the Barnes clay loam and the Fargo silty clay loam. The finer textured soils rank higher in phosphorus than the more sandy soils. The same relations exist in the subsurface and subsoil of the various types as are found in the surface, except that the phosphorus content of the subsoil of the Lamoure clay is somewhat higher than that of the other types. It is also higher than in the surface and subsurface of this type. The average of all determinations excepting Peat and Muck is 0.06 per cent for the surface, 0.05 per cent for the subsurface, and 0.05 per cent for the subsoil. The phosphorus content of Peat and Muck is higher than that of any of the other soils except in the stratum from 18 to 40 inches.

There is much more variation in the content of calcium carbonate than of nitrogen and phosphorus. The Barnes silt loam contains 0.04 per cent, which is the smallest quantity contained in any surface sample, and the Lamoure clay 8.24 per cent, which is the largest. The Barnes loam, heavy-subsoil phase, contains the lowest amount of any subsurface sample, and the Barnes loam from the Lansford area the highest. The Valentine fine sand contains the smallest amount of limestone in the subsoil and the Barnes loam sample from east of the Mouse River the highest. The analysis indicates that about one-third of this sample is limestone. The average limestone content of the surface soils is 0.10 per cent, the subsurface 3.91 per cent, and the subsoil 11.08 per cent. The calcareous nature of the surrounding soils is emphasized by the fact that the Peat and Muck which naturally have a tendency toward acidity show a high carbonate content.

The Maple clay loam is characteristically an alkali soil, and in order to ascertain the amounts of the more common salts in the type determinations of bicarbonate, sulphate, and chloride have been made.<sup>1</sup>

*The soluble salt content of the Maple clay loam, expressed as sodium salts.*

Sample number.	Depth.	Location.	Sodium bicarbonate (HNaCO <sub>3</sub> ).	Sodium sulphate (Na <sub>2</sub> SO <sub>4</sub> ).	Sodium chloride (NaCl).
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1301	0-7	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 33, T. 163 N., R. 77 W . . . . .	0.1169	2.1519	Trace
1302	7-13	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 33, T. 163 N., R. 77 W . . . . .	.1040	3.1185	0.0210
1303	18-40	NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ sec. 33, T. 163 N., R. 77 W . . . . .	.0884	4.2418	.0031
1347	0-7	NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 10, T. 162 N., R. 77 W . . . . .	.7480	.1067	.0245
1348	7-18	NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 10, T. 162 N., R. 77 W . . . . .	.4020	.0495	.0123
1349	18-36	NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ sec. 10, T. 162 N., R. 77 W . . . . .	.1440	.0000	.0052

<sup>1</sup> The soluble alkali salts have been dissolved by digesting 25 grams of soil with 500 cubic centimeters of distilled water for 24 hours. The bicarbonates were determined by standard volumetric and the sulphates and chlorides by standard gravimetric methods.

There is considerable variation in the salt content in the two localities. In sec. 33, T. 163 N., R. 77 W. sulphate is the predominating soluble salt, while the soil in sec. 10, T. 162 N., R. 77 W. contains a higher percentage of bicarbonate. The salt content of an alkali soil varies with the distribution of the soil moisture, so that the actual amounts of the various salts present is a temporary condition. The data furnishes an indication, however, of the relative amounts of the various salts. There is considerable variation in the salt content of the type. This is in accordance with field observations. In some spots there is so much soluble material that there is practically no vegetation, while in others there is a rather heavy growth of grass. The high salt content of this type is largely due to its defective drainage. If it could be drained to remove the salts and manured to improve its physical structure, its productiveness would be much increased.

Taken as a whole, the chemical analysis of Bottineau County soils compares favorably with those of other rich agricultural regions. Like many of the other soils of the Middle West they are lower in nitrogen and phosphorus than in the other important elements when measured on the basis of standard crop demands. They differ from the soils of the more humid regions in the Middle West in that they contain much larger amounts of calcium and magnesium. They also contain larger amounts of limestone or calcium carbonate. Owing to defective drainage, small areas contain considerable amounts of soluble salts. These areas constitute a very small percentage of the land in Bottineau County.

#### SUMMARY.

Bottineau County is situated in north-central North Dakota, along the Canadian line. It has an area of 1,681 square miles, or 1,075,840 acres.

Parts of two physiographic provinces are included—the Prairie Plains and the Turtle Mountains. The topography in the former ranges from nearly level to gently undulating and in the latter from undulating to hilly. Practically all the area can be cultivated.

The county is drained by the Mouse River and its tributaries. The drainage system is far from complete, but is sufficient to take care of the run-off.

Settlement began about 1883 and was comparatively rapid in the eastern part after 1887 and after 1900 in the western part. In 1910 the population was 17,295. The entire population is classed as rural. Bottineau, the county seat, with a population of 1,331, is the largest town and Willow City, population 623, the second largest town.

The climate is subhumid. The mean annual precipitation is only 15.33 inches, but 75 per cent of this falls in the growing season. The

mean annual temperature is 36.1° F. and the absolute range from —54° to 104° F. The winters are long and cold, but the cold is tempered by the dryness of the air. The average annual snowfall is 22.3 inches.

The agriculture consists of the production of grains, principally wheat. There is a tendency toward greater diversification of crops and an increase in the number of live stock.

Land values range from about \$5 to \$50 an acre.

The soils of the county belong in the Glacial and Loessial and the Glacial Lake and River Terrace groups. In all 8 series, embracing 18 distinct types and 7 type phases, exclusive of Peat and Muck, are mapped.

The Barnes fine sandy loam is developed mainly in the eastern part of the county. It is inclined to be droughty, but produces very good yields in favorable seasons. It is best suited to intertilled crops but is used principally for small grains, corn, flax, potatoes, and hay crops.

The Barnes fine sandy loam, stone-free phase, is inclined to be droughty and to drift, but produces good yields in favorable seasons. The crops are the same as on the typical soil.

The Barnes very fine sandy loam is an extensive and productive soil, especially well suited to intertilled crops. In favorable seasons it produces yields which compare well with those of any other soil type in the county. Crops are, however, more likely to suffer from drought than on the heavier types.

The Barnes very fine sandy loam, stone-free phase, is the second most extensive soil in the county. The topography is undulating to nearly level and drainage is sufficient. This is one of the most desirable soils in Bottineau County, and about 95 per cent of it is cultivated. Wheat, oats, rye, barley, and corn are the principal crops grown.

The Barnes loam is the most extensive soil type in the county. It has a very gently undulating topography and is naturally productive and retentive of moisture. All crops common to the region are successfully grown on this soil, but it is recognized as being particularly well suited to general farming. About 90 per cent of the type is cultivated.

The Barnes loam, stone-free phase, is inextensive. It is devoted mainly to the production of small grains, giving yields intermediate between the Barnes silt loam, stone-free phase, and the Barnes very fine sandy loam, stone-free phase.

The Barnes loam, heavy-subsoil phase, is confined to the Turtle Mountains. The topography is undulating to rolling and the drainage is good. Only about 15 or 20 per cent of this phase is under cul-

tivation at present. Wheat, oats, and barley are the principal crops grown.

The Barnes silt loam is one of the most desirable soils in the county and practically all of it is cultivated. All the crops common to this section are grown on it, with good results.

The Barnes silt loam, stone-free phase, is as productive as any other prairie soil in the county.

The Barnes clay loam is the most extensive type in the Turtle Mountains section, to which it is confined. About 20 per cent of the type is under cultivation. All the common crops do well.

The Barnes clay, an inextensive type, also occurs in the Turtle Mountains. Drainage is fair. About 40 or 50 per cent of this type is in cultivation, wheat, oats, and barley being the important crops.

The Williams gravelly loam is inextensive and is one of the less valuable soils of the Williams series. Most of the type is in pasture. The part cultivated gives rather low yields.

The Williams sandy loam, rolling phase, occurs only in the Turtle Mountains. Wheat, oats, barley, and potatoes are grown on a part of the type. It is less productive than the associated Barnes clay loam and loam, as it is inclined to be leachy.

The Williams loam, rolling phase, was mapped in a fringe on the outer edge of the Turtle Mountains and on eroded areas of limited extent in other parts of the county. Most of it is too rough to cultivate and is used for pasture.

The agricultural value of the Valentine fine sand is seriously affected by its tendency to drift. The common crops are grown on it, but the yields are somewhat below the average for the county.

The Fargo silty clay loam has about the same agricultural value as the Fargo clay.

Much of the Fargo clay is poorly drained, but this does not as a rule seriously affect its agricultural value. All crops grown in the county are produced on this type and good yields are obtained when the soil is thoroughly cultivated. Cultivation is difficult. This type is locally known as "gumbo."

The Rogers clay loam is a light-colored soil containing considerable alkali. The greater part of it is in pasture.

The Sioux gravelly loam is inextensive. The soil has a large content of gravel and is droughty. Most of the type is used as pasture land.

The Sioux sandy loam is inextensive. Owing to the porous subsoil, it is excessively drained, and its agricultural value is low. It is best suited to intertilled crops. Oats do better than any other grain crop.

The Sioux loam is also inextensive. It is droughty and of lower agricultural value than the Barnes loam. The crops common to the section are grown on it.

The Lamoure fine sandy loam is a dark-colored alluvial soil occurring along minor streams. It is a very productive soil, but owing to the small areas in which it occurs, it is used mainly as pasture land and for the production of hay.

The Lamoure silt loam is an alluvial soil in the bottoms of South Antler Creek and the Mouse River. It is seldom overflowed and is fairly well drained. Flax, wheat, and oats are the principal crops. The yields equal those on the Barnes loam.

The Lamoure clay is an alluvial soil occurring in the lower parts of the flood plain of the Mouse River. Only a small proportion of this type is under cultivation, flax being the principal crop grown. Most of the uncultivated areas are either pastured or cut for hay.

The Maple clay loam has a small extent. It occurs chiefly as narrow strips in small drainage-way depressions and is poorly drained. It contains alkali and none of it is cultivated.

The areas mapped as Peat and Muck occupy old lake basins, mainly in the Turtle Mountain sections. They support a luxuriant growth of marsh grasses and are utilized for pasturage and hay.



[PUBLIC RESOLUTION No. 9.]

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

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

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

Approved, March 14, 1904.

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

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