SOIL FERTILITY PROBLEMS AND AGRICULTURAL CONDITIONS OF ST. JOSEPH COUNTY, MICHIGAN

THESIS FOR DEGREE OF M. S.

LEWIS HUNT VANWORMER

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St. Joseph County lies in the southern part of the lower peninsula of Michigan, approximately in latitude 41° north and longitude 85° west. It is bounded on the north by Kalamazoo County, on the east by Branch County, on the west by Cass County and on the south by the State of Indiana. The County is four townships square, however, the four southern divisions contain only about 24 square miles each as the two southern tier of sections are missing. This gives the County an area of slightly over 500 square miles.

The surface features of the County are characteristic of a glacial region. The topography is for the most part gently rolling, though parts of Sherman, Flowerfield and Fabius townships are hilly enough to make cultivation difficult, while in many parts of the county are level plains covering several sections. There are numerous lakes scattered about the County varying in size from small ponds of a fraction of an acre to one (Klinger lake in White Pigeon township) covering two square miles.

The St. Joseph river is the principal water course of the county, and into this river all the drainage of the county flows. This river enters the county from the east on section one of Colon township and flows in a general southwesterly direction and enters Indiana at the extreme southwestern corner of the county. The principal northern branches are Rock creek and Portage river, which flows into the St. Joseph at Three Rivers, thus giving the name to the city. From the southeast, Prairie creek and Pigeon river join the St. Joseph within the limits of the county, while Fawn river crosses the southeastern part of Fawn river township into Indiana.

In several parts of Michigan are found remains of the mound builders, that interesting people of whom nothing is known but what can be discovered by studying their monuments which have given them their name. In southwestern Michigan the early settlers found what are called the garden beds. One of them was found near Three Rivers. These beds occupied the most fertile of the land and are believed to have been vegetable gardens. This would seem to indicate that this county was an agricultural community before the coming of the white man.

About 1730 father La Salle and some companions crossed the State from the mouth of the St. Joseph river to Detroit. This trip would take them not far from what is now St. Joseph county and it is quite possible that they touched some part of the county. The first known visit of the white man to Cass county was in 1813 and it is probable that St. Joseph county was visited at about the same time. In the thirties, settlers began coming into the county from New York, Ohio and Pennsylvania, coming

by way of the old Chicago road, which is today one of the well known highways of the county. In 1837 Mr. Farrand settled on what is still the Farrand homestead, north of Colon. At about the same time Mr. John Stettler's grandfather settled on the farm on which the grandson now lives on section thirty-five of Notawa Township.

Thus the older farms have been cleared and farmed for seventy or eighty years. While the farmers were reluctant to make any definite statements as to present and former crop yields, they all agreed that the yields were much smaller than formerly. St. Joseph and neighboring counties have long been considered one of the most fertile and prosperous farming regions of the State. It was a portion of what was known as Michigan's wheat belt. A trip through the county last June showed many fields uncropped, while most of these fields showed evidence of recent cropping, the indications were that the yields were light, and on all sides were indications of the abandoned farm.

The population of the county in 1837 was 6,333. This number gradually and steadily increased until 1870 when the population was 43,575. Since this time it has remained stationary, in 1910 being 45,408. Cass county on the west and Branch County on the east show the same stationare population for the last 40 years.

Three Rivers, a city of 5000 population, is the principal town of the county. Sturgis, Colon and Constantine have some manufacturing industries. In addition to these, Centerville, the county seat, Mendon, White Pigeon and several other villages are distributing centers for farm machinery and general supplies.

The county has an excellent system of railroads, furnishing ready and accessible markets for the products of the farm. The Air Line of the Michigan Central runs through the county from east to west near the center, joining the main line at Niles for direct shipment to Chicago, and at Jackson for service to Detroit and the east. The northern branch of the New York Central passes through the southern part of the county. At White Pigeon it meets the Grand Rapids branch coming from Grand Rapids through Kalamazoo and running the full length of the county, north and south. This road furnishes a main line connection with Chicato, about 130 miles away, or in the other direction with Toledo, Cleveland and the eastern states. The Battle Creek branch of the Michigan Central passes through the eastern part of the county, connecting with the main line at Battle Creek. A few miles west of this, the G. R. & I passes through the county from north to south, connection with Kalamazoo and the resort section of northern Michigan and passing south to Fort Wayne and the eastern part of Indiana.

CLIMATE

Heat and moisture are the most controlling conditions of plant growth. Climatic conditions control and largely determine what crops can be profitably grown in a given region. The factors usually mentioned as constituting climate are temperature, rainfall and winds. In the present case wind is of little importance except as it may influence temperature, especially in the spring. At this time a long period of prevailing north winds may lower the temperature so as to delay or injure crop growth. With regard to rainfall, not only its amount but its distribution through the growing season is important. As to the amount, the "rainfall" as irrigation water transforms the arid deserts of the west into luxurious gardens. As to seasonal distribution, an excess in the spring hinders the farmer in planting his crops, while a drought in July and August will injure and may ruin the potato and corn crop. Regarding temperature, the mean annual temperature furnishes little information to the agriculturist. It is the extremes of temperature, together with the length of the growing season which determines the crop possibilities of a region.

The following table, compiled from the records of the Weather Bureau at Wasepi, shows the normal monthly and annual temperature and precipitation. Wasepi is a few miles east of the center of the county.

NORMAL MONTHLY AND ANNUAL TEMPERATURE AND PRECIPITATION.

Month	Temperature F°	Precipitation Inches	Month	Temperature F°	Precipitation in.
January	24.1	2.37	July	72.1	4.07
February	21.3	2.56	August	69.0	3.84
March	36.2	3.37	September	62.9	2.71
April	46.9	2.01	October	53.7	3.00
May	58.3	3.17	November	38.4	3.04
June	66.0	3.84	December	25.1	2.07
			Year	47.9	34.65

In the table below are given the dates of the last killing frosts in the spring and the first in the fall. The average growing season is about one hundred and sixty days, or something more than five months. These data were obtained by the U. S. Department of Agriculture Weather Bureau Station located at Wasepi.

DATES OF FIRST AND LAST KILLING FROSTS.

Year	last in spring	first in fall	Year	last in spring	first in fall
1900	May 2nd	Oct. 17th	1903	May 1st	Oct. 24th.
1901	April 30th	Oct. 3rd	1904	April 22nd	Sept. 28.
1902	April 20th	Oct. 19th.	Average	April 29th	Oct. 11th

AGRICULTURE.

General farming is the main occupation of the county, as it has been since its settlement. The older cleared land has been under cultivation for eighty or ninety years. This part of Michigan was long known as the wheat belt. Wheat was raised more extensively than any other crop, often year after year on the same land. On some of the prairie soils of this section it is said that one half of the crops removed have been wheat. This is a very "exhaustive" practice and in all parts of the county the soil begins to show signs of soil depetion. Stock raising and dairing are carried on to some extent, but these industries both require considerable capital and a good supply of grain and forage. Both of these requirements are inclined to be limiting factors. The census report of 1910 shows that one half of the farms are mortgaged. Many of the farmers are unable, financially to purchase fertilizer to build up the land or to raise a crop to use for green manure; thus the problem is to build up the land and yet not lose the cash income from the land.

SOILS.

The soils of St. Joseph county are derived from the glacial till which covers the county to a great depth. This material has been modified more or less by erosion, the action of the wind and the growth and decay of vegetation. The glacier which traversed this region moved in a general southwesterly direction and in general the ranges of hills and courses of streams run in this direction. The underlying rocks have been covered to a depth of a hundred to several hundred feet by the glacial debris and have had no influence on the formation of the soil. This material was transported often for great distances by the glaciers, modified by the action of water and deposited either in the form of morains or as nearly level stretches of land. The heavier soils are found almost altogether in the northern part of the county while sands and some sandy loams occupy the southern part. Patches of muck are scattered throughout the county but the only area of any size is in Florence township in the southern half of the county.

For the purpose of this study no attempt at a detailed classification of the soils into series and types was made Rather the popular local classification based upon timber and vegetation was adopted. This classification divided the soils into three classes; the prairies, the beech and maple land, and the oak openings. The three somewhat small areas of prarie soil are classed by the government as Carrington loam. The beech and maple land, largely if not entirely belongs to the Miami series. In type it ranges from a sand through various phases of sandy loam to some areas of silt loam. The land known as "Oak Openings" belongs largely to the Colona series, though some of it is probably Miami. In the northern part of Notawa and southern part of London townships is a lighter type of the oak land. A sample of this soil was analyzed as a lighter phase of the oak land.

This method of classifying land is one long in use by settlers and practical farmers. In a county not yet settled or newly settled the question of the agricultural value of lands, the fertility and the duration of fertility are matters of supreme importance. This need has lead the settlers to make approximate estimations of value of land from native vegetation, especially tree growth. Experienced men have been able to make very accurate estimations of the value of land where the tree species were familiar. In some of the newer states this method has been used to determine the market value and also the tax rates. In the long leaf pine uplands of the cotton states fertilization is absolutely necessary for paying cultivation after two or three years cropping. Should the short leaved pine mingle with the long, production may hold out for five to seven years. If oaks and hickory are added, twelve years profitable production may be looked for. Should the long leaf pine disappear altogether the farmer may hope for twelve to fifteen years profitable production without fertilization.

Similar estimates based on tree growth and to some extent on minor vegetation, are common throughout the county. In Michigan "pine land" and "hard wood land" are very definite terms to anyone who knows anything about farm lands. We have a good illustration of the correspondence of tree growth and agricultural value in the Coloma sands of Allegan county. In this county we have four types of tree growth on sand that shows little or no difference in appearance. According to tree growth this land may be classified as follows: (1) Hard wood land. (2) Hard wood and Pine land. (3) Heavy pine land. (4) Buckwheat pine land. The "hard wood" land is an excellent peach soil and is good for plums, cherries and small fruits generally. The county is thickly settled, the farms are small and carefully cultivated. The second and third phases are each respectively of less value. While the fourth class covered with a sparce growth of small so called "buckwheat pine" is practically worthless. The peach and the apple are a failure, the yield of farm crops is light and uncertain. June grass dies out in summer so it cannot be useful for grazing.

Since the vegetation of an area is due to plant adaptation to climatic and soil conditions during a long period of time, this method of soil classification seems a reasonable one. The difference of plant adaptation on adjacent areas is due to the difference in topography or to the difference of chemical or physical properties of the soil, including the subsoil perhaps to considerable depth. If a method of correlating this difference of flora with climatic, chemical and physical differences of the soil could beworked out, a valuable method of soil valuation would be developed. This is a large problem and so far practically nothing has been done along that line. In 1857 Dr.Hilgard, then in Mississippi, was attracted to this problem and did some work along this line. However, the problem was of such vast size that one man could scarsely hope to do more than to intelligently state it, and very

SOIL ACIDITY.

On many of our long cultivated soils it has become difficult to grow red clover and impossible to start a field of alfalfa. A study of these soils has disclosed the fact that they are sour or acid. On upland soils at least this is due to lack of bases in the soil. The main cause of this lack of bases in the soil is their loss from the soil. In connection with acidity in soil, when we speak of bases we usually mean lime, especially carbonate of lime, although Mg, NA and K have a similar action as far as acidity is concerned. A large part of these elements in the soil is in the form of neutral salts, and in this form are of no avail for correcting acidity. Thus when we speak of bases in the soil we mean carbonates of the bases, and especially carbonate of calcium. Magnesium carbonate has the same beneficial effect on most soils. The principal source of the loss of bases from the soil is the loss in the drainage water. This may amount to the equivalent of 400 to 500 pounds of calcium carbonate per acre in a year. Also crops remove considerable amounts of bases each year. This removal may amount to from 25 to 200 pounds per acre, each year. This amount depends upon the crop and upon the yield. When the excess supply of bases is small to begin with, these continual losses soon make themselves felt and the large areas of acid soil are the result.

As compared with Europe all American humid soils are low in lime. The civilizations of the world have been built upon soils rich in lime. The soils of the Tigris and Nile valleys and of Europe are of this type. In Europe the lime problem is rather one of excess of this element than of a deficiency. Thus the problem of an acid soil is distinctly an American problem and possibly it may require a radical American solution.

INDIVIDUALITY OF PLANTS:

Each species of plant has an individuality of its own. This applies to cultivated plants, (farm crops, fruits and vegetables) as well as to plants of no agricultural value. This subject has already been touched upon in discussing the classification of soils according to natural flora. As an extreme example cotton is not grown in Michigan, nor wheat on the Gulf coast. The cherry can be grown in the Upper Peninsula, while the pineapple is confined to Florida, kaffir corn is at home in the semi arid southwest while lowland rice needs almost a swamp condition. Winter wheat will live through the winter, when the ground is frozen. In contrast to this, the tomato cannot be placed out of doors until the settled warm weather of summer has come.

Some crops can adapt themselves to a wide range of conditions. Oats is one of the crops of British America and is grown successfully several hundred miles north of the Canadian border. At the same time they are one of the agricultural crops of Alabama. On the other hand the cranberry is so extremely sensitive to growing conditions that it is almost useless to attempt to grow it in localities where it does not naturally occur.

In one other line there is a very great individuality shown by plants. This is in regard to their response to soil reaction, or their tolerance of acid or alkali. Considerable study has been made on this subject, especially as to alkali tolerant plants. The Tussock grass, a native of the southern arid region, has been found growing on soils which contain nearly half a million pounds of salts to an acre four feet. Its minimum requirement of salt is probably in the neighborhood of fifty thousand pounds per acre four feet. At the other extreme we find the huckleberry or blueberry, which cannot be grown on a soil which is not distinctly acid. During the last few years the subject of acid tolerance of plants has been given some attention: It has been discovered that some twenty-five or thirty of our agricultural plants can be grown on an acid soil.

While soils may be sour or alkaline there are degrees of sourness. Above I spoke of the enormous amounts of salts that Tussock grass would withstand. In speaking of alkali soils there are two kinds of alkali; the black alkali due to the presence of sodium carbonate, affects the reaction of the soil and is comparable, with acidity, the white alkali due to the presence of soluble neutral salts, has no alkaline reaction and is not alkali in the chemical sense of the word. All plants are more tolerant of white alkali than of black. For instance, sugar beets will tolerate only about two tons per acre of sodium carbonate, while they will grow in soil containing nearly fifteen times that amount of total alkali. Theoretically we might have an alkali (white alkali) soil which had an acid reaction. Practically this is impossible because alkali soils are caused by lack of percolation of water through the soil. Alkali of both kinds is easily soluble. With a rainfall and a soil texture allowing percolation and underground drainage, the alkali would quickly leach away. Acidity of soil is caused by excessive leaching of soluble salts from the soil, not only the readily soluble alkali but the slightly soluble calcium carbonate is carried away.

A soil may be so deficient in lime as to prevent the growth of one kind of plant and yet produce good crops of some other plant. Red clover is nearly a failure on nearly all of our acid soils, yet it will grow fairly well on land that is too sour to raise alfalfa.

The individuality of plants is very noticeable in regard to their tolerance of varying degrees of acid or alkali. In all probability the sensibility is as great in regard to other plant growth. Some plants are known to be very sensitive to

varying degrees of heat and moisture. Our present agricultural plants have been modified and developed by civilized man, for his use. The civilization of the world has been developed on soil rich in lime and hence of an alkaline reaction, so our important plants have been developed on such soils and require similar conditions for best development. This is particularly true of alfalfa. This plant has been grown for years in the alkaline West and now refuses to grow in the east unless it can have its favorite soil condition, an alkaline reaction.

CHEMICAL ANALYSIS OF SOILS.

When the chemical analysis of soils was first started, extravagant hopes were entertained as to its practical value. It was thought that a chemist, by analysis, could tell at once what crop a soil was adapted to and what fertilizer was needed. When these extravagant hopes were not realized the whole subject was discredited. Even today its value is scarcely realized.

Plant food exists in the soil in two forms, that which is immediately available to the plant and that which is beyond the immediate reach of the plant. The amount of the first class determines the immediate producing capacity of the soil, while the amount of the latter determines the permanent producing value of the soil.

During late years much attention and labor have been given to efforts to determine the available plant food in a soil. This has been an attempt to duplicate, in the laboratory, with laboratory solutions and laboratory methods, the action of plants on soils. Various dilute acid solutions have been used. The results were then compared with field experiments, sometimes they agree, more often not. The practical value of the methods may be questioned.

Here the individuality of the plant comes into play, and we find that infinite variation which is present in all nature. Different plants with different root systems and other differences are able to extract different amounts of food from the soil. The temperature, the length of the growing season, the amount of moisture, the physical conditions of the soil, the amount of organic matter and the number and kind of bacteria present all affect the amount of food immediately available to the plant. The discovery of a simple laboratory method to cover all the factors is practically hopeless.

Many soil students are now turning to the determination of the "permanent productive" value of soils. This consists of the determination of the total amount of plant nutrients in the soil. This information has been compared with trials in the field. In this way it has been possible to fix a minimum for the total amount of the various plant nutrients necessary to a fertile soil. It has also made it possible

to determine which element is likely to become the limiting factor to profitable crop production. There are ten elements that are absolutely necessary to the growth of every plant, several of these are abundantly plentiful for all the needs of growing crops, nitrogen, phosphorus and potassium being the only ones usually considered in fertilizer problems. Calcium and magnesium carbonates are used to correct acidity. In this study I made determinations of the total amounts of each of these five elements. The methods used were as follows:

NITROGEN

Ten grams of soil were digested for four hours in a Kjeldahl flask with 50 CC of sulphuric acid, 10 grams of potassium sulphate and 2 grams of copper sulphate. This was then neutralized, distilled and titrated as usual.

PHOSPHORUS.

For this element the magnesium nitrate method for total phosphorus as given in circular No. 43 of the U. S. Bureau of Chemistry, was used.

POTASSIUM.

For potassium the "J. Lawrence Smith" method of fusion for total potash was used.

CALCIUM AND MAGNESIUM.

For the determination of these elements one gram of soil was fused with a mixture of sodium and potassium carbonate. The calcium was precipitated as oxalate and estimated with permanganate. The magnesium was then separated and weighed as magnesium pyrophosphate.

DESCRIPTION OF SOILS.

Prairie Soil or Carrington Loam.

The prairie soil or Carrington loam soil consists of a dark brown to almost black loam soil, to a depth of 12 to 16 inches. In some places there was a high percentage of silt present giving the soil a smooth feel. In other places, there is enough sand or fine gravel present to make the soil feel gritty and a few stones occur along the border. The subsoil consists of a yellowish brown, somewhat more compact loam. At about 24 inches there is a small amount of sand or fine gravel. This type is underlaid at no great depth, by beds of sand or gravel, sometimes these beds are no deeper than 36 inches.

The prairie soil is an easy soil to cultivate. If plowed when comparatively dry, which is the most favorable time, there is no difficulty in securing a mellow seed bed. If plowed when wet and allowed to dry out in furrow, large clods are formed. After a slight rain, these clods easily pulverize under the roller and the soil can soon be put into good physical condition.

Three areas of this prairie soil are found in the county. One of these is south of Mendon, in Mendon and Notawa townships. Another area is north of White Pigeon in White Pigeon, Constantine and Florence townships. The third area is found around Sturgis. The village is built on this soil, and the area extends out in all directions, into the townships of Burr Oak, Sherman and Fawn River.

The surface of the Mendon prairie is level and it is somewhat lower than the surrounding country. The other two areas grade into the surrounding Burr Oak land with little change of elevation. A heavy growth of wild grass originally covered the prairie and the dark color of the soil and the large amount of vegetable matter present is due to the decay of this annual growth.

The prairie soil is devoted to general farming and stock raising. Corn, wheat, oats and hay are the principal crops. Yields of 45 bushels of wheat have been secured on this land. This crop was formerly grown almost continuously on the same field. Judging from the fields I saw last summer the yield has fallen to from 15 to 25 bushels per acre. This type is excellent for grain farming or some branch of stock farming or for a combination of the two.

Each sample for analysis was taken in triplicate, being in fact three separate samples; one of the cultivated land, one of the virgin land nearby in an old fence row, or in the woods, and a third was of the subsoil to the depth of about 24 inches. The surface samples were taken down to the change in color. This depth varied from 6 inches to about 15 inches. For this prairie soil this change was at 15 inches. Below is given the analysis of the two samples or sets of samples of this soil analyzed.

CHEMICAL ANALYSIS OF PRAIRIE SOIL.

Soil	N%	P%	K%	Ca%	Mg%
3 cultivated	.0794	.04833	1.2144	.5049	.2474
	.0794	.04969	1.2322	.5049	.2474
21 cultivated	.1711	.0603	1.3340	.488	.2900
	.1711	.0603	1.3389	.488	
3 virgin	.1592	.0730	1.2838	.5265	.2746
	.1564	.07364	1.3067	.5065	.2569
21 virgin	.2202	.0715	1.3581	.5821	.3513
	.2202	.0715	1.3743	.5916	.3689
3 subsoil	.0780	.04019	1.2643	.5212	.2916
	.0780	.04019	1.2773	.5111	.3137
21 subsoil	.0768	.04595		.488	
	.0768	.04663		.488	lost

Beech and Maple Soil.

This type of soil covers practically all of the township of Leonidas, the northern part of Mendon and Park and nearly all of Flowerfield and Fabius townships. The topography is undulating to rolling in Leonidas, Mendon and Park townships, while in western Flowerfield and Fabius it is rough and hilly. This soil is probably all of the Miami series. In type it ranges from a sand or sandy loam to a stony silt loam in some parts of northern Leonidas.

This soil consists of a yellow or light brown loam of medium to fine texture. This extends to a depth of about eight inches. Over most of this area there is a small amount of gravel in the soil. In some places the soil is quite gravelly. A few stones and boulders are scattered over the area.

The most of this soil is comparatively easy to cultivate. The heavier portions if plowed too wet will clod quite badly. The greater portion works up readily into a mellow seed bed. Some of the rougher portions, in Flowerfield and Fabius, are too hilly to work easily. A number of lakes and kittleholes are found in this part of the area. Other than in these places the drainage is good. This soil is a glacial till and the rougher parts are probably morainic remains.

This soil is devoted to general farming. Wheat, corn, oats and hay are the chief crops. A few fields of good clover were noted, but on most of the fields the growth was poor and scattering. Few of the clover fields would produce more than a ton per acre. Hogs and cattle are kept on most of the farms and I saw one or two small flocks of sheep.

In the following table is given the analysis of samples of soil of this type:

ANALYSIS OF BEECH AND MAPLE SOILS.

Soil	N%	P%	K%	Ca%	Mg%
8 cultivated	.1427	.06525	1.4111	.5590	
	.1441	.06595	1.4224	.5488	
17 cultivated	.1036	.0538	1.5482	.4145	.2918
	.1050	.0538	1.5709	.4245	.3095
25 cultivated	.1327	.06375	1.4361	.6102	.2714
	.1327	.06375	1.4473	.6000	.2580
8 virgin	.1746	.0660	1.3406	.7246	.3757
	.1760	.0660	1.3406	.7344	.3637
17 virgin	.1680	.0705	1.5185	.4973	.3197
	.1694	.0712	1.5346	.4872	.3285
25 virgin	.1800	.0864	1.4868	.6763	.2770
	.1800	.0864	1.5061	.6763	.3075
8 subsoil	.0454	.0306	1.4911	.4949	.1812
	.0454	.0306	1.4944	.5151	.1855
17 subsoil	.0484	.03694	1.505	.4062	.3733
	.0498	.03762	1.524	.4062	.3733
25 subsoil	.0719	.0321	-----	.4061	.2931
	.0719	.0328	-----	.3960	.2804

BURR OAK SOIL. (Lighter Phase)

North of the St. Joseph River in the N. W. corner of Notawa and S. W. corner of Mendon townships is a small area of very light sandy soil. This is a lighter phase of the Burr Oak soil. This soil drifts with the wind. These drifts are plainly seen along the road and near the fences. Some of these farms have excellent buildings, far better than the crop indications would warrant. This soil must have been more productive in the recent past.

The topography of this area is quite level. The soil to a depth of 6 to 8 inches is a light brownish sand of medium texture. The subsoil is of about the same texture but lighter in color. There is a little gravel in both soil and subsoil. The amount of organic matter is low. From the nature of the soil the drainage is good, in fact the drainage is too good and there is danger of drought in dry weather. General farming is practised, wheat, rye, oats, buckwheat, potatoes and corn are grown. The yield is light and in dry seasons is uncertain. On one field of rye the yield would be about 8 to 10 bushels, wheat yields about the same or perhaps a little better. During a season of good rainfall corn may produce 40 bushels per acre but the average would probably be less than thirty. Below is a table giving the chemical analysis of this soil.

CHEMICAL ANALYSIS OF BURR OAK SOIL. (LIGHTER PHASE)

Soil	N%	P%	K%	Ca%	Mg%
2 cultivated	.0664	.04606	1.2058	.5026	
	.0677	.04538	1.2058	.5026	
2 virgin	.0932	.0447	1.1585	.4932	.2198
	.0932	.0447	1.1762	.4932	.2198
2 subsoil	.0381	.0352	1.1853	.5525	.4397
	.0381	.0359	1.1982	.5425	.4527

BURR OAK SOIL.

This is the most extensive soil in the county. The prairie soil covers three comparatively small areas, already described. The boundary line between this soil and the "Beech and Maple" area runs west near the northern line of Colon township, bends northward through southern Mendon and up into central Park township. From there it turns southwest and south near the west line of Lockport, then southwest across southeastern Fabius and reaches the Cass County line near the southern line of Fabius township. This formation extends south from this line to the State line. The prairie soils are within these limits and three or four square miles of muck in Florence township. There are numerous lakes and streams in this section and near them are many small patches of muck and swamp land.

The soil of this area consists of a brown sand of medium texture for a depth of 6 to 8 inches. The organic matter content is usually light and the soil is open and porous. In a few places in depressions resembling old water courses, the soil is quite black, due to the amount of organic matter present. In these places the soil has a loamy appearance. There is usually a little gravel on the surface and mixed with the soil. The subsoil consists of a yellow medium textured sand, frequently somewhat coarser than the surface. Some gravel is usually found in the subsoil though it may be absent. On account of the loose open character of this soil, it is easy to cultivate.

The surface of this type varies from level to hilly. This is a glacial soil, derived from the thick mantle of glacial till which covers the county. In some places it will be a flat level area, covering nearly a square mile or more, due to the presence of an outwash plain or to a river flood plain. The roughest part of it is in Sherman township and extends northeast into southwestern Colon. Most of the surface is undulating to gently rolling. On account of the loose open character of the soil and subsoil and the irregularities of the surface the drainage is good. The soil is liable to suffer from drought during dry weather. Numerous small patches of muck and swamp near streams and lakes need drainage. Some of these could be readily drained, others could not.

This soil is used for general farming. Wheat, corn, oats rye and potatoes are grown. In a good year, potatoes will yield 100 bushels per acre of excellent quality. The yield of other farm crops is somewhat better than on the light phase of this soil. The lighter soil is somewhat more affected by drought. The following table gives the chemical analysis of three samples of this soil.

CHEMICAL ANALYSIS OF BURR OAK SOIL.

Soil	N%	P%	K%	Ca%	Mg%
4 cultivated	.0677	.0305	1.106	.5025	.3077
	.0677	.0305	1.121	.4925	.2859
6 cultivated	.0678	.0482	1.344	.4038	.1233
	.0707	.0482	1.345	.4128	.1410
22 cultivated	.0860	.0413	1.154	.3816	.1275
	.0874	.0420	1.160	.4016	.1150
4 virgin	.1505	.0600	1.262	.6170	.2788
	.1505	.0600	1.286	.6170	.2964
6 virgin	.0792	.0589	1.015	.4836	.3757
	.0792	.0589	1.020	.4736	.3627
22 virgin	.1261	.0599	1.079	.4036	.2207
	.1247	.0606	1.090	.4136	.2384
4 subsoil	.0381	.0427	1.190	.5629	.3035
	.0395	.0427	1.210	.5730	.3035
6 subsoil	.0296	.0373		.5332	.2068
	.0282	.0379		.5232	.2068
22 subsoil	.0719	.0345		.4017	.2768
	.0719	.0345		.4017	.2768

DISCUSSION OF THE ANALYSIS.

Potassium.

The analysis discloses an abundance of K in all the soils. The potash problem of the county is to render available the supply already in the soil. Potatoes, sugar beets and such crops generally require a large amount of readily available potash. At present no potash is within reach for fertilizers. Under ordinary conditions it might be profitable to use a small supply of readily available potash (as muriate of potash) for growing the crops mentioned above. A plentiful supplt of organic matter and of calcium carbonate in the soil assists in bringing the potash within reach of the growing crops. The organic matter in a soil may be increased by plowing under farm manure, the various crop stubble, and by turning under an entire crop as green manure.

CALCIUM AND MAGNESIUM.

The analytical results show an abundance of these elements for the needs of growing plants. The carbonate of these elements may be needed for the purpose of correcting acidity, but this will be discussed later.

PHOSPHORUS.

Investigation has shown that about 1% of the phosphorus in a soil becomes available each year. Inspection of the analyses given above shows that there would not be more than 13 pounds per acre available on any of the cultivated soils. In one case this amount is reduced to six pounds. A corn crop of 50 bushels per acre would require 11½ pounds P., 50 bushels of oats or 25 bushels of wheat would need 8 pounds P., 25 bushels of Soy beans would take 21 pounds P., Eight tons of alfalfa hay would need 36 pounds of P. Evidently the phosphorus problem has settled in St. Joseph county.

NITROGEN.

The other elements, which the plant derives from the soil, are held more or less firmly in the soil. This is true even when the nutrients are in more or less soluble form. For most plants nitrogen must be in the form of nitrates. The soil has little or no holding power for nitrates. They are readily soluble and move freely through the soil with soil water. Thus, large amounts of nitrates may be lost in the drainage water. In this climate there is little nitrogen in the subsoil. Some of this nitrogen will be in the form of old, undecomposed humus, and be unavailable to the crop. Soil students have fixed the nitrogen-content limit between a fertile soil and one likely to need nitrogen fertilization at one-tenth per cent.

About two per cent of the nitrogen in the soil becomes available to the plant each year. Thus, on most of these cultivated soils there would be less than fifty pounds per acre available to crops. A corn crop of fifty bushels per acre would require seventy-four pounds of nitrogen per acre, fifty bushels of oats or twenty-five bushels of wheat would take forty-eight pounds of nitrogen. This indicates that there is a deficiency of nitrogen in the soil. Nitrogen causes a heavy growth of the plant and also causes a dark green color. The oats and corn throughout the county have the pale yellowish-green color which indicates lack of nitrogen.

LIME.

Some seventy samples of soil were taken throughout the county and tested for their lime requirement. In all cases the laboratory test showed the need of lime, the amount of carbonate of lime required per acre varying from twelve hundred pounds to nearly two tons. Conditions about the county indicate the same thing, if the poor growth of clover and the abundance of sorrel in many of the fields are good indications.

Thus we see that the fertility problems of the county are, lack of lime in the soil and a deficiency of nitrogen and of phosphorus. Lime may be applied as marl, hydrate or limestone, nitrogen may be supplied by growing legumes, and phosphorus by the application of phosphate fertilizers.

SUGGESTION FOR IMPROVING AGRICULTURAL PRACTICE.

THE PRAIRIE SOILS.

The analysis shows this type to be deficient in nitrogen and phosphorus. The laboratory test for the lime requirement of a sample taken near the edge of the prairie showed a deficiency of this substance in the soil. This field needed about thirty-six hundred pounds of carbonate of lime to meet this requirement.

These soils are well adapted to either grain or live stock farming. Of the latter a combination of dairying and hog raising would probably be most profitable. This would involve some outlay for fences, buildings, and possibly for stock, but most of the farmers on this type of soil would be able to meet the investment. With hogs, required stock could be soon raised. It would take a little longer to build up a herd of cows.

In grain farming, it is desirable to keep enough cattle to use up the roughage, such as corn fodder, straw, etc. This can be done by keeping dairy cattle, or buying feeders from other sections. This latter plan requires capital and experience.

As a rotation for grain farming, a four years rotation, wheat, corn, oats (or barley), and clover, could be followed. As entirely a grain farm the clover should be grown for seed. The clover that would go for hay, should be left on the ground to be plowed under for manure. It may be necessary to cut the clover twice before letting it grow for seed. Clover should also be spring seeded on wheat and plowed under as late as possible the next spring for corn. If the growth is heavy it might be necessary to disk it before plowing. All threshed straw from wheat, oats and clover seed should be drawn to the field and spread as evenly as necessary. It may be used as a top dressing for wheat or applied, not too thickly, on the young clover after the wheat, to be plowed under the next spring for corn. Care must be exercised not to turn under too large amount of coarse material, especially late in the spring. It may assist in causing drought if the season is dry.

Dairying has become one of the most profitable farm occupations of Michigan, hog raising (barring cholera) is also profitable. A combination of dairying and hog raising, with a cash crop of wheat, in the rotation, would be best for this area. A four or a five year rotation could be provided. A four year rotation could consist of corn, corn, oats and clover. The oat stubble could usually be pastured some in the fall and the clover used for hay and pasture. Seeding timothy with

the clover and using the land two years for hay and pasture, would give a five year rotation. If desired, wheat could follow the hay instead of the first crop of corn. Clover could be sowed in wheat and plowed under the next spring for corn. This clover would furnish some pasture in the fall and perhaps in early spring. Some of the corn could be placed in the silo for silage and some raised as grain for feed.

If a large number of hogs were raised it might be well to substitute barley instead of wheat in the first year of corn, or to grow barley instead of oats. If the system of dairying and hog raising were adopted, it probably would be well to put out a field of alfalfa. This plant undoubtedly furnishes more valuable stock food per acre than any other crop that can be grown in Michigan. This crop should be grown outside of the rotation. Alfalfa hay together with corn silage makes an almost ideal food for cows. In the winter hogs like the hay, while in the summer alfalfa pasture with some middlings and corn meal, make about the cheapest hog feed known. The cream could be sold and the skim milk used to feed the hogs and chickens.

A flock of two or three hundred hens should pay well on any farm. The farmer has the ground for range and abundance of straw for litter in the scratching pen for winter. He raises nearly all the feed required, and with a little intelligent attention, the hens should pay as well as any other branch of the farm.

A farmer should produce as much of his food as possible. A few hours a week spent in a home vegetable and fruit garden would give him a variety of fruits and vegetables that few city men can afford and none obtain.

All the crops mentioned above do best on soils which are high in lime. In fact, clover and alfalfa cannot be grown to advantage without it. The laboratory test showed that these soils are greatly in need of carbonate of lime. This lime should be supplied before an attempt is made to grow either red clover or alfalfa. This limestone should be finely ground, evenly spread over the field and harrowed in, after the land is plowed.

The soil also is in need of phosphorus, or soon will be. I would suggest the use of raw rock phosphate. An application of about 1000 pounds per acre in each round of the rotation would maintain the supply. This also should be finely ground and well mixed with the soil. Acid phosphate will give quicker results and it might pay to use the acid phosphate for the first application. In both systems of farming all manure and crop residues must be returned to the land.

THE BEECH AND MAPLE SOIL.

On the smoother and heavier portions of this soil, the system of dairying and hog raising outlined for the prairie farmers ought to succeed. This type is a good wheat and an excellent corn soil. These soils are all deficient in lime and low in phosphorus, so limestone and phosphate should be applied as on the prairie soil. Poultry and the home garden should have a place on all these farms.

There are some low, poorly drained spots and fields on this formation. These will furnish good permanent pasture. Red top is an excellent pasture grass and will do well on damp ground. It might be well to introduce it in these places. It makes a good hay although the yield is light. All slopes at all steep should be included in the permanent pasture or in the permanent hay land. No attempt should be made to cultivate these slopes, as the water erosion on this bare land is very destructive of fertility.

Soy beans and potatoes would be good cash crops for this soil. These crops, together with oats and corn, will grow on soil deficient in lime. If dairying were followed cowpeas might be introduced into the rotation. These can be used for pasture and the residue turned under for green manure. On these lands it would be better practice to use limestone and then grow clover and alfalfa.

On the rougher portions of this soil, the smoother fields might be devoted to the rotations outlined above and the alfalfa established on the steeper slopes. Other portions of the slopes could be used for pasture. June grass and white clover could be used for this purpose. June grass is a lime loving plant so an application of ground limestone would be necessary. The area of alfalfa could be increased and used for hog pasture.

Sheep raising ought to be a success on this hilly land. The alfalfa hay furnishes a good winter feed, and the June grass and white clover would be good pasture. In some parts of the country feeders are growing sweet clover for pasture. Animals soon acquire a taste for this plant and then it makes good pasture. This plant grows wild in several parts of St. Joseph County. The white variety makes the most forage but is rather coarse and becomes somewhat woody. For this reason many growers prefer the yellow variety, which is a smaller plant.

BURR OAK SOILS.

The laboratory test of these soils, in all cases show them to be low in lime. The amount of limestone required to meet this requirement varies from about twelve hundred pounds to twenty-five hundred pounds, and should be met if clover is to be grown.

First, I will offer a few suggestions of minor or local application. In the vicinity of the streams and lakes are numerous and small pieces of muck or swamp land which are too wet for ordinary cultivation. Some of these can probably be drained without much trouble, others cannot. These wet patches could be cleaned of weeds, covered with sand to a depth of three or four inches, and set out to cranberries or to blueberries. In many cases along these water courses, small private fish ponds could be arranged without much labor. In a few years these would furnish a supply of delightful food for the home, and in many cases a small income.

This soil is well adapted to poultry raising, but general farming is generally practised. The crop yields are low and becoming lower. The amount of feed that can be raised on an acre is small, hence but few live stock can be kept. Many of the farmers are unable to spend money in building up the soil, hence the problem is to get returns from the land and at the same time build up the soil.

The suggestive solution is in the growth of soy beans or cowpeas or both, first for seed and then for forage or for hay. Each has its advantages and its disadvantages. The soy bean is the better crop for this section.

To begin the process of improvement, provide for a liberal amount of corn and hay and then grow soy beans for seed on as much of the remainder of the farm as possible. Raise the soy beans on the same field for two or three years in succession. In this way the soil becomes thoroughly inoculated. The land must be inoculated before either soy beans or cow peas can be successfully grown. The soy bean should be sown about June first. After the crop is harvested in the fall the land should be disked and sown to rye. This rye can be turned under the next May as a green manure and another crop of soy bean sown. After two or three crops of soy beans are grown, corn can be introduced into the rotation, growing rye in the corn for a green manure.

If dairying is carried on corn may be used for silage. At this time it may be well to establish a small acreage of alfalfa. This will grow on the lightest sand, but it may require a little care to get it established. For this purpose, one better use some of the land on which soy beans have been grown. To this soil add ground limestone, and an application of barnyard manure if possible. The soil must also be inoculated for the alfalfa. As soon as the finances will permit two or three hundred pounds of acid phosphate per acre should be applied and this repeated every two years.

As the soil becomes built up other crops can be introduced and a greater variety secured. Crimson clover is a valuable crop for localities farther south, and it might be well to try it in Southern Michigan, inasmuch as it does not require so much lime as other clovers. Potatoes could be introduced. While the yield would be light the quality would be unexcelled. On much of the land it might be possible to

grow wheat profitably, but other crops would likely give better returns. With the introduction of a field of alfalfa and with corn enough for silage, dairying could be commenced. Brome grass could be used for pasture and this could be supplemented with rye, rye and vetch, or cowpeas could be grown for fall pasture. Or lime could be applied and clover introduced into the rotation for pasture.

By more expensive fencing hogs could be raised. Alfalfa soy beans, or the clover would make excellent pasture. After live stock farming was commenced, alfalfa would probably give as large an amount of valuable feed as any crop that could be grown and would not need to be started every year. If weeds and grass got started it would be necessary to drag it with a spring tooth drag. Alfalfa cannot be pastured with cattle or sheep.

On the sandy land farther north a five year rotation of vetch and rye, potatoes, rye, clover, and corn, has become common. This might well be introduced in this county as soon as clover was introduced. In connection with dairying, there are three of these crops that could be used for emergency pasture. The only objection to the continued raising of soy beans for seed is the danger that their price would become too low for profit. They are being used to some extent for human food and this use will probably be extended. If so, the price will probably raise instead of fall. Soy beans might take the place of clover in this last rotation and the vetch and rye turned under for potatoes. This would cut the rotation to four years with a catch crop of vetch and rye. In this case liming would not be necessary, or at least not to the extent necessary to grow clover.

This soil is well adapted to small fruits and to vegetable growing. these both call for considerable labor and the vegetables require a large amount of manure. Both of these are not available at present. The home garden has already been discussed. It applies to this soil as well as to other parts of the county. With the solution of the labor problem, asparagus, pieplant, strawberries, raspberries, cherries, blackberries and poultry ought to pay well. Chickens ought to be kept for eggs or for meat or both. The big packers are making money on crate feeding chickens which they buy. There is no reason why the farmer cannot make money crate fattening his own chickens or those he can buy from his neighbors.

CONCLUSION.

The fertility problems of this county are lack of nitrogen, small supply of phosphorus, and a deficiency of lime.

The agricultural problem is to correct the above trouble without making a large initial investment.

The prairie land is an excellent grain land. The Beech and Maple land is a fair grain soil, but not so valuable for that purpose as the prairie. The crops which give the best returns on this land require plenty of lime. The first step in improving these lands would be to lime them quite heavily. Clover could then be grown. These lands are quite well supplied with organic matter, and rock phosphate could be used to supply the deficiency of phosphorus.

If the farmer desired to follow dairying or hog raising, or both, he could sow a field to alfalfa. This would furnish good hay for the cattle, or good pasture for the hogs. A supply of corn for silage and of corn and barley for grain could be provided for in the rotation. On much of the Beech and Maple land the methods given above could be used. The grain yields would hardly be as large as on the prairie, with the possible exception of corn. The steeper slopes of this land should be kept in permanent grass. This meadow can be used for hay or for pasture. This would necessitate some form of stock raising. The keeping of hogs, sheep, or cows, would fill this requirement.

The BUrr Oak soil is well adapted for small fruits and vegetables. The scarcity of labor and need of large amounts of manure prevent the immediate growth of these crops. On much of this soil the crop returns are small. The problem is to build up the land without any expensive investments, either in time or money. The farmer should grow what corn and hay is required for his stock, and then grow soy beans for seed on as much of the farm as he can. With the soy beans, rye should be sowed in fall and plowed under the next spring for the next crop of beans. In a few years other crops could be introduced, and then dairying and hog raising could be carried on. Clover could be raised, or a rotation arranged consisting of crops which require less lime than the most of the clovers. In this way a well diversified system of farming could be built up on these sandy farms.