THIRTY-SEVENTH ANNUAL REPORT

OF

Department of Geology and Natural Resources

INDIANA

EDWARD BARRETT
State Geologist

1912

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THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,

May 28, 1913.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

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OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, September 6, 1913.

The within report has been examined and found correct.

W. H. O'BRIEN,
Auditor of State.

SEPTEMBER 6, 1913.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

B. B. JOHNSON,
Secretary to Governor.

Filed in the office of the Secretary of State of the State of Indiana.

L. G. ELLINGHAM,
Secretary of State.

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ED D. DONNELL,
Clerk Printing Board.

STATE OF INDIANA,
DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND., May 28, 1913.

Samuel M. Ralston, Governor of Indiana:

MY DEAR SIR—I am sending you today the manuscript of the Thirty-seventh Annual Report of the Department of Geology and Natural Resources of Indiana. The assemblying of the data of the report was delayed several weeks because of the inability of the U. S. Bureau of Soils to get their portion of it completed and transmitted to me. Through the courtesy of Milton Whitney, Chief of the Bureau of Soils, the report on the co-operative work between the State of Indiana and the United States Government was hurried to completion, and our citizens will get the benefit this year of the work done under the co-operative contract.

Respectfully submitted,

EDWARD BARRETT,
State Geologist.

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INTRODUCTION.

By Edward Barrett.

The major portion of the State Geologist's time during the field season of 1912 was taken up in the investigations of the Soils of the State.

He believes that a survey of the Soils of the State is a proper function of the Department of Geology. He has never been able to see why an investigation and discussion of the geological formation known as Soil is not as important as the next formation below it, whatever that formation may be. Hence, the bulk of the energy and means of the Department during the calendar year 1912 were devoted to the Soil problem.

In the investigations and discussions of the Soils of the State, the State Geologist endeavors to stay within the realm of Geology; therefore he approaches the Soil problem under the following heads:

1. Topography and its influence on plant life, native and cultivated.
2. Geological formations, study of outcroppings, areal extent and classification of same.
3. Soils—their derivation and classification.
4. Study of exceptional soil conditions—sour, acid, swamp, peat and muck areas.
5. Drainage, natural and artificial.
6. Cultural methods in farming.

In past years almost every rock formation known in Indiana, from the lowest Ordovician up to the recent Glacial have been surveyed. Days, months, years of time and thousands of dollars of money have been spent by former geologists in these surveys, but only in recent years has any systematic survey of the Soils been made. The present Geologist during his first year—1911—in charge of the Department, made the Soils the major part of the Department's work.

In 1912, the Soil surveys by counties were prosecuted under a co-operative agreement with the United States Government. This work will be continued during 1913.

During 1912, Mr. L. A. Hurst of the U. S. Bureau of Soils, and Messrs. E. J. Grimes and H. G. Young of this department, surveyed the soils of Tipton and Hamilton counties.

Mr. W. E. Tharp of the U. S. Bureau, and E. J. Quinn of the Indiana Department, made a close, detailed survey of the soils of Boone County.

The soil work of Montgomery County was done by Grove B. Jones, from the U. S. Department of Agriculture, and Harold Orahood from this office.

The Putnam County work was in charge of Mr. Noble Coryell and Ralph S. Hesler of Indiana University. These field men went carefully over the area assigned them, and their report and map is one of the best in the present volume.

It is not the purpose of the Department of Geology to survey at present the soils of Madison, Tippecanoe, Newton, Marshall and Allen counties. These counties were surveyed some years ago by the U. S. Bureau of Soils and the reports were published on each county in bulletin form. So few of these bulletins ever reached Indiana, and there has been such a great demand for information on the soils of these counties, that it is deemed advisable to incorporate the reports and maps of these counties in the present volume, and with the consent of the United States Bureau this has been done.

The State Supervisor of Natural Gas.—Much of the time of the Supervisor during 1912 was spent in the field, safeguarding the gas and oil interests of the State. The Legislature of 1913 amended the law relating to the waste of gas, by which a fine of $50 to $500 is imposed on persons convicted of violating the law. Heretofore no penalty was attached to the law for the waste of gas, and the Supervisor and prosecuting attorneys were almost helpless in prosecutions. Much good will doubtless come from the penalty amendment where reckless oil drillers and companies permit escape and destruction of gas.

The present report closes with a discussion of the Stratigraphy and Paleontology of the Tanner's Creek Section of the Cincinnati Series, by Dr. E. R. Cumings of Indiana University and his students. The paper is the result of several years' study in field and laboratory, of the Stratigraphy and prevailing types of Bryozoa as shown in exposures of the Cincinnati formations in Indiana.

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Topography of Indiana—Map.

By Edward Barrett.

1st. Highest elevation in the State—1,285 feet above sea level, Summit, Randolph County, eight miles south of Winchester.

2d. Lowest elevation in the State—313 feet above sea level, at the confluence of the Wabash and Ohio rivers, Posey County.

3d. Average elevation above sea level—estimated to be 700 feet.

A topographic map of an area is an expression of the surface features of that area. Such a map could be absolutely true in detail only when based upon a system of contour lines having the smallest possible intervals.

The map herewith is not offered as a piece of perfect workmanship. The elevations were derived from the data published in the Thirty-sixth Annual Report, and in the absence of complete topographic contours the boundaries of areas of different elevations could not be established with exactness, but the boundaries are generally true. The writer is willing to bear the criticism of inexactness in this first attempt at a topographic map if he can but point out the necessity for a topographic survey of the State. Indeed, any criticism will but serve to emphasize the necessity for exact information.

A Word as to Geologic Horizons and Elevations.—Could one but stand at some point in southeastern Indiana, say between the southeastern corner of Switzerland County and the southeastern corner of Union County, and look westward or southwestward and see the outcropping features of the geological formations of the State, they would present an ascending series, geologically speaking, from the Lower Silurian, in the extreme southeastern part of the State, up to the highest formation, the Merom sandstone, along the Wabash River on the western side of the State. Above this of course is the glacial drift. Or, to put the matter in another way, the formations are successively younger as we ascend geologically from the eastern and southeastern parts of the State to the western part, the sediments and drift of the western part having been laid last.

The picture is more difficult to draw from any viewpoint along the eastern margin of the State, from Union County northward,

The State Supervisor of Natural Gas, in his report for the year for the reason (1) that the northern two-thirds of the State are covered with a thick mantle of glacial drift; and, for the further reason, (2) that erosion has not played such a prominent part in the northern part of the State as in the southern part, where it has profoundly influenced the topography of the State.

While the above is true from a geologic standpoint, the reverse is true from a topographic standpoint. Topographically speaking the eastern parts of the State are the highest, the slope or dip being to the south and southwest. The only exception to this southwestern slope worthy of notice is a small area in the extreme northern end of the State, which area is drained by the Pigeon, Elkhart and St. Joseph rivers. The lower courses of these rivers have been largely influenced, if not entirely changed, by the deposition of drift materials during the later glacial periods.

The elevation along the eastern margin of the State, from Franklin County to Steuben County, is from 800 to about 1,200 feet above mean sea level. Along the western margin of the State from Posey County to Lake County, the elevation varies from 313 feet in the extreme southeastern part of Posey County to about 750 feet in Lake County.

Indiana is not a mountainous State. It has never been such. There is no geological evidence within the State of violent agitation or upheaval in the formative period of the portion of the earth's crust now known as Indiana. All of the valleys and hills and undulations in the State were formed by the erosive power of water, either glacial or stream. The differences in elevation above sea level in the State are not sufficient to cause any marked difference either in climate or in vegetation, either native or cultivated. The oak, the maple and the ash grow as vigorously in Randolph County, where the altitude is greatest, as in Posey County, where it is the least. The same thing is true of corn and wheat. The slight difference in seeding time in the southern part of the State, and seeding time in the northern part is due to latitude and not to altitude. Perhaps spring is incidentally encouraged in the southern part of the State by the prevailing south to southwestern slopes, and retarded somewhat by the flat and slopeless areas in the northern part of the State. The same thing would be true of harvest time. While differences in life and crop zones of the State have not been profoundly influenced by altitude, nevertheless an intimate knowledge of the topography of the State is of inestimable value to the people in the several ways enumerated under the head of Hypsometry of Indiana in the Thirty-sixth Annual Report of the Department of Geology, as follows:

1. As preliminary maps for planning extensive irrigation and drainage projects, showing areas of catchment for water supply, sites for reservoirs, routes of canals, etc.

2. For laying out of highways, electric roads, railroads, aqueducts, and sewage systems, thus saving the cost of preliminary surveys.

3. In improving rivers and smaller waterways.

4. As bases for the compilation of maps showing the extent and character of forest and grazing lands.

5. In classifying lands and in plotting the distribution and nature of soils.

6. In locating and mapping the boundaries of the life and crop zones, and in mapping the geographic distribution of plants and animals.

7. As base maps for the plotting of information relating to the geology and mineral resources of the country.

8. In connection with questions relating to State, county and town boundaries.

9. As a means of promoting an exact knowledge of the country and serving teachers and pupils in geographic studies.

10. In connection with legislation involving the granting of charters, rights, etc., when a physical knowledge of the country may be desirable or necessary.

Fertilization of Soils.

By J. B. Edmondson.

The man who farms is engaged in a business so complex and many-sided that it is no uncommon occurrence for him to escape to the city to take up a more simplified profession, or to see young men hesitate long before choosing the farm for their life's work. The universal cry of such individuals is that there is too little money in farming, when the trouble lies in the fact that they are not able to measure up to what is required of the man who is making a success on the farm today. One has but to glance about him and note the many examples that the country affords of men who have turned farming into a highly successful business, financially and otherwise, to be convinced of the truth of this statement. Reduced to its simplest terms, good farming consists of raising the biggest crops possible every year the business is followed, and, incidentally, the longer it is followed the more satisfactory should be the returns. That is, farming is a growing business if rightly engaged in. While the manufacturer's plant will be subject to several thousand dollars deterioration during the twelve months, the plant of the intelligent farmer will be in even better condition for manufacturing crops at the end of that time, notwithstanding the fact that it has already turned over a good crop account to the owner. The longer the intelligent farmer remains on the farm the more productive it should become, but the sooner the careless or ignorant farmer gets to town and into the shops the better off it is all around, provided his place is taken by one of more thorough understaning of the business in which he is engaged.

Of first importance in farm economics and in farm practice is the soil. So intimately is the soil related to every operation, and so complicated is its management, that a working knowledge of the principles that underlie its power to produce crops is one of the very essential qualifications of the farmer. So true is this that a man's success or failure can be determined by the manner in which he treats his soils almost as accurately as by an examination of his bank account. Fundamentally, it is not a question of whether the farmer is raising pure bred stock, whether he is feeding balanced rations, or whether he is providing sanitary quarters for his cows; all these things are important, yet they will fail to keep him off the breakers unless he is on right terms with the soil that grows his crops. Essential as live stock is on the well regulated farm, even that must be regarded as subsidiary to the tilling of the soil and the raising of crops. With the soil cheerfully responding at harvest time with bountiful crops, all these other things will be added unto the farm by a sort of an evolutionary process; but with the soil sick and out of harmony with mankind and all useful plants, the whole situation is changed to one of more or less hopelessness. Strangely enough the great farming class seems to be the least concerned of any in regard to the condition of the soil. While business men, lawyers and ministers are agitating the subject of soil conservation through the medium of the press and from the platform, farmers continue to sow and plant their acres *with little or no evidence of improvement.* In fact, it is safe to say that the movement for better agriculture will have to be carried along and fostered by forces that are entirely foreign to the actual farming interests. The farmer has plenty to eat and wear and does not feel the pinch of high prices nor experience the prospects of finding his larder empty, and, consequently, he is unable to realize the necessity of increasing the output of his farm. The cry is gaining in volume every year from one end of the country to the other that the productive value of the soil is growing less and less under the present system of management, and very slowly the tide is turning in the direction of more careful and scientific methods.

In discussing the fertilization of soils, the writer realizes that the task is no simple one. In talking to farmers in regard to this matter one is impressed with the fact that, as a rule, the principles underlying practical soil fertility are but little understood. Thousands of farmers who have tilled the soil all their lives, feed to the soil fertilizer by the sack, much as they feed oats to the horses, and believe the problem is solved. While there are many points in regard to the action of fertilizers, the assimilation of plant food from the soil, and the relation of soil bacteria to plant life that are not clearly understood by the scientists, yet a man must have a fairly definite understanding of what his soil is actually in need of before he can set about to supply it. The more of a soil expert the farmer is the more liable he is to prosper; but it does not follow that the average farmer with the average education is doomed to failure. There are so many phases of soil management made manifest to the eye that every farmer has ample opportunity to act intelligently in regard to it, whether he be able to write his name or not. A man need not be a college graduate to be able to tell that his soil is acid and needs lime; that his soil needs draining out in order to give the air and soil bacteria a chance to enter; that the humus is entirely burned out of the soil on his heavy, clay upland, or that a one-year rotation is a quick and sure way to destruction. The close observer can determine all these points from the outward indications of the soil itself. But before he can do even this he must know what to look for; that is, he must understand the ills of the soil sufficiently well to be able to recognize them whenever the symptoms are found. His own observations, coupled with his experience, will go far in guiding him in his operations.

When a soil refuses to produce crops in profitable quantities it is an indication that it is lacking in some essential that others, which raise large crops, possess. Just what this is is not easily determined in every case, but it is a safe assumption that were its needs supplied it would respond as satisfactorily as the other. Generally speaking, farmers do not believe this. That is, they consider the poor farm on the hillside as nothing but a hill farm with its stunted growth of corn and wheat, and that its chances of ever doing anything more are extremely remote; consequently such farms are usually farmed in accordance with this view. True, there is a wide variation between the rich, black loam of one section and the raw, gully-washed hillsides of another, with one producing seventy-five bushels of corn per acre and the other barely fifteen; but it has been clearly demonstrated many times over by practical farmers that whenever the latter extreme type of soil is supplied with those things which it was either deprived of by nature or robbed of by man, and which the former soil contained in abundance, the variation in the yields dwindles down until the hillside is growing as luxuriant crops as the other. The point is that, except in rare instances, there is no such thing as naturally sterile soil or permanently exhausted soil; but there is such a thing as keeping soils in such a low state of productiveness as to render their cultivation unprofitable. One man is considered a wizard because he succeeds in doubling the yield of his neighbors on the same type of soil; in short, it is not a question of soil in most cases nearly so much as one of whether the farmer understands the particular kind of treatment that his particular soil needs.

But another consideration enters here which accounts largely for why poor farms remain poor, and why they usually grow poorer and poorer each year. Generally speaking, the poorest soil is compelled to support the most shiftless farmers. This means that soil which above all else needs a careful and intelligent farmer to manage it is doomed to sink lower and lower in the productive scale through the exploitation of ignorant soil robbers. On the other hand, soil that by happy circumstance was adapted for the growing of crops before man entered on the stage, from the first attracted the better class of farmers, and in the sifting and shifting process that followed the best farmers through their own fitness gained possession of the most productive lands. As a consequence of this the poorer farmers were gradually crowded out and were compelled to take up the cheaper and less productive lands. In studying rural conditions in the different sections of the State, it is a matter of observation that the poorer the land in a section the more shiftless and unconcerned are the farmers on it in regard to its needs. So many of our so-called "worn-out" soils are forced to carry a double burden—their own condition of semi-starvation and the persistent scourging inflicted by a grasping taskmaster. Under such conditions it is useless to expect the soil in the poorer sections of the State to be rapidly regenerated. The situation is all the harder to cope with since the many educational forces of the present day are unable to reach a large per cent. of those who are most in need of such help. The agricultural press, farmers' institutes, agricultural experiment station work and educational trains are not patronized by a large number of farmers simply because their interest is as slack in those things as in the welfare of their own soils.

The term "soil fertility," which has in the last few years come into such common usage, is a general one to denote that quality in the soil that determines its productive power when measured in crop yields. It is quite obvious from such a broad definition that many and varied conditions are involved. The supply and seasonal distribution of rainfall, the drainage facilities, the origin of the soil, the humus and mineral plant food supply, and even the cultivation, all figure largely in the production of the crop, and must be considered as phases of the soil fertility problem. While the rainfall is clearly beyond the control of the farmer, the drainage, the cultivation and, in a very large measure, the supply of plant food should be considered as under his controlling hand. True it is many farmers consider themselves responsible only for the cultivation and trust to nature for both the supply of plant food and the provisions for drainage; but such farming is extremely hazardous, for nature was not trained to grow crops by the well regulated systems worked out by man. Nature's plan of sowing and reaping differs in that she is able to select her crop from a long list to suit the condition of the soil in which it grows, and she makes no attempt to alter the soil to suit the crop. For instance, red sorrel finds itself in almost undisputed possession of acid soils where other vegetation is unable to thrive; certain swamp grasses and smartweeds fill up the wet areas; and the various legumes assume control of the lime enriched soil. In fact, so wisely does nature distribute and establish her various crops that the farmer often finds it an extremely difficult task to subdue them, unless he strikes at the heart of the situation and alters the favoring condition of the soil. When man plants he has but a limited number of crops from which to choose, and he sows the seed on the ground that is white or black, rich or poor, heavy or light, without ever considering the adaptability of the crop itself in the matter. While it is not practicable to choose a special crop for every type of soil, it is practicable and necessary to approach as nearly as possible the ideal soil for the crop raised, whatever the original nature of the particular soil may be. Farmers fail to raise clover often because they expect it to thrive on soil that it better suited for red sorrel, and wheat is sown on ground that is the natural habitat of swamp grass or smart weeds. If the farmer is to claim the ground for the exclusive use of his cultivated crops he has a difficult problem before him all the time, for he must assist them in the struggle for supremacy by changing the soil conditions in their favor in every way that is within his power. This, in short, is what is involved in the great soil fertility question.

The yield of corn or wheat is the practical means of judging the quality of a soil, under normal conditions. A low yield indicates that something is wrong, and the real test of a farmer's efficiency lies in his ability to detect the causes and then to set about to remedy them. After years of failure the farmers on the muck soils of northern Indiana found that the secret of their troubles lay in the fact that their soils were practically devoid of available potash. The cause of their failure once determined, the remedy was easily applied, and enormous crops are now being raised in those sections. Although the above is a special and clear-cut instance, yet it illustrates the point that unless the farmer can put his finger on the specific needs of his soil he will necessarily remain in the dark as to what action to take toward improving it. Close observation of the soil in various conditions of moisture, and of the crops that grow on it, will reveal much, if rightly interpreted.

However, the lack of faith in the earning power of the soil is often now more responsible for the farmer's seeming indifference than is the lack of knowledge. For instance, the farmer of small means who gets meager returns for his labor is inclined to lack the moral courage to spend any considerable amount of hard-earned money on his land for drainage or fertilization, even though he may know that until these steps are taken he cannot hope for any improvement. The man with unlimited faith in the power of his land to return with interest every dollar that is rightly spent on it finds himself growing into prosperity.

From the average farmer's viewpoint the matter of using fertilizers is considered as the all-important one in keeping the soil in a prime condition for the production of crops. Commercial fertilizers have been thrown on the market in such quantities of late years, and such varied results have been obtained from their use, that the moment the subject of soils is introduced the farmer hastens to ask about commercial fertilizers. "What kind of fertilizer does my soil need?" is the universal question that is raised. The writer has visited many farms and discussed the soils with their owners, and almost invariably a deep concern was shown in the quality of fertilizer that should be used, to the exclusion of all other phases of the subject. For instance, the subject of drainage was rarely mentioned, even though the farm may have lain like a water-soaked log, every foot of which was crying out to be relieved of its load of water. Buying fertilizers of any kind for such a farm is extremely hazardous in any event, yet there are thousands of farmers who drill the commercial fertilizer into their soils year after year in the belief that they are doing all that can be done to insure a paying crop, when the thing that is needed is tile. Until land is drained, either naturally or artificially, there is little use to consider its fertilizer needs or any other phase, because, in the very nature of the case, the removing of the surplus water and admitting the air is the first furrow, and it must be turned first if the others are to follow successfully. If a goodly per cent. of our farmers were less concerned about having a chemical analysis made of their soils and were more interested in installing a complete drainage system in their fields fewer crop failures would be recorded.

The tendency among farmers in planning their drainage systems is to shy around the elevations and run the drains only through the low areas, in the belief that the upland, especially if sloping, is amply drained and that a string of tile extending down a slope is so much money uselessly buried. This theory is a mistaken one, for it is often responsible for missing the wettest spots in the field with the drains, since they may be found on the higher points. Over large areas of upland in Indiana, where the Miami clay loam and Knox silt loam are found, the surface soil is fine and compact and is almost universally underlaid by a heavy, impervious subsoil, and natural drainage is decidedly poor, even on the slopes where the water has an excellent chance to drain away. Many instances have been found where tile drainage proved a great boon to such land, even in places where its installation would seem foolish to the casual observer. While the writer would not undervalue the practice of supplying plant food to the soil, he would, before taking that matter up, emphasize the importance and necessity of draining the land as the requisite for all later operations. If the surplus water were removed from the ground many fields that are believed to be exhausted of their available plant food would respond in a surprising manner. A free, open soil can go a long ways toward manufacturing its own food for the plants within certain limits; but when it is cold, heavy and sodden it is practically helpless.

A farmer goes to the field and plants a gallon of seed corn. After cultivating it carefully for five months he gathers seventy-five bushels from the gallon of seed; or, in other words, he takes off six hundred times as much grain as he put on. Another farmer plants the same amount of seed corn, cultivates it as carefully, and gets in return only forty bushels, while a third may get only fifteen bushels. This is a matter of common experience; but why did not the third man fare as well as the first, and why will one acre raise only fifteen bushels of corn while another, across the fence, will produce five times as much? Why, indeed! If the farmer would seat himself on a stump in his own cornfield and ponder this question seriously himself he would undoubtedly be able to rub some of the scales from his eyes and see more light in his soil problems. The quality of the food ready for the use of the plant in the different soils can alone explain the difference in these yields. When the chemist analyzes the soil he finds certain elements; and when he makes an analysis of the corn that grew on the soil he finds several of those same elements in it. Ten of these elements of the soil, it has been found, are absolutely essential to plant growth. By leaving one of these out experimenters have been able to starve the plant to death after it has begun to grow, even though all the other nine are present. So, in farming practice, if one element is seriously deficient or entirely exhausted the plant is just as helpless as if all its food were limited in the same degree. The comparison between the plant food in the soil and the weak chain is an apt one in this respect; the faulty link determines the strength of the chain, and the most nearly exhausted element of plant food determines the agricultural strength of a soil. By comparing the analyses of the soil and corn three elements are found in each, in considerable quantities in the corn plant, but in very small amounts—sometimes mere traces—in the soil. These elements—phosphorus, potassium and nitrogen—are the only three of the ten necessary elements that the farmer need concern himself about, because these are the only ones that show any likelihood of becoming exhausted. Their scarcity, then, and the ease with which they can be removed from the soil give them a place of greater importance than the others, and not the fact they are any more necessary to the plant itself than oxygen or iron.

In writing and speaking of chemical fertilizers and the chemistry of soils it is customary to refer to the element potassium as potash, the name given to the compound in which two parts of the element are combined with one of oxygen. In like manner phosphorus is spoken of in terms of phosphoric acid, or the compound containing two parts of phosphorus and five parts of oxygen. Just why these terms are used instead of the true ones is not clear, for it has led to considerable confusion and is misleading in many ways to the farmers. There has recently been an effort made on the part of some of the prominent soil chemists of the country to eliminate these old terms and to speak of the elements in their true sense, but little progress seems to have been made as yet. In this discussion the terms potash and phosphoric acid will be employed according to the common usage in referring to potassium and phosphorus respectively.

Practically all soils that are unable to produce profitable crops are limited by the lack of one or more of these three elements in available form. It is always the province of the wise farmer to induce the soil to manufacture its own plant food into a form that the crop can readily use, but experience has proven that it is a wise procedure to supplement this with ready-for-use plant food, either in the form of commercial fertilizers or manures. It is notably true that many soils are in greater need of an application of lime than of any of the three elements mentioned, but lime cannot be rightly considered in the sense of a fertilizer, since its action serves more as a tonic or conditioner for the soil than for furnishing actual food for the plant. For instance, the soil, through its physical condition, may show a very great need for lime, yet, at the same time, it may contain sufficient to supply what lime the crops may actually need for years. Thus the liming of soils, which is becoming a very general practice in some sections of the State, is a distinctly different operation from that of applying chemical fertilizers. In fact, liming and its effect in opening the soil is more nearly comparable to artificial drainage, although the best results of the lime are never realized unless its application is preceded by adequate drainage. Wet upland soils that have been farmed for a long period are nearly always sour, and these two qualities are more responsible for low yields and total failures than even the lack of nitrogen, potash or phosphoric acid.

The means at first hand for the farmer to meet the demands of his soil is through the use of barnyard manure. Indeed, so important is the farm manure as a source of plant food to replace that which is removed in the crops that the whole system of live stock farming is centered around the production of this by-product; in fact, the manure is almost considered in the light of being the chief product by many successful farmers, with the gains produced on the animals relegated to a place of secondary consideration. While this is true in some cases, unfortunately it does not hold true in all. Thousands of our farmers, on farms that need the manure the worst, see in its accumulation about the barns little more than the disagreeable task of removing it to the fields. Under average conditions a farmer's success is in direct proportion to the value that he places on the manure that is produced on the farm. Where this crop is conserved as carefully as the corn, hay or any other crop produced on the farm, low yields are the exception and not the rule.

Even the most unskilled farmer is able to note the quick response that crops make when manure is used on the field. While the increase in crops by this means is easily demonstrated, it is not so clearly understood how the manure brings the change about in the soil, or how far it can be depended on to replace the supply of available plant food that leaves the field in the form of grain or hay. To a certain extent farm manure performs the same office as chemical fertilizers, in that it carries a considerable quantity of available plant food, but it goes farther than that—it furnishes a sources for a large amount of vegetable matter, which the soil is often in greater need of than the other. It can be said, then, that manure applied to the soil gives the combined results of both commercial fertilizer and green manuring crops. While each of there functions is distinct, yet they are so intimately associated with each other in promoting the growth of the plant that it is impossible to distinguish sharply between the two and say that a certain part of the beneficial results derived from the manure was due to one or the other. While usually the emphasis is laid on the fertilizing ingredients of the manure, common experience teaches that such quantities as are found are entirely inadequate to account for the ready response made by the crops for several years after its application. So the situation as regards the use of manure, and its action on the soil, is a decidedly complex one, and it cannot be pinned down by figures and calculations as is done in the case of commercial fertilizers. However, a technical understanding of these things is not at all essential or necessary to convince the farmer that his farm manure is of great value to his soils. Practical results are what interest and convince the farmers, and whatever they may think of the wisdom of using commercial fertilizers, all are agreed that in some way manure has a wonderful life-giving power to the soil.

Considering the average farm manure from a strictly mineral and chemical standpoint, it is worth something near two dollars per ton when it reaches the field, figured on the basis of the cost of the mineral elements in commercial fertilizers. As every farmer knows, this amount is entirely too small to account for the results that are obtained when compared with those obtained from mineral fertilizers. Even twice the plant food value of the manure invested in mineral fertilizers would be less valuable to the soils than the one ton of manure. The conclusion is, then, that the actual supplying of plant food is by no means the chief and only function of manure when applied on the heavy upland soils, which usually receive the bulk of the farm's supply. How the manure can so favorably affect the soil, over and above any consideration of its plant food, is a matter that has received much attention from scientists, and is now being cleared up. Suppose a farmer, becoming discouraged, goes to the chemist with a sample of soil from his worn-out field. The chemist makes an analysis and finds to the astonishment of the farmer that the supposedly exhausted soil actually contains enough plant food per acre to raise record-breaking crops for a number of years. At the same time, however, he knows from experience that the best the soil can do, even under favorable conditions, is thirty or forty bushels of corn. It is evident, then, that the corn plant, like shipwrecked sailors who die of thirst with an ocean of water about them, is actually stunted in its growth for want of food even in the midst of plenty. In practically all our so-called "worn-out" soils the above condition prevails. It is not that the soil is actually exhausted of its mineral elements, as is generally believed by farmers, but the trouble lies in the fact that the plant food, while present more or less abundantly, is encouraged by the unfavorable conditions of the soil to enter into such compounds as will preserve them in a stable condition; consequently the plant is deprived of its source of available food, and so far as the plant roots themselves are concerned the plant food may just as well be entirely removed from the field. A worn-out soil, then, is not an exhausted one in the true sense, but merely a dead soil—dead because even the chemical changes that are continually going on in a productive soil are brought to a standstill, since the more active compounds—those containing the important elements of plant food—are converted into forms that are very slowly changed. There is little doubt but that manure, when allowed to decay in the soil, so influences the latter that as much or more plant food is rendered available than is actually supplied by the application. This factor entering as it does in the consideration of the beneficial effects of manure makes the matter of furnishing a balanced fertilizer for the crop an exceedingly complex and uncertain one. Manure is usually considered as being especially rich in nitrogen and the effect that its application has on the growth of the crop would warrant such a belief. Yet when the requirements of the plant itself are considered we find that were there no other source of plant food except what is applied in the manure the nitrogen would be the first element exhausted. Roberts calculated that for every 100 pounds of nitrogen contained in mixed manure there are 49.6 pounds of phosphoric acid and 77.8 pounds of potash; yet the corn plant in using this 100 pounds of nitrogen requires only 32 pounds of phosphoric acid and 100 pounds of potash. This means that for every 100 pounds of nitrogen furnished the corn crop by the manure there is an excess of 17.6 pounds of phosphoric acid and a deficit of 22.2 pounds of potash, when the composition of the manure and plant are compared. Conclusions based on these facts alone would lead the farmer to apply phosphoric acid sparingly and to make heavy applications of potash and nitrogen. Indeed, the figures show that manure should be a means of building up the supply of phosphoric acid in the soil, but in actual practice we know that this is not true, but rather the reverse; for manure is decidedly weak in phosphoric acid, and, as stated above, all the indications in the growth of the plant point to a gorging of nitrogen. How to account for this seeming paradox is not easy, but it at least proves that the composition of the plant is not a safe guide in determining its fertilizer requirements in all cases. In the case of manure, experience teaches that its limiting element is its low supply of phosphoric acid, and many up-to-date farmers have been highly successful in increasing its value by adding acid phosphate or floats to it in the stable while it is being made. Not only is the ration for the plant balanced in this way, but at the same time the nitrogen in the manure is fixed and is prevented from escaping in the form of ammonia; likewise it has become the custom to use a fertilizer high in phosphoric acid for corn and wheat, and, in fact, many farmers use pure bone meal alone with excellent results. The only satisfactory means of explaining this situation is through the action of the manure itself. While the analysis shows that it is strong in phosporic acid as compared with the other plant food elements, experience proves that it is notably weak in this respect. The conclusion is that the manure releases large quantities of both nitrogen and potash in the soil that had been held in an unavailable form, and this additional supply given over to the use of the plant makes the amounts too great for the phosphoric acid to balance, hence the deficiency.

Obviously the man with worn-out soil has two recources that, theoretically, should meet the situation. He can make the ground itself the basis from which to work an improvement by persuading it to unlock its treasure house, or he may start the endless campaign of furnishing the available plant food for the crop each year before it is planted through the use of fertilizers. No more disastrous mistake could be made than depending on the fertilizer sack for every crop, yet thousands of farmers are doing it, to the exclusion of other means of fertilization, such as barnyard manure, green manuring crops or the growing of leguminous crops. While it is not denied that most soils respond readily to an application of commercial fertilizer, and will continue to do so for some time, it will eventually become sluggish through such an exclusive system of feeding; it will not only refuse to produce its former yields, but the soil will gradually become heavier, more cloddy and in poorer physical condition each succeeding year. Indeed, this has been the common experience of many farmers, and, as evidence of the final outcome, the cry is being raised in every section of the country that "commercial fertilizer ruins the soil."

There is little doubt but that mineral fertilizers, used alone, will actually work an injury to the soil after a number of years of heavy cropping, but in an indirect way. Where the farmer looks after the supply of humus as zealously as he does the plant food, and keeps the soil darkened with vegetable matter, commercial fertilizers can be used for an indefinite number of years, and with intelligent management the soil should become more and more productive. It must be kept in mind that mineral fertilizers are unable to furnish the soil with anything but the nitrogen, phosphoric acid and potash that they contain, even though the soil may need, and very often does, a liberal supply of vegetable matter. Where this need is disregarded the putting on of the raw minerals only hastens the final exhaustion of the humus, since the crops are stimulated to more rapid growth and the soil is exhausted of its humus supply all the quicker. While salt is considered as essential to the growth of the human body, one would be extremely foolish to give an exclusive salt diet, simply because there are several other needs of the body that are in no way satisfied by the salt. Shall we say that salt ruins the body just because it will do so when eaten exclusively? Many farmers fail to recognize the limitations of commercial fertilizers, but consider them a panacea for all the ills to which the soil is subject.

But to return to a further consideration of the effect of barnyard manure on the soil. As every farmer's experience well teaches, the real value of the manure to the soil is out of all proportion to its content of plant food, due to the fact that it is able to influence the soil in such a way as to render available considerable quantities of the inert minerals that are locked up in the difficultly soluble compounds. The organic matter in the manure is responsible for this good work, an advantage that is entirely lost sight of by the man who depends on commercial fertilizers. Humus is the heart of the soil and common observation teaches that the deadest soil is the one most nearly exhausted of this important element of fertility. Very many of our so-called "thin" soils are suffering more for want of organic matter than from the lack of plant food. A rank-growing nonleguminous crop plowed under gives remarkable life and productive power to a humus-exhausted soil, yet there is absolutely nothing added to the soil in such a process but organic matter. The beneficial results of such green manuring crops are so pronounced that many farmers are firmly convinced that the soil is actually enriched in plant food. When the vegetable material is plowed under it is eventually converted into humus, a process which is of immense importance in giving life to the soil.

It would doubtless be putting the matter more nearly in the true light to consider barnyard manure as a source of organic matter, which, incidentally, carries considerable quantities of plant food in addition. If it could be definitely determined it would doubtless be found that the organic matter is the most important and most valuable part of the manure. At any rate the good effects of a load of manure can be noted on a poor soil for years, while the same quantity of plant food that is contained in the manure, if applied in commercial fertilizers, would be swallowed up in less than two growing seasons. While crossing an exceedingly thin, worn-out pasture recently the writer was ruminating on the possibility of anyone ever being able to bring such a soil back to a state of productiveness. The outlook was indeed a discouraging one. About the middle of the field an irregular patch of grass was noticed which had made a growth far beyond that surrounding it. This was found to be the site where one lone load of manure had been scattered some years before. So readily and certain did the grass respond to this treatment that it was almost possible to trace the separate forkfuls of manure as it was thrown from the wagon. Without question the supply of plant food that the manure contained had long since been exhausted, yet the good effects of the organic matter was still plainly visible after several years. Here, then, was the key to the situation—manure, and more manure, is what is needed to bring life back to our failing upland soils, and this can be done all the more quickly if it is properly balanced with commercial fertilizers. While the importance of commercial fertilizers in maintaining the fertility of the soil is not to be underrated, yet, under the present system of utilizing them, they can be considered nothing less than a very extravagant commodity. Thousands of dollars are paid out every year in this State for mineral fertilizers by farmers who allow their manure to collect under the eaves of the barn and wash away to the creeks or pile it up in some vacant stable to heat and burn out. The writer believes that the soils of Indiana, as a general rule, are not in need of more commercial fertilizers nearly so much as more barnyard manure, the use of cover crops to protect the humus from burning out, and a frequent plowing under of some green manuring crop. The more these things are practiced the more can commercial fertilizers be used to advantage both to the soil and to the pocketbook of the owner, but commercial fertilizers without any provisions for maintaining the supply of humus lead to final destruction.

A discussion of farm manures would be conspicuously incomplete if the matter of handling and caring for the manure on the farm were left out of consideration. The idea is quite prevalent among farmers that quality in manure is a thing of little or no importance, and that manure will give equally good results when once gotten on the field, regardless of the manner in which it is cared for. As a matter of fact, there is often much more variation in the composition of the manure when produced under different conditions than in the composition of commercial fertilizers whose analysis serves as a guide in buying. The proper methods of caring for manure has been so often exploited by writers and lecturers that it hardly seems necessary to enter into an extended discussion of it here. However, the principles that underlie its preservation or deterioration are so fundamental that they cannot be brought to the farmer's attention too often.

Happily, the best way to handle the manure on the stock farm is the simplest way; that is, to haul it directly to the field as soon as made. Farmers, chemists and soil experts are agreed on this point and recommend that the practice be followed whenever possible. When the manure is hustled to the field in this manner two very serious dangers are avoided—dangers that together are responsible for the loss of thousands of dollars of plant food to the farmers of the State—leaching and heating. While these two processes are directly opposed to each other, they nevertheless often occur in the same manure pile at different times. Where the manure is removed at frequent intervals from the stables the most convenient means of disposing of it is to throw it through the window to the outside, where it is allowed to accumulate, unprotected from the sun and rain. In the meantime the barn roof collects the water that falls over a considerable area and pours it down bodily on top of the manure. During the spring months especially is the damaging effect of leaching felt. At this time the accumulation of manure is usually greatest and the wetting process is repeated until the pile is saturated in a short time. Following this, then, as much water runs away from the base of the pile as falls on top, and it naturally follows that whatever of a soluble nature that the water comes in contact with in percolating through the manure is carried to the bottom and away to the ditches, in solution. It happens that most of the nitrogen contained in fresh manure is held in the nitrate form, and this is very easily soluble in water. The water when it falls on top of the manure is clear, but when it issues at the base it has taken on the reddish brown color that is familiar to every farmer. In a very short time manure under such conditions will lose practically all its available nitrogen, the most valuable element that figures in the purchase of fertilizers. This happens just as surely, and in the same way, as if a sack of commercial fertilizer were left under the eaves of the barn to catch the rains. The farmer who would treat his commercial fertilizer in this manner would be considered a disgrace to his profession, yet there is really little difference between letting nitrogen and potash wash away from the sack and allowing it to escape from the manure pile.

In view of the above, it seems logical that the manure should be kept dry if allowed to accumulate before hauling to the field. However, when piled so loosely as to allow the air to penetrate it manure is subject to even greater injury than in the other case. Animal manure is literally teeming with millions of bacteria which are ever ready to begin the work of removing it from the earth by converting it back to its primary elements. They must have a supply of oxygen, however, before they can thrive. Where the manure is not packed so closely, or is so wet as to exclude the air, the bacteria soon give evidence of their presence through the heating of the manure. This is especially noticeable in horse manure, which has much less moisture than other kinds. When allowed to remain in this condition for some time "fire fanging" results. During this process the various constituents of the manure part company and each goes its own way—the nitrogen escapes into the air in the form of ammonia, the mineral elements are either lost or converted into unusable compounds, and, most important of all, perhaps, the vegetable matter is burned out by the excessive heating so that when the process is completed only a white, chaffy mass of light material is left that is hardly worth hauling to the field. Obviously, then, the exclusion of air is just as essential for the preservation of manure as the exclusion of excessive water. A certain amount of water is of direct benefit to the manure, since it prevents the air from entering, and this is, in fact, the most practical means of preventing it from heating where it is piled in heaps. The only precaution necessary is to prevent it from becoming saturated, in which case leaching results.

The essential difference between barnyard manure and artificial fertilizers is that the latter is able to supply only the constituents that are actually demanded by the plant, and when this is done the fertilizer has spent its force. On the other hand, the manure not only does this, but also carries back to the soil large amounts of organic matter which affects the physical makeup of the soil in a very marked degree. This function of manures may be considered as the power for doing good to the soil, held in reserve, which is entirely absent in commercial fertilizers. In fact, where the after effects of commercial fertilizers have been noted they are believed to be actually harmful to the physical texture of the soil. This occurs only on heavy clay land that has been exhausted of its humus and on which a continuous use of such fertilizers has been made, since on other soils they have no visible effect.

In view of these facts, it may seem that the use of artificial fertilizers is unwise in any case, and that the whole practice is more or less fallacious after all, since manures, legumes and turned-under crops seem to be able to take care of the situation. Such a conclusion is not based on fact, however, although many farmers cling to the belief that their soil can be kept in its present state of productiveness without in any way using artificial fertilizers. There are two legitimate reasons for urging every farmer to make a judicious use of commercial fertilizers in keeping the soil up to its standard of productiveness. In the first place, there is, on the average, not nearly enough manure produced on the farm to replace the plant food constituents that are removed through the medium of the hay and grain that are carted away to the cities. While this deficit varies greatly on different farms, according to the amount of live stock that is fed and the manner in which the manure is cared for, yet on every farm some of the products are removed, such as wheat, straw or hay, and there is also a considerable additional loss of plant food through leaching, heating, etc. This means that each year finds the farm somewhat poorer in plant food unless its equivalent is brought in from outside sources. While it is true that, under careful management, a naturally productive soil can be maintained for a long time by growing clovers and returning the manure, that results from feeding the crops, to the fields, yet sooner or later the yields will begin to dwindle as a direct result of exhausting the native supply of available plant food. If it were possible for the farmer who sells his farm products to realize a cash value for the plant food elements that thus leave the farm the objections to such a system of farming would not be so serious. But this is not the case; the prices of his crops and other products are based solely on their feeding value, and no consideration whatever is given to the fertilizing ingredients that they contain. This simply means that a considerable part of the farm's permanent asset is thrown in for good measure whenever a crop is removed bodily from the land that grew it. Since it is an absolute necessity to replace this plant food, farmers have naturally turned to the artificial fertilizers as the simplest way out of the dilemma.

There is still another important consideration in regard to the use of commercial fertilizers that would tend to give them a permanent place on every farm, even where an abundance of manure is produced. As has been previously noted, the immediate effect of an application of manure is to gorge the plants with nitrogen, especially if the application be heavy on a soil naturally deficient in phosphoric acid. This condition is noted by the rank growth of the stalk and leaves, with a disproportionately small production of grain. The overabundance of nitrogen can probably be accounted for by assuming that considerable quantities are made available in the soil by the action of the manure, and to this is added the amount that the manure carries with it. It is quite obvious in such cases that there is a notable deficiency of phosphoric acid as compared with the nitrogen at hand, and if no attempt is made to balance this excess of nitrogen it will not only likely be wasted, but the soil will be able to produce nothing more than stalk and leaves. The careful farmer who has figured these things out, and then has sufficient faith in his figures to act accordingly, finds that artificial fertilizers are indispensable to successful farming, simply because they are needed to maintain the supply of phosphorus, which is being removed more rapidly than any other of the plant food constituents in grain and stock, and also to balance the excess of nitrogen that is liable to accumulate in the manure.

Farmers as a rule do not understand the makeup of fertilizers. What the various ingredients are, how they are put together, and how much of the bulk of fertilizer is of actual use to the plant are matters that are perplexing to those who have not a thorough knowledge of the subject. Fertilizers usually look much alike to the farmer; they smell alike, and, in fact, the chief difference is found only in the attached analysis, which may mean much or little, and the prices that are paid for them. There is little wonder then that cheap, low grade fertilizers were pawned off on the farmers in the past so persistently that it became necessary for the State authorities to take the matter in hands to compel the fertilizer manufacturers to make the contents of the bag conform to the analysis on the outside.

So far as weight is concerned, the farmer who buys the ready-mixed fertilizers obtains the plant food in a very dilute form. In the ordinary 2-8-2 brand of fertilizer only 12 per cent. of the total weight of the material is accounted for on the analysis tag. That is to say, the farmer must handle and pay freight on eighty-eight pounds of filler in order to get twelve pounds of plant food. Just what this eighty-eight pounds of material is composed of and how, if at all, it influences the value of the fertilizer, are questions that are often raised by farmers, and are answered in various ways by the representatives of the fertilizer manufacturers. It would be well to discuss briefly the different materials that are most commonly used as filler. In the first place, it should be understood that this material is not put in the fertilizer for the purpose of cheating the farmers, but because it is absolutely necessary in ordinary practice to dilute the concentrated compounds that carry the plant food. Were one to attempt to apply the twelve pounds of nitrogen, phosphoric acid and potash over the same ground that he would the hundred pounds of mixed fertilizer containing the filler he would not only get it unevenly distributed, but the concentrated material would come in contact with the roots of the plants and kill them. It would also be difficult to get these materials evenly and thoroughly mixed. So there is no complaint to be made against filler as such, but whatever material is used for this purpose, its value to the fertilizer in furnishing plant food ingredients should receive little consideration by the purchaser, notwithstanding the claims of the fertilizer companies to the contrary. It is safe to say that any material that contains any appreciable amount of available plant food would not be used for this purpose.

A filler that is used extensively by fertilizer companies in the Southern States is made of tobacco stems and bits of leaves, the waste which results from stripping the leaves for the manufacture of cigars and smoking tobacco. When ground, this material contains both nitrogen and potash in available forms. The tobacco wastes are free from harmful compounds and, withal, make a very excellent filler. Besides this, they have a decided insecticidal value, farmers reporting that both wireworms and cutworms can be successfully combatted by using a fertilizer with the corn which has a tobacco filler. Muck and peat are used by certain companies as filler, and are given credit for enhancing the value of the fertilizer. The basis of this claim lies in the fact that analysis shows that peat or muck contains a high per cent. of nitrogen, often running as high as two or three per cent. This fact is used to mislead the farmers, because it has been pretty well established that the nitrogen of muck or peat is largely organic, and that very little of it is available for the plant. There has been a tendency among companies using this material in their fertilizers to include the organic nitrogen which it contains, in the analysis of their fertilizers, and this, of course, would lead farmers to buy nitrogen in the unavailable or practically useless form. However, aside from a consideration of its chemical analysis, muck or peat makes excellent filler, since they are highly efficient absorbents, and can be depended upon to maintain the fertilizer in the very best mechanical condition. They are made up largely of partly decayed vegetable matter, and this, added to the soil in the fertilizer, contributes somewhat in keeping up an adequate supply of vegetable matter, and improves the physical condition. Leather scraps, ground up, have been used to some extent as filler. This product contains a considerable amount of nitrogen, but it is almost entirely in an unavailable form, and is of little use to the plant on that account.

It is not a wise plan, then, to buy a fertilizer on the strength of the filler that is used, for the filler usually has little influence on the efficiency of the fertilizer, provided its mechanical properties are satisfactory. Unless a fertilizer has more to recommend it than an alleged superior filler, it had best be left alone. By purchasing the raw materials and mixing them at home, the expense of handling and shipping eighty-five or ninety pounds of this filler for every ten or fifteen pounds of plant food purchased, is saved, but the latter operation is more or less complicated and requires some careful calculation and work that every farmer is not equipped to carry out successfully.

Nitrogen is by far the most expensive element to purchase, and unless it is derived from such materials as can furnish it in an available form, its purchase is a gamble. There are two general sources from which nitrogen in fertilizers is obtained—from organic materials, such as blood, tankage, guanos, etc., and from inorganic sources, chief of which compounds are sulphate of ammonia and nitrate of soda. Of the two classes of compounds, the latter is much more satisfactory in furnishing nitrogen in definite quantities, and in available form. In all organic matter, the rapidity with which its nitrogen becomes available, depends on the rate that it decays. In some cases, such as ground leather, this is very slow and, consequently, its nitrogen is of little value. Such homogeneous compounds always vary more or less in their total amounts of nitrogen as well as in their availability, and this fact renders uncertain the actual amount of nitrogen that is ready for use. However, the nitrogen in nitrate of soda or sulphate of ammonia is a definite quantity, and always remains the same in amount and availability. That is, a pound of nitrate of soda contains just as much, and of the same quality, of nitrogen as another, and it can always be depended on, regardless of the source of the material; provided, of course, it is free from impurities. In other words, these are standard nitrogen furnishers, and stand in direct contrast to the organic forms; this is a very important point in favor of the commercial forms as the source for the nitrogen in the fertilizers. The rapidity with which the nitrogen in any material becomes available depends on how rapidly it is converted into the nitrate form, as this is the form in which it is taken up by the roots of the plants. Another great advantage in favor of the nitrogen in nitrate of soda and sulphate of ammonia is that in the one case it is ready to be absorbed by the plant forthwith, and in the other the change is quickly made. As both are perfectly soluble, they are rapidly and evenly diffused through the soil if the ground contains a fair amount of moisture. Nitrate of soda is obtained almost entirely from the rainless regions of Chili and is known commercially as "Chili saltpetre." The pure salt contains 16.47 per cent. of nitrogen, the other 83.53 per cent. being the sodium and oxygen with which the nitrogen is combined. Sulphate of ammonia is a product obtained in the manufacture of boneblack and in making illuminating gas and coke. It is a highly concentrated salt, the pure form containing 21.2 per cent. of nitrogen. It is a quick acting salt and is especially useful for quick-growing crops. Both of these are distinct and definite products and can always be depended on to give practically the same amount and quality of nitrogen at all times.

The phosphoric acid in artificial fertilizers is likewise obtained both from organic and mineral sources. The bones of animals are comparatively rich in phosphate of lime and serve as a very important source of this plant food for agricultural purposes. "Raw bone" is the term applied to ground bone that has not been altered in its composition in the process of manufacture. This form has the advantage of being pure, but the phosphoric acid is not so quickly available as in the treated product. Oftentimes raw bone contains considerable fatty material, which retards the decay of the bone in the soil. Good average raw bone should contain slightly over 20 per cent. of phosphoric acid and 4 or 5 per cent. of nitrogen. The greater part of the bone that is used to furnish phosphoric acid is first steamed or cooked and is known as "steamed bone." By this process the fatty material and some of the nitrogenous matter is removed. The effect of steaming, then, is to increase the per cent. of phosphoric acid and to lower the per cent of nitrogen. The average composition of steamed bone is about 28 per cent. of phosphoric acid and 1½ per cent. of nitrogen. Animal charcoal is becoming an important source of phosphoric acid. This material is a waste product resulting from the manufacture of sugar. The charcoal or boneblack has for its first purpose the clarifying of sugar, after which it is ground and used to furnish the phosphoric acid in artificial fertilizers. It contains 30 to 35 per cent. of this plant food. It has the disadvantage of being slow to decay in the soil, which means that its plant food constituents are only slowly available.

The mineral phosphates are found in natural deposits, chiefly in the States of South Carolina, Tennessee and Florida. They are found either in veins of in lumps and are obtained both from the beds of rivers and from the earth. After the impurities are removed by washing the South Carolina phosphate rock contains from 25 to 30 per cent. of phosphoric acid, while that from Florida often runs as high as 40 per cent. After the rock is ground finely it is known as "floats," and is either used on the soil in this form or is subjected to further treatment. As a matter of fact, the greater part of the phosphoric acid found in commercial fertilizers has been further treated in such a way as to render it quickly available to the plant. There is a wide difference of opinion as to whether best results can be obtained from the raw material or "rock phosphate" or from the treated form or "acid phosphate." The striking difference between the two is readily seen to be in the quickness of their action. Where immediate results are not desired and the crop to be raised is a slow-growing one, rock phosphate is highly efficient, as it becomes available slowly and is used by the plant as it changes to a soluble form. Acid phosphate or superphosphate is made from the raw material by treating it with a definite proportion of sulphuric acid. By considering the action that takes place it is easy to understand why the acid phosphate is so radically different in solubility. Most of the phosphorus in bones and in the minerals exist in combination with lime or phosphate of lime. While these elements are capable of uniting in several proportions, the most common form consists of three parts of lime in combination with one part of phosphoric acid. This form is insoluble and when ground and placed on the soil in the form of raw bone it changes slowly to the available form. Obviously such a compound would not be satisfactory to furnish the phosphoric acid in a commercial fertilizer, since only plant food that is ready for immediate use is wanted. So the bone phosphate is digested or made available artificially before it is mixed with the fertilizers by grinding it fine and mixing it with sulphuric acid. The phosphate is dissolved, and during the reaction two parts of the lime in combination with the phosphoric acid is set free and taken up by the sulphuric acid to form sulphate of lime or "land plaster." This leaves the phosphoric acid in combination with only one part of lime and two parts of water, which takes the place of the lime that is removed by the acid. This form of phosphoric acid is very soluble and is ready for the use of the plant as soon as it comes in contact with the roots, and is known as acid or superphosphate.

While potash is probably more generally distributed through the surface soil than either phosphoric acid or nitrogen, and while it is removed in less quantities than either of the others, nevertheless it is an important constituent of fertilizers and should not be considered in any other light. Before the discovery of the potash mines in Strassfurt, Germany, its chief source for agricultural purposes was from barnyard manures and wood ashes. Now, however, the world's supply is taken from these and other mines, and there is little danger of there ever being a famine in this constituent. Potash may exist in the form of a chloride, sulphate or carbonate, and seems to be equally acceptable to the plant, judging from the rate at which it is absorbed. Of the crude products of the mines, kainit is used more in this country than any other. This material is ground fine and contains about 23 per cent. of sulphate of potash, 30 per cent. of common salt, and smaller quantities of other salts. The disadvantage of using kainit is that the various impurities found with the potash salt make the expense of handling and shipping rather high per unit of plant food obtained. Muriate of potash is a manufactured product and is used extensively in fertilizers and in the raw state. The average muriate contains about 50 per cent. of actual potash, with considerable quantities of common salt.

The question that arises every spring and fall is whether it will pay to sow commercial fertilizers with the corn or wheat crop. Entire dependence on fertilizers to increase the yields sufficiently to make the investment in them safe has not, nor can be, firmly established, on account of seasonal influences. If the season chances to be a very dry one, it is extremely doubtful whether commercial fertilizers will be able to influence the yield to any considerable extent when applied in the spring with corn. The occasional dry seasons are hence responsible for the refusal of many farmers to use commercial fertilizers, since, apparently, they fail to get any results. Yet, even when the immediate crop does not receive the benefit from the application, it is doubtful if anything is lost, since the plant food is retained in the soil and is ready to be taken up by the wheat crop. For this reason the owner of the land is always pretty safe in investing in fertilizers, regardless of the season, while with the renter, who, according to custom, pays half the fertilizer bill, runs the risk of losing it all, since a dry season would mean little benefit and the owner would reap the results the following season. However, many careful farmers do not make a practice of fertilizing their corn, and it is an established fact that, except in special cases, corn does not respond as satisfactorily to an application of fertilizer as wheat. This is due largely to the fact that the corn is a warm weather crop and is not planted until after the ground is warmed in the spring and is mature before cold weather. A warm soil is able to produce large quantities of available plant food from its own store, and the corn plant draws from this supply much more than is possible for the wheat plant, which needs food right at the time when the soil is unable to furnish it. However, the farmer who uses fertilizers consistently, year after year, finds that the practice is a profitable one, even on his corn ground. While these cannot be depended on entirely, they are an important and indispensable supplement to the other farm practices that seek to retain the health and strength of the soil.

It is not to be hoped that the average farmer of the land will ever be able to understand all the theories that are involved in the fertilization of his soils; it is not necessary that he should. Others can work these things out for him while he is busy with his crops—others who, perhaps, know much less than himself in regard to the actual business of growing corn and wheat. While the theorists theorize, then, let the farmer farm, and let him put into practice those theories that are proven to be worthy of consideration in a practical way. Professor Roberts sums up the situation in the following words: "Timeliness, adaptation, thoroughness, economy in the use of energy and good judgment in the management of details —that is, farm practice—play such important parts in modern agriculture that they may be considered to be equal, if not superior, to the facts revealed in chemistry, botany, and allied sciences. Knowledge, and the application of it, should not be divorced, but joined so firmly by intelligent thought and action that the twain become one."

Soil Survey of Tipton County, Indiana.

By Lewis A. Hurst, of the U. S. Department of Agriculture, and E. J. Grimes, of the Indiana Department of Geology.

DESCRIPTION OF THE AREA.

Tipton County is situated in the north-central part of Indiana and has an area of 166,400 acres, or 260 square miles. The county forms a rectangle about twenty miles long from east to west and thirteen miles wide from north to south. It is bounded on the north and west by Howard and Clinton counties, on the south by Hamilton County, and on the east by Madison and Grant counties. As a whole the surface of the county is a monotonously level and featureless till plain, interrupted in places by morainic knolls and swells. The boldest relief is found along the larger stream courses, especially along the lower course of Cicero Creek and in the vicinity of Duck Creek, which crosses the extreme southeastern part of the county. A rather prominent moraine in the southwestern section and small morainic areas in the northwest and northeast afford some relief to the generally level topography. The average elevation of the county is between 850 and 900 feet above sea level.

The summit of the drainage divide between Wabash and White rivers extend in a general east and west direction across the center of the county. The streams north of this divide empty into the Wabash, while those on the southern side lead to the White River. Since almost all of the area is so level that its streams have a very gentle, gradual fall, the entire area might be said to occupy the so-called summit of the watershed. There are no large rivers in the county.

The drainage of the area south of the divide is affected through Cicero, Duck and Pollywog creeks and their tributaries. Cicero Creek and its tributaries, including Prairie, Wallace, Jericho, Nixon, Wolf and Buck creeks, drain the central and southern parts of the county, emptying into the White River. Pollywog Creek receives most of the drainage from the southeastern portion of the area through various minor stream courses, most of which are merely open ditches, and flows into Duck Creek.

North of the divide Mud and Turkey creeks form the chief drainage outlets. These streams rise in the western part of the county, and, receiving the waters of various small tributaries, flow in a general northeasterly direction until they reach the northeastern portion of the area. There they unite to form Wild Cat Creek, which empties into Wabash River outside the county. Turkey Creek receives the drainage of the central portion of the county north of the divide, while Mud Creek drains the northern section of the area. Irwin Creek, a small tributary of Wild Cat Creek, drains a part of the northeast corner of the county. Swamp and Little Wild Cat creeks are minor streams which furnish the drainage for the northwest corner of the county.

The railroad facilities are adequate for all the needs of the county. In 1854 the Peru and Indianapolis Railroad was constructed across the county in a general north and south direction. This railroad is now a part of the Indianapolis and Michigan City division of the Lake Erie and Western Railroad. The Pennsylvania also has a leased service over this line from Kokomo to Indianapolis. In 1860 the main line of the Lake Erie and Western Railroad was opened, the line extending through the county from east to west. These two railroads intersect at Tipton and form the main transportation outlets for the county. The Logansport and Indianapolis division of the Pennsylvania system traverses the northeastern corner, passing through Curtisville, Windfall and Nevada.

In addition to the steam roads there are two interurban electric lines. The Indianapolis and Logansport division of the Indiana Union Traction Company parallels the Michigan City division of the Lake Erie and Western Railroad across the county. A line of the same company extends east from Tipton and parallels the Peoria and Sandusky division of the Lake Erie and Western Railroad. In addition to furnishing passenger accommodations these electric lines are well equipped with freight and express facilities which are used extensively by both farmers and merchants for shipping dairy and other farm products from local stations and towns to Indianapolis and other cities. The local passenger accommodations on the interurban lines are especially advantageous to the farmers, since the cars may be boarded at the intersection of many of the public highways, thus furnishing ready and convenient access to the cities and towns.

The construction of a few State roads through the county was commenced about 1830. Gravel-road building began in 1880, the principal thoroughfares being completed about 1905. Nearly all the present roads have been constructed and graveled since that time under the three-mile gravel road law. Gravel pits have been opened at various points throughout the area and the gravel used for constructing and repairing the roads. Practically every section line in the county is traversed by a graveled road, and in many places they have been built even on the half-section lines. At present there are probably not more than ten miles of open roads in use by the public which are not improved. Next to the construction of outlet ditches for drainage purposes probably the one thing which has aided most in the development of the area is the development of an excellent sectionized public road system throughout the county.

Tipton county was created in 1844 and was one of the last in the State to be settled. The southern portion of the county was settled first, the first land claim being entered in 1829. The settlement of the northern half began in 1843. The earliest settlers were for the most part from southern Indiana, chiefly from Rush, Fayette, Jefferson and Switzerland counties.

New Lancaster, Tetersburg, Normanda and Canton, now Tipton, the county seat, which was settled in 1839, are among the oldest towns of the area. Prior to 1880 development was slow owing to the swampy condition of the land and the expenditure necessary in providing drainage systems. From 1880 to 1890 the settlers, mainly from Franklin and Dearborn counties, came in very rapidly. The greatest agricultural development in the county has taken place since 1890.

Originally the markets for the surplus products of the settlers were distant and the roads leading to them were almost impassable the greater part of the year. No railroad facilities were available until the Indianapolis and Peru Railroad was constructed in 1854. Indianapolis was and is still the leading market and trading point for the county.

At the time of the organization of the county it had a population of only a few hundreds. In 1880 the total population was 14,402, and in 1890 it was 18,157. According to the census of 1910 the population was 17,459. This shows a decrease, however, of 1,657 from the figures of 1900, due largely to the migration of the rural population to the large cities outside the county, the rapid growth of Indianapolis having drawn heavily upon the surrounding country. The population is generally quite well distributed over the area. The most thickly settled portion of the county is a neighborhood of small farms about four miles north of Tipton. The average is from eight to ten houses on every section or square mile, or more than one house for every eighty acres. Some of the farms range as low as ten to twelve acres in size. In some portions as many as twelve or fifteen farmhouses may be found to a section. Of the 17,459 people in the county, only about 7,300 live in the towns and villages.

Tipton, the county seat, the largest town in the county, is located on Cicero Creek, a little south of the center of the county and thirty-six miles north of Indianapolis. It is a modern town and shows a steady growth. According to the 1910 census it has a population of 4,075. Its manufacturing interests are relatively unimportant, consisting mainly of two canning factories and an incubator factory. Tipton is a division point for the Lake Erie and Western Railroad, and the railroad yards located here furnish employment to a large number of men. It is also a division point for the Logansport and Indianapolis division of the Indiana Union Traction Line, and a number of its employes also make their homes in Tipton.

Windfall and Sharpsville, in the northern section, and Kempton and Goldsmith, in the western part of the county, are thriving towns of 900, 700, 600 and 225 population, respectively. Hobbs, Curtisville, Normanda, New Lancaster, Jackson, Nevada, Tetersburg and Groomsville are other towns and villages in the county. Only parts of West Elwood, Ekin and Atlanta are included in this county.

The reclaiming of the swamp lands has given rise to one of the chief industries of the county, the manufacture of tile. Such factories are located at Hobbs, Curtisville, Kempton and Goldsmith. Gas wells are of frequent occurrence throughout the area. These afford fuel supply to Tipton and some of the other towns of the county and are also used largely by the farmers for home purposes.

In general the county presents a prosperous appearance, with excellent farmhouses and large, well-kept barns and outbuildings. Telephone lines and rural mail routes extend to all parts of the county. Numerous schools and churches are accessible to every section, but many of the smaller county schoolhouses are being abandoned in favor of the segregation system of schools, and large township high schools are being established in the towns and villages.

Climate.

No official weather records for Tipton County are available, but the general climatic conditions are shown by the figures in the following table, which are taken from the records of the nearest United States Weather Bureau Station, located at Marion, Indiana. The table below shows the normal monthly, seasonal and annual temperature and precipitation covering a period of years:

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION, AT MARION.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	30	66	—12	2.4	3.3	2.4	6.0
January	26	66	—25	1.9	1.8	3.9	9.5
February	26	67	—19	2.6	0.5	1.8	7.6
Winter	27	....	....	6.9	5.6	8.1	23.1
March	39	81	— 2	3.3	2.2	6.2	5.0
April	51	89	15	3.5	1.7	2.6	1.0
May	62	96	26	4.7	0.8	8.4	0.2
Spring	51	....	....	11.5	4.7	17.2	6.2
June	71	100	35	4.5	1.4	4.3	0.0
July	74	105	37	2.9	0.8	2.1	0.0
August	73	101	40	2.9	1.4	2.1	0.0
Summer	73	....	....	10.3	3.6	8.5	0.0
September	67	101	29	2.8	2.5	2.5	0.0
October	54	91	15	1.9	0.9	3.5	T
November	40	75	2	3.6	5.4	3.5	2.9
Fall	54	....	....	8.3	8.8	9.5	2.9
Year	51	105	—25	37.0	22.7	43.3	32.2

It will be noted that the average annual temperature at Marion is 51° F. and the average annual precipitation 37 inches. An average from the records of the stations located at Indianapolis, Lafayette and Greenfield show the annual temperature for the territory covered by these stations to be 55° F. and the average annual precipitation 44.06 inches. From all these figures an approximate estimate of conditions prevailing over Tipton County may be obtained.

There are no very marked extremes in temperature, with the exception of an occasional extremely cold winter. The maximum and minimum temperatures quoted, 105° above and 25° below zero, are usually of short duration. Hot spells rarely last any great length of time except in very dry weather, when they may continue for several weeks, but any excessive heat is usually tempered by winds. The annual mean snowfall for the county is 32.2 inches. Snow sometimes remains several weeks, and even months, but more frequently disappears within a short time. The thermometer occasionally drops to twenty or more degrees below zero, but these temperatures are rare. Even zero temperature is uncommon and when it occurs is of short duration. The depth to which the ground freezes is variable. Ordinarily it remains frozen only a few weeks and thaws in February or March.

The precipitation is fairly well distributed throughout the growing season, so that crops rarely suffer from extreme drought or excessive moisture. As shown in the foregoing table, the greatest amount of rainfall is received during May and June.

The length of the growing season is about five and a half months, the average dates of the last killing frost in the spring and the first in the fall being April 24 and October 2, respectively. The earliest date recorded of a killing frost in the autumn is September 14 and the last in the spring is May 22.

AGRICULTURE.

At the time of its settlement Tipton County, with the exception of a few swampy prairies, was covered with dense forests of oak, beech, maple, walnut, hickory, sycamore and tulip trees, with a dense undergrowth. The first attempts at clearing the forested areas for cultivation were made in the southern part of the county, where the natural drainage was better developed. With the exception of that used for domestic purposes the timber was burned.

Owing to the difficulty of hauling products over long and frequently impassable trails, practically no crops were grown for market. Corn, wheat, oats, rye, flax and potatoes were among the early crops grown in the area. Hay was cut from the open prairies. Wheat and corn were grown year after year on the same land, the wheat being grown principally upon the lighter colored upland soils and the corn in the bottoms and the so-called "black lands."

In 1855 the first agricultural society for the improvement of the area was organized, but it was not until about 1880 that the greatest development of the county began. At that time many of the main outlet drainage ditches were constructed and thousands of acres of the most productive land in the county brought under cultivation.

Originally the natural drainage ways throughout the greater part of the county consisted of shallow depressions, and the meandering streams were so sluggish as to carry off only a small part of the annual rainfall. This condition prevailed more generally in the central portion of the county owing to its level surface over the crest of the watershed, and most of the territory was in a semi-swampy condition. In the southern, southeastern and extreme northern sections there was sufficient natural surface relief to give fairly adequate drainage to those areas. Cicero and Duck creeks in the southern part and Wild Cat Creek in the northeastern part of the county occupied much deeper and more clearly defined valleys than the water courses on the divide, and it was along these streams that the earliest settlement took place. The only solution of the problem of reclaiming the entire acreage of the county for cultivation was the establishment of connections for the swampy, water-soaked areas of the watershed with the larger and deeper drainage outlets of other sections. The first work of this kind was done between 1855 and 1860 by private companies.

In 1875 a law relative to the drainage of the surface water from the county was passed. By 1883 the county had built 190 miles of drainage outlets, and private companies and individuals had expended $200,000 in reclaiming the swampy black lands.

Drainage was provided through the construction of wide, deep, open ditches or canals, generally in line with the natural stream courses. The channels of practically all the streams in the county have at some time been straightened and deepened by dredging throughout almost their entire length. Into these have been trained the numerous lateral ditches which receive the water from individual farms along their courses. About 1890 under or tile drainage began to take the place of the open ditches, 12, 18 and 24-inch tile being used. In recent years many of the open drains have been converted into underground or "blind" ditches by the use of tile, so that fields which were dissected by the open drains are now unbroken. Hundreds of thousands of dollars have been spent by private corporate enterprises to establish the excellent system of drainage which now prevails throughout the county.

The building of the several railroads and traction lines has been an important factor in developing the agricultural resources of the county by creating ready access to the larger markets. The establishment of canning factories at various places in the area has given rise to a more intensive system of farming in the vicinity of these industries, and the present high price of land is largely attributed to the farmer's greater income from the growing of peas, sugar corn, beans, tomatoes and other crops for the canning industry. The increasing demand for canned goods warrants the extension of this form of agriculture.

The introduction of labor-saving machinery has done much to increase the output of the farm, but increased returns must necessarily depend upon the successful handling of the soil to conserve it and add to its fertility. This requires a more intimate knowledge of the various soil types, including their limitations and possibilities as well as their needs.

Corn has always been the chief crop of the area. The acreage of this crop has steadily increased from 33,914 acres in 1880 to 55,476 in 1910. The yields have correspondingly increased from 1,115,816 bushels in 1880 to 2,935,971 bushels in 1910. It will be seen from the above figures that the average number of bushels per acre has also increased from thirty-three to fifty-three within that period. This increase has come about through the added acreage of black lands, which are among the best upland corn soils in the State, yields of seventy to eighty bushels per acre being quite common. The clay lands seldom yield more than thirty-five to forty bushels per acre.

Deeper plowing, supplemented by subsoiling, and better drainage would considerably increase the corn yields from the lighter colored soils since better stands of clover and other legumes could be obtained. The use of a complete fertilizer is also recommended. Where ground limestone is used the fertilizer should be applied at another time, preferably before wheat and clover. For the black lands a fertilizer consisting of ten parts of phosphoric acid and five parts of potash, or eight parts of phosphoric acid and four parts of potash, is recommended. This soil usually contains sufficient nitrogen, but is deficient in the other two elements of plant food. In applying phosphoric acid the acid phosphate should be mixed with barnyard manure at the rate of thirty pounds of the former to a ton of the manure, to be spread at the rate of eight tons per acre. This should be applied to timothy or clover sod and turned under in the spring.

The advantage of seed selection is generally recognized, but the methods of selecting the seed can be improved. No attempt at corn breeding to improve the quality of the corn is made.

Check drills are generally used in planting the corn, so that it may be cultivated both ways. This frequently does away with the necessity of hoeing. In general, three to four, and sometimes five, cultivations are given to the crop. The cultivators used are chiefly of the riding type. The use of power corn cutters has also reduced the labor of harvesting. A large per cent. of the corn now grown is cut usually late in September for ensilage.

Oats has never been a paying crop commercially, but it fits in well with the customary rotation of crops and is especially valued for its straw. The average yields are about thirty-five to forty bushels per acre. The introduction of the cowpea and soy-bean will probably cause a decrease in the acreage of oats in the future, especially where used with corn for ensilage. Oats are sown with an end-gate attachment at the rate of two and a half to three bushels per acre.

The acreage devoted to wheat was originally restricted by the expense and difficulty of harvesting the crop. With the reap-hook or sickle a good hand could cut only one-half acre per day. The manual labor necessary in harvesting the crop has been reduced to a minimum by the introduction of the self-binder, and the acreage has been increased. The yields, however, have not increased proportionately. At present an average yield of fifteen to twenty bushels per acre is obtained instead of the thirty-five to forty bushels produced when the land was first cleared. Wheat is generally recognized as not particularly profitable, but as a nurse crop it is conceded to be better than oats, since the straw is lighter and shades the clover less.

The use of ground limestone will be equally beneficial to the wheat and clover. The lighter colored soils of the area are better suited to wheat. They also show a stronger reaction when tested for acidity. Wheat should be seeded in corn during the latter part of September, not later than the 10th of October, preferably after the corn is shocked. It is generally sown with a disk drill having a fertilizer attachment.

The production of hay shown in the 1910 census report was only about half that for 1880. Of the 4,165 tons produced in 1910 the clover yield was 4,044 tons. The acreage of timothy is being rapidly reduced as its soil-robbing properties become more generally known. Some of the leading farmers of the area have excluded it entirely from their rotations. The growing popularity of the silo has also done much to reduce the acreage of timothy. The advantage of growing leguminous crops rather than such soil-depleting crops as timothy is becoming better understood.

The average yield of hay for the county is about one and a half tons to the acre, though as much as two and a half tons per acre are frequently obtained. The planting of cowpeas and oats for hay has been tried, but the results thus far have not been generally satisfactory. Hay makes a ranker growth on the black lands, but the quality is said to be better where it is grown upon the clay soils.

Heavier yields are obtained from the latter soils where ground limestone is applied.

Stock raising and dairying are important industries in the county. The 1910 census shows an annual production of 1,607,230 gallons of milk and 321,096 pounds of butter from 3,389 cows. The milk is handled through creameries, located in towns along the railroads and traction lines. The milk and cream is collected by wagons sent out from the creameries. Jersey and Holstein milkers are the favorite cows. A large number of beef cattle is marketed annually.

Fruit culture was profitable up to about 1880. Since that time various diseases have affected both trees and fruit, so that the neglected orchards have become practically worthless. It has been demonstrated, however, that with proper care excellent fruit can be produced. The pear is probably most seriously affected at present. One or two large commercial orchards in the vicinity of Tipton have recently been partially destroyed by blight. The growing of fruit for domestic use is to be encouraged, but it is doubtful whether its commercial production would prove profitable in this county. The orchards should be small, in order that they may be given proper attention. In many cases adequate care is given to the orchards, but the spraying is not practiced at the proper time.

Most of the farmers in Tipton County follow some form of crop rotation, but in many cases without a definite purpose. The rotation should be so planned as to produce larger yields, to distribute the work more evenly throughout the year, to be more certain of a regular income than is possible with a one-crop system, to maintain, or rather increase, the productivity of the farm, and to reduce to a minimum the injury from weeds, insect pests and disease which frequently accompany the one-crop system. Hence in formulating a rotation it is necessary to take into account the income it will bring, the needs of the land, the requirements of the stock at hand, the effects of one crop upon another if followed in succession, and the profitable distribution of labor. The three main classes of crops to be dealt with in planning a rotation are small grain, hay and cultivated crops. Every successful rotation must include some legume to enrich the soil. Red clover is now used for this purpose throughout a greater part of the corn belt. This crop often fails to make a stand, and in this case a good practice is to disk or plow the land and plant in cowpeas or soy-beans. The planting of cowpeas or soy-beans in the corn at the time of the last cultivation, as a green manure or for pasture, is particularly recommended for the light thin land. Alfalfa sown at the rate of two to three pounds per acre with clover and timothy until the fields are thoroughly inoculated will enrich both the hay and the soil, and better yields of corn will be obtained. Alfalfa can be grown successfully in the county and should be grown more extensively. Wherever difficulty is encountered in maintaining a stand of clover commercial fertilizers or lime should be applied. Commercial fertilizers if depended upon alone for increasing crop yields will injure rather than improve the soil, but if used judiciously in improving the yields of clover and other legumes from which the ultimate enrichment of the soil must come they will generally increase the profits of the farm. A good rotation, with proper utilization of all the farm manure, is required for success in farming.

In 1909 there were mortgages aggregating \$598,810 held against the lands of Tipton County. These mortgages usually represent loans which were made to parties increasing their holdings of land. The price of land has increased rapidly within the past twenty years, and little if any land can now be bought in the county for less than \$150 to \$200 an acre.

Farm hands receive from \$20 to \$25 a month, in addition to board, lodging, washing and horse feed. Harvest hands and extra laborers receive from \$1.50 to \$2.50 per day.

SOILS.

A heavy mantle of glacial drift or till was deposited over the entire county during the glacial period by the last invasion of the ice, known as the Wisconsin stage. The drift material consists of a moderately stiff, clay-like mass at the surface, grading downward into a lighter, sandy and gravelly material. Occasionally rock fragments and bowlders occur throughout the till, but nowhere in large quantities. The glacial deposit has a depth of forty to seventy-five feet along the northern and eastern borders of the county and 200 to 300 feet along the southern and western boundary.

The underlying geological formations have not contributed to the formation of the various soil types. The Devonian measures in the western part of the county and the Niagara limestone in the eastern section occur at too great depths to outcrop at the surface or influence the soils.

It is from the upper part of the glacial till that the upland soils of the Miami series have been derived directly through weathering.

This series is represented in Tipton County by two types, a silt loam and a loam. The loam member is confined to the more rolling areas along stream courses and the few moraines that were large enough to be indicated on the map.

Two soils of the Clyde series, a silty clay loam and a loam, are developed in numerous enclosed tracts formed by the promiscuous deposition of till material during the recession of the ice sheet at the close of the Wisconsin stage of glaciation. These areas remained in a semi-swampy condition until artificially drained, and this favored the accumulation of organic matter. The Clyde series therefore comprises essentially till material or wash from till soils modified by weathering under conditions of restricted drainage and by the accumulation of large quantities of black organic matter.

The alluvial deposits, consisting of reworked drift material, have been separted into two series on the basis of certain physical differences, principally in color. A dark colored, nearly black, soil has been classed as Wabash silty clay loam, and two types of brown soil are included with the Genesee series.

The narrow strips of unassorted alluvial material developed along some of the smaller streams are mapped as Meadow, while in some depressed areas which were formerly swamps or lakes the accumulation of organic matter has resulted in the formation of small bodies of Muck.

In the survey of Tipton County nine types of soil, including Muck and Meadow (Genesee material) have been mapped on the scale of one inch to the mile. These types are distinguished by separate colors.

Miami Silt Loam.

The Miami silt loam includes the greater part of the better drained uplands of the county. It is known locally as "clay land," as distinguished from the "black land." The type is a silt loam, and the term "clay land" probably has reference to the tendency of the soil to clod or run together. This tendency is due to the lack of humus in the soil and to the fact that it is frequently plowed when too wet.

The surface soil to an average depth of about eight inches is a compact silt loam. It is light brown when moderately moist and grayish when dry. The subsurface portion of the soil frequently has yellow or a creamy-yellow color when partially dried out.

The subsoil between eight and about twelve to fifteen inches is a grayish-brown or yellowish-brown heavy silt loam or silty clay loam. Below this the material is a yellowish-brown silty clay loam to silty clay, mottled with gray in the upper part, grading below into a darker brown, friable silty to sandy clay, known as "bowlder clay." This is generally encountered at about twenty-four to thirty inches, although along the stream courses and over the sharper knolls and ridges it occurs at a depth of eighteen to twenty inches. Below three to four feet the substratum gradually becomes lighter both in color and texture until at a depth of about eight to ten feet the material is made up largely of sand and gravel.

The surface soil throughout the area is fairly uniform, with occasional local variations. Upon the crests of the ridges and knolls it is sometimes slightly sandy, with a few chert, granite and quartz pebbles upon the surface. Where the type occupies nearly level areas the surface soil often has a leached or ash-colored appearance. This condition is generally found in those sections where the black soils are the predominant types. These areas are naturally poorly drained and artificial drainage must be established if the best results are to be obtained, since the soil is less productive than that of the better drained areas. Where the surface is more undulating and the natural drainage better developed the soil is darker in color, being more nearly brown. In the level areas the subsoil is more mottled, cold and dense, as if water-logged, while in the better areas it is more open and porous and has a yellowish-brown color. In addition to tiling and draining these level areas, they should also be subsoiled and limed to render the soil and subsoil more open and porous and to correct the acidity which numerous tests have shown to exist.

The Miami silt loam occurs in various areas throughout the county in association with the "black lands" comprising the Clyde soils. Next to the Clyde silty clay loam it is the most extensive soil type in the county. The largest proportionate acreage occurs in the southern and southeastern parts of the county and along the Howard County line. In the nearly level sections it occupies low, flat ridges, as previously described, where the "black lands" predominate. In general, the type is most extensively developed in the vicinity of stream courses.

In the early settlement of the county the Miami silt loam was one of the first soils to be cultivated because of its better natural drainage. When first cleared the soil was darker in color and much more productive than at present. Subsequent cultivation has greatly reduced the natural store of humus.

This type can generally be distinguished in any particular field from the black soils by the more vigorous growth on the latter in the early development of the crop, particularly with corn, oats and hay. If the season is favorable the yields on this soil—the "clay land"—is generally a little more than half that of the associated black Clyde soils except in the case of wheat, which is better adapted to the Miami silt loam. The quality of the hay, corn and oats is generally better upon this type as compared with the darker colored soils.

Tests made with litmus paper show the soil to be distinctly acid in reaction. The use of phosphatic manures and liming is strongly recommended. The lime can probably best be applied in the form of finely ground limestone, since the type is already deficient in humus, and lime in the more soluble form might tend to destroy the remaining organic matter. Still, burnt lime could be used, and any lowering of the organic content thereby could be made up by plowing under vegetation or applying barnyard manure. From two to four tons per acre of the ground limestone should be applied, preferably on clover sod in advance of corn. The wheat and clover which follows will be especially benefited. Where barnyard manure is also used the addition of ground phosphate rock or acid phosphate would materially increase the yields of wheat and corn. The application of barnyard manure and phosphate is treated in the chapter on agriculture.

The deepening of the soil by deeper plowing and subsoiling will tend to correct the unfavorable "sour" condition of the land by the more thorough aeration thus brought about. The turning under of such crops as clover, cowpeas, Canada field peas, soy-beans, rye and oats stubble will improve the physical condition of the soil and furnish a store of food supply for the plants.

The one thing that has probably done most to reduce the crop yields from this type is the plowing of the soil when too wet and not in condition to produce the best possible tilth. This is generally due to a desire to force the crops in season. Under such conditions the soil clods badly and as a rule it is not reduced to the proper tilth by subsequent cultivation.

Tomatoes and potatoes grown on this type are generally superior to those grown upon the black lands. Owing to reduced yields, however, tomatoes are more often grown upon the Clyde silty clay loam.

The Miami silt loam is better adapted to fruit growing than the darker soils.

The native vegetation consists of beech, black walnut, white oak, yellow poplar, sugar maple, red oak, shell-bark hickory, chinquepin oak, white ash, hazel, pawpaw, redbud, wild plum, flowering dogwood, etc.

Farms upon this type are valued at $150 to $200 an acre.

Miami Loam.

The surface of the Miami loam is a brown to yellowish-brown silty loam or loam to a depth of ten to twelve inches, grading into a yellowish-brown silty clay loam. At eighteen to twenty inches a dark-brown, brittle clay (bowlder clay) is encountered which contains an appreciable amount of sand and gravel. The content of sand and gravel increases with depth, and below three to four feet the material becomes a lighter colored gravelly loam.

The type is not extensively developed in Tipton County. It occurs along the larger stream courses and over the larger morainic knolls and ridges. It is typically developed along Duck Creek in the southeastern portion of the county and also in the northeastern section. It occupies a well-defined morainic ridge in the southwestern part of the county and several smaller ridges and knolls throughout other sections.

This type is very similar to the Miami silt loam. Since it has a more rolling topography it is more subject to erosion, and this has had much to do with effecting a higher content of sand and other coarse materials.

The Miami loam is probably best adapted to fruit.

Clyde Silty Clay Loam.

The Clyde silty clay loam is the most extensive as well as the most productive soil type in the county. Owing to the dark color of the soil, due to its high content of organic matter, it is generally known locally as "black lands."

The surface soil of this type to an average depth of eight inches is a dark-brown to almost black silty clay loam. As the surface dries the material assumes a grayish or grayish-black appearance. The intensity of the dark color is proportionate to the amount of organic matter in the soil. This constituent also affects the chemical and physical properties and the agricultural value of the soil, making the land more retentive of moisture and mellow and easy to till.

The subsoil between eight and twelve to fifteen inches is a bluish-black silty clay loam, grading below into a drab silty clay. This in turn is underlain by a medium to light gray, stiff, plastic clay which is mottled with brown streaks or iron stains. Below twenty-four to thirty inches the subsoil is more deeply mottled, with a gradual tendency in texture from the stiffer clay to a lighter textured silty to fine sandy clay. Where this type follows the course of the natural drainage ways it is generally underlain with sand and gravel at various depths, usually at about six to eight inches. This sand and gravel is generally highly stained with iron compounds. Since Tipton County embraces but few morainic hills from which to draw its gravel supply, a large per cent. of the road material has been obtained by dredging the gravel from these old stream valleys.

This type comprises the greater part of the low-lying, poorly drained areas of the county which in their natural state were in a semi-swampy condition throughout the greater part of the year. After being drained the land was cleared of the underbrush and standing timber and put in corn, as this was about the only crop that could be cultivated and harvested among the roots and stumps. An occasional field is to be seen in which the stumps remain, but over far the greater part of the type they have been removed and the soil is in a high state of cultivation.

The Clyde silty clay loam is derived from the same material as the Miami silt loam, the glacial till of the late Wisconsin epoch, but owing to its low-lying position and water-soaked condition the character of soil and subsoil is very different. This type occupies irregular shaped depressions which are widely distributed throughout the county, but more generally confined to a wide strip extending diagonally through the center of the county from northeast to southwest. It occurs as low-lying or depressed areas in the uplands, and forms the main background of the soil map throughout which the Miami silt loam is shown.

The type was slowly developed. It was not until the early eighties that its possibilities were understood or appreciated. This came about through the building of good roads and adequate drainage outlets, giving the individual farmer an opportunity to drain his land. The development was attended by a rapid increase in land values, and the present high price of land in Tipton County is due in large measure to the productivity of this type and its wide distribution throughout the county. The value of individual farms is generally determined by the included area of this "black land."

The soil is fairly uniform throughout the area, but owing to differences in the natural drainage it has certain local variations in color, texture and depth of soil. The texture is heaviest and the color darkest where the depth of the surface soil is only about six to eight inches. This condition is largely found in the areas of the type east and southeast of Windfall, in the vicinity of the Madison County line, extending as far south as Cedar Point and West Elwood. The larger bodies of this soil in the vicinity of Tipton and elsewhere throughout the county have the same characteristics. The type usually reaches its maximum organic content and darkest color in the center of the depression or at its lowest point, shading off gradually toward the surrounding lighter colored soil of the Miami silt loam. The texture also follows this same general relationship. Both these conditions are due to the movement of the surface waters, and carrying in suspension and depositing the finely divided soil particles from the uplands as well as the decomposed native vegetation.

The Clyde silty clay loam is used extensively in the vicinity of Tipton, Sharpsville and other towns in the area for growing tomatoes, peas, beans, etc., for local markets and for the canning factories. The yields are larger from this type than from the Miami silt loam, but the weight and quality of the product are somewhat inferior. The tomatoes on the black lands decay more readily and in wet seasons crop yields are greatly reduced from this cause. By the judicious use of commercial fertilizers the yields from the clay lands could be materially increased.

The type is probably best adapted to corn and oats. Yields of sixty to eighty bushels of corn per acre are not infrequent, and fifty to sixty bushels of oats are obtained, but in wet seasons this crop lodges badly and considerable loss is incurred, except where it is mowed and used for hay. Its value as a green manure when turned back into the soil is not to be underrated, however. Alsike and red clover and timothy produce heavy yields, the average being from one and a half to two tons per acre.

Where commercial fertilizers are applied to this type it is recommended that a mixture be used containing about 8 per cent. of phosphoric acid and 8 to 10 per cent. of potash. Nitrogen is not generally needed for this soil and can best be obtained from the supply stored in the roots of leguminous crops, which should be included in all crop rotations.

The surface of the type is flat to depressed, so that ample drainage is required to remove the surface waters. Open ditches were at first installed, but these have generally been replaced in recent years by underground or tile drains, which permit the cultivation of the land formerly dissected by the ditches, making it possible to cultivate the type in large bodies.

With proper drainage and liming of the soil alfalfa can be grown as successfully on this type as on the Miami silt loam.

The native forest growth of the Clyde silty clay loam consisted of swamp white oak, swamp pin oak, white elm, silver maple, burr oak, black ash, green ash, cottonwood, prickly ash, spice bush, buttonwood, wild rose, willows, etc.

Clyde Loam.

The surface soil of the Clyde loam to an average depth of eight to ten inches is a black, heavy silty loam or loam containing a high percentage of organic matter. The presence of this organic matter not only gives the soil its dark color, but also imparts to it a slightly pasty feel when wet, making it resemble Muck. However, the amount of organic matter in the soil is not sufficiently high to justify its classification as Muck.

The subsoil of the Clyde loam is a heavy black clay loam which grades below into bluish-black to grayish silty clay, and this in turn into mottled brown, drab, and gray, rather stiff, plastic clay. At a depth of about thirty to thirty-six inches silty to fine sandy clay of a lighter gray color mottled with brown is generally encountered. The content of sand generally increases with depth and in some instances a wet, loose, fine sand, similar to quicksand is encountered. This material is most common in the soils of "Round Prairies," southeast of Windfall, which was originally a lake or shallow basin.

The Clyde loam was originally treeless. The native growth consisted of sedges, grasses, cattails, flags button bushes and willows. The better drained areas supported a heavy growth of native prairie grass which was used extensively by the early settlers for hay and pasture for their stock. The annual decay of this vegetation was the source of the high content of organic matter in the soil, so that it is frequently referred to as "made land." Where this soil carries a very high content of organic matter it is generally loose, "chaffy" or fluffy, or mucky. The latter condition is more noticeable when the soil is first put under cultivation, following reclamation by artificial drainage. Corn planted on the mucky areas makes a vigorous growth in the early stages of its development, but usually turns yellow or "burns" before reaching maturity. The application of barnyard manure, deeper plowing, and thorough cultivation so as to aerate the soil as much as possible will tend to correct this chaffy condition and greatly increase the yields from this type. The use of fertilizer mixtures containing potash and phosphoric acid in the proportion of about two parts of the former to one of the latter is also recommended.

The largest single body of this type comprises the area known locally as "Round Prairie."

The Clyde loam is naturally fertile, but generally the best results are obtained through the use of barnyard manure and commercial fertilizers. The soil is generally lacking in phosphoric acid and potash, particularly the latter. Corn yields have been greatly increased by the application of potash fertilizers. Lime is also beneficial.

It is only within the past few years that satisfactory yields have been obtained from this type. Oats produce a rank growth and lodge badly. It is recommended that the oats be sown thicker on this than on the lighter colored soils.

Clyde Loam, Prairie Phase.—In the vicinity of Kempton and running as far east as Goldsmith a darker phase of this type occupies an area which is known locally as "Indian Prairie." This development is almost 20 miles long and 2 to 3 miles in width. The term "prairie" was applied to this area because of its original treeless condition. It supported a dense growth of aquatic vegetation, consisting chiefly of sedges, grasses, cattails, flags, button bush, and willows. About 40 to 90 per cent. of the soil was under water throughout the year. The better drained portions supported a growth of bluestem prairie grass and numerous species of typical prairie plants. The grass was cut for hay by the early settlers. Interspersed throughout the low-lying prairie lands were small, low morainic knolls and ridges which supported a growth of hazel and sumac. Many of these knolls are now covered with hickory, and shingle, white, and red oaks.

The surface soil of the prairie phase of the Clyde loam to a depth of 8 to 10 inches is a black or brownish-black silty clay loam or heavy silt loam which grades into a bluish-black clay or clay loam, sometimes mottled with yellow. This in turn is underlaid at 20 to 24 inches by a bluish or drab, tenacious silty clay which becomes light gray in color and more intensely mottled with depth. The mottling in the lower depths consists of deep brown iron stains or streaks. At 30 to 36 inches a lighter textured, deeply mottled silty to sandy clay is encountered, and this in some places is underlain by marly material. Probably at least a part of the prairie phase is underlain by gravel at various depths similar to that underlying portions of the Clyde silty clay loam.

The soil is deeper in the depressions, has a darker color, and is frequently loose and fluffy. The fluffy soil, which occupies button wood ponds, produces a good growth of corn and other crops, but the plants tend to "burn out" or turn yellow without reaching full maturity. This is possibly due to the excess of certain organic acids in these muck-like areas, which can be corrected by heavy applications of barnyard manure or by liming, or to a deficiency of potash. The use of commercial fertilizers containing a high percentage of potash has greatly increased the yields from this land. Where the barnyard manure is needed for the clay knolls it is advisable to use commercial fertilizers, maintaining a proper balance in the available nitrogen by crop rotation.

This land is especially well adapted to corn, producing an average for the past ten years of about 50 bushels per acre. Average yields of 50 bushels of oats, 12 to 20 bushels of wheat, and 25 to 30 bushels of rye per acre are obtained. Oats lodge badly, especially in wet seasons. Clover and timothy do well upon the prairie phase and an average of two tons or more to the acre is produced. Alsike clover does especially well. Potatoes yield from 200 to 300 bushels per acre.

Genesee Silty Clay Loam.

The surface soil of the Genesee silty clay loam is a medium-brown heavy silt loam grading at a depth of 5 or 6 inches into a silty clay loam which extends to 12 or 15 inches, when the subsoil is usually encountered. The subsoil is a gray or steel-blue, stiff, plastic clay mottled with shades of brown or iron stains, the color becoming lighter with depth.

This is generally subject to overflow, but where it occurs above ordinary high water the soil is a light-brown, loose silty loam to 18 to 20 inches, below which it is a dark-brown to drab, mottled silty to sandy clay.

The type resembles to some extent the Clyde silty clay loam, except that it is lighter in color and occurs in the better defined valleys of the streams along which it is found.

The largest single body of the type occurs in section 29, T. 21, R. 4, where Wallace and Prairie creeks unite to form Cicero Creek, extending along the latter for a distance of two miles or more. The soil is also found as first bottom land in a narrow strip along Mud Creek, which traverses the northern part of the county.

The Genesee silty clay loam, like the Genesee loam, belongs to the youngest group of soils in the county, representing alluvial material recently deposited by the streams along which it occurs. The soil is generally lighter in texture near the stream, where the currents during periods of overflow are swifter and can carry the heavier materials in suspension. The heavier materials are deposited in the outlying bends of the creek where the movement of the water is more sluggish.

Originally this type comprised poorly drained bottom lands along streams of very shallow, crooked channels, through which the water flowed sluggishly. In recent years the channels have been straightened and deepened by dredging, and the land along their courses has thus been reclaimed for cultivation through an improvement of the drainage.

Some of the largest yields of corn in the county have been obtained from this type, the average being from 50 to 60 bushels per acre, while a yield of 80 bushels is not unusual. Heavy yields of oats and hay are also obtained, but corn is the leading crop. Being subject to overflow, this type does not require as much fertilizer to produce maximum yields as is needed on the upland soils, since fertile deposits of alluvium are being laid down over the bottoms from time to time.

If cultivated under normal moisture conditions, this soil turns up a loose, mellow loam, but if plowed when too wet it has a tendency to form heavy clods which cannot be readily reduced to subsequent cultivation. Too often this physical characteristic of the soil is overlooked by the farmers in their haste to plant crops, especially when the season is late, and by such practice the crops are affected for even more than one season.

The native vegetation consisted of swamp oak, white oak, bur oak, pin oak, silver maple, white elm, cottonwood, black ash, prickly ash, spice bush, etc.

GENESEE LOAM.

The surface soil of the Genesee loam to a depth of about 6 to 8 inches is a medium dark brown silty loam to loam. This grades into a lighter colored brown loam as the depth increases. At 10 to 12 inches the texture is slightly heavier, and the material becomes a silty to fine sandy clay or clay loam. Varying amounts of sand and gravel are encountered throughout the soil and subsoil. The surface material varies to a fine sandy loam in places, but these spots could not be mapped on account of their small size. Occasionally at depths of 24 to 30 inches a fairly loose, sandy and gravelly material is encountered.

The Genesee loam, being of alluvial origin, is subject to local variations over small areas, due to the uneven deposition of alluvial material at different intervals of overflow, the greatest uniformity being found in the broader bodies.

This type occurs as first bottom land along Cicero Creek, from the Hamilton County line to the junction of Cicero and Nixon creeks. A narrow strip also extends along Nixon Creek for about two miles. Where this type occurs near the Hamilton County line the soil is more nearly a fine sandy loam, but in the vicinity of Tipton it is much heavier in texture.

Only a limited acreage of the Genesee loam is under cultivation, since it is subject to intermittent overflow. It is used almost exclusively for pasture. There is generally some growth of silver maple, white elm, sycamore, buckeye and red oak. The type is cultivated only over the better drained areas which in places have the character of second terraces but are too small to be mapped separately. Corn and oats are the chief crops.

Where market facilities are adequate the lighter, sandy soil of the type might be used to advantage for trucking purposes since it is especially adapted to watermelons, muskmelons or cantaloupes, cucumbers, and potatoes, particularly sweet potatoes.

Wabash Silty Clay Loam.

The soil of the Wabash silty clay loam to an average depth of about 8 inches is a black heavy loam to silty clay loam containing a high percentage of organic matter, the amount of which is sufficient in places to impart a mucky character to the soil. The subsoil consists of a bluish-black silty clay grading at about 12 to 15 inches into a stiff, impervious drab-colored clay. The water table is frequently encountered at a depth of 30 to 36 inches. The lower subsoil has a light-gray color, deeply mottled with brown and yellow.

The area in which the Wabash silty clay loam occurs is a slightly depressed or outlying basin adjoining the bottom lands along Prairie Creek. The supposition is that it is a part of that valley, representing an abandoned channel way of Prairie Creek. It is said that in times of high water a part of the overflow from Prairie Creek breaks across into this basin and finds its outlet through Devil's Den Run. The latter stream has in recent years been straightened and deepened as a drainage outlet for the basin. The area was formerly a dense swamp which was inundated during a greater part of the year. Only in recent years has it been drained and made suitable for agriculture.

When first cleared and put under cultivation the soil was highly charged with organic matter and in places was chaffy, so that the corn showed a tendency to "burn" without properly maturing the grain. This condition has been gradually remedied by the use of large quantities of stable manure and subsequent cultivation. The use of potash as a fertilizer has also increased the efficiency of this soil.

The type occurs as a single body, and includes a greater part of the N. E. ¼ sec. 31, and the S. W. ¼ sec. 29, T. 21, R. 5. It extends to the southeastern and northwestern corners of sections 30 and 32 respectively.

Corn is the leading crop and has been grown continuously. Owing to the natural fertility of the soil yields of about 60 to 80 bushels per acre have been obtained, but unless crop rotation is practiced these yields will decline and the growing of corn become unprofitable.

MUCK.

The type of land classified as Muck consists of black or dark-brown organic matter in a state of partial decomposition, mixed with varying quantities of soil material or mineral matter. These areas are generally referred to locally as "made land." The depth is quite variable, ranging from a few inches in the margin to 3 feet or more in the center of the body. The color changes little with depth but the organic matter is more noticeable in the lower portion. At an average depth of about 24 inches the mucky layer is underlain by bluish-black, plastic clay or silty clay which grades below into a lighter colored or grayish, mottled clay. In places the lower portion of the 3-foot section consists of Peat. Occasionally an impure shell marl is found imbedded with the underlying material. Considerable mineral matter in the form of fine sand and silt have become incorporated with the Muck along the margin of the larger areas.

There is only a small total area of this type, the largest body being in the northeastern part of the county, north of Groomsville, in an old channel now drained by Swamp Creek and Turkey Creek. Two small bodies occur in the morainic areas of the extreme northwestern section of the county. A few isolated patches are found in depressions in various parts of the area. Some of these patches were too small to be indicated on the map.

Small areas of Peat consisting of pure deposits of less thoroughly decomposed decaying vegetable matter, were included with the Muck. These are so intimately associated with the Muck as to preclude their being mapped separately. The Peat deposits were formed along with the Muck in shallow basins and ponds from the decayed remains of water-loving plants and accumulations of other forms of vegetation, particularly mosses. The Peat commonly occurs near the center of the body of Muck where the deposition of vegetable matter has been more recent and has not undergone as thorough decomposition, though it sometimes occurs in spots throughout the entire body.

Since the Muck occupies low-lying, depressed areas which lack natural outlets, drainage must be supplied before the material can be successfully utilized for crop production. Muck land was first brought under cultivation about twenty years ago and most of the type in the county is now reclaimed. This has been accomplished by the construction of large open ditches into which many tile ditches drain. In the early settlement of the area the native grasses were cut from these soils and used for hay, but at present most of this land is under cultivation and used chiefly for general farm crops, such as corn, oats, and hay.

Corn will produce an average yield of 50 to 60 bushels per acre, and oats 40 to 60 bushels. Some very heavy yields of oats have been obtained, but the grain makes a rank growth of straw which becomes lodged so that harvesting is difficult as well as damaging to the crop. This condition may be partially remedied by the liberal use of mineral fertilizers. Corn frequently ''burns'' or turns yellow on this soil and does not mature. Timothy is easily set and makes a rank growth, but it usually ''burns'' at the ground, and the hay is lighter than that grown on other soils. Alsike clover is well adapted to this soil and should be grown in combination with timothy. The crops grown on this type are subject to injury from early and late frosts. It is often necessary to replant corn two or three times, and early frosts sometimes prevent the corn from maturing. If the seed bed were made firm with a heavy roller the movement of the soil moisture would be so regulated as to lessen the danger from frosts. Applications of potash salts and phosphatic fertilizers are very advantageous to these soils. Coarse barnyard manure and lime are also beneficial.

This soil is seldom used for the crops to which it is best adapted, including celery, onions, cabbage, Irish potatoes, beets, turnips, cauliflower, and other garden products. Such crops have been successfully grown upon this material in northern Indiana and adjoining States, but for the cultivation of such special crops the accessibility of city markets and rapid transportation must necessarily be a matter of consideration, except in those cases where grown for local consumption.

MEADOW *(Genesee Material.)*

The term Meadow, as here employed, denotes a generalized type or classification embracing the narrow strips of first bottom land lying along certain minor stream courses of the county, such as Irwin, Turkey, Little Wild Cat, Nixon, Jericho, Wallace, and Prairie Creeks. These bottoms are subject to periodic overflow, but they are not particularly swampy, the drainage of much of the soil being fairly good between overflows. There is wide variation in the color, composition, and texture of the soil, as also in local drainage and surface conditions. The predominant material is a heavy silt loam, dark brown in color, and resembling the Clyde and Genesee soils. The boundaries indicated upon the map are arbitrary, since no definite line can be drawn between meadow and the other alluvial types having a similar origin.

The subsoil is a mottled drab or grayish silty clay. Near the stream channel the soil may be lighter in texture, but throughout most of the area the sediments are fine and the soil is rather heavy. Deposits are being added repeatedly, each successive overflow bringing in new deposits and spreading them over the bottom lands.

The areas of meadow are ordinarily too wet for cultivation yet they are not permanently swampy. By straightening and deepening the stream channels much of this poorly drained land has been reclaimed, like the Genesee silty clay loam, for agricultural purposes. Corn is the chief cultivated crop upon such areas, and when proper means of drainage are employed the yields are excellent. Where the valleys are deeply cut and narrow and the land frequently interspersed with shallow depressions or marshy places its chief value is for pasturage. Complete drainage of the meadow lands is not essential when they are used for this purpose.

The greater portion of meadow in this county is being used for pasture, the native forest growth generally being allowed to remain as shelter for stock. It also affords a supply of timber for domestic use, chiefly for fence posts and rough lumber.

Silver maple, white elm, sycamore, and red oak are the trees commonly found on such areas.

SUMMARY.

Tipton County, with an area of 166,400 acres or 260 square miles, is located in the north-central part of Indiana.

The surface is a level, featureless till plain, the greatest relief being found along the larger stream courses, especially along Duck Creek and lower Cicero Creek. The average elevation is from 850 to 950 feet above sea level.

The summit of the drainage divide between the Wabash and White rivers extends east and west through almost the center of the county. About half of the county drains to the north, the other half to the south. Much of the drainage is artificial.

The county was first settled in the southern portion. The greatest influx of settlers was between 1880 and 1890.

Tipton, the county seat and largest town in the county, is located near the center of the county. It has a population of 4,075. There are 12 other towns and villages in the county, not including Atlanta, Ekin, and West Elwood.

The county has a population of 17,457, of which only about 7,000 live in the towns and villages. The rural population is well distributed.

An excellent sectionized public system of graveled roads extends over the entire county. Adequate transportation facilities are furnished by three railroads and two electric interurban lines. The county has only a few manufacturing interests. Its prosperity is due almost entirely to its fertile soils.

The entire county is highly developed and prosperous, having good homes, towns, churches, schools, electric interurban lines, telephones, rural delivery routes, excellent public roads, and other modern conveniences.

The climate is not subject to very great extremes. The absolute maximum and minimum temperatures reported, 105 degrees above and 25 degrees below zero, are unusual. The mean temperature for the winter months is 27°, and the summer 73° F.

The county has an average rainfall of about 37 inches, which is well distributed throughout the year. The growing season is about 5½ months.

Corn is the principal crop, 50 to 55 bushels being the average yield. Oats, wheat, and hay are also grown in considerable quantities. These crops are largely fed on the farm to the stock, which constitutes one of the main sources of revenue. The surplus of corn, oats, and hay is sold in the local markets. The wheat is generally sold or exchanged at the elevators for flour and meal. Corn is also being cut and stored as ensilage which is used as green food for stock in winter.

The growing of tomatoes, peas, beans, etc., for the canning industry is profitable, and there is promise of an extension of this form of agriculture. Dairying is an important industry.

The rotation of crops is generally practiced throughout the area. Barnyard manure is the principal fertilizer used, although some commercial fertilizers are applied, particularly with special crops and upon the black land of the county. Ground limestone could be profitably applied to most of the soils.

The average size of farms is about 80 acres. The tendency is to increase the size of farm buildings. The tenant system is growing.

The value of land ranges from $150 to $225 or more an acre. The price of land has advanced rapidly since 1880, owing to the reclamation of the black lands.

The soils are derived almost entirely from the glaciated till of the late Wisconsin epoch. The greater part of the soils are rich in organic matter and are classed as "black lands." The light colored soils are called locally the "clay lands." The soils generally are of a silty character. Those of the uplands, comprising nearly all of the county, are classified in two series, the Miami and Clyde soils, the former including the light-colored soils and the latter the black lands. Both are of wide extent. The black soils are best adapted to corn and oats while the lighter colored soils are better suited to wheat. One type of the Wabash series was mapped and this is also generally included with the black lands. The first bottom lands were classed with the Genesee of Meadow.

Nine soil types, including Meadow (Genesee material) and Muck, were recognized and mapped. The Miami silt loam and the Clyde silty clay loam are the predominating types. Muck and the Clyde loam represent the so-called "made lands" of the area, the latter type being especially rich in organic matter.

The alluvial soils are limited to narrow strips along the large streams. These were classed with the Genesee loam and silty clay loam, or Meadow. The Genesee loam is developed along Cicero, Duck, and Jericho creeks, while the silty clay loam is confined principally to Prairie and Mud creeks, Meadow (Genesee material) occurs along the upper courses of many of the smaller streams.

Practically all of the soils are under cultivation or used for pasture. The agriculture of the county is in a prosperous and highly developed condition. Scientific farming is being practiced to a considerable extent, but further recognition of its possibilities is necessary for the fullest development of the county.

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS—MILTON WHITNEY, Chief
In Co-operation with the State of Indiana, Department of Geology
EDWARD BARRETT, STATE GEOLOGIST

SOIL SURVEY

OF

HAMILTON COUNTY, INDIANA

BY

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[Advance Sheets—Field Operations of the Bureau of Soils, 1912]

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By Lewis A. Hurst, of the U. S. Department of Agriculture, and E. J. Grimes, R. S. Hesler and H. G. Young, of the Indiana Department of Geology.

DESCRIPTION OF THE AREA.

Hamilton County is situated north of the geographic center of Indiana and is bordered on the north by Tipton County, on the east and south by Madison, Hancock, and Marion, and on the west by Boone and Clinton counties. It is approximately a square, with its sides 20 miles in length and has an area of 400 square miles or 256,000 acres.

In topography it varies from a level till plain to an undulating and sometimes hilly surface, the latter being found only in the vicinity of stream courses or where moraines exist. Moraines are not very common in any part of the county but they are more numerous in the western part than elsewhere, the most prominent one being situated north of Sheridan. The roughest country lies along Hinkle Creek in the vicinity of Deming. The banks along the larger stream are usually precipitous, ranging in height from 30 to 100 feet or more. They rise in two distinct terraces to the broken country, which along most of the streams, merge rapidly into the broad level plain. There are numerous old filled-in valleys in the area, and preglacial topography was apparently much more irregular than the existing topography. Among the more prominent topographic features of the county is an old valley or glacial channel on the west side of West Fork White River below Noblesville and a similar valley above the city on the same side of the river. Another feature of note is a broad depression extending northeast and southwest and connecting the valley of the West Fork of White River with that of Prairie Creek. The valleys of Fall and Mud creeks are joined by a similar depression.

The county has a range in elevation of 150 feet, the western part lies between 900 to 950 feet, and the eastern part from 800 to 850 feet above sea level. The general slope of the surface is from north to south.

In the northern part of the county the surface is in general more level and the drainage less mature than the southern part. Thus the greater dissection of the latter region produced a more rolling surface. This is especially true near the junction of the smaller streams with West Fork White River.

The drainage is performed by West Fork White River and its tributaries. The river enters the county from the east, about five miles from the north boundary, and leaves it near the center of the southern border.

The principal tributary of West Fork White River in the county is Cicero Creek, which empties into West Fork White River 2 miles south of Noblesville. This creek has a remarkably narrow channel and a winding course. The flood plain is bordered on each side by bluffs 20 to 40 feet in height. Cicero Creek with its tributaries, Little Cicero, Little Wersel and Hinkle creeks, drains about 150 square miles of the area. The drainage of the northeast section of the county is delivered to West Fork White River through Duck Creek and its tributaries, and Pipe Creek. Stony Creek and its branches drain the central eastern portion, Fall Creek and its tributaries, the southeast section, and Eagle and Williams Creeks, the southwest section. Drainage of the extreme northwest part of the county is performed by Prairie Creek. The valleys of Eagle and Williams creeks are bordered by heavy drift deposits. Along Cool Creek the surface is quite broken, while Stony Creek has developed a scond terrace along the greater part of its course.

As stated previously, the regional drainage of the southern part of the area is better developed than that of the northern. In the latter region numerous inequalities were formed in the surface by glaciation. These depressions filled with water and existed under natural conditions as swamps or ponds.

Hamilton County was organized in 1823, the first settlement having been made a few years earlier. The section first developed lay along West Fork White River, in the central and southern part of the county. Most of the immigrants came from Ohio, Kentucky, Virginia and Pennsylvania. In 1820 a settlement was made on the present site of Noblesville, the county seat, and in 1823 this town was founded. The greatest influx of settlers came in 1852 when the Peru and Indianapolis Railroad was extended to Noblesville. The construction of this road greatly stimulated agricultural development by opening up new markets and increasing the price of farm products.

In the early period Indianapolis and Lafayette were the chief markets, though cattle were sometimes sold at Cincinnati, and hogs at Madison. At the present time Indianapolis, situated in Marion County on the south, is the leading market and trading center of the county.

The population of the county has grown steadily since its settlement, and according to the census of 1910, it is now 27,026. Of this number more than 12,000 live in Noblesville and the other towns and villages of the area. The remaining population is distributed rather evenly over the rural sections.

Noblesville with a population of 5,073, is the county seat and largest town in the county. It is located on West Fork White River 20 miles north of Indianapolis. It is not only the center of a rich agricultural section from which it draws much of its support, but the site of several important manufacturies.

Sheridan, in the northwestern part of the county, with a population of about 1,200, is the next largest town. Cicero, Atlanta and Arcadia, situated north of the county seat, Westfield in the western part of the county, and Carmel in the southern part are thriving towns with populations between 500 and 1,000. In addition to these towns there are 14 other smaller towns and villages in the county. All of the towns and villages of the county depend mainly upon agriculture for their existence, though a few of them draw part of their support from manufacturing industries. The manufacture of condensed milk is carried on at Sheridan. Arcadia has a fruit canning establishment and a glass factory. At Westfield there is a cannery, and a mill for the manufacture of sorghum and cane molasses.

The shipping facilities of the county are excellent. The Indianapolis and Michigan City division of the Lake Erie and Western Railroad runs north and south through the center of the county. The Central Indiana Railway passes through the area east and west, a little south of the center of the county. The latter railroad crosses the Lake Erie and Western Railroad at Noblesville. These two lines furnish the chief outlets for the products of the county. A main line of the Chicago, Indianapolis and Louisville Railway (Monon route) enters the county near the southwest corner and traverses the southwest and central-western townships. Carmel, Westfield, Hortonville, and Sheridan are situated on this road. At Westfield it intersects the Central Indiana Railway. An interurban line of the Indiana Union Traction Company traverses the county in a general north and south direction, passing through Carmel, Noblesville, Cicero, Arcadia and Atlanta. It affords freight and express accommodations and is a valuable means of shipping dairy and other farm products to Indianapolis and other cities.

The present road system of Hamilton County has developed from the toll pikes which at one period prevailed in the county. A number of pikes radiate from Noblesville. Chief among these are the roads connecting the county seat with Fortville, Greenfield, Anderson, Pendleton, Lapel, Elwood, Tipton, Frankfort, Lafayette, Lebanon and Indianapolis. Within recent years these pikes have been purchased by the county and thrown open to the public. At the present time they are the main highways. From time to time the sectionized road system has added new local roads wherever needed. As a result every part of the county is easily accessible. Most of the roads have been surfaced with gravel and are in excellent condition. There are unlimited quantities of gravel available for road and other construction.

Climate.

The average annual temperature of Hamilton County is 55° F., the absolute maximum 106° F., and the absolute minimum—25° F. Hot spells occur during June, July and August, but rarely last any great length of time. Periods of extremely dry weather with relatively high temperature are sometimes experienced. Zero weather is not common and periods of such low temperature seldom last more than a day or two.

The average annual precipitation for the county is 41.9 inches. May, June, and July are the months in which the greatest amount of railfall occurs, but the precipitation is distributed rather uniformly through the year.

The length of the growing season is about 5½ months, the average date of the first killing frost in fall and the last in the spring being October 19 and April 16, respectively. During the period for which records have been kept, the earliest date of a killing frost in the fall was September 21, and the latest in spring May 22.

The following table gives salient climatic data of the region, as shown by the records of the Weather Bureau Station at Indianapolis, about 20 miles from the center of Hamilton County:

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT INDIANAPOLIS.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	33	68	—15	3.0	4.1	0.9	5.1
January	28	69	—25	2.8	1.6	4.9	6.9
February	31	72	—18	3.3	1.6	4.6	4.4
Winter	31	....	....	9.1	7.3	10.4	16.4
March	40	82	0	3.8	4.2	7.4	3.6
April	52	87	19	3.4	3.2	2.3	1.2
May	63	96	31	4.0	2.4	5.1	0.1
Spring	52	....	....	11.2	9.8	14.8	4.9
June	72	100	39	4.4	3.5	7.5	0.0
July	76	106	48	4.2	0.8	7.5	0.0
August	74	101	46	3.2	3.6	5.9	0.0
Summer	74	....	....	11.8	7.9	20.9	0.0
September	67	98	30	3.3	0.7	3.9	0.0
October	55	89	22	2.8	3.5	4.4	T
November	42	76	—5	3.7	1.2	2.3	1.6
Fall	53	....	....	9.8	5.4	10.6	1.6
Year	55	106	—25	41.9	30.4	56.7	22.9

Agriculture.

At the time of settlement the region of which Hamilton County is a part was for the most part heavily forested with hardwoods. Interspersed in this forest were occasional open prairies and swamps. In fact a considerable section of the county was originally poorly drained and unsuited for agriculture in its natural condition. A relatively large proportion of the land was, however, topographically well suited to farming and the use of labor saving machinery, and much of the forest has been removed and the poorly drained lands reclaimed. Some undrained areas still exist, but nearly all these are reclaimable and will ultimately be brought under cultivation.

The early settlers took up their claims along West Fork White River, as it gave them access to outside markets by raft or a flatboat. The bottom lands along the river were better suited to corn, than to other grains and this became the main crop. The bottom lands were subject to overflow and did not require fertilizing, and corn was grown upon the same land year after year without materially diminishing the yields. The uplands in the vicinity of the river were generally better drained naturally than the more remote uplands and when first cleared large yields were obtained. The cost of draining the "black lands" and in many cases the lack of adequate drainage outlets precluded the early use of these lands. However, much of the later prosperity of the county came from the occupancy and development of these lands, which began about 1875 with the deepening, straightening, and widening of the natural drainage outlets by dredging.

Wherever the surface is level it generally has been necessary to make use of artificial means. At first open ditches were employed, but the disadvantages of having the fields cut up with them led to the installation of tile drains. Thousands of dollars have thus been expended in reclaiming the so-called "black lands" and bottom lands along the shallower stream courses.

Corn has always been the main crop of the area, and the aim of the majority of farmers is to further increase the production of this staple. The acreage of corn in 1879 was 60,479, with a total production of 2,233,158 bushels, or an average of about 37 bushels per acre. According to the census of 1910, the acreage had increased to 77,815 acres, from which a production of 3,857,667 bushels, or an average of about 50 bushels per acre, was secured. This increase in the yield per acre is due largely to the increase in corn acreage upon the "black lands" (Clyde soils), considerable areas having been drained and brought under cultivation in recent years. These soils produce approximately twice as much corn as the lighter colored clay soils (Miami soils). The increase is also due to better cultural methods, including fertilization and seed selection. Some commercial fertilizer is being used in the production of corn, but barnyard manure is chiefly employed. Fertilizers may be used with profit to increase the yields of corn, but other methods of maintaining the fertility of the soil should also be employed, such as crop rotation, green manuring, etc.

Selection of the variety of corn best suited to the soil on which the crop is to be grown is an important factor in increasing the yields. Too often no attention is given to this matter or to the testing of seed corn. The seed, to produce the best results, should be strong in vitality and the kernels graded to uniform sizes so as to drop evenly when used in the planter. In general, Reid's Yellow Dent, Leaming, and Boone County White are well adapted to the climatic conditions of the county. The best varieties to grow on the different kinds of soil can best be worked out by the farmers themselves. The seed corn selected from the clay lands should be planted on the clay lands so far as practicable, and that selected from the "black lands" should also be kept for the black lands. Well selected home grown seed is generally preferable to any other on any soil. By this method it is believed that the quality and yields from these lands can be increased.

The application of two or more tons of ground limestone to the acre, particularly on the clay lands, will increase the yields of corn, largely through the better growth of clover that will be produced. Subsoiling of the clay lands is also recommended. Phosphoric acid and potash are the fertilizer ingredients that produce the largest increase in the yield.

Corn is generally planted with the check drill so that it may be cultivated both ways, which frequently does away with hoeing. Three or four cultivations are usually given although five are not uncommon. Riding cultivators are in general use. In the last few years a large per cent of the corn has been cut for ensilage. This practice is being extended as the value of silo feeding becomes better understood. The planting of cowpeas and soy beans in the corn for ensilage is being practiced extensively. The advantage of having a legume growth in connection with corn can readily be appreciated as it adds organic matter and nitrogen to the soil.

The acreage in wheat in Hamilton County in 1879 was 36,988 acres as compared with 30,827 in 1909. The average yield of the earlier year was about 21 bushels, and in the later about 18 bushels per acre. In order to produce the largest yields of wheat on the clay lands, which embrace the types of soil best suited to the crop, they should be subsoiled if possible every three years. The application of two tons or more of finely ground limestone to the acre, as recommended for corn, will be equally beneficial to the wheat crop. The general practice is to apply lime or finely ground limestone to the wheat ground prior to seeding. The effect is particularly noticeable upon the following clover crop and subsequent wheat crops are benefited by the increased productiveness of the land due to the addition of organic matter and nitrogen by the clover crop. More attention should also be given to the selection of suitable varieties of wheat for the soil and a proper grading of the seed. The rotation to follow, and fertilization, treatment of seed for disease, and the combating of insects which attack the wheat are important factors in the production of this crop. The Purdue Experiment Station recommends the use of: 300 pounds per acre of a fertilizer analyzing 2 per cent. nitrogen, 8 per cent.

available phosphoric acid, and 2 to 4 per cent. of potash. This can be applied at time of seeding by using a drill with fertilizer attachment. When clover has been turned under for corn and the latter is followed by wheat an application of nitrate is generally advisable. This can best be supplied by a top dressing of nitrate of soda in the spring, using 50 to 100 pounds per acre. Where barnyard manure is used it is best to turn it under with the clover sod preceding the planting of corn. The most profitable results from the use of commercial fertilizers with wheat are obtained where this practice is followed.

Oats are not generally considered a paying crop, but this grain fits in well with the customary rotation of crops. The crop is valued chiefly for the straw, and when cut for hay it makes an excellent roughage feed to use in conjunction with ensilage. The ordinary yield of oats ranges from 30 to 40 bushels per acre. The growing of cowpeas and soy-beans as a substitute for oats is being tried by some of the more progressive farmers. Oats are generally sown with an end-gate attachment at the rate of 2½ to 3 bushels per acre.

The production of hay as shown by the 1910 census, is only about one-fourth that grown in 1880. In 1910 the number of acres of clover hay is given as 2,667, which means that only one acre in ninety is used for this purpose. It is evident from this that clover is not generally included in the rotation of crops, or if so it is turned under without being cut for hay. The latter practice was not observed during the course of the survey.

The growing of alfalfa has received some attention in the county in recent years, but its value as a feed has evidently never been realized or its culture would be more general. It is especially well adapted to the second bottom lands or high terraces along West Fork White River. However, with proper attention it can be grown on almost any soil in the county except the muck. Even if it is not grown as a money crop its value as a nitrogen storing agent should recommend its culture, especially upon the clay lands or lighter colored soils of the county. It is never advisable to sow alfalfa after the 10th of August, for unless it makes considerable growth before frost, it is liable to winter-kill. It may, however, be sown as early as the latter part of April. Where it is sown on wheat land it is practicable to get the seed in between July 15th and August 10th.

Hamilton County is becoming more and more a dairy country. There is no better hay for dairy stock than alfalfa. The crop also has a high value in the permanent upbuilding of the soil, particularly those soils which are lacking in humus, as is the case with all the light colored soils of the area. Three to four cuttings a year can be made with a yield of three to four tons per acre.

To succeed with alfalfa it is necessary first that the land be well drained, second that it be limed, third that it be thoroughly inoculated, and fourth that it be thoroughly prepared and free from weeds.[1]

With proper attention fruit growing can be made a profitable industry in this county, particularly in the southern part. It has not flourished recently. There are many old and neglected orchards in the county, and diseases and insect pests spread from these and affect the more recent plantings. Modern methods of control and state inspections are needed to put the industry on a satisfactory basis.

Most of the farmers in Hamilton County follow some form of crop rotation. It should be the purpose of a crop rotation, 1st, to get larger yields and profits, directly or indirectly; 2nd, to distribute the work more evenly throughout the year; 3rd, to give a more certain and regular income than is possible with a one crop system; 4th, to maintain or better to increase the fertility of the soil; 5th, to reduce to a minimum the injury from weeds, insect pests, and diseases that frequently accompany the shiftless methods of farming. The three main classes of crops to be considered in a rotation are, 1st, small grain; 2nd, hay, and 3rd, cultivated crops. In planning a rotation it is necessary to consider the income, the needs of the land, the feed required by the stock, and the effect of each crop in the rotation on another. It is thus a question requiring more particular study of individual problems than can be given in the prosecution of the soil survey. Every rotation should, however, include at least one legume as a soil enricher.

The price of land has advanced rapidly in the past few years and but little of it can be bought for less than $150 an acre, and where it is well improved from $200 to $225 is often asked. The more prosperous farmers are satisfied with their holdings and refuse to put a price upon their land. The demand for suburban property, particularly in the vicinity of the main transportation lines, will undoubtedly cause a steady advance in the price of land. As an index of the prosperity of the farmers it may be stated that mortgage, indebtedness secured by farm property in the county decreased nearly 40 per cent. between 1908 and 1909.

[1] For detailed information regarding the growing of alfalfa see Farmers' Bulletin No. 339.

Farm hands are paid from \$20 to \$25 a month, besides board, lodging, washing, and feed for a driving horse. Harvest hands and extra helpers receive from \$1.50 to \$2.50 per day. The manufacturing plants and public works in Indianapolis have drawn heavily upon the labor of the county, so that desirable farm labor is scarce. Most of the work is done by the owner and his family.

SOILS.

Hamilton County is covered with a mantle of till varying in thickness from a few feet in the eastern portion of the area to as much as 300 feet in the north and west portions. The mean average thickness is about 100 feet.

The glacial till is a stiff compact, clayey, matrix with which is mingled sand, gravel, and bowlders in varying proportions. Some of the rock is of local origin, but other kinds, for instance, granite, gneiss, and trap rock, also found imbedded in the till and strewn over the surface, have been brought from the Lake Superior region, whence they were carried by the ice. In the eastern half of the county the Niagara limestone underlies the glacial deposits, and the rock outcrops in the valley of West Fork White River above and below Strawtown, and in the valleys of Fall and Stony creeks. It appears near the surface at a few other points in the area. The Devonian measures underlie the till in the western half of the county, but are not exposed at any point.

It is from the glacial till that the upland soils of the area have been derived. The alluvial soils or bottom lands represent stream deposited material composed largely of wash from the upland soils. The underlying rocks have directly contributed little if any of the materials of which the soils of Hamilton County are composed, but they may have contributed to the ice-ground mantle covering the uplands from which the various types are derived.

The drift or till is largely of foreign origin and is more or less general in distribution. It is said to belong geologically to the late Wisconsin stage of glaciation and represents materials which were ground and mixed by the sheets of ice which in prehistoric time advanced over this region as a great ice sheet or glacier. On melting there was left a mass of finely ground rock material. Since this time the mantle of glacial debris has been acted upon by the various agencies of weathering, water, air, vegetation, change in temperature, etc., and changed to give the present soils. The more uniform silty surface layer is frequently underlain at about 2 to

6 feet by sandy or gravelly material. This accounts for the high content of silt in the upland soils. The bottom lands, along the larger streams, are more sandy, owing to the wash, not only from the silty upland soils but from exposures of the coarser substratum. Where the drainage has been more sluggish along the smaller streams the bottom lands are also quite silty.

Five series of soils were mapped, including the Miami, Clyde, Fox, Waukesha, and Genesee. In addition the miscellaneous soils Meadow and Muck are encountered.

The Miami series is the most extensive in point of area. This series, including two types, the Miami silt loam and Miami loam, is characterized by the brownish color of the surface soil and the lighter brown or yellowish-brown color of the subsoils. The soils occupy undulating to gently rolling to nearly level, well defined areas. The material is derived from glacial till.

The Clyde soils, which also represent an extensive upland series, including the loam and silty clay loam types, are derived from glacial till, but they differ from the Miami in having black soils rich in organic matter. They occupy poorly drained situations which have favored the accumulation of dark colored organic matter. There has been considerable washing in of soil material over the depressions, from the adjacent higher land. The overflowed first bottom lands were mapped as Genesee loam, Genesee silty clay loam, and as Meadow (Genesee material). The Genesee loam occurs mostly along West Fork White River and the larger streams, while the silty clay loam is found along Stony, Mud, and Fall creeks and some of the smaller streams. The Genesee soils are composed of brown colored alluvial material representing wash from the uplands which was deposited by stream overflow. The classification Meadow comprises alluvial material so variable in texture that satisfactory separation into definite types could not be accomplished. The material in the main, possesses the characteristics of the Genesee.

The Fox and Waukesha soils are confined to the stream terraces, the second bottoms, which were built up by the overflow waters when the streams were flowing at higher levels than at present, just as the present first bottoms are being built up by additional deposits from local successive overflow. The Fox series includes the brown colored terrace soils, while the Waukesha series includes the black soils. The Waukesha soils differ from the Sioux, which are also black terrace soils, in its mineralogical composition, containing less limestone material.

In the subsequent chapters the various types are described in detail.

Miami Silt Loam.

The surface soil of the Miami silt loam to an average depth of about 8 inches is a compact silt loam of light-brown color when wet, but having a grayish surface when dry. The soil below the surface is also frequently a grayish-yellow or creamy-yellow when partly dry. Below 8 inches and to a depth of 12 to 15 inches the color changes to grayish-brown, with a gradation in texture from the silt loam to a silty clay loam. Below this depth the subsoil is a yellowish-brown silty clay mottled with gray, grading into a darker brown friable silty clay containing an appreciable amount of sand and fine gravel. The darker brown material, bowlder clay, is encountered at 24 to 30 inches, where the surface is level to gently undulating and at 18 to 20 inches where the surface is more broken or hilly. The soil under the latter condition, however, approaches more nearly the Miami loam. Areas of this kind are found generally in the vicinity of stream courses.

Below 3 or 4 feet the substratum gradually becomes lighter, both in color and texture, and at a depth of 8 or 10 feet a large per cent. of the soil mass is made up of sand and gravel. Below this a stratum of drab to bluish clay is frequently encountered, which in turn is underlain by strata of sand and gravel. The latter condition is more general along the stream courses. The deposits are less stratified farther back from the stream valleys.

The Miami silt loam, being derived from glacial till, is fairly uniform throughout the county, but slight local variations in the surface soil exist as the result of inequalities of drainage. Upon the crests of the knolls and ridges the soil is more sandy, with a few chert, granite, and quartz pebbles strewn upon the surface. Where the type occurs as level or slightly undulating areas, the surface soil often presents a leached or ashy colored appearance, due to its natural poorly drained condition. It is not as productive as the better drained areas in which the soil is darker colored. Where the drainage is inadequate the subsoil is mottled, cold, and heavy, while in the case of the better drained areas, the subsoil is darker, frequently of a yellowish-brown color and is more open and porous, allowing a freer circulation of air and water. Such conditions render it more productive.

The Miami silt loam is the most extensive type in the county and includes a greater part of the better drained uplands. It is distinguished by its light color and is known locally as ''clay'' land. The term thus applied probably has reference to the tendency of the soil to clod if plowed when wet, as its texture is that of a silt loam and not a clay. The tendency of the soil to run together is due mainly to the insufficiency of organic matter.

The Miami silt loam is not only the most extensive but also the most widely distributed type in the county, being found in all parts except along the larger streams, where a similar though lighter textured soil of rolling surface occurs. Throughout the northern half of the county the Miami silt loam is fairly evenly distributed with the Clyde silty clay loam, but in the southern, particularly the southwestern portion of the county, the area of this type far exceeds that of all others. In the more nearly level sections it occurs as low, flat ridges and knolls interspersed with the ''black lands,'' or Clyde soils. The type is best developed in the southwestern portion of the county along the Marion County line.

In the early settlement of the county the pioneers naturally preferred this soil to the ''black lands,'' because of its better drainage. When first cleared it was darker in color than at present, being rich in humus, and was very productive. Continued cropping, frequently without rotation has largely depleted the humus supply. To this is due its light color or leached appearance, the low yields of certain crops, and the tendency of the soil to run together when wet and to bake or clod upon drying. The latter condition can never be remedied until sufficient organic matter has been incorporated with the soil to keep it loose and mellow. Liberal applications of finely ground limestone will aid in mellowing up this soil as well as help to stimulate the action of bacteria in storing nitrogen in the roots of clover and other leguminous crops. This soil showed a decided acid reaction wherever tests were made, indicating the need of lime. Ground limestone can be used to advantage for this purpose. Applications of phosphatic fertilizers, either as ground phosphate rock, or in the more soluble form of acid phosphate, should increase the yields. Subsoiling, supplemented by deeper plowing each year will aid materially in increasing the water holding capacity of the land.

The existence of the Miami silt loam in any particular field can usually be told by the early growth of corn, oats, clover, etc. It will be noted that the black land areas, the Clyde soils, produce a much more vigorous growth of these crops, and this is reflected in the yields, a mean average for several successive years showing that the yields of corn, oats, and hay from the Miami silt loam are but little more than half as great as obtained from the Clyde silty clay loam. This is offset to some extent, in the case of the grains, by the better quality of the product of the Miami soil. This type is well adapted to wheat, and the best soil in the county for that crop.

The growing of sorghum for molasses gives promise of being an important industry in the vicinity of Westfield. The lighter phase of this type is particularly well adapted to this purpose, as it produces a mild-flavored, light-colored sirup.

While larger yields of tomatoes are obtained on the Clyde soils, a finer and more highly flavored tomato is produced on the lighter colored soils, where the vine growth is less luxuriant. The tomatoes grown on the Miami are less subject to decay than those grown on the darker Clyde soils. Peas as well as tomatoes, are grown on this soil for market and canning. Ground limestone or burned lime improve the yields and quality of the products.

A winter cover crop of some kind should always be sown upon this type. Wheat is generally used for this purpose, but rye to be turned under in the spring where corn is to follow, makes an excellent crop for the purpose. If this practice is followed there will be less tendency for the soil to clod.

The Miami silt loam is not generally valued as highly as the black lands, the average price being about $150 an acre. Adjacent to the towns and villages it commands a higher price. Some of the best improved farms in the county are located upon it and where up-to-date methods are being employed the returns from this soil are being increased, the crops being more certain than upon the Clyde soils.

The native forest growth consisted of beech, black walnut, white oak, yellow poplar (tulip), sugar maple, white ash, chinquapin oak, red oak, shell bark, hickory, hazel nut, pawpaw, redbud, wild plum, and dogwood. Only small scattered areas of forest remain.

Miami Loam.

The surface soil of the Miami loam, to an average depth of 10 or 12 inches is a brown to yellowish-brown silty loam or loam, grading into a darker silty clay loam. Below 18 to 20 inches the subsoil is a dark-brown friable silty clay to sandy clay with an appreciable amount of fine gravel. The content of sand and gravel increases with depth so that below 3 or 4 feet a lighter colored gravelly loam is encountered. Erosion, which tends to remove the finer material from the till, has been the main factor in differentiating this soil from the Miami silt loam.

This type occupies the more rolling uplands in the vicinity of the larger stream courses, and the larger morianic ridges throughout the area. It is confined almost entirely to the southern half of the county where the rivers and creeks have cut deeper into the glacial till plane, causing more active erosion in the vicinity of their stream valleys.

This type is rolling to hilly, the greatest relief being found along Hinkle Creek in the vicinity of Deming. No definite boundary exists between it and the Miami silt loam, the change from one to the other being very gradual, both as regards texture and topography. The texture does not always follow the rolling topography, for even these rolling areas are sometimes quite silty and could easily be classed with the Miami silt loam in this respect. In the vicinity of West Fork White River a level to undulating plane is sometimes encountered where the soil is darker in color than the Miami silt loam, but otherwise like that type. This intermediate phase of the types is well drained and is quite productive.

The Miami loam as a whole is probably better suited to fruit culture than to general farming, as it is often too rolling for the successful use of machinery. Existing orchards are profitable. The dark colored phase described above is one of the best wheat soils of the county.

In some places this type is sufficiently steep to warrant its being terraced, but no terracing is practiced in the area to prevent washing of the hillsides. The steeper slopes should be kept in sod whenever it is practicable to do so.

Clyde Loam.

The surface soil of the Clyde loam to an average depth of 10 inches is a black loam to silty clay loam. This grades into a bluish-black silty clay loam. This in turn is underlain at 18 to 20 inches by a drab or gray silty clay, mottled with yellow or brown. In the lower depths the mottling is darker. Below 30 to 36 inches the subsoil becomes lighter in texture, being often a fine sandy clay. The water table is frequently encountered at this depth, so that the clay is soft and putty-like.

The dark color of the surface soil is due to the high content of organic matter. The soil when wet has a slightly pasty consistency for the same reason. The amount of this organic matter, however, is not sufficient to justify its correlation with the Muck, although the two are sometimes confused by the farmers.

The Clyde loam is commonly referred to as prairie land, similar lands being called wet prairie in other parts of the State and in Illinois. The term prairie as applied to these areas has reference to their original treeless condition. They represent depressions or swamp lands which in their natural state were covered with water a greater portion of the year. Hay was cut from the better drained areas by the early settlers, and was the chief source of this crop at that time. The native vegetation consisted largely of sedges, grasses, cattails, flags, "button bush" and willow. The annual decay of this vegetation has supplied the store of organic matter found in the soil.

Where the soil is loose and mucky it is generally "chaffy" or fluffy. Corn grown upon these areas burns or turns yellow before it is fully matured. This condition is more noticeable when the land is first put under cultivation. The free use of barnyard manure, deeper plowing and thorough cultivation to increase aeration of the soil as much as possible will tend to correct this chaffy condition. The liberal application of potash fertilizers is also recommended as a means of increasing the yields from this type.

The occurrence of this type in Hamilton County is limited to a small body about one-half mile west of Sheridan, which has been reclaimed by artificial drainage. It is used mostly for corn and oats. Being situated near the town of Sheridan, with ample railroad facilities, trucking would be more profitable, as this soil is particularly well adapted to cabbage, beets, turnips, Irish potatoes, cauliflower, celery, etc. The only other area mapped is located in Section 8, T. 19, R. 5.

Clyde Silty Clay Loam.

The Clyde silty clay loam includes a greater part of what is known locally as the "black lands." It was originally of a semi-swampy nature but in recent years it has been drained artificially and now constitutes one of the most productive types in the area. It is particularly well adapted to corn. The term "black land" as applied to this type has reference to the dark color of the surface soil, the result of its high content of organic matter, which accumulated as vegetable remains when these areas were in a semi-swampy condition.

The surface soil of the Clyde silty clay loam to an average depth of 8 inches is a dark-brown to almost black heavy silt loam to silty clay loam. As the surface dries it has a grayish-black appearance. The dark color of the soil is proportionate to the percentage of organic matter present. The latter affects also the chemical and physical properties, the soil being enriched by this material, and its power to hold water increased. The subsoil from 8 to 20 or 24 inches grades from bluish-black to drab or gray, with brown iron strains below 12 to 15 inches. The texture of the subsoil for the first few inches is a silty clay loam which in turn is underlain by a stiff, plastic clay to a depth of 24 to 30 inches. Below this depth a gradual transition from the stiffer clay to a deeply mottled lighter textured silty to fine sandy clay is encountered. Where this type follows the natural drainage channels it is generally underlain by sand and gravel at various depths, the average depth being 6 to 8 feet. The gravel and sand is usually highly stained with iron.

Although the Clyde silty clay loam is derived from the same materials as the Miami silt loam—glacial till of the late Wisconsin period—topographic differences are sufficient to form distinct types of soil. The former type occupies the lower lying areas or depressions in the uplands, originally deficient in drainage, while the better drained uplands are largely occupied by the Miami silt loam. During the early settlement of Hamilton County the Clyde silty clay loam was covered with water or semi-swampy during certain seasons of the year and little or no agricultural value was attached to these lands. But with the building of good roads and adequate drainage outlets the type has been gradually brought under cultivation and now includes some of the most productive and high priced lands in the area. Farms often bring as much as $200 to $225 an acre, and the selling price is frequently based on the number of acres of black land they contain.

The Clyde silty clay loam is darker in color and heavier in texture where the surface soil is only 6 to 8 inches deep. The percentage of organic matter is greater near the center of the areas or at the lowest point.

This type occurs widely distributed over the county, but the main bodies are confined chiefly to the northern and eastern portions. In the vicinity of Sheridan it is the predominating type. Between Cicero and Duck creeks its acreage is about the same as that of the Miami silt loam. In the eastern and southeastern parts of the county the latter type predominates, while in the southwestern part, its extent is proportionally less. The type occurs as irregular shaped bodies throughout the uplands.

The Clyde silty clay loam is especially well adapted to corn, and yields of 60 to 80 bushels per acre are not infrequent. Oats produce a heavy stand and lodge badly in rainy seasons. If the season is favorable, 50 to 60 bushels per acre are generally obtained. Clover produces a rank growth and with timothy produces from 1½ to 2 tons or more hay per acre. In the vicinity of the towns in which canning factories are located this type is used extensively for growing tomatoes, chiefly because of the heavier yields. For domestic use where a firmer tomato is desired they should be grown upon the lighter colored Miami soils. Tomatoes grown upon the Clyde soil decay more readily, and during wet seasons much of the crop is lost in this way.

Where commercial fertilizers and barnyard manure are to be applied it is better to use the commercial fertilizers upon the Clyde silty clay loam and the barnyard manure on the lighter colored soils, which have a lower content of organic matter. For use upon this type a mixture having 8 to 10 per cent. of phosphoric acid and 4 to 5 per cent. of potash, is recommended. Nitrogen is not generally needed, and where its use is advisable can best be supplied by growing legumes in the rotations.

The surface of this type is flat to depressed, and artificial drainage is required to remove the surface waters. Open ditches were first employed, but these have generally been replaced in recent years by tile drains.

With proper drainage and liming alfalfa could be grown upon this type, but since it is used so extensively for corn and oats, legumes that occupy the land for shorter periods, such as clover, vetch, cowpeas, or soy-beans, are probably more profitable.

The native forest growth consisted of swamp white oak, white elm, swamp pin oak, silver maple, bur oak, black ash, cotton wood, green ash, prickly ash, and willow. Spice bush, button bush, and wild rose are characteristic plants of smaller growth.

Fox Gravelly Sandy Loam.

The surface soil to a depth of 10 inches is a brown gravelly sandy loam. The subsoil is a brown gravelly sandy clay.

This type is very open and porous and admits of a free circulation of air and moisture. The substratum below 3 to 4 feet is more often a coarse gravel so that its natural drainage is adequate if not excessive. In dry weather this soil suffers from drought, but by keeping it well stocked with organic matter this difficulty may be overcome to some extent.

The Fox gravelly sandy loam occurs upon the high terraces on the north side of West Fork White River in Secs. 16, 19, 20, T. 19, R. 5.

It occurs in small bodies associated with the Fox loam and has a limited acreage in the county. It forms narrow strips.

This type would be well suited to trucking, being especially well adapted to sweet potatoes, watermelons, cucumbers, cantaloupes, and other crops requiring a light-textured, friable soil.

Fox Gravelly Sandy Loam—Poorly Drained Phase.—The Fox gravelly sandy loam, poorly drained phase, occupies only a few acres of the S. W. ¼ of Sec. 23 and the N. W. ¼ of Sec. 26, T. 18, R. 4. The surface soil to a depth of 6 or 8 inches is a grayish-brown, coarse sandy loam or gravelly sandy loam, the percentage of sand and gravel being quite variable over small areas. The subsoil ranges in texture from a gravelly sandy loam to a light-gray, iron-stained sandy clay. The texture is heaviest at 20 to 24 inches. Below this the material becomes more sandy and in the lower depths very gravelly. In some places the subsoil is mottled with bluish and drab colors, but for the most part it is light gray. Where this soil is plowed a rather high percentage of fine to medium gravel accumulates on the surface.

The poorly drained phase of the Fox gravelly sandy loam requires drainage to improve its physical condition. Undrained areas are cold and soggy. The place occurs on second terraces of West Fork White River and is made up of reworked sedimentary materials assorted and laid down by the river at the time when it flowed at a higher level than at present.

This type is at present valued chiefly for the production of hay, but is sometimes used for corn. It cannot be rated as a strong soil and can probably be best reserved for pasture and hay production.

Fox Loam.

The soil of the Fox loam to an average depth of 12 inches, is a mellow brown to yellowish-brown light, silty loam or loam, grading into a yellowish-brown silty clay loam. At 18 to 20 inches the subsoil is a brown friable silty clay to gravelly sandy clay, similar to the bowlder clay which underlies the Miami silt loam. Below 3 to 4 feet a coarse gravelly sandy loam is encountered, which in turn is underlain by coarse gravel.

The Fox loam occupies high terraces along the larger streams in the southern part of the county. A greater proportion of the type is found along West Fork White River.

The Fox loam is known locally as second bottom land, although it occurs on both the second and third terraces above the river. It is also called "sugar tree flats." The boundary between it and the Genesee loam is very distinct. In some places it rises to 30 feet or more above the first bottom lands. The boundary between it and the upland types is not so marked, although in some places a fairly well-defined bluff or sharp slope, 10 or 20 feet high, was observed. The surface is generally level, except along Fall Creek in the southeastern part of the county, where the surface is more undulating.

The Fox loam differs from the Miami silt loam in that the surface is coarser in texture and darker in color. The soil contains less silt and the subsoil a much larger percentage of gravel than either the Miami silt loam or Miami loam. The open, porous nature of the subsoil allows a freer internal movement of moisture, the type warms earlier, and crops make a more rapid growth. They are also somewhat more subject to injury by drought. This type reaches its maximum producing capacity in wet seasons, when the Clyde silty clay loam, Genesee loam, and other types are too wet to produce average yields. The Fox loam is very easy to cultivate and a mellow seedbed is readily obtained.

The Fox loam occurs on one or the other side of West Fork White River throughout its course. It is sometimes found upon opposite sides of the river, but in general it shifts back and forth from one side to the other. The town of Noblesville is located upon this type. The type is probably of alluvial origin, having been deposited when West Fork White River flowed at a higher level than at the present time.

The largest continuous body of this type occurs south of Noblesville, extending thence to the county line. This area is nearly 3 miles in width. The average width of the strip, however, is only about 1 mile. Narrow strips of the type are found along Stony Creek, a considerable acreage of it along Fall Creek, and smaller areas along Mud Creek and Cool Creek, the former, a tributary of Fall Creek.

The Fox loam is a good general farming soil. It is used for the production of corn, hay, oats, and wheat, being better adapted to the latter. Alfalfa does especially well upon this type, but for the best results it must be limed frequently. Alfalfa well tended should yield better returns from this soil than from any other type in the county. The soil is also well adapted to potatoes, tomatoes, peas, and beans and other truck crops, and their culture should be extended. A large proportion of the type has easy access to the Indianapolis markets.

Land of the Fox loam type is valued at $150 to $175 an acre, although some of it is held as high as $200 or more an acre.

The native timber growth was largely hard maple, from which fact it takes the local name "Sugar Tree Flats." The native forest included also white oak, beech, black walnut, and other hardwood species.

Waukesha Silty Clay Loam.

The surface soil of the Waukesha silty clay loam, to an average depth of 9 inches, is a dark-brown to black, heavy, silt loam or silty clay loam. The subsoil is a bluish-black silty clay grading into a drab-colored material. Below 30 inches it is of a lighter gray color and slightly sandy. The Waukesha silty clay loam is similar in general appearance and texture to the Clyde loam, except that in most areas it is not quite so dark in color.

This type occurs as low-lying or depressed areas along the outer margin of the higher terraces of West Fork White River. It is confined to the southern part of the county, where the second terraces have their greatest development, being found in Secs. 27, 33, and 34, T. 18, R. 4, and in Secs. 7, 8 and 9, T. 17, R. 4. To its depressed surface and the annual accumulation of decayed vegetable matter is due its dark color and loamy structure. A small area is also found along Prairie Creek in Secs. 13, 23, and 24, T. 19, R. 5. Its position upon the terraces along West Fork White River and particularly near the confluence of some of the smaller streams with the river indicates that the material consists of old alluvium.

Most of this type has been reclaimed by artificial drainage and devoted to corn culture. Heavy yields are obtained. In small areas, throughout the type, the soil is inclined to be "chaffy." This unfavorable condition can be gradually remedied by deeper plowing and by liberal application of barnyard manure, as was suggested for the Clyde loam, where similar chaffy conditions are found. The use of ground limestone and potash fertilizer, properly applied, would also increase the yields from this type.

Thus far the cultivation of this land has been confined largely to the growing of corn, though some oats and hay are produced. The yield of corn is heavy, averaging 50 to 60 bushels per acre. Oats make a luxuriant growth and lodge badly. Grasses also produce a rank growth and the quality of hay is not generally as good as that grown upon the uplands, or upon the Fox loam. Owing to the natural fertility of this land and the growing demand for corn, the tendency is to keep the fields in this crop almost continuously. In time the present high yields will be reduced unless crop rotation is practiced.

Genesee Gravelly Sandy Loam.

The surface of the Genesee gravelly sandy loam, to a depth of 15 to 18 inches, is a brown to dark brown gravelly sandy loam, very similar in texture to the Fox gravelly sandy loam. The subsoil varies from a gravelly sandy clay to a gravelly loam. Below 24 to 30 inches it is more often a coarse gravel.

The Genesse gravelly sandy loam occurs in small bodies in the first bottoms along West Fork White River. It is subject to overflow and additional deposits of the coarser materials borne by the river are constantly being laid down over the surface.

This type is open and porous and air and moisture circulate freely through it, and drainage is adequate if not excessive, owing to the underlying gravel. The water table is generally near enough the surface, however, to be within capillary reach of the root zone and the crops are able to withstand ordinary periods of droughts.

The Genesee gravelly sandy loam is used with the Genesee loam for growing corn, and oats or for pasture. The land being subject to overflow, fertilization is not so necessary as on the upland soils.

Only a small acreage of this type is found in the county. It occurs as narrow strips along West Fork White River in Sec. 2, T. 19, R. 5, northeast of Strawtown, and in Secs. 21 and 30, T. 19, R. 5 and Sec. 36, T. 19, R. 4, north of Noblesville, and Secs. 1, 12, 23, and 26, T. 18, R. 4, south of Noblesville.

Genesee Silty Clay Loam.

The Genesee silty clay loam occurs largely along the smaller streams, and is the heaviest first bottom land type in the county. The surface soil, to a depth of 10 or 12 inches, is a brown, heavy silt loam to silty clay loam. The subsoil is a brownish silty clay grading into a drab or steel-blue stiff plastic clay, mottled with dark-brown or reddish-brown iron stains. The color of the subsoil becomes lighter with depth. Along Stony Creek the subsoil contains an appreciable amount of sand in the lower depths. The soil along this creek is also less uniform in texture than elsewhere. Where the areas lie above the level of usual overflow the soil is a light-brown loose silty loam to 18 or 20 inches, below which it is a drab, mottled silty to sandy clay.

The Genesee silty clay loam forms the first bottom land along Little Cicero, Taylor, Stony, Mud, Cool and Dismal creeks, Dry Branch, and other small streams. It occurs as narrow strips, the valleys being seldom more than one-eighth to one-fourth mile in width. The largest area occurs along Mud Creek above the mouth of Sand Creek. It is in this body that the type finds its most typical development.

The Genesee silty clay loam like the other first bottom soils, is of alluvial origin, the material being derived largely from reworked glacial till deposited by the streams along which it occurs. Only a small per cent. is washed in from the adjacent uplands. Near the banks of the streams lighter textured materials, generally occur, and where it was of sufficient extent to map separately it was included with the Genesee loam. The heavier materials were deposited in the outlying bends and wider portions of the valleys. Most of the streams along which this type occurs have been straightened and deepened by dredging, so that practically all of the land which was formerly poorly drained is now under cultivation.

This type is especially well adapted to corn, and some of the largest yields of the county have been obtained from this type. Yields of 80 bushels per acre are not infrequent, though the average is probably close to 60 bushels per acre. Heavy yields of oats are sometimes obtained from this type, but the late springs and wet condition of these bottom lands frequently prevent the planting of this crop. It is an excellent grass soil and an average of 2 tons of hay per acre is obtained. As much of it is subject to overflow, it does not require as heavy fertilization as the upland soils.

If this type is cultivated under normal moisture conditions a good loose tilth is obtained, but if plowed wet it forms large, compact clods which cannot be readily broken down by subsequent cultivation. Too often the farmers in their haste to get in their crops, disregard this matter of moisture condition, and the physical condition of the soil is thus frequently impaired for more than one season.

The native vegetation upon this type consists of swamp, white oak, silver maple, bur oak, white elm, swamp or pin oak, black ash, cottonwood, and other hardwoods.

Genesee Loam.

The Genesee loam includes the greater part of the first bottom lands along the larger streams. It occurs chiefly along West Fork White River, Cicero and Fall Creeks.

The surface soil of this type, to an average depth of 12 to 15 inches, is a medium brown to dark-brown loam, underlain by a yellowish-brown silty clay or sandy to sandy clay or clay loam. Below 24 to 30 inches sand and gravel are frequently encountered. The type is subject to local variations over small areas, owing to the unevenness of distribution of the alluvial materials. Where the first bottom lands are narrow and the currents at times of overflow are swift the alluvial materials thus deposited are coarser, the texture being more often a medium to fine sandy loam, but in the outlying bends where the waters are less turbulent the soil is heavier and is more nearly a light silt loam or heavy loom. The subsoil is also quite variable, the soil being underlain frequently by medium to fine sand at various depths. This phase of the type occurs mostly in proximity to the stream courses.

The Genesee loam is found most extensively along West Fork White River, and Cicero and Fall Creeks. It also occurs as narrow strips along Little Cicero, Dock, Pipe, Mud, Cool, Williams and Hinkle creeks. The widest area is found in the Strawtown bend of West Fork White River, northwest of the town, where there is an area nearly a mile in width. The soil in this body is a rich brown loam, with a yellowish-brown subsoil. At other points along the river the areas are rarely more than one-fourth to one-half mile wide. Along Cicero and Fall creeks they seldom exceed a quarter of a mile in width, and along the other creeks much narrower strips exist. The soil in the smaller bottoms is sometimes influenced by wash from the adjacent uplands.

The Genesee loam is an alluvial soil, being composed of materials washed from the upland glacial soils and reworked and redeposited by the streams, along which it occurs. Except for a few small depressions or low sand ridges,, the surface is generally level. This type was formerly poorly drained but with the installation of tile drains, open ditches, etc., a greater part of the type is now under cultivation. The open structure of the soil and subsoil permits of the ready percolation of the surface waters, so that the soil dries out rapidly after floods.

The original timber growth was principally silver maple, white elm, sycamore, buckeye, red oak and hickory.

The Genesee loam is an easy soil to cultivate and breaks up readily into a rich mellow loam. The additions of fresh alluvium from year to year tend to keep the soil in a productive condition. Large yields of corn are annually obtained from the same fields. Oats and grass also produce well, the yield of oats ranging from 50 to 60 bushels, and of hay from 1½ to 2 or more tons per acre. Occasionally crop rotations are followed, but generally the fields are planted to corn year after year, or the land used for grass and pasture, being plowed only when the sod fails or the field is needed for corn. Wheat is sometimes grown upon this soil, but usually only on areas lying above overflow. This type is best adapted to the production of corn.

Near the learger towns or shipping points this type could be profitably used for trucking, being especially well adapted to watermelons, cantaloupes, potatoes, particularly sweet potatoes, peas, beans, tomatoes, etc. Alfalfa is being tried upon the higher portions of the type, which are above annual overflow and it is reasonable to expect that the results will justify the extension of the crop to a larger acreage. Cowpeas, soy-beans, vetch, and clover are all well adapted to the better drained areas and their inclusion in regular crop rotation should not be overlooked, especially where stock is to be fed upon ensilage.

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

MECHANICAL ANALYSES OF GENESEE LOAM.

No.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
281421	Soil	0.3	2.4	5.7	16.8	17.0	45.6	12.1
281422	Subsoil	.8	3.2	8.5	26.5	14.0	33.9	12.9

Muck.

The areas mapped as Muck are referred to locally as "made land." They are of very small extent in Hamilton County. The largest body occurs about 3 miles north of Noblesville, and is called Fox Prairie. Another considerable body is found along the upper course of Prairie Creek in the eastern part of the county. Small areas occur in Sec. 33, T. 20, R. 4; Secs. 10 and 15, T. 18, R. 4; Secs. 14 and 23, T. 18, R. 4; Sec. 5, T. 20, R. 3.

Muck consists mainly of vegetable remains in various stages of decomposition. It is black or dark brown in color, and varies in depth from a few inches at the margins of the areas to 3 feet or more at their center. There is but little change in color with depth, but the deeper material is usually in a less advanced stage of decomposition, resembling peat. The mass of organic remains is usually underlain by a bluish-black, stiff, plastic clay or silty clay which grades into a heavy drab-colored or gray mottled silty clay, or clay. In some places an impure shell marl is found in the subsoil or substratum. Along the margins of the larger areas considerable mineral matter in the form of fine sand and silt have become incorporated with the Muck.

Peat is occasionally found with the Muck, but in too small areas to be mapped separately. It represents a more fibrous and less decomposed mass of vegetable matter than Muck. It usually occurs near the center of the bodies of Muck where the accumulation of organic matter has been more recent and has not undergone as thorough decay, though it sometimes occurs in spots throughout a given area.

The areas occupied by these organic soils were at one time shallow lakes or ponds which have been gradually filled with the accumulated remains of different forms of aquatic vegetation.

The native sedges and grasses flourishing on the areas of Muck were the chief sources of hay for the early settlers. The water table was near the surface and the drainage was originally poor, but this has been remedied to a great extent by the construction of large open ditches which form outlets for many small tile drains. Further improvements may be brought about by the construction of open ditches along the margin of the swampy areas to intercept the drainage from the adjacent uplands and prevent the temporary flooding of the fields during heavy rains.

The greater part of the Muck has been brought under cultivation, though a few areas are still suitable only for pasture. Corn, oats, and timothy are at present the chief crops. Corn will yield from 50 to 60 bushels, and oats from 40 to 60 bushels per acre. The latter crop is not very successful, however, as the straw makes a rank growth and lodges badly. Timothy is easily seeded and does well, making a very rank growth. But it usually "burns" the ground and does not yield as much hay as other soils. Alsike clover is well adapted to this soil and should be grown in combination with timothy.

Early and late frosts are very injurious to crops grown on soils of this type. It is often necessary to replant corn two or three times, and early fall frosts sometimes prevent the corn from maturing.

This soil is especially adapted to onions, cabbage, celery, Irish potatoes, beets, turnips, cauliflower, and other garden products and has been successfully handled in the production of such crops in Northern Indiana and adjoining States, but transportation facilities in most cases hardly warrant the growing of such special crops for commercial purposes in the area.

Applications of potash salts and phosphatic fertilizers are very advantageous to these soils. Coarse barnyard manure and lime are also beneficial.

MEADOW *(Genesee material).*

Where the bottom lands are subject to frequent overflow the alluvium deposited is usually of a miscellaneous character and cannot be correlated with any established soil type. The term Meadow has been used to cover these conditions and as here employed denotes a generalized type embracing the low-lying, flat, poorly drained areas along certain minor stream courses. If shown in detail the included types would be classed with the Genesee soils. The predominating material is a heavy silt loam, dark brown in color. Because of its constant change from year to year, as the result of fresh deposits from overflows, there is a wide variation in the color, composition, and texture of the soil, as also in local drainage and surface conditions, and boundaries between Meadow and the other alluvial types of similar origin and topographic position must necessarily be arbitrary ones, and subject to future modification.

The subsoil is prevailingly a mottled drab or grayish silty clay somewhat heavier in texture than the soil. Near the stream channel it may be lighter in texture, but throughout most of the area subject to annual overflow the sediments are fine, so that soils are rather heavy.

Meadow areas in their natural condition are ordinarily too wet for cultivation, yet they are not permanently swampy. Most of this poorly drained land in Hamilton County has been reclaimed by dredging and straightening the stream channels. Corn is the chief cultivated crop upon such areas and where they are properly drained excellent yields are obtained. Where the valleys are deep and narrow and the surface is frequently broken in shallow depressions or marshy places, the chief value of the land is for pastures. Complete drainage of Meadow is not essential for this use, and the greater part of the Meadow in the county is being utilized in this way. The native forest growth consisting of silver maple, white elm, sycamore, and red oak, is usually allowed to remain.

The acreage of this type is very small. It is confined to a few narrow strips along Sand, Tharp, Hinkle, Mud, Prairie, Bear Creeks, and Long Branch, and the other small streams of the county.

SUMMARY.

Hamilton County is situated slightly north of the geographical center of the State of Indiana. It has an area of 399 square miles or 255,360 acres.

The surface varies from level to undulating, becoming broken near some of the streams, particularly in the southern part of the county along Hinkle and Fall creeks and West Fork White River. The elevation above sea level ranges from 800 to 950 feet.

West Fork White River and its tributaries control the drainage of the entire area. The river has a general southern course through the county.

The first settlement in the area was made in 1818. The county was organized in 1823. The greatest activity in settlement came in the fifties.

Noblesville, the county seat and chief business center, with a population of 5,073, is located near the center of the county. There are twenty other towns and villages in the area.

The population of the county is 27,026, of which about 15,000 is rural.

The county possesses an excellent system of free pikes and sectionized gravel roads, and there are only a few miles of unimproved roads within its borders. All toll roads have been abolished.

Transportation facilities are afforded by three railroads and one electric line.

There are a number of manufacturing industries in the county, but it owes its prosperity chiefly to its productive soils.

The area is highly developed and prosperous. Good homes, towns, schools, churches, excellent roads, telephone lines, electric railways, and rural mail delivery, are among the advantages enjoyed.

The mean temperature for the winter months is 31° F., for the summer 74° F. The average rainfall is about 41 inches, and the precipitation is evenly distributed throughout the year. The period between killing frosts is about 5½ months.

Corn is the principal crop, the average yield for the county being 45 to 50 bushels. Wheat is next in acreage, and oats third. The acreage in corn is considerably more than that of oats and wheat combined. Hay is also an important crop. Corn is being cut and stored extensively for ensilage. Cowpeas are also being grown and used for this purpose.

Much of the farm produce is fed to stock, which has proved to be the most profitable method of disposing of it. The surplus corn, oats, and hay finds a ready sale in the local markets. Wheat is sold or exchanged for flour and feed at the elevators.

Very little truck is grown in the area except for canning purposes. The excellent market afforded by Indianapolis would seem to warrant the extension of this branch of agriculture. The growing of potatoes, beans, and peas should prove profitable, particularly to those having small holdings of land.

Dairying is an important industry especially in the vicinity of Sheridan, at which point a condensery is located. Much milk is separated on the farm and the cream shipped to Indianapolis or manufactured into butter at the local creameries. Dairying can be profitably extended, as the demand for these products in the larger cities is rapidly increasing.

In 1910 the average size farm was 81 acres. The tendency is to increase farm holdings, with a proportionate increase in the number of tenants.

Five series of soils were recognized and mapped in the county, the Miami and Clyde, which occur on the uplands, and the Fox, Waukesha, and Genesee, which are found upon the bottoms and terraces. The Miami series represents the areas locally called "clay lands", and the Clyde series includes the greater part of the areas known locally as "black lands." The silty clay loam, which is the only type of the Waukesha series found in the county, is also generally classed with the "black lands."

The uplands soils are derived directly from glacial till of the late Wisconsin stage. They have undergone local changes which give rise to the various types. The bottom lands are also derived largely from the same parent materials, but have been reworked and redeposited by the streams along which they occur.

Of the Miami series two types were mapped, the silt loam and loam. The former is the most extensive and widely distributed in the area. The latter type occupies the more rolling areas along the stream valleys and the morainic hills. The Miami soils are best adapted to wheat and fruit growing.

The Clyde silty clay loam is the predominating type of that series. Only a small acreage of the Clyde loam, the only other type of this series developed in the county exists. The Clyde soils are especially well adapted to corn. Oats and hay also yield well.

The Fox loam and gravelly sandy loam occupy the greater proportion of the higher terraces. Only a small acreage of the Fox gravelly sandy loam is developed. These soils are well adapted to alfalfa. Fox gravelly sandy loam, poorly drained phase, is a level type of limited acreage.

Of the Genesee series, which occupies the first bottom lands, three types were mapped, the silty clay loam, loam, and gravelly sandy loam. The loam is the predominating type of the series and occurs principally along West Fork White River and Cicero and Fall creeks. The Genesee soils are best suited to corn, though oats and hay produce good yields.

Muck and Meadow (Genesee material) are undifferentiated soils and are of limited extent in the area.

The agriculture of the area is in a properous and highly developed condition. Practically all of the land is in cultivation or used for pasture. Scientific farming is being practiced to some extent, but its possibilities are not fully appreciated. Much can be done to increase the crop yields by a more thorough study of the individual soil types and the adjustment of crops and cropping system on the basis of soil adaptation.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF SOILS—MILTON WHITNEY, Chief

In Co-operation with the State of Indiana, Department of Geology

EDWARD BARRETT, STATE GEOLOGIST

SOIL SURVEY

OF

BOONE COUNTY, INDIANA

BY

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[Advance Sheets—Field Operations of the Bureau of Soils, 1912]

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Soil Survey of Boone County, Indiana

By W. E. THARP, of the U. S. Department of Agriculture, and E. J. QUINN, of the Indiana Department of Geology.

DESCRIPTION OF THE AREA.

Boone County is located in the central part of Indiana and is bordered on the north by Clinton, on the east by Hamilton, on the south by Marion and Hendricks, and on the west by Montgomery County.

Its general altitude is from 850 to 950 feet above sea level with a few hills exceeding the latter height by about 100 feet.

The total area of the county is 420 square miles, or 268,800 acres.

The surface of the greater part of this county is undulating to very moderately rolling. In general it consists of innumerable broad, low ridges, or divides, extremely irregular in outline and absolute elevation, although the local relief, except near the streams, is usually less than 50 feet, and apparently not this great, on account of the very easy slopes that usually prevail. The depressions are equally irregular in size and outline. The smaller ones range from mere kettle holes to swales a few rods or a fraction of a mile in the greater diameter, and most of them have no very definite connection with others in the vicinity. The surface of the larger ones are flat or nearly so, and constitute the only level areas in the uplands proper.

A conspicuous feature of the landscape in nearly all parts of the county are the numerous mound-like elevations and occasional isolated hills of considerable height. Some of the latter rise 100 feet or more above the surrounding country, and the slopes on all sides are rather steep. More frequently these elevations are ridges, one side standing in clear relief, while the other declines very gradually to the average surface level, which may be much above that on the opposite side. Many of the smaller mounds are mere "bumps", a few feet high and a few rods across, while the larger ones are from 10 to 50 feet high and from one-eighth to one-half mile in length along the major axes. These local elevations have a pronounced relief but the slopes are usually mild and in very few instances too steep to prevent the convenient use of farm machinery.

In the northwestern part of the county along Sugar Creek or more frequently, for some distance on either side of its southern tributaries the surface is rolling, with some short, abrupt slopes along the streams. On the northern side of Sugar Creek the general decline of the uplands is almost imperceptible to within a short distance of the valley, then it flattens into a nearly level terrace. The outer margin of this terrace drops abruptly to the bottom land, the height of the glacis, or sloping part, ranging from 25 to 50 feet. Similar topography prevails along the lower course of Eagle Creek, but the terraces in general are higher than those on Sugar Creek, and the uplands adjoining are rolling to moderately hilly. The untillable portion of these hilly areas includes very little ground other than the gravelly slopes immediately bordering the trenchlike valleys.

All the Eagle Creek drainage and that of Fishback and White Lick creeks represents the extreme extension of a part of the White River system, while that of Sugar Creek is similarly related to the Wabash River. The watershed between these two systems is a broad belt extending across the county from northeast to southwest. Here the natural drainage is very poorly developed, although the average elevation is something like 100 feet above the major streams at Zionsville and at Mechanicsburg. The upper branches of Eel River in this area are little more than artificial ditches that follow structural depressions. This is also true of much of the drainage in the northeastern, central and southwestern townships. The innumerable lines shown on the map are mostly artificial waterways. The larger ones are dredge ditches 10 to 15 feet deep straightening the former illdefined and obstructed course of natural channels while the smaller ones are outlets for depressions that had little or no connection with each other or with the creeks.

All the creeks and the larger ditches maintain their flow the year round. Many of the small ditches carry more or less water throughout the entire summer, since so many tile drains open into them. Excellent water for domestic use can usually be obtained on the higher lands at depths of from 30 to 60 feet.

With the exceptions of a few grassy swamps all this region was originally forested. On the well drained land walnut, sugar tree, hickory, poplar, and oak were the dominant varieties, while beech, elm, ash and white oak were more commonly found on the lands deficient in natural drainage. The present shallow muck beds, or "chaffy lands" and the central portions of most of the larger areas of black land were then ponds or swamps in which aquatic plants and water loving grasses constituted most of the vegetation. Willow, cottonwood, and buttonwood bushes followed as fast as the processes then in operation increased the area of ground partially free from water.

All that now remains of the once dense deciduous forests are numerous open woodlots, very few of which include more that 20 acres. Many of these are merely groups of trees around farm buildings, but there still remain many beautiful groves, usually free from undergrowth and the ground covered with blue grass. Possibly ten but certainly not more than twenty per cent. of the total area has as yet escaped tillage.

The present price of well improved farms desirably located ranges from $150 to $175 an acre. Those at a greater distance from a town or electric railway command about $125. These are very general estimates. The total value of land and improvements exclusive of buildings, according to the 1910 census returns, was $27,280,190, of buildings $4,485,470.

About 35 per cent. of the farms are operated by tenants. A common rate of rent given is two-fifths of all grain and cash payment for hay and pasture ground. In many cases all the rent is paid in cash, the rates varying from $7 to $9 an acre.

Nearly all the public roads are well graded and surfaced with gravel. Practically all the bridges are most substantial structures of iron, concrete, or stone. Thirty delivery routes insure daily delivery of mail to almost every farmhouse. Two steam roads and three interurbans connect Lebanon, the county seat, with outside points. Most of the farmhouses are well built, with good barns and outbuildings.

The high tone of rural improvements is due in part to the generally prosperous conditions that have prevailed during the last two or three decades, in which period thousands of acres of highly productive black lands have been reclaimed, and in larger measure to the fact that this is an area of small holdings. The average size of farms is about eighty acres, but in each township there are many holdings of from ten to sixty acres each. In the county there are sixty-one estates embracing between 260 and 500 and only two farms that contain 500 or more acres.

CLIMATE.

The following table compiled from the records of the weather bureau at Indianapolis gives the means and extremes of precipitation and temperature for each month.

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT INDIANAPOLIS.

MONTH.	TEMPERATURE.			PRECIPITATION.			
	Mean.	Absolute Maximum.	Absolute Minimum.	Mean.	Total Amount for the Driest Year.	Total Amount for the Wettest Year.	Snow, average Depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	33	68	—15	3.0	4.1	0.9	5.1
January	28	69	—25	2.8	1.6	4.9	6.9
February	31	72	—18	3.3	1.6	4.6	4.4
Winter	31	....	....	9.1	7.3	10..4	16.4
March	40	82	0	3.8	4.2	7.4	3.6
April	52	87	19	3.4	3.2	2.3	1.2
May	63	96	31	4.0	2.4	5.1	0.1
Spring	52	....	....	11.2	9.8	14.8	4.9
June	72	100	39	4.4	3.5	7.5	0.0
July	76	106	48	4.2	0.8	7.5	0.0
August	74	101	46	3.2	3.6	5.9	0.0
Summer	74	....	....	11.8	7.9	20.9	0.0
September	67	98	30	3.3	0.7	3.9	0.0
October	55	89	22	2.8	3.5	4.4	T
November	42	76	—5	3.7	1.2	2.3	1.6
Fall	53	....	....	9.8	5.4	10.6	1.6
Year	55	106	—25	41.9	30.4	56.7	22.9

It will be observed that the mean rainfall from 3 to 4 inches for each of the spring and summer months is ample for most crops, but that the total amount in the driest years is too low to meet the requirements of a heavy crop of corn and grass. Short periods of deficient rainfall will occur in most seasons, their effect upon a particular crop depending largely upon the stage of growth when the shortage in precipitation occurs. For this reason the moisture relations of the several types have been set forth with some care, and the tillage operations necessary to minimize injurious effects of exceptionally wet or dry periods have been suggested. In this respect, however, neither the soils nor climatic conditions differ from those of the adjacent sections of the State.

The average fall of snow, 22 inches, is extremely variable from year to year. Since there is so little timber and most farm land is almost free from obstruction like hedge rows or lines of weeds along the wire fences, the snow drifts more than formerly. This is frequently the cause of injury to fall sown grains.

The average date of last killing frost in the spring is April 16th; of the first in the fall October 19th. The earliest killing frost in recent years occurred on September 21st and the latest reported for the spring months was May 21st.

Agriculture.

Since in the earlier stages of the agricultural devolopment of this county only land with good natural drainage could be utilized, the greater part of the black lands, or Clyde silty clay loam, remained in nearly its original condition for many years. Some small areas were reclaimed by individual efforts of farmers and others later as a result of the construction of road ditches and co-operation of owners of low lands within short distances of natural outlets, but most of the larger bodies of black land have been brought under cultivation within the last 25 or 30 years. Within this period the deep dredge ditches that form the upper part of Eel River, Prairie Creek, and a number of other streams have been brought to their present high degree of efficiency and thus afford an adequate outlet for the hundreds of branches since constructed.

Practically all the black land has been relieved of standing water or of any liability to injury from this cause. Nearly every field consisting entirely or in part of the black clay loam has tile drains, but in many instances a greater number are needed to insure a prompt lowering of the level of the ground water after heavy rains. This is practicularly true of those large areas having a substratum of heavy clay instead of gravel.

The next stage in the development of this artificial system will be the extension of the tile drains into the Miami silt loam. As suggested in the description of that type, such an improvement is now almost as much of a necessity, considering the advancing price of land and cost of producing crops, as was the surface drainage of the black land some years ago.

The comparatively late development of so large a portion of the arable lands has had the effect of conserving the virgin fertility of the black lands until a period when improved machinery, accessibility to markets, and the generally high price of grain rendered their cultivation extremely profitable. Fortunately the occurrence of this type is so common throughout the county that the increase in average crop yields and the enhancement of land values has been shared by the owners of hundreds of small farms.

The general trend of agriculture may be seen in the following table complied from census returns:

PRODUCTION OF LEADING CROPS IN BOONE COUNTY.

Census.	Corn.		Wheat.		Oats.	
	Acres.	Bu.	Acres.	Bu.	Acres.	Bu.
1910	91,080	4,572,233	19,742	317,758	38,867	1,213,582
1900	81,472	3,912,050	34,900	266,710	3,297	119,330
1890	60,048	1,783,060	40,067	464,972	7,810	191,869
1880	63,087	2,280,742	33,679	623,289	4,285	117,070

Corn, oats, wheat, and clover are the chief crops. With regard to cash value they rank in the order named, and in late years the acreage of grain is in the same order with the clover acreage as a rather changeable member of the group. Farmers no longer consider wheat a profitable crop. The average net returns from oats are more favorable, but neither of these crops would be so generally grown were it not for the necessity of frequently seeding the ground to grass or clover. This is recognized by all farmers having soil types other than the Clyde or Genesee as absolutely indispensable in good farm management. In most instances the problem of maintaining fertility is considered chiefly in its relation to the production of corn. The steadily increasing demand for this grain is stimulating interest in every means that promises greater average yields. In the last few years many farmers have used commercial fertilizers, and the probable result of their more extensive employment is becoming a matter of great interest.

In a report of this kind it is quite impracticable to go into detail regarding commercial fertilizers or their probable effect upon crop yields. Local conditions enter so largely into the problem that specific directions or statements to be of any value whatever must be based upon field experiments extending over a term of years. But some principles of soil fertility and their application to local conditions in this area may be considered.

The Miami soils require more thorough pre-crop preparation than is usually given on the average farm. Whether by deeper plowing, subsoiling, or frequent changes to deep rooted crops like the clovers, the subsurface soil ought to be loosened and made as highly absorbent of moisture as possible. Instead of getting rid of excess rainfall by a rapid surface discharge into the natural drainage lines more of the water should be held in the soil and upper subsoil until it is absorbed by the lower subsoil and the underlying stratum. The structure of the latter, a sandy clay, is highly favorable to such storage of moisture, but the compact layer between the depths of 12 to 25 inches in the Miami silt loam, and to a less marked degree in the loam, prevents as effective absorption of heavy rainfalls as is desirable and tends to increase the surface run-off, or at least to render the latter necessary in order to prevent undue saturation of the surface soil.

The frequent occurrence of periods of deficient precipitation in the months of July and August and consequent reduction in yields of corn or other late maturing crops, emphasizes the need of conserving as far as practicable the excess of rainfall that usually occurs earlier in the season. Of course the average level of the ground water must be held below 20 or 30 inches, but there is no danger of its standing for any length of time above this height in the types mentioned, or in any other where tile drains have been installed.

The necessity of an increase of organic matter in the Miami soils is discussed in the description of those types. It is needed to improve their physical condition and to insure a sufficient supply of nitrogen for good crops of grain, which require a liberal supply of this element. Its development in a soil is dependent largely upon the presence of humus, or of decaying vegetable matter, and the available supply will vary from year to year according to heat, moisture and conditions of tillage.

Except to meet the requirements of some special crop, or to hasten profitable yields on previously mismanaged land where the results of a crop rotation with clover cannot be awaited, the use of complete fertilizers does not seem advisable. Certainly none of the expensive element, nitrogen, should be purchased, and chemical analyses show that there is no lack of potash if the soil is handled in a way to render it available. As to the profitable use of phosphatic fertilizers no definite statements can be made. It is a problem to be worked out by field experiments.[1]

In the last few years considerable quanities of commercial fertilizer have been used, and their use is rapidly increasing. With the exception of the potash used on the "chaffy lands" the most of the brands have about the following composition; from 1 to

[1] See Bulletin No. 155, Ind. Ex. Station.

2 per cent. of nitrogen, 2 to 4 per cent. of potash (K20), and from 6 to 8 per cent. of phosphoric acid (P205). The results reported by farmers are variable, but in the main an increase of both corn and wheat has usually followed the application of fertilizers. Wheat has generally been improved both in quanity and yield.

In many instances the increased yield was due to the presence of immediately available plant food where the natural sources of supply were locked up through lack of organic matter and otherwise bad physical condition of the soil. The very light colored types, in such a wet spring as that of 1912 remain cold and inert after the black ground has become warm and in good condition for corn.

The following four-year rotation is practicable under present conditions on most farms: 1st year, corn; 2d, oats or wheat, 3d, clover with timothy and the hay harvested; 4th, land used for pasture. The elimination of the small grain is favored by many farmers were it not for the advantage these crops afford of seeding the land to clover. Winter rye may be substituted for oats or wheat and is a better nurse crop than the latter. Rape has also been used for the same purpose, and furnishes excellent pasture for hogs. Since the latter form so large a proportion of live stock on most of the small farms, and also on many of the larger ones, it is very desirable to reduce the acreage of small grain and increase that of corn and forage crops.

With regard to maintenance of fertility, dairying affords opportunity for the best methods of soil management. In the northeastern part of the county many farmers are engaging in this business to a greater or less extent, since there is a milk condensing plant at Sheridan which takes all the product the surrounding country offers. In all parts of the county an increasing number of farms are shipping milk or cream to Indianapolis. This business is causing much attention to be given to the problem of securing cheaper feed. Several hundred silos have been constructed chiefly to afford better feed for dairy cows but also for other stock, as the advantages of the method become better known.

Much interest is taken in the cultivation of alfalfa, and so far efforts to establish this valuable forage plant have not been entirely successful. The best observed results were on well drained bottom land. This is probably due to the rather high degree of fertility, abundant moisture supply at moderate depths, and freedom from acidity in the soil. On the Miami silt loam there are a few small fields that have stood a number of years, but in many instances on this type the roots of the plant turn brown and die. Blue grass usually spreads into fields of alfalfa in a few years and so thins the stand that it is no longer profitable.

Alfalfa requires a fertile soil in which the drainage and aeration to a depth of several feet is excellent, suitable for the best growth of corn. It also needs much water during practically the entire growing season, so that a good reserve of moisture in the lower subsoil, or at somewhat greater depths is almost a necessity. Another prime requisite is lime. The soil and subsoil of normal types can hardly contain too large a percentage of this material. If the soil is not inoculated with the bacteria necessary to this plant no very long continued growth will be made. These soil conditions must be assured and in addition a very thorough preparation of the seedbed is necessary and freedom from competition of grass or weeds during early growth must be assured.

In this area the Miami types are too deficient in humus and lime to suit alfalfa. After becoming established the large amount of carbonate in the lower subsoil might prove sufficient for the plant requirements, but in its early stages the acidity of the surface soil is decidedly unfavorable. Well drained Clyde silty clay loam should prove satisfactory, especially if a permanent supply of water is within 8 to 10 feet of the surface. Those phases where lime nodules or slightly calcareous clay occur in the subsoil should be selected, other conditions being favorable. But liming of the soil and also inoculation doubtless is necessary in all cases.

Tomatoes are the only truck crop grown to any extent in this county. There is a canning factory at Lebanon, and several of the smaller towns are shipping points from which canneries at Indianapolis secure their stock. The crop in 1912 was generally poor on account of the unfavorable season. The previous years' yields of from 8 to 10 tons per acre are secured in good seasons and the contract price is about $9 per ton. The black soils usually make the heavier yields.

On both Prairie Creek and Eel River there are locations where the Clyde silty clay loam affords good sites for the cultivation of celery and onions, these crops requiring very loose rich soils and an abundant water supply. It seems possible that supplemental irrigation on a scale practicable to assure success with small acreages of these crops could be successfully practiced in certain locations along these deep dredge ditches.

The same observations apply to the cultivation of strawberries near the streams. The fruit could be successfully grown almost anywhere except on the Muck and on the heaviest phase of the Miami silt loam. The local markets are very poorly supplied with this or other small fruits of desirable quality.

Little attention is paid to the production of apples or pears on a commercial scale. The orchards are generally small and in most instances not well cared for. The opportunity for fruit culture here is quite as good as in most sections in the adjoining States. The Miami loam affords most excellent sites for orchards, and the proximity to Indianapolis assures a ready market for all that could be grown. Besides the well recognized requirements of pruning, spraying, and proper cultivation, a co-operative plan of marketing would be necessary. Since most farmers are able to make fair returns from their land without such an effort, it is not probable that fruit growing will become a business of great importance.

SOILS.

The surface formations of this county consist of glacial material known geologically as the early Wisconsin drift covered by a thin layer of wind-blown loess. The thickness of the drift is quite variable, ranging from less than 50 to more than 150 feet. The average, at a very rough estimate, may be placed at less than 100 feet. The older drift sheets and the sedimentary rocks are thus buried so deeply they exert no influence upon the soils.

In general the first 10 to 15 feet of the Wisconsin material is a very light brown or pale yellowish mixture of fine sand, silt, and clay carrying a large proportion of gravel and small stones. The latter consist largely of granites and various kinds of hard, dark colored rocks apparently as resistant to decay as the quartzic gravel, and with some schistose and gneissic fragments. As a rule there is not much sandstone or shale, but pieces of limestone are usually abundant from within 4 to 5 feet of the surface downward. The matrix in which these are imbedded varies in composition, but there is almost everywhere a rather high percentage of fine sand, so that the material is porous. The surface of artificial exposures usually weathers to a loose, friable silty or fine sandy loam of light color. With few exceptions, it contains sufficient lime to react freely with hydrochloric acid.

Notwithstanding the fact that bowlders and coarser material are scattered through this silty material near the surface, it is generally conceded by geologists that it represents a reworked glacial deposit transported to its present position by wind action. This material has entered into the composition of the soils over a large part of the county, but it is an important constituent only of the Montgomery silt loam along the western border.

The above description is applicable to the glacial material, or till, of the uplands in general, but along the creek valleys and in many of the depressions that were formerly lakes the light-colored bowlder clay gives place to beds of gravel. The substrata of the terraces on Sugar and Eagle creeks are irregularly stratified sand and gravel, and pockets, or streaks, of this material occur along many of the small branches forming the substratum of the black soils.

But neither the bowlder clay nor the gravel beds directly form the soils, except in areas of very limited extent. Almost everywhere the glacial material is covered with a silt or silty clay layer having an average depth of about 30 inches. Its mechanical composition and general appearance, as well as its relation to the topography, is strongly suggestive of a loess. Over practically all the uplands and on all the higher terraces of the larger streams this silty material forms an almost unbroken surface mantle. On the short, steep slopes near the creeks and on the apex of the sharper ridges and mounds it is either very thin or has been modified through loss of its finest particles by erosion and through admixture with the underlying till. On all the wider divides and whereever the surface is but moderately rolling or undulating the silty surface stratum is present. Its rather uniform depth and the persistence with which it invests all the major topographic irregularities is remarkable. To this fact must be attributed the wide extent of fertile, stone free soils of this and adjoining counties.

Through the various agencies of weathering, as erosion, oxidation, and effect of vegetable covering, there has been more or less modification of the silty layer, and several distinct soil types have thus been formed.

On the gently undulating uplands and on the wider terrace there has been least change in depth and composition of the silty stratum. In such locations the depth is seldom less than 2 feet and very rarely exceeds 5 feet. In the first 10 or 15 inches silt particles usually form as much as 50 to 60 per cent. of the soil, with very fine sand as the next highest component. Between the depths of 15 to 30 inches there is a rapid increase in the percentage of clay, so that this zone is usually a stiff, silty clay loam, not quite so favorable to good moisture conditions as if the texture were a little coarser. At 30 or 40 inches there is usually a fairly well marked contact between the silty clay and the underlying glacial material, which at this depth is reddish brown clay, with more or less sand and gravel.

The light color of the silty surface soil is due to lack of organic matter, a result of the original timber cover. The coloration of the middle and lower subsoil is determined chiefly by drainage conditions, or may be taken as an indicator of the average moisture content. Owing to the somewhat imperfect internal drainage and aeration that are characteristic of most of the silty material, where it exceeds two feet in depth light gray and pale yellowish tints prevail, with more or less mottling. As a rule there has not been much segregation of the iron content, so that "buckshot" or small concretions are seldom abundant.

Wherever such general conditions as these prevail the soil type locally known as "clay land" has been developed. In this survey the name Miami silt loam is used and has been given wider application than the local term. The latter is often restricted by farmers to the heaviest and deepest phase of the silt loam where its inability to endure wet weather occasions considerable difficulty in tillage.

Wherever the surface inclination is quite pronounced as on the flanks of the innumerable morainic mounds and in the vicinity of the larger creeks, the silty layer is not only thinner than elsewhere but it is also coarser in texture. This it due to erosion, whereby much of the silt and clay have been removed, leaving the fine sand, or coarsest constituents, as permanent soil material, usually a silty fine sand. In most instances there is more or less gravel scattered over the surface and stones from the bowlder clay beneath are frequently exposed. In such locations the comparatively coarse texture of the surface soil and the presence of the sandy bowlder clay within a foot or two of the surface induces so much better circulation of soil water and air to a depth of several feet that a distinct soil type has been developed. It has been correlated with the Miami loam, but is generally known throughout the section of the State as "sugar tree land." It is distinguished from the silt loam by rolling topography, coarser texture of soil grains, and the uniformly brown tints that prevail in soil and subsoil. These physical properties are very favorable to the maintenance of equitable moisture conditions, a factor of highest agricultural importance. It is also probable that the total quantity of available mineral plant food is somewhat higher in the 3-foot soil section, including as it does more or less of the glacial material, than in more thoroughly leached and weathered silt. This is the case with regard to lime and doubtless applicable in some measure to other essential minerals.

The Clyde silty clay loam, or the "black land", is distinguished from the preceding types by the high content of organic matter. The latter is chiefly in the form of carbonaceous material, or vegetable tissue in the condition which it acquires when decomposed under water, or where air is mostly excluded. It is doubtless less active as an element of soil fertility than the brown humus which results from the decay of plant remains upon the surface, or in the first few inches of a well drained soil. The abundance of this black humus which often extends to a depth of 18 or 20 inches, imparts a fine physical structure to a soil that would otherwise be a heavy clay or clay loam.

The type owes its origin primarily to lack of surface drainage and to the character of vegetation such conditions imposed. While most of the "black lands" were timbered when the first settlers entered the region, up to a comparatively recent period the low areas are illy drained prairies or marshes in which grassy vegetation prevailed. Indeed many areas of limited extent were in the latter condition until artificially drained. It was during the prairie stage that the black humus accumulated, with lesser accretions, perhaps, after the encroachment of the forest from the adjoining higher ground.

In some of this type there is still such an excess of vegetable matter in the surface soil that the latter is "mucky", or as it is locally called "chaffy ground."

A few areas of true Muck are found but its depth seldom exceeds 15 or 20 inches. The subsoil of some of the Muck is a highly calcareous clay, a marl in some instances. The rather high percentage of lime in the Clyde silty clay loam is probably due to the former abundance of this mineral in the subsoil, when the latter was in the same condition as the clay under the present muck beds. As the natural drainage improved the lime was reduced, but there is still sufficient of it to most favorably affect the fertility of the soil.

The alluvial soils consist of material from both the glacial deposit and its silty covering. The latter has doubtless contributed the more on account of its greater surface exposure. As a rule fine sand and silt are the chief components of the bottom land types.

Coarse surface material does not usually occur, except in the immediate vicinity of the larger streams, although sand and gravel commonly form the substratum. With one exception, the Genesee loam, there is a remarkably low content of organic matter in the alluvial types. This is true of virgin land as well as that which has been cultivated many years. The prevailing color of both soil and subsoil is a shade of brown that may be described as a ''mineral brown'' in contradistinction to the darker brown of the soils having a moderately high percentage of vegetable matter. This is principally owing to the good drainage and aeration that most of these soils enjoy, induced by their elevation above the stream channels, their open structure, and the presence of a gravelly substratum. Notwithstanding their deficiency in humus, these brown soils are very productive and show few signs of exhaustion, although cropped almost continously to grain for many years.

Clyde Silty Clay Loam.

The surface soil of the Clyde silty clay loam to a depth of 8 or 10 inches is a black silty clay loam having a high content of silt. The organic matter content is high and consists almost entirely of black humus, rather than the brownish-black vegetable mould commonly occurring in upland soils or in land where the organic matter is of more recent origin. The relatively high percentage of humus imparts a friable or mellow property to the soil very apparent in cultivated fields. The ''crum structure,'' or tendency to assume a finely granular condition, so desirable in all soils, is remarkably well developed in most of this type. This property, being a function of the humus content, is dependent upon the amount as well as the condition of vegetable debris present. Where there is a very high percentage of organic matter the soil is somewhat spongy and approaches muck, while in other places the organic content is not more than sufficient to impart a black color and good physical properties to what would otherwise be a heavy, compact soil.

Below the surface soil and to a depth varying from 15 to 25 inches the material is a silty clay loam of black to dark drab color. This part of the material is usually quite compact, in many instances rather gummy. It would be much more resistant to penetration to any implement and less pervious to water were it not that the organic matter it contains gives it a well-developed, granular structure. Exposures in ditches of this layer usually show it to have a coarsely cubical or blocky structure that greatly facilitates aeration and subdrainage.

The lower part of the 3-foot soil section is usually a smooth, plastic silty clay of yellowish-gray color, mottled faintly with brown iron stains. In places the subsoil is a yellowish-brown silty clay where immediately underlain by gravelly material. It seldom has the granular structure characteristic of the middle soil stratum. It is less pervious as a rule, although varying considerably in this respect, often within a few rods or even in the same boring. The coloration usually indicates the natural drainage conditions. In many places a gravelly clay is found a little below the subsoil proper, at depths of from 30 to 40 inches. In such instances its presence is indicated by numerous small pebbles upon the surface, or the proximity of a gravel pit in which loose sand and gravel are found at less than 5 or 6 feet. Such land is in condition for tillage sooner after a rain than those larger areas where clay is the basal material to a considerable depth.

The above description is applicable to most of the black land in this county. The greater portion of all the larger tracts consist of soil having essentially these characteristics. The smaller areas, the more or less isolated bodies of less than 40 acres and the innumerable narrow and rather illy defined swales found almost everywhere in the uplands present variations of this type ranging from very black, loose soils to those but slightly darker colored and nearly as firm as the adjoining Miami silt loam. As a rule the central part of the small areas corresponds very well with the type description, but the outer portion, or in many instances all of the body of black land, has a firm, silty soil, very black but never approaching a ''muck'' condition. In such places the subsoil is usually a dull yellow or yellowish brown clay or clay loam. The latter is not generally so heavy, nor inclined to be so ''gummy'' as the subsoil of some of the larger areas of the type, the color being indicative of the better underdrainage. The soil has a well developed, granular, with a consequent tendency to a grainy, friable structure that is highly favorable to easy tillage.

Such comparatively light colored developments of the type occur everywhere in intimate association with the typical soil, but in Jefferson, Jackson, Clinton and Marion townships this phase is the most commonly found. In many instances it simply represents the condition which the type assumes after many years of cultivation. The small areas were generally drained years before the larger ones were reclaimed. The latter still have, in most cases, a very large content of organic remains that has not yet been reduced by long continued cultivation or thoroughly mixed with mineral matter from the subsoil by plowing and other operations of tillage.

Along the upper course of the drainage lines, where the obstructed drainage of the ponds and sloughs begin to take some definite direction and form a channel, the Clyde silty clay loam resembles an alluvium. There is more or less sand in the soil and the subsoil is usually a mixed material, quite heavy but admitting of an easier movement of water through it than is possible in the light colored clay subsoil of most of the type.

These various phases of the type are important chiefly with respect to convenience of tillage and economy in drainage. Some of this land that has been in cultivation for many years has lost so much of its original high percentage of organic matter that the ground is inclined to become cloddy unless carefully managed. This is the first stage in the gradual decrease of the black organic matter subsequent to continued tillage. In all the larger bodies, and often in those that are mere "pot holes" or sharp depressions in the uplands there are some places where the soil still has such an excessive proportion of vegetable matter that the surface is "chaffy" or resembles muck. All of these will improve in course of time. Deep plowing, in order to mix the loose material with the gummy clay subsoil, is to be recommended and the admixture of silt and sand from the surrounding land may be encouraged. Such places may be profitably treated with potash, as suggested for the cultivation of corn on the Muck.

It is impracticable to represent these varations in the type on a map of the scale used in this survey, because two or more fairly well defined phases are usually involved in every area, however small. In many of the larger ones in the southern part of the county every gradation may be found from a brown silt loam at the margin to a mucky soil in the lowest places.

Limited areas of the type were grassy marshes when the first settlers came to this county, but most of the type was heavily timbered. Excepting the places where the soil was practically muck or essentially a permanent swamp, the timber consisted chiefly of swamp white oak, pin and burr oak, silvery maple, black ash, and elm. Hickory was abundant on those areas of this type which approaches the Miami silt loam. All of these species are still seen in woodlots where the black soil is found. In small ponds where water stood the most of the year buttonwood bushes, willow, and occasionally cottonwood were the characteristic varieties.

With the exception of a very few small ponds or an occasional slough, all this black land has been artifically drained. In the central townships thousands of rods of 4 to 8-inch tile have been laid in recent years. The main line and principal laterals of the several extensive drainage systems are complete, but more branch lines could be profitably installed. Most of the areas in the remainder of the county are well drained, both open and tiled ditches being employed. As a rule few landowners consider any further ditching necessary than what is required to provide prompt relief from excess water. The suggestions concerning the advantage of installing tile drains in the Miami silt loam apply equally well to parts of this type. Where there is a heavy, compact subsoil, better aeration would be secured if tile drains were laid a few rods apart. As the surface soil becomes more compact through exhaustion of its present liberal supply of humus the advantage of the improvment suggested will become more apparent. In most instances the average level of the ground water in all flat or markedly depressed areas is only a little below the bottom of the ditch or tiles.

The average yields of corn on the Clyde silty clay loam may be placed at about 50 bushels per acre. On most well managed farms 60 to 70 bushels is a common yield and returns of 80 and 100 are not uncommon. The quality in most instances is not so good as that of the lighter colored soils. Practically all of this land endures continuous cropping to this grain remarkably well. Some fields have had little change to other crops for twenty years and still give good average yields.

Oats fall down or lodge badly in wet seasons. On the firmer ground in dry years the returns are satisfactory, from 40 to 60 bushels being commonly secured. The yield of wheat is most variously reported, indicating the varying effects of drainage, time of seeding, and seasonal conditions. In most years yields of 25 bushels are above the average, although this is quite frequently exceeded. In the winter of 1911-1912 this crop suffered great injury by accumulation of ice in the low places.

Timothy and blue grass make a vigorous growth on this soil, but the quality in each case is somewhat below that of the grasses on lighter soils. Clover also makes a vigorous growth. The soil is seldom acid and in many instances lime nodules are found in the lower subsoil. Alfalfa should do well on well drained ground

MECHANICAL ANALYSIS OF CLYDE SILTY CLAY LOAM.

No.	Description.	Fine Gravel Per Cent.	Coarse Sand Per Cent.	Medium Sand Per Cent.	Fine Sand Per Cent.	Very Fine Sand Per Cent.	Silt Per Cent.	Clay Per Cent.
281126	Soil	0.2	1.2	2.2	6.7	7.0	58.0	24.5
281127	Subsoil	.2	1.4	2.2	6.8	7.9	62.1	19.4
281128	Lower Subsoil	.0	.0	.9	3.2	4.9	68.4	22.0

where corn does well without potash. A phase that is neither very chaffy nor exceptionally gummy just below the plow line should be selected. Since this plant requires much water, location where the water table is about three or four feet from the surface should prove most suitable in this respect. It is probable that lime and stable manure if free from weed and blue grass seed, would be beneficial. In places the litmus paper test showed the soil to be slightly acid. To favor the proper inoculation soil from an alfalfa field should be scattered on the ground. It is also suggested that the common sweet clover might be encouraged to grow along ditches where seeding to alfalfa is intended. This plant is indicative of conditions suitable for the alfalfa. However, if alfalfa is seeded to this soil it would be advisable to correct any acidity of the soil.

Miami Silt Loam.

The Miami silt loam is the light colored upland soil commonly called "clay land." It is the dominant type in the county.

To a depth of about 10 inches the soil is a light gray silt, variations in shade ranging from ashy gray when dry to a pronounced brownish gray as the characteristic color under usual moisture conditions. Silt and very fine sand constitute the greater part of the material, but there is usually a little medium sand present and in most instances a few pebbles. A hand sample, if dry, has a rather fine, floury feel, with a little coarse grit, and there is a noticeable lack of granulation, or the "crum" structure so easily observable in the black soils. There is usually very little humus, even virgin soil containing no visible quantity of vegetable matter below 5 or 6 inches.

The subsoil to a depth of 25 or 30 inches is a stiff clay, technically a silty clay loam, since silt and clay, the smallest kind of soil particles, make up most of the mass. The upper part of the subsoil is generally a mottled gray and yellow silty loam, only a little less friable than the surface soil, but with slight increase in depth the physical properties of a clay are very apparent. As a rule the material has a rather high degree of plasticity if wet and is so tenacious as to offer considerable resistance to penetration by any implement. With the usual moisture content it is stiff and crumbly, but there is not a marked development of the granular structure noticeable in clayey subsoils of types having much organic matter in the surface soils. This stratum is not impervious but heaviest phases admit of a slow gravitational movement of excess water and of rather poor aeration.

The color is variable, but in most instances the upper part of this substratum is light gray, more or less mottled with pale yellowish streaks. In the lower portion brown or reddish brown tints more commonly prevail, but not infrequently brown and grayish mottlings occur throughout the entire stratum, with some very light colored streaks due to unequal oxidation and suggestive of ineffective subdrainage. Soft, black iron concretions sometimes are numerous in poorly drained places, occurring chiefly in the soil and upper subsoil.

The lower portion of the 3-foot section is usually a brownish clay or clay loam containing considerable sand and gravel. This coarse material gives it a comparatively open, porous structure and the difference in physical character between this stratum and the silty clay above is very marked. The line of contact is fairly well defined and usually occurs between 25 and 40 inches below the surface. At a little greater depth the clay is more sandy, with gravel and stones forming an appreciable portion of the entire mass. The brownish coloration due to oxidation and other processes of weathering extends a few feet further down and then gives place to the light yellowish tints of the comparatively unaltered glacial material.

The Miami silt loam almost everywhere in this area has this characteristic structure, a gray silty surface soil grading downward to a mottled silty clay subsoil that at 25 or 30 inches is underlain by brown sandy gravelly clay. There are departures from this type with respect to the depth and color of the soil and thickness of the middle subsoil, as well as variations in the relative proportions of sand, a silt, and clay in each, that cause some difference in the moisture relations and tillage requirements. As a rule all such variations are toward the Clyde soil on the one hand or the so-called "sugar tree land" on the other; and their occurrence is generally indicated by surface configurations similar to the topography characteristic of one or the other of these types. On local elevations and the short steep slopes or banks near ditches the soil is essentially the Miami loam and corresponds to the description of that type. In depressions the darker color is due to a greater content of humus and the loaminess is further increased in most old fields by material washed from adjoining higher grounds.

The surface of most of the Miami silt loam is undulating to very moderately rolling. On some of the pronounced slopes that are concave downward rather than arched, or convex upward, the silty clay is deeper than the average elsewhere, causing rather poor underdrainage. This is very often evident in the light gray color of soil and the presence, in some instances, of small brown iron concretions. The upper subsoil is usually a whitish, putty-like silt, with abundant pale-yellow mottlings. The lower subsoil is often a tough, bluish clay and the sandy substratum is not found at less than 4 feet. These "clay spots" are also found on land that is nearly level, but the poor drainage is due to the structure of the subsoil rather than lack of surface inclination. Fortunately such phases are limited to small spots, seldom more than an acre or two in one body, but approaches toward this heavy phase are very common in all sections of the county, possibly a little more in the western and southwestern townships than in the eastern ones, on account of the slightly greater average depth of the silt. They are more frequently found in large bodies of the type than in small areas, and on low swells rising but a few feet above adjoining black lands than on divides that have a pronounced decline toward a well defined drainage line. In many instances the light color of the soil and its tendency to a putty-like consistency when wet is due to exhaustion of the humus through long-continued cultivation. On account of their small size and lack of pronounced structural or textural differences when compared with the normal type, it is impracticable to outline these areas. For the same reason it is impossible to show the hundreds of small mounds, ranging in size from a few square rods to a few acres, where the soil approaches the Miami loam in color and texture.

All of this type was originally forested. The timber was a mixed growth of hardwoods with less tendency toward the dominance of certain species than obtained upon the black soils or the "sugar tree land." While on the latter hard maple and black walnut were the characteristic varieties, they also formed much of the forest on the Miami silt loam, and the woodland pastures on this type usually include specimens of these trees. On the heavy phase described in the preceding paragraphs beech was the most abundant species, and ''beech land'' is a local term often applied to these soils. In depressions inclined to be ''seepy'' and where the surface drainage is poor, ash, elm, and hickory were more common. The originally meagre supply of humus was due to this forest cover, for well drained timber lands accumulate but little vegetable remains below the immediate surface soil. There were formerly many boulders of various size, but most of them have been removed to fence lines or used in farm buildings. Small stones are usually found on the slight elevations and slopes near streams.

With the exception of wood lots, practically all this type is cultivated. Taking the type as a whole, the average yield of corn is probably less than 40 bushels certainly not much above this estimate. On many farms where frequent changes to clover have been practiced the average production is from 50 to 60 bushels or even more in favorable seasons.

The average yield of wheat has declined during the last 20 years. Formerly returns of from 25 to 30 bushels were frequently secured, but in recent years from 15 to 20 bushels are more commonly reported. This decrease is doubtless due in part to causes not attributable to the soil, but this type seems to have suffered a greater decline than other soils in yields of this grain.

Oats do best in seasons of abundant rainfall. They will make a good growth and usually stand up well. In 1912 about 50 bushels per acre were matured, though not subsequently saved in good condition. Oats require much moisture in a comparatively short period. The heavier phases of this type have too tight a subsoil to admit of as rapid delivery of water as seems necessary for the best development of the oat plant, except in seasons of very frequent rains. In dry seasons the crop is usually poor on the heavier phases or on land that is in bad condition through long tillage to corn.

Timothy does well on this type and the quality of hay is better than that from the Clyde soils. This is also true with respect to corn. Clover does not, in most years, make so rapid a growth or produce so much hay as on the Clyde silty clay loam. Since the surface soil is so generally acid it is somewhat remarkable that so little difficulty is experienced in getting a stand or maintaining it for several years. In most cases failure to secure a stand may be attributable to seasonal conditions or improper management.

Tomatoes, potatoes, and garden crops are successfully grown on this silt loam. The difference in yields, other conditions being equal, coincides pretty closely with observable variations in the humus content of the soil and to a less degree in the character or structure of the subsoil. This, of course, is true regarding all crops, but is most in evidence with those that are more exacting in their requirements than corn or small grains.

The origin of this type and its general mineralogical composition, as well as some chemical determinations, are discussed in previous chapters. There is no evidence of a marked deficiency in the mineral elements of fertility. Lime is needed in the surface soil to correct acidity but in the lower subsoil there is a relatively large quantity of this mineral. To the deficiency of inorganic matter is due the lack of available nitrates so often indicated in the slow growth of the corn. The bad physical condition of the soil is also caused chiefly by the low content of humus. The mechanical composition is highly favorable to easy and effective tillage, but without some vegetable matter there will be a decided tendency to pack after rains, and to remain cold and wet in the spring after darker soils are in good condition. Whether these undesirable conditions are improved by applications of barnyard manure or by a return to the soil of green crops is a matter of farm management. The effects on the soil are essentially the same. In most cases, however, not enough vegetable matter is put back into the ground. There should be enough to give the soil a darker color and a noticeable increase in the granulation, or "crumb" structure, when compared with the ashy gray soil of fields that have long been subject to tillage with few changes to grass. Clover and alfalfa are especially beneficial to this type. Besides adding available nitrogen the deep penetration of their roots and their subsequent decay renders the subsoil much more permeable to air and water.

Deep plowing should be practiced, but this does not mean that the yellowish silty clay of the subsurface soil should be turned up, with the highly probable result of forming clods or packing to a close crust, as it is likely to do under the usual conditions of spring plowing. The depth should be increased as the effects of previous tillage and influence of the humus is apparent. Subsoiling or any process that renders the subsoil more permeable to air will give direct and lasting benefit.

While not practicable to loosen up or otherwise materially alter the structure of the middle subsoil by tillage, its physical condition, or rather its influence upon the moisture content of the entire soil section, may be changed by tile drainage. The surface drainage of all the type is good, but the tight subsoil, as previously stated, is too retentive of moisture. The water movement both downward and laterally, is rather slow. Tile drains would facilitate this movement, thus hastening relief after heavy rains. In dry periods the soil moisture would be increased by the more rapid circulation of the air through the subsoil, because there is considerable condensation of moisture upon the soil grains by this process. During critical periods in crop development such increase in the total amount of soil water may prove of greatest value. This is doubtless the chief cause of corn making a steadier growth in dry weather over tile drains. In a number of instances a rather incomplete system has been installed and the results are very apparent, and the owners of the land state that the increased returns soon pay for the improvement.

All the heavier phases of the type, regardless of local elevation, need tile drainage and all would be benefited by the extension of the laterals that have already been laid in the adjoining Clyde soils. The size of the tile and the distance apart of the lines should be governed by the surface configurations of the fields and also by the character of the subsoil. Where the clay is especially tight and the depth to the brownish sandy clay is 4 or 5 feet ditches a few rods apart are needed. In the more sandy phase and where the subsoil is more porous the lines need not be close together.

With the improvement suggested above, deeper tillage and an increase in the humus supply this soil would prove very nearly as valuable for corn as the Clyde soils, while its adaptability to other stable crops would be enhanced and the average yields less dependent upon seasonal conditions.

Miami Loam.

The soil of the Miami loam is a light brownish gray silty loam. In many instances, as on the tops of the slight elevations that are a characteristic feature of the type, the soil is a brown sandy loam On the hillsides there is a considerable textural variation, but silt and fine sand are the chief components, there being but a small percentage of clay and seldom any coarse sand. The organic matter content is everywhere low, and therefore, the surface when dry has a grayish color but not so light a shade as the dry surface of the Miami silt loam. The moist soil invariably has a pronounced brownish tint, approaching reddish brown on gravelly slopes.

There is usually a little gravel scattered through the soil and occasionally some small stones, but such material is not very abundant except upon the crests of some of the mounds, and on a few small spots on comparatively level ground.

The subsoil from 10 to 15 inches below the surface to a depth of three or four feet is usually a brown or dull reddish brown clay. It is rather heavy and compact and these qualities would be more pronounced were it not for the coarse angular sand and small bits of gravel that it contains. This coarse material, with some fine sand, increases the porosity and imparts a degree of friability that would otherwise be lacking. The sand and gravel usually increases with depth, so that at 4 or 5 feet the material is a clay loam, or in many instances a sandy clay. In some places the underlying stratum is comparatively loose gravel and the total thickness of soil and clay subsoil may not exceed 4 or 5 feet, but such conditions are not of common occurrence and are usually limited to areas of a few acres. The clay substratum is evidently of sufficient thickness to be a good moisture reservoir and the capillary movement of the soil moisture is not affected, with regard to average crop requirements, by beds of gravel, even where the latter are known to be present at moderate depths.

This type is the prevalent soil in the rolling to moderately hilly sections of the uplands. The largest tract is a few miles southeast of Whitestown. The surface consists of mounds and rather narrow ridges quite irregularly disposed and of unequal height. The local relief, that is, the difference in elevation in any 20 or 40 acre field is usually less than 30 to 40 feet; but the difference in elevation of the higher hills near the railroad and the slopes near Fishback Creek is much greater. All the land is tillable and very little is so rolling as to erode seriously. The higher ground is in part gravelly and is somewhat stony. The lower slopes of the larger ridges have a more silty soil than the higher ground, but the variation in this respect is not of great importance for the clay or sandy clay subsoil largely determines the physical conditions with regard to drainage, aeration, and average moisture content.

The areas east of Jamestown have somewhat similar topography, but most of this land is less gravelly than that near Whitestown and the soil varies from a fine sandy loam to a silt loam.

These small areas are most numerous in the western and southwestern parts of the county, and there are some very conspicuous elevations a few miles east and north of Lebanon having a sandy phase of this soil. Those in the northeastern townships have but slight elevations above the surrounding land. All the morainic hills or innumerable small elevations occurring throughout the county have in general this type of soil. In many instances the surface soil, even to the crest of the elevation, is a silt loam, but as a rule the slightly reddish sandy clay subsoil prevails, insuring good aeration and underdrainage. The mounds and ridges whenever of sufficient size have been indicated on the map. In many such cases the extent of the fine sandy loam is exaggerated, for on the flanks of the mounds there is frequently a whitish silt loam with a tight silty clay subsoil to a depth of 2 to 3 feet. This close structural subsoil imparts to these places about the same physical properties as distinguish the "clay spots" in the Miami silt loam.

These knolls and ridges are favorite sites for farm buildings. It is noticeable that apple trees on such locations average larger and evidently are longer lived than those on lower grounds. In some measure this may be due to the earlier improvements made compared with those on the Miami silt loam, but the soil in general is well adapted to the apple. This tree prefers a moderately loamy or friable surface soil with well drained clay or clay loam subsoil. The air drainage in orchards on the morainic hills is also a factor of importance in the average productiveness of the trees.

In the areas of Miami loam embracing the rolling to moderately hilly lands along the creeks, the surface features have been determined in large measure by erosion. These include the low bluffs that form the sides of the valleys of Sugar and Eagle creeks and the limited areas of broken ground on ravines breaking through these bluffy hills. In a few instances elsewhere short steep hillsides form a considerable part of the fields through which small drainage lines extend; but with these exceptions this land is easily tilled with the usual farm implements. The soil on the crests of the broader sides approaches the Miami silt loam, while on the steep slopes it is more sandy and gravel and stones are usually numerous, but never so abundant as to interfere with cultivation.

As a rule land in the immediate vicinity of the "bluff lines" is quite broken. In some instances, however, the uplands extend with comparatively little relief almost to the crests of the escarpments, such topography being found on the south side of Sugar Creek, west of Thorntown, and in the upper curves of the stream. Most of the areas on the southern tributaries of Sugar Creek are rolling, with but little ground too rough to be farmed.

In the vicinity of Zionsville much of the type is quite hilly, and farther north it has in general a rather mild topography and the boundary between the loam and the silt loam is more or less arbitrary.

The average yield of corn, wheat and oats on the Miami loam is somewhat higher than that on the Miami silt loam. The inherent fertility with regard to the mineral elements may be a little higher than that of the silt loam, because erosion has removed the surface materials, which may be assumed to have lost some of the valuable elements through long continued leaching and weathering, and brought within the zone commonly occupied by plant roots the comparatively unchanged bowlder clay beneath, for the latter is undoubtedly rich in the mineral elements, consisting as it does of a heterogeneous mixture of rock debris. Throughout most of the type free lime is found in the lower subsoil. The physical condition of the soil and subsoil insures good drainage and aeration. The pronounced brownish tints usually prevailing and the rare occurrence of mottling are due to the relatively free circulation of air and good capillarity that exist throughout the entire soil section. As stated elsewhere, the underlying glacial material is a reservoir of soil moisture and in this type the capillary connection between this substratum and the surface soil leaves little to be desired. There are many variations in this respect, but as a rule the reddish brown sandy clay subsoil, or layer between the depths of 10 to 36 inches, has good capillarity and is seldom so compact as to prevent a comparatively free downward movement of excess water in wet seasons.

Crops on this soil do not suffer so much from seasonal extremes as on the heavier Miami silt loam. The average yields of corn, wheat, and oats are somewhat higher than on the silty phases. This statement, of course, does not apply to those places where surface wash has been permitted to remove much of the surface soil and the sandy clay thus exposed has not been loosened by deep plowing and organic matter worked into it. But even badly eroded hillsides soon respond to the treatment suggested and prove quite as productive as other parts of the field.

Clover and bluegrass find this a congenial type, owing in part to lack of acidity in the soil and the presence of lime at such comparatively shallow depths in the subsoil. The yields, however, are not generally so great as on the Clyde soils. Timothy does best on the lightest colored or more silty phases of the soil. The quality of all these crops is good, there being no tendency toward slow maturity of grain or coarseness of fiber in straw and grass that is observable in soils with high organic matter content and a tendency to be wet.

In common with all the upland soils, this one is deficient in humus. The suggestions concerning the need of more vegetable matter in the silt loam apply equally well to both phases of this type.

On account of the former abundance of hard maple and black walnut, this type is popularly termed "sugar tree land." Practically all of it has long since been cleared and is now in cultivation. It is held in high esteem by farmers, chiefly because it is less susceptible to either wet or dry weather than the heavier soils, and in less measure by the easy tillage of its somewhat sandy surface soil. The areas mapped as Miami loam include only the more pronounced development of the type, phases of the silty soil approaching this loam but not distinctly characteristic of it having usually been referred to as the Miami silt loam.

Montgomery Silt Loam.

In some places in the extreme western part of Boone County the silt deposit is deeper and of slightly different appearance from that which the Miami silt loam represents. The change as one travels from Lebanon to Crawfordsville is so gradual and local variations according to topography so frequent that the transition is hardly noticeable. While the upland silt loams of the eastern and central parts of Boone are sufficiently different from those of the central part of Montgomery County to warrant separation, any line of distinction drawn between them must necessarily be more or less arbitrary. As a rule the pronounced grayish color of the Miami silt loam is not so noticeable in the Montgomery type. The latter is usually a light brown, or grayish brown silt loam to a depth of 10 or 15 inches. There is frequently considerable fine sand present and gravel and small stones very commonly occur on all the rolling areas. The subsoil is a brown silty clay loam to depth of 30 or 34 inches. Below this is encountered the glacial till similar to the subsoil of the Miami silt loam. It thus averages a little deeper than the subsoil of most of the Miami, but the tendency toward imperviousness, or tightness, that characterizes much of the deeper phases of the latter is not usually apparent. In this respect the type resembles the Miami loam, although the underlying glacial material is deeper.

The limited areas outlined in the western part of the county are essentially transitions between the Miami soils and the Montgomery silt loam which a few miles farther west is more characteristically developed. These areas in general resemble the better drained bodies of the Miami silt loam and have practically the same agricultural value along the line of contact, but the agricultural value increases toward the west bordering Montgomery County.

Fox Silt Loam.

The surface soil of the Fox silt loam to a depth of about 12 inches consists of gray or grayish brown silt loam. Upon drying out it has a grayish cast. When wet the brownish color is pronounced. Silt is the chief constituent, but there is enough fine sand present to render the material quite friable. Coarse sand is almost entirely lacking, except along the margins of the terraces and upon the occasional slight elevations that occur in the larger areas of the type. In such places the surface soil may be a fine sandy loam, with more or less gravel and some small stones, but not enough to interfere with cultivation. Beginning at about 12 inches the subsoil is a stiff, firm, brownish silty clay, not nearly so friable as the surface soil. Between the depths of 15 to 30 inches the subsoil is generally a clay, with enough coarse and medium sand to give a moist hand sample a most decidedly gritty feel. If dry the material is coarsely granular, checking into blocky fragments on exposure to the atmosphere. Vertical exposures, as in gravel pits, usually show this middle zone to be a reddish brown, crumbly clay, frequently mottled with dark chocolate brown iron stains. In the lower portion pebbles are generally quite abundant and at 25 to 36 inches there is such a rapid increase in the proportion of coarse sand and gravel that it is difficult to penetrate below 30 inches with a soil auger. The basal part of the 3-foot soil section is often a clayey gravel or very gravelly clay, while at a somewhat greater depth, usually less than 5 feet from the surface relatively clean gravel or sand is found extending to an unknown depth. In general a representative section of this type consists of about one foot of grayish silty loam resting upon a reddish brown clay or a very heavy silty clay loam that in many places is underlain by a deep bed of gravel.

This type is found on the comparatively level terraces or high second bottoms of Sugar and Eagle creeks. The elevation above the first bottoms ranges from 20 to 50 feet.

Usually in depressions in the surface of the terraces the soil is very similar to that of the higher ground surrounding them, for the gravelly substratum induces such thorough underdrainage that no semi-swampy condition ever existed. In some places, however, where there were formerly shallow ponds a black soil with a high content of organic matter has been developed. Several small areas of this kind are found on the terrace northwest of Thorntown. In such areas there is enough coarse sand in the soil to be easil observable, and pebbles are usually abundant. It is more crumbly than the lighter colored soil adjoining and may be reduced to a deep, mellow seedbed with less labor than is generally necessary on the black soils of the uplands. In a few places a "gummy" clay stratum is found just below the plow line, but such conditions are not commonly found. The subsoil is a dark colored clay or a clay loam free from the mottling usually observable in the subsoil of types of similar origin. At a depth of about 40 inches reddish brown gravelly material is generally found. This doubtless favors good underdrainage, but the close structure of the stratum between 20 and 30 inches necessitates artificial drainage in some places.

Practically all of this type is cultivated, a very small proportion being timbered. The soil yields easily to tillage, and, on account of the slightly higher percentage of very fine sand, is less inclined to pack than the Miami silt loam. Except in the depressions, the humus content, even of virgin soil, is low, due in large measure to almost continuous cropping to grain.

The substratum of gravel insures thorough drainage and aeration. The terrace lands may be cultivated sooner after heavy rains than the upland silt loams. For the same cause crops show the effects of continued dry weather, especially near the outer margins of the terraces and on some of the gravelly knolls. The stratum of heavy material over the gravel is essentially the moisture reservoir, and in normal seasons most of the type maintains a good moisture content except in places where loose gravel is found at 3 to 4 feet from the surface.

The largest bodies of this type are found on the north side of Sugar Creek near Thorntown. The elevation of the southern edge of the terrace is from 20 to 40 feet above the creek bottoms. In most places the elevation very gradually increases toward the north and the comparatively level surface of these areas merges almost imperceptibly into the undulating Miami silt loam along the somewhat arbitrary line on the map that indicates the approximate boundary between the two types. The areas on the south side of the creek are better defined topographically. The soil of the small bodies of Fox silt loam in general is more sandy than that in the larger areas, and a relatively greater proportion of the surface consists of steep slopes with more or less exposure of the underlying clay or gravel. The small areas near Zionsville have in general so much local relief that the original silty covering has been largely reduced by erosion to a fine sandy loam or shallow silty loam. A considerable part of each area is underlain by gravel and is somewhat susceptible to drought.

The average crop yields on all the heavier phases of this type are about the same as on the Miami silt loam, except such variations in wet seasons as would be expected on account of the somewhat better drainage the terrace land enjoys. The interior portions of some of the larger bodies, however, would be benefitted by tile drainage, although the absolute need of such improvement is limited to occasional flat spots having exceptionally light-colored soil. The latter are usually acid but elsewhere the soils are generally free from such trouble.

In the vicinity of Thorntown farms that consist largely of this type are now valued at from $150 to $200 an acre. The convenience of tillage the level surface affords and the generally recognized adaptability of the type to endure seasonal extremes, as well as the desirability of location, have much to do with this high valuation. The smaller areas are usually considered about equal to the Miami loam and are locally rated at about the same price.

Fox Sandy Loam.

On all the larger creeks small areas of second bottom land are found. In most instances they are fairly well defined terraces of moderate elevation, usually less than 20 feet above the overflow land. While most of the surface rises to about the same level, it is generally more or less uneven and no very well defined separation may be made between it and the adjoining upland slopes, except that the latter rise, at some distance back from the creek, to a greater altitude. The approximate extent of a number of these rather illy defined terraces has been indicated upon the map and the soil classified as Fox sandy loam.

The basic material of the areas near Zionsville is stratified sand and gravel, or at least gravelly material. The original capping of silt or silty loam has suffered much erosion on account of the uneven surface and the relatively larger extent of slope the outward margins of the individual areas usually present. On such uneven ground the soil is quite variable, ranging from a gravelly sandy loam, too loose and open to be of much agricultural value, to brown fine sandy loam having a depth of about 6 to 12 inches. The subsoil is a brown or faintly reddish brown clay that is very similar to Miami loam. On the nearly level portions the soil is usually a silty loam with sufficient depth of silty clay substratum to have good moisture holding properties. The surface is generally gravelly with a good many small stones on the more broken ground. Exposures of the underlying gravel are generally numerous.

The small areas on Sugar Creek and its tributaries have generally a brown silty or fine sandy soil, with a relatively heavy subsoil.

With such diversity in soil texture and structure no statements relative to actual agricultural value are applicable to the type as a whole or even to the different parts of the same area. Nearly all is regularly cultivated, and, except in unusually dry seasons, the crop yields on the most of this ground are very satisfactory. On nearly all of it clover does well and blue grass makes a good growth, but of course does not remain green so long in summer as on the soil capable of holding moisture better.

Genesee Sandy Loam.

A considerable portion of the first bottom land on the lower course of Eagle and Sugar creeks consists of rather coarse-textured material, ranging from a brown loamy sand to a moderately heavy sandy loam. The latter represents the more common development, for drifts of loose sand occur for the most part only in the channel, and very light sandy soils are seldom found except on the immediate banks and the inner sides of short curves. Most of the areas mapped as Genesee sandy loam have a surface soil in which sand of various grades is the chief component, but there is usually enough silt and clay to give more or less coherency and favorably affect the moisture holding properties. There is usually but little humus, except in depressions. The characteristic color is a brown suggestive of iron stained particles but slightly affected by organic matter. In most instances there are but few stones or pebbles.

The subsoil is exceedingly variable in texture. It ranges from a stiff sandy loam of brown color or slightly mottled with rusty iron stains to a light brown sand that a few feet below the surface may be loose and coarse.

The substratum in most places is sand and gravel. The water table fluctuates with the rise and fall of the stream, but it seems that it usually stands well up toward the bottom of the 3-foot soil section. For this reason, most of the type maintains a fair degree of moisture, except in unusually dry seasons. In normal seasons and during usual stages of the streams corn does well and other crops make very satisfactory yields. Nearly all the type is subject to overflow, but the inundations seldom last more than a few hours. The fertility of this rather coarse open soil is thus frequently renewed, which accounts in large measure for the excellent returns almost invariably secured on some low lying and very sandy phases of the type. Much of this type is well adapted to melons, sweet potatoes, and other crops requiring a light soil.

The color in what may be considered the typical development of this soil, is a pronounced brown, suggestive of a dull shade of ochre rather than the dark brown coloration usually associated with soils in which there is more or less humus. In this type there is a noticeable lack of organic matter, the surface soil differing slightly in this respect from the subsoil. This observable deficiency in humus and the brown color, which is undoubtedly due to a rather high degree of oxidation of the iron content and uniform distribution of this ferruginous material throughout the soil mass, differentiating this soil from the Genesee loam. The distinction is easily apparent when the average material of the Genesee silt loam is compared with a sample of the Genesee loam.

Genesee Silt Loam.

The Genesee silt loam consists of a brown silty loam to a depth of 8 to 12 inches. The proportion of fine sand is usually so high that the surface is very friable and has in general the properties somewhat characteristic of a fine sandy loam, rather than those of a heavier soil. It yields easily to tillage and only in the very heaviest phases becomes cloddy or is inclined to pack after rains. The subsoil is a light-brown silt loam, being a little heavier in texture and more compact than the surface foot, but it is not difficult to penetrate with a soil auger. As a rule it has a texture and structure highly favorable to the maintenance of good moisture conditions. Except in local depressions or in the occasional sandy mounds, saturation or extreme dryness seldom occurs. This is due to the average elevation, which ranges from a few feet to as much as 10 to 15 feet above the adjacent portion of the stream channel, and is also favored by the presence of a rather coarse sandy substratum that is frequently reached with a 40-inch soil auger.

This type is of alluvial origin and is found along Sugar and Eagle creeks and their larger tributaries.

The surface is generally free from stones and gravel and there are comparatively few abandoned channels or deep depressions of any sort. The slight mound-like elevations found in some of the larger areas are more sandy than the lower ground. The immediate banks of the streams and lines of "cut-off" for the current during floods are also quite sandy and in places gravelly.

The water table is not generally more than a few feet below the surface, so that the moisture content seldom falls below that necessary for a growing crop. Exceptions to this occur along the channel where coarse sand may be found a little below the surface, or in spots in the interior of the fields where the structure is similar, but these are limited to a very small proportion of the total area anywhere. The equitable water supply is doubtless the chief factor in the excellent average yields of grain and grass.

Practically all of this type is now cultivated. Clover, timothy, and bluegrass do especially well on this land, but as a rule it is so generally devoted to grain that alternates with grass or clover are not frequently made. It is quite apparent, however, that some of the higher lying areas are in need of more frequent change to crops that tend to increase instead of diminishing the organic matter. On one rather heavy phase of this type near Thorntown yields of 80 to 90 bushels of corn have been secured, but the ground has been frequently manured and otherwise well cared for.

Oats do not generally grow so rank as on the Clyde soils. Rye and wheat do better than on the average upland soil. Returns of from 30 to 40 bushels of the latter having been reported in favorable seasons.

Notwithstanding its deficiency in humus, the type has a high value as a corn soil. The short inundations to which much of it is subjected almost every year and the rare overflows that sometimes extend over all but the highest parts deposit much fine material, and the fertility is thus renewed to an extent that compensates for the temporary loss sustained when floods come, as they sometimes do, in the growing season.

The higher lying portions of this alluvium are well adapted to alfalfa. The short overflows are not liable to cause much injury except in the quantity of weed and bluegrass seed thus scattered on the land.

Genesee Loam.

The Genesee loam embraces those black alluvial soils found along the smaller streams and in some of the widest parts of the valleys of the larger streams. In the former locations the surface soil is usually a dark-brown or dark-drab silty loam with enough sand to render it rather friable and loamy. Where it approaches in texture a clay loam the surface is crumbly and the subsoil usually less compact than that of the other black lands. The organic matter content is moderately high and effects the color to a depth of 15 to 18 inches.

The subsoil is a clay or clay loam and ranges in color from gray, mottled with yellow or yellowish brown, to dark brown or drab, with many rusty-brown iron stains in the lower portion. In the lower part of the 3-foot section there is considerable coarse sand and fine gravel. The lighter tints indicate poor aeration and a rather high average level of the water table. On the other hand, the darker colors are found where the natural drainage is better, a condition usually prevailing in most of the type. It is a little more compact than the surface soil but seldom "gummy" or containing a semi-impervious layer. It is generally so open in structure that it admits of comparatively good underdrainage and aeration. The exceptions to this are generally confined to low places where the average level of the ground water is close to the surface.

The Genesee loam on Sugar Creek generally occurs on the outer margin of the wider parts of the flood plain, where there is little sedimentation, except from the back water of the highest floods. Since the burden of these is mostly silt and clay particles, comparatively heavy soils have been developed. At the foot of some of the hillsides narrow strips of muck are often found, due to seepage from the higher ground. In some of these places the subsoil contains so much bog iron that it is very yellow and sticky. Near the stream channel the texture is coarser and there is less organic matter in the surface soil.

This soil has a high degree of fertility and possibly is as nearly inexhaustible with regard to the element of mineral plant food as any soil can be, but the organic matter content in some of the higher lying areas is decreasing. The soil is slowly assuming a higher color and the physical conditions are possibly less satisfactory than when the land was cleared. Such ground would be benefited by more frequent change to clover or to pasturage grasses. Lower ground subject to more frequent inundations in thus rejuvenated, but well drained higher valley lands will in time at least show the effects of almost continuous cropping to corn.

The yields of corn on this type are frequently as high as 80 to 90 bushels per acre. Wheat usually gives better returns than on the Miami silt loam, but the possibility of injury by flood is, of course, a serious menace. On the highest location, where floods of a few hours duration seldom occur, alfalfa would do well, the fertility of the soil and the permanency of the water supply being especially favorable to this crop.

Muck.

In soil classification Muck is a term applied to those deposits consisting chiefly of vegetable remains where the decomposition occurred in part under water or at least under conditions of almost constant saturation. The earlier stage of the process usually forms peat, a brown, fibrous mass, in which the plant tissues are still discernible, but further change, with more or less exposure to atmospheric agencies, generally gives a very black, finely divided carbonaceous material, loose and porous when dry and very soft and spongy if wet. All these cumulative deposits are in a later stage of decomposition and many of them have so far changed under the influence of artificial drainage and admixture of silt and clay from adjoining cultivated land that they are now essentially a soil, with an abnormally high content of organic matter. This is frequently the case in the lowest portions of the Clyde silty clay loam.

The muck areas indicated on the map are as yet true muck. From a depth of about 4 inches to a foot or more the material is black, finely divided plant tissue with comparatively little earthly material. In artificially drained and well cultivated fields the surface is loose and offers but little resistance to any implement. Its general physical properties are indicated by the local name "chaffy" land, but it is in too fine a state of division to render this term correctly applicable.

In the smaller areas the muck is usually but a few inches deep and as a rule more or less earthy material is mixed with it. The upper subsoil is generally a black, granular clay or silty clay loam, grading with increase of depth to a yellow or mottled yellowish and gray clay. In many cases the subsoil is identical with that of the Clyde silty clay loam.

In the larger areas along the Eel River ditches the muck has a depth of from 10 to 20 inches, the lower part of which is often quite compact and invariably contains much moisture. Beneath the vegetable material is often found a close, heavy dark-drab clay, in many instances so sticky and gummy as to be very difficult to penetrate with a spade. This layer is not usually more than a foot or so thick, but changes at a depth of 15 to 20 inches to a brown marly clay that at 36 inches is a light gray marl, with many small shells. In this material the lime carbonate may be so high that it is rather friable and chalky. Four or five feet below the surface there is generally a clay. In no instance was this substratum found to be sand or gravel.

Practically all of this type, which is locally termed "chaffy" soil, is now drained and in cultivation. Bluegrass and timothy make a rank growth, but the quality of the hay is not so good as that made from grass on normal soils. On all this type corn fails to thrive so well as on the Clyde silty clay loam. The plants when from 2 to 3 feet high are very liable to turn yellow, the lower leaves being affected first. The stalk ceases to grow and even if it does not die, it fails to mature any grain. The extremity of the roots die and in many instances are shriveled and brown nearly to the base of the stalk. This trouble, common to many muck and peat soils throughout northern Indiana, may be remedied by the application of potash. From 100 to 200 pounds of muriate of potash per acre should be used. It is better to distribute the potash over surface, or, at least to drill in the hill. This soil is also improved for corn by applying several loads of manure per acre. It is probable that the manure introduces bacteria that are necessary to the growth of corn but are not present in the muck. The latter is generally acid, as indicated by the litmus paper test.

The Muck soils will improve in physical character and lose the "chaffiness" with continued cultivation. The black carbonaceous subsoil will yield to atmospheric agencies wherever drained and gradually assume a granular structure similar to that of the other black soils. In the management of this soil deep plowing of those areas where the mucky material is but a few inches deep will hasten the process, rendering the soil more firm and of better texture. Whenever practicable it should be done in the fall so that the stiff gummy clay may be frozen and thawed as many times as possible. This will render it less troublesome to cultivate later.

The deeper Muck is easily cultivated and by the use of potash or stable manure the production of corn should be attended with little chance of failure. Yields of 70 to 80 bushels have been secured under favorable conditions or when the soil was more or less loamy. The quality of corn is invariably improved by the potash, but it is not generally so good as that on a normal soil.

Some of the tracts near the large ditches could be utilized advantageously for truck, such as onions, cabbage and celery. It also seems possible that a limited acreage could be thus used and profitably irrigated by means of pumps.

MEADOW.

This type embraces those narrow strips of alluvium on the small branches and upper courses of several of the creeks. The conditions of deposition prevent the development of any well defined type. As a rule most of the material is rather fine textured, varying from a silty loam to a fine sandy loam, and generally there is but little coarse sand or gravel, except near the channel of the stream. The surface in most places is more or less uneven and in the wider development low, seepy spots frequently occur on the margin. There is usually a low, bluff-like bank on one or both sides of the Meadow where the stream is a short tributary of one of the larger creeks. On the heads of small branches this topographic feature is lacking and the distinction between this type and the Clyde silty clay loam is not well defined. In nearly all cases the width of the alluvium on the small drainage lines is considerably exaggerated upon the map.

Practically all of this type has been cleared of the original timber, wholly or in part, so that it is now mostly set to blue grass. Some of the widest portions of these little valleys are cultivated, the soil usually being a very fertile, dark colored fine sandy loam, but crops are liable to injury by overflows.

SUMMARY.

Boone County is located in the central part of Indiana and has an area of 420 square miles. The surface is undulating, becoming more rolling and hilly along the larger streams. There is very little land unsuitable for tillage and practically all is included in well improved farms. The public roads are excellent, and several steam and electric lines afford most convenient transportation facilities.

Corn, oats, wheat, and clover are the principal crops. Comparatively few cattle are fattened but dairying is carried on quite extensively. Some attention is given to sheep, and many draft horses are raised, but hog raising is the principal live stock industry.

All the upland soils are the derivatives of a thin surface deposit of silty material overlying glacial material. The alluvial types are of limited extent and generally consist of brown sandy loams.

The Miami silt loam, or "clay land," is the most extensive type. It is a light colored silt loam, with a rather heavy silty clay subsoil. It is deficient in humus and on this account requires rather careful management. Clover does well on it and it is excellent timothy and blue grass land. The average yields of corn are about 40 bushels per acre; of wheat 15 to 20 bushels; and of oats from 30 to 40 bushels.

The Miami loam, or "sugar tree land," embraces most of the rolling lands and the local elevations of the uplands. The soil contains more fine sand than that of the Miami silt loam and the subsoil is more open in structure. On account of its more effective underdrainage and aeration, this type is less susceptible to seasonal extremes than the heavier types and the average yields of grain are somewhat higher.

The Clyde silty clay loam locally termed black lands owes its origin to the semi-swampy conditions formerly prevailing in practically all the depressions of the uplands. Under artificial drainage it is an ideal corn soil, the average yield in favorable seasons being 80 bushels per acre. Wheat does well and timothy, clover, and bluegrass make heavy yields. Limited areas of this type have an excess of vegetable matter in the surface soil and are called "chaffy" land. A few small areas of true Muck occur in association with these black lands.

The Fox silt loam occurs on the level bench lands of Sugar and Eagle creeks. It is similar to the Miami silt loam, but the smooth surface and generally good natural drainage render it somewhat easier of management. On these terraces that have an eroded surface the soil is quite variable in depth and texture, but most of it is a sandy loam. This variable condition is represented by the Fox sandy loam.

The Genesee silt loam embraces most of the larger areas of alluvium. It is a brown silty or fine sandy loam rather low in organic matter, but the physical structure and topographic position insure good moisture conditions. Most of this type has a very high agricultural value.

No very close distinction can be drawn between the latter type and a moderately coarse sandy loam of common occurrence along the channels of the larger creeks. This latter type, mapped as Genesee sandy loam, has a rather limited areal extent and is not so safe a soil in dry seasons as the silt and fine sandy loam.

The narrow strips of alluvial soil on the branches are represented by Meadow. The texture, structure and drainage conditions are quite variable, and most of this land has little present agricultural value except for pasture.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF SOILS—MILTON WHITNEY, Chief

In Co-operation with the State of Indiana, Department of Geology

EDWARD BARRETT, STATE GEOLOGIST

SOIL SURVEY

OF

MONTGOMERY COUNTY, INDIANA

BY

GROVE B. JONES, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND
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[Advance Sheets—Field Operations of the Bureau of Soils, 1912]

CONTENTS.

Soil Survey of Montgomery County, Indiana

By Grove B. Jones, of the U. S. Department of Agriculture, and C. H. Orahood, of the Indiana Department of Agriculture.

DESCRIPTION OF THE AREA.

Montgomery County, Ind., is situated in the west-central part of the State. It is bounded on the north by Tippecanoe County; on the east by Clinton, Boone, and Hendricks counties; on the south by Putnam and Parke counties; and on the west by Parke and Fountain counties. It has an area of 508 square miles or 325,120 acres.

The county is divided into two nearly equal parts by Sugar Creek, the largest stream in the area, formerly known as Rock River. This stream enters the county from the east about 5 miles south of the northern boundary, and leaves the county about 5 miles north of the southern boundary. Its tributaries from the north are Lye and Black creeks and from the south, Walnut, Offield, and Indian creeks. The extreme south and southeastern parts of the area are drained by the Raccoon Creek and Cornstalk Creek; the northwest part by the branches of Coal Creek, a stream emptying directly into the Wabash River.

The topography, which varies from level to rolling and hilly, is characteristic of a glacial region. Probably the highest elevation in the county is to be found in the vicinity of Alamo, where the glacial moraines attain an altitude of approximately 870 feet. Other morainic elevations of considerable height are found north of Yountsville. One point known as "Bald Hill" rises to a height of 190 feet above Sugar Creek. In general the surface varies be tween 700 and 850 feet above sea level.

The largest level area in the county, geologically known as ancient Lake Harney, lies in the south-central part, and until reclaimed by artificial drainage was called Black Swamp. The surface of this entire area presents but slight varation in elevation. A strip of prairie land from 1 to nearly 5 miles wide, gently undulating in character but broken by occasional wooded areas, extends entirely across the northern part of the county.

From its point of entrance into Montgomery County to about two miles below Yountsville, Sugar Creek has a valley of considerable width consisting of bottom or overflow land and terraces at varying elevations. Below this point the valley is contracted by precipitous bluffs, many of which are bare rocky cliffs from 100 to 200 feet or more in height. Numerous springs give rise to streams which have reduced the country for nearly a mile on either side of Sugar Creek to a net work of deep gullies and steep slopes, for the most part unsuited for cultivation. The accompanying soil map is not a topographic sheet, and since it does not show the elevations it is difficult to get a correct idea of the unevenness of this section of Montgomery County.

Montgomery County was organized in 1823 and the town of Crawfordsville, situated in the central part, founded. As the country was settled Crawfordsville became an important business point. It was incorporated as a city in 1865 and today is the county seat, with a population of about 10,000. Several manufacturing industries are located here. Crawfordsville is also the site of Wabash College, organized in 1832. Ladoga, situated in the southeastern part of the county, is second in size, with a population of about 1,200. Here is located the only canning factory at present in the county. Waveland affords an outlet for the produce of the southwestern part of the county, while Darlington, Linden, New Richmond, Wingate, Waynetown, Kirkpatrick and Alamo are thriving market towns, supplying the communities in which they are located.

The system of consolidated schools has recently been introduced. Modern commodious structures advantageously situated have displaced the more numerous small schoolhouses. The system is said to be satisfactory.

The roads throughout the county are as a rule in good condition, most of them being graveled. During the last few years some have been macadamized and each year the mileage is increased.

The county is well supplied with steam and electric roads. Three railroads pass through Crawfordsville, the New York Central and Pennsylvania systems and the Chicago, Indianapolis and Louisville Railway. The Toledo, St. Louis and Western crosses the northern part of the county, passing through Wingate, New Richmond, Linden and Kirkpatrick. In the southern part of the county the Central Indiana Railway connects Waveland and Ladoga with Lebanon in Boone County.

Crawfordsville is also the terminus of two electric lines. The Indianapolis, Crawfordsville and Western—Ben Hur Houte—extends southeast, connecting the county directly with Indianapolis. The Terre Haute, Indianapolis, and Eastern traction line, known as the Northwestern, runs east to Lebanon and other points. It is planned to extend this line west from Crawfordsville, connecting it with Danville, Ill. The construction of a system of spurs into parts of the area not at present served with transportation facilities will be welcomed. Alamo and vicinity will be especially benefited.

CLIMATE.

The tables following give the records of the Weather Bureau stations at Lafayette and Veedersburg in counties adjoining on the north and west, respectively. No means have been established

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT LAFAYETTE, TIPPECANOE COUNTY, IND.

MONTH.	TEMPERATURE.			PRECIPITATION.			
	Mean.	Absolute Maximum.	Absolute Minimum.	Mean.	Total Amount for the Driest Year.	Total Amount for the Wettest Year.	Snow, Average Depth.
	°F.	*°F.*	*°F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	29.7	69	—17	2.59	1.95	5.84	3.5
January	25.3	70	—33	2.47	1.18	0.40	7.0
February	26.9	69	—26	2.75	2.94	5.78	6.3
Winter	27.3	69	—25	7.81	6.07	12.02	16.8
March	37.6	83	—5	3.20	1.41	3.30	4.4
April	50.5	89	10	3.27	2.94	2.25	0.4
May	61.5	97	25	4.40	2.11	3.82	T
Spring	49.9	90	10	10.87	6.46	9.37	4.8
June	70.7	100	33	4.43	1.97	7.16	0.0
July	74.6	105	42	3.77	0.88	2.05	0.0
August	72.6	102	39	3.23	3.08	0.47	0.0
Summer	72.6	102	38	11.43	5.93	9.68	0.0
September	66.1	101	29	2.77	3.02	4.20	0.0
October	53.3	92	16	2.35	1.62	4.42	T
November	39.5	95	—1	3.06	3.72	6.49	1.2
Fall	53.0	96	15	8.18	8.36	15.11	1.2
Annual	50.7	89	10	38.29	26.82	46.18	22.8

Average date of first killing frost in Autumn, October 5.
Average date of last killing frost in Spring, April 26.
Earliest date of killing frost in Autumn, September 14.
Latest date of killing frost in Spring, May 27.

for Crawfordsville, nor is there any station in the county with satisfactory records. The data compiled from the two stations mentioned are, however, applicable to local conditions.

The climate of Montgomery County is humid. It is characterized by wide variations in temperature. It will be seen that the mean annual precipitation is about 34 and 39 inches and is favorably distributed through the year.

The average snowfall recorded at Lafayette covering a period of 22 years, is 22.8 inches, which under normal conditions, is sufficient to protect crops of winter wheat, rye and clover.

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT VEEDERSBURG, FOUNTAIN COUNTY, IND.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute Maximum.	Absolute Minimum.	Mean.	Total Amount for the Driest Year.	Total Amount for the Wettest Year.	Snow, Average Depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	31.0	62	—12	2.17	3.20	0.43	....
January	27.3	69	—24	2.34	1.34	0.43	....
February	25.1	64	—14	1.91	1.39	2.65	....
Winter	27.8	65	—17	6.42	5.93	3.51	....
March	42.9	84	—6	3.20	3.78	3.18	....
April	51.2	88	20	2.23	2.13	0.69	....
May	63.1	94	23	4.33	2.68	5.80	....
Spring	52.4	89	12	9.76	8.59	9.67	....
June	70.3	97	36	4.97	7.98	9.06	....
July	75.3	105	42	3.51	0.39	6.46	....
August	74.0	101	44	3.29	4.40	3.87	....
Summer	73.2	101	41	11.77	12.77	19.39	....
September	68.7	97	31	2.23	T	2.19	....
October	57.0	90	20	2.27	4.45	3.30	....
November	41.6	78	7	2.12	0.98	3.43	....
Fall	55.8	88	19	6.62	5.43	8.92	....
Annual	52.3	86	14	34.57	32.72	41.49	....

Average date of first killing frost in Autumn, October 5.
Average date of last killing frost in Spring, May 1.
Earliest date of killing frost in Autumn, September 14.
Latest date of killing frost in Spring, May 21.

Records of frost occurrence at Crawfordsville give the average date of last killing frost in spring as April 24, and of first in fall as October 20. There is thus 189 days free from frost of sufficient severity to injure even tender plants. The season is ample for the maturing of the principle crop, corn.

Agriculture.

In Montgomery County agriculture is the principal resource. It dates back to 1823, when the first settlement was made on a high bluff overlooking Sugar Creek, at what was destined to be Crawfordsville. The development of agriculture was slow, for nearly all the county was originally forested with hickory, oak, elm, maple, beech, and walnut.

Corn was the first crop grown but was later planted in alternation with wheat. Wheat for a long time was extensively grown, but for nearly a score of years there has been a rapid falling off in wheat production.

Formerly stock raising was a leading industry, as the soils are nearly all adapted to the growing of grasses, the native bluegrass and prairie grass of the northern section of the county affording ample grazing for large herds of stock. At present, however, only a few head of cattle are fed on most of the farms and more attention is paid to raising of hogs. The present high prices of beef and pork it would seem should stimulate the development of these forms of animal husbandry.

The raising of sheep was once extensively carried on and there are still some flocks in nearly all parts of the county. The rough areas in the southwestern part of the county are well adapted to sheep raising.

Some good horses are kept for teaming and farm work and a number of mule colts are raised.

At the present time the farmers of Montgomery County are devoting most of their attention to growing corn, hay, oats, wheat, and rye, and to a limited extent, millet, alfalfa, truck crops, and tomatoes for canning purposes.

The growing of alfalfa is in its infancy in Montgomery County, but it can be grown with profit; a few farmers recognize this fact and are taking advantage of it. Its importance as a feed, especially for dairy cows, and as a soil renovator are recognized. Alfalfa is usually difficult to start, and for this reason many farmers become discouraged. Alfalfa is successfully grown on a small scale on a number of soil types but failures have been made in attempting to seed this crop on these same soils in other parts of the county. As a general rule it is difficult to introduce any new crop into a region where farming is well established along fixed lines and when the attempt is made and attended by no pronounced success there is no disposition to give the crop another trial.

For the production of alfalfa the soil should be well drained, liberally supplied with lime and barnyard manure and reduced to the best physical condition. Inoculation may be necessary, although it is not always so, especially where sweet clover grows. Soil from a field where alfalfa has grown successfully may be used for this purpose. Weeds are inclined to crowd alfalfa out, and only by frequent cutting can they be kept back.

About 20 pounds of alfalfa seed per acre is sown without a nurse crop in August or September, or it may be seeded in the spring with oats. The introduction of this crop into the rotation would be of great value. Besides adding nitrogen to the soil the deep subsoil is loosened by the roots, which penetrate to great depths.

Corn is grown extensively over the entire area, and it is the most important crop. A few silos are in use by the dairies around Crawfordsville and their number is gradually increasing. Late corn planted for ensilage forms excellent feed for both dairy and market cattle. Oats are grown extensively and the acreage devoted to rye is being increased.

The growing of tomatoes for canning has developed extensively in the vicinity of Ladoga where the only canning factory in the county is located. From 125 to 250 bushels per acre are generally obtained and 20 cents a bushel is the average price paid. As the canning industry grows other canning crops, such as sweet corn and peas, will doubtless be produced.

The trucking industry has not been extensively developed. A number of gardens in the vicinity of Crawfordsville supply that local market. Strawberries, tomatoes, cabbage, melons, cantaloupes, lettuce, and cucumbers are grown successfully. This industry could be profitably extended, especially upon the sandy loams.

Other special crops could be profitably grown on many of the soils. Muck is well suited to the production of celery, lettuce, cabbage, and carrots, and sugar beets are grown farther north on soils similar to those existing in the county.

Conditions are favorable for dairying. The product of the several existing dairies is at present consumed within the county, but there appears to be no reason why a surplus for export should not be produced.

The agriculture of the area is highly developed and the crops which are being grown are well adapted to the soils and general conditions. The general appearance of the farms indicates a high average condition of thrift and prosperity. The farm buildings as a rule are well built and substantial, and many are equipped with modern improvements.

About 60 per cent. of the farms are operated by the owners. There is thus considerable tenant farming. Both cash and share systems of renting are practiced. When rented for cash farm lands bring from $3 to $6 an acre. The more common plan of rental is on a share basis, the landlord receiving one-half of the products. The tenant often pays a cash consideration usually designated the "privilege", for use of house, barn, garden, and pasture. Threshing expenses are usually equally divided. Many landowners rent their farms to tenants and live in the towns and villages.

The value of farm lands in the county varies from $15 to $50 an acre for steep broken land to $200 an acre for well-improved "black land" (Clyde soils). Values have advanced sharply in the past few years.

The light-colored soils of the county are in need of organic manures. The black soils are well supplied with organic matter, but frequently are more or less acid, and some form of lime, such as pulverized limestone should be applied. On such soils phosphoric acid is also often beneficial.

On the whole, fairly good cultural methods are practiced in handling soil, but in many cases crop yields may be increased by deeper plowing, more thorough tillage, and systematic rotations. The importance of crop rotation is recognized and generally followed, though a greater portion of the land might be kept in clover to good advantage.

There is need of improving the drainage conditions on the Clyde silty clay loam and the Miami silt loam.

SOILS.

Montgomery County lies within that portion of the glaciated region covered by the later or Wisconsin invasion. This great ice sheet, which covered the country to a depth of many hundred feet, not only brought about by its abrasive action great changes in the general configuration of the surface but by the deposition of ground up material, covered the county with a mantle of unconsolidated material which now in a more or less modified condition constitutes the source of the soil material.

The bed rock underlying the whole of Montgomery County consists of many thin strata of shale, sandstone, and limestone, which have been classed as regards age with the Lower Carboniferous. These rocks were originally so deeply covered by the unconsolidated glacial drift that they are never exposed in sufficient extent to weather into distinct residual soils and only slightly influence the composition of the glacial soils, as the debris of local derivation makes up only a small proportion of the drift. The varying degrees of hardness of the several strata have, however, brought about changes in topography, as shown by preglacial valleys and by valleys eroded since glacial times.

These rocks have contributed to the industries of the region some materials of economic importance.

The rocks of the Knobstone group consist mainly of blue-gray shales and sandstone and are conspicuously exposed along Sugar Creek in many places. In the vicinity of Crawfordsville the shale is used in the manufacture of a fine quality of building brick. Overlying the Knobstone group is the Harrodsburg limestone, exposures of which are seen along Sugar Creek, west of Waynetown and south of New Ross. The Bedford Oolitic limestone outcrops a quarter of a mile north of Parkersburg. The Mitchell limestone overlies the Bedford Oolitic limestone and is found in the southwest corner of the county.

The Mansfield sandstone being more resistant than the strata above and below it has weathered into the bold cliffs at Shades and into lesser cliffs and terraces in many places along Sugar Creek and its tributaries.

The agency of the ice flow in influencing topography is to be seen in altered stream channels and in the presence of preglacial valleys and lakes. The present course of the deeply entrenched channel of Sugar Creek beginning a few miles west of Crawfordsville and a short distance north of Yountsville, indicates conclusively the recent origin of this chasm. Before becoming obstructed it is thought that the outlet for Sugar Creek was by means of two channels, one leading more directly to Coal Creek, the other to the southwest of Yountsville. Lye Creek is believed to have also occupied a preglacial valley.

Ancient Lake Harney, a preglacial lake several miles in extent, is found south of New Market. It was known to the early settlers as "Black Swamp."

The covering of drift, combined with the reworked loessial material, varies in depth in different parts of Montgomery County from a few inches over the steep broken land to 100 feet or more over the morainic portion. The till consists of a heterogeneous mass of sand, gravel, clay, and bowlders at lower depths, but as a rule the surface covering is more homogeneous over considerable areas and has weathered into fairly uniform types of soil. Occasional large bowlders apparently dropped promiscously, are a feature of the landscape. A train or dyke of these bowlders, one-fourth to one-half mile wide extends across the northeastern part of the county. These bowlders consist for the greater part of crystalline rocks derived from distant sources.

The glacial drift is overlain almost everywhere by loessial material. Hills, slopes, and valleys alike have this silt covering which varies in depth from a few inches to nearly three feet.

The Montgomery silt loam is the most extensively developed soil type. The material of the surface soil or of the surface soil and the upper subsoil appears to be closely related to the loess, while that of the subsoil or lower subsoil is glacial till.

The Miami silt loam represents the weathered product of the glacial till over gently rolling or nearly level areas.

The Carrington silt loam is composed of bowlder drift material weathered under conditions that have produced a dark colored surface soil.

The Clyde silty clay loam has been produced where till and loessial material have weathered under poor drainage conditions, favorable to the accumulation of dark organic matter. It has also been modified to some extent by the washing in of silty material from the higher lands.

Two terrace soils are found in the county, the Fox silt loam and the Fox sandy loam. Both contain gravel which increases with depth. The type represents reworked glacial material deposited when the stream flowed at a higher level than at present.

The Rodman gravelly sandy loam is found occupying morainic lines and ridges.

The soils of the Genesee series and Meadow represent recent alluvium and are composed principally of reworked glacial and loessial material.

Montgomery Silt Loam.

The surface soil consists of a light-brown silt loam about 10 to 15 inches deep. In some localities a small quantity of pebbles or gravel and occasionally some cobblestones and bowlders are found, but the distribution is not general.

The subsoil to a depth of about 30 inches, is a yellowish-brown, heavy silt loam to silty clay loam, where the glacial drift material is usually encountered. This bowlder till closely resembles the lower subsoil of the Miami silt loam and consists of a brown to slightly reddish-brown sandy clay or clay loam. Below three feet gravel cobbles, and bowlders become more numerous.

There are some included patches too small to map in which the texture ranges to a loam or fine sandy loam, particularly on some of the knolls and slopes.

The Montgomery silt loam is the most extensive soil type in the county. For the most part it occupies rolling country, although there are some nearly level areas and a few morainic hills. In the vicinity of Alamo the topogaphy is billowy and the surface soil in this region and around Waynetown and east to Wesley Chapel generally speaking contains a higher percentage of medium and coarse sand that is typical.

The Montgomery silt loam consists of the finer grades of glacial drift material modified more or less by the addition of what appears to be loessial material. In some localities the effect of wind action upon the material is quite apparent.

Where the type occupies level to undulating areas there is a close resemblance to the Miami silt loam. The likeness, however, is found in the subsoil, which is more compact and has the characteristic mottling of gray and yellow. This condition is due to immature drainage and poor aeration. In these areas the surface soil has a brown color while the Miami silt loam under similar conditions is light gray to whitish.

The natural drainage of the Montgomery silt loam is in most places good, and only in a few localities is artificial drainage practiced. The type is locally known as ''sugar tree land'' on account of the predominance of the hard maple on such areas. Besides maple, oak, hickory, walnut, and beech are abundant.

The type is a typical general purpose soil. All the farm products common to this region are grown successfully. As in the case of the other soils of the county, the principal crop is corn, with yields ranging from 40 to 70 bushels per acre. The acreage of oats is large and the soil is productive of this crop. The average yield in the year 1912 was about 65 bushels per acre. The preceding year the yield was about 40 bushels per acre which is nearer the average. A large area is devoted to wheat which yields 20 to 27 bushels per acre. Some rye, buckwheat, and millet are grown.

Timothy and clover do well on this soil, ordinarily yielding from 1½ to 2½ tons of good quality hay per acre. Of timothy seed

7 or 8 bushels per acre and of clover seed from 1 to 2 bushels are obtained. Excellent bluegrass pastures are found, supplementing the hay crops during about six months of the year. Alfalfa is another forage crop which succeeds on the type. The crop is gaining in favor but the acreage devoted to it is still small.

A common rotation valuable for use on the Montgomery silt loam covers a period of four years and consists of corn, oats, wheat, and clover. Corn is frequently planted two years in succession, the remaining steps in the rotation being unchanged.

Corn is fertilized at the rate of 100 to 175 pounds per acre with a mixture analyzing 1.5 per cent. nitrogen, 9 per cent. phosphoric acid, and 4 per cent. potash, though the formulas of different brands may vary slightly from this. For oats and wheat about 125 pounds per acre of the same mixture is applied.

The Montgomery silt loam is a mellow, friable soil of easy tillage. Its loamy structure allows the free circulation of air and moisture and the land is in condition to plant at a relatively early date. The internal drainage is not sufficiently free to make the soil unretentive of moisture.

Truck crops and fruit are grown for home consumption in all parts of the area. Apples, pears, cherries, grapes and small fruits do well. Tomatoes for canning are grown to a limited extent and are found profitable.

The Montgomery silt loam is naturally deficient in organic matter. This should be supplied by plowing under legume and other green crops, and by returning to the soil the straw and other litter left from the harvested crops. Weeds are valuable for this purpose. Barnyard manure is, of course, the most valuable means of adding organic matter to the soil, and where an ample supply is available, green manuring may be dispensed with. Alfalfa, clover, and other leguminous crops also help to maintain the nitrogen content of the soil through their ability to collect this ingredient from the air.

Montgomery Silt Loam, Flat Phase.—The Montgomery silt loam, flat phase, consists of a grayish-brown to dull or dark gray silt loam about 6 to 8 inches deep.

The subsoil is a mottled brown and gray, crumbly silt loam which becomes gradually heavier and more compact as the depth increases, passing at 15 to 20 inches into heavy silty clay loam of a mottled yellowish-brown or yellow and gray color. The subsoil usually contains some small iron concretions, and these are also scattered over the surface and through the soil.

The main body of this phase of soil occurs in the south-central part of the county, south of New Market and east of Browns Valley, where it occupies a nearly level country. This large area is locally known as "Black Swamp." It is poorly drained, and requires tiling or ditching for best results with crops. Evidences of glacial lake origin do not seem to be strong enough nor is the color of this soil dark enough to warrant the classification of this soil as a member of the Clyde series. It has been suggested by some geologist that Big Swamp represents the site of a former glacial lake.[1]

A few small areas of the Montgomery silt loam, flat phase, were mapped to the south of Alamo. These areas probably represent small glacial lakes or swamps at one time more or less closely connected with the larger body.

The Montgomery silt loam, flat phase, yields from 50 to 75 bushels per acre of corn, from 50 to 60 bushels of oats and from 1 to 2 tons of hay.

Very little wheat is grown, as it is not a profitable crop on this phase. During winter months it leaves badly and if it survives the winter it usually lodges on account of the heavy growth of straw. The phase needs to be improved, especially in case of the small depressions. This will improve it somewhat for the production of the cereal crops.

Farm values on this type of soil range from $100 to $150 an acre, and of the flat phase from $125 to $150.

The results of mechanical analyses of samples of the typical soil and subsoil of this type are given in the following table:

MECHANICAL ANALYSES OF MONTGOMERY SILT LOAM.

No.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cnet.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
281319	Soil	0.1	1.2	1.6	3.8	5.5	74.1	13.4
281320	Subsoil	.3	1.3	2.0	5.0	5.0	63.1	23.6

Miami Silt Loam.

The soil of the Miami silt loam consists of a light gray to light brown silt loam about 8 to 12 inches deep. The subsoil to an

1. See description Montgomery County, Indiana. Geological Survey. 7th Annual Report 1875.

average depth of 25 inches is a light-gray to mottled yellow and gray silty clay. On handling the subsoil material the crushing of the iron concretions often gives an ochreous yellow or brownish coloration. Below 25 inches the subsoil is a brown clay containing considerable sand and gravel, in places showing a reddish tint. This glacial drift material containing gravel, stones, and bowlders continues to an undetermined depth. Small iron concretions occur both on the surface and throughout the soil.

The type as developed in this area is not altogether representative of the typical Miami silt loam of other areas in that the soil is somewhat lighter in color or mottled and the drainage not so well established.

The Miami silt loam occurs in the extreme eastern part of the county. It is extensively developed in the adjacent county of Boone, and eastward.

The topography is nearly level to gently undulating. On this account, and also on the account of the dense subsoil, the natural drainage is not good. Tile drains and upon ditches are common, but more complete drainage systems would no doubt pay through increased crop yields.

The original timber growth on this type consisted of oak, hickory, ash and beech. Numerous groves and woodland pastures include these and other hardwoods.

The greater proportion of this type is devoted to general farming. Corn produces a slow and uneven growth, but yields ordinarily from 25 to 35 bushels per acre. The yield of wheat ranges from 12 to 15 bushels and of oats from 25 to 30 bushels. Timothy does very well on this soil, a better quality of hay being produced than upon the soils containing larger quantities of organic matter.

The Miami silt loam is deficient in organic matter. Stable manure is usually applied to the sod land, but this is not sufficient to maintain the supply. Little commercial fertilizers are used. The land would be much benefited by plowing under vegetable matter in the form of clover, rye or peas.

A great improvement would result in this type from deeper plowing and more thorough drainage to give better aeration. Deep rooted crops such as the larger clovers and alfalfa will be found beneficial in this respect, as well as in maintaining the nitrogen content.

The Miami silt loam is valued at $125 to $150 an acre.

Carrington Silt Loam.

The Carrington silt loam consists of a dark-brown to black silt loam, 10 to 15 inches deep. The subsoil is a brown to yellowish-brown silty clay loam varying in places to a yellow silty clay, slightly mottled with splotches of gray and iron stains. The surface soil is usually free from stone and gravel except on some low ridges and knolls. Bowlders are occasionally found scattered over the surface of both the undulating and level areas. In the deeper subsoil considerable stony material is found where the type occupies low ridges and knolls.

In Montgomery County the Carrington silt loam occurs only as a strip 1 to 5 miles wide extending across the northern edge of the county. This area represents the southern boundary of the extensive areas of this type occurring in upper Indiana. The area embraced within this survey is generally spoken of as prairie, although it is dotted with many island like groves.

The surface features vary from low ridges to areas of undulating and gently rolling topography. The type is derived from the weathering of the drift which deeply covers this region. Bowlders are especially numerous in this deposit south and southeast of Linden.

Nearly all of the Carrington silt loam has sufficient natural drainage, although some areas have been benefited by tiling.

The soil is devoted to general farming, to which type of agriculture it is very well suited. Practically all of it is used for agricultural purposes, a few woodlot areas being the exception.

The Carrington silt loam is an excellent corn and grass soil. The yield of corn ranges from 40 to 80 bushels per acre. Oats constitutes an important crop, yields of 40 to 60 bushels per acre being usual. Wheat is not generally grown. The acreage planted to rye has increased in recent years. Timothy and clover are generally sown together, giving yields of 1¾ to 2 tons per acre. Clover seeded alone is also grown, the first cutting for hay, and the second often for seed. From 1 to 2 bushels of seed per acre are obtained.

A rotation common on this type consists of two years of clover followed by corn, and then by oats, rye or wheat. No commercial fertilizers are used and the soil receives but little barnyard manure.

No attempt has been made to cultivate special crops on a commercial scale. Fruits, vegetables and truck crops are grown for home consumption and excellent yields are secured. Farther north in this State sugar beets are being successfully produced on the Carrington silt loam. The scarcity of labor is the chief drawback to the production of this crop.

Farms on this type of soil are valued at $150 to $200 an acre.

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

MECHANICAL ANALYSES OF CARRINGTON SILT LOAM.

No.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent	Fine Sand, Per Cent.	Very fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
281309	Soil	0.3	2.3	3.4	7.9	6.8	62.9	16.3
281310	Subsoil	.3	1.8	2.5	6.2	6.1	65.1	17.7

Clyde Silty Clay Loam.

The soil of the Clyde silty clay loam, to a depth of 8 to 15 inches, is a black or dark-gray, heavy silt loam or silty clay loam. The characteristic dark color is due to the high content of organic matter. The subsoil is a drab-colored, sticky, and plastic, silty clay, which varies to a mottled yellow and light-gray color. In some cases in the lower part of the 3-foot section there is an appreciable quantity of sand mixed with the clay.

This type is the heaviest soil in the county, and care is required in handling it. If worked when too wet large clods form which are subsequently pulverized with difficulty. Also when disturbed in this condition the soil is likely to run together and to assume a hardened condition on drying out, frequently cracking. A few areas were noticed, notably east of Darlington, where a small amount of sand has become mingled with the soil rendering it more friable, easier to cultivate, and less liable to clod and bake. A good many patches were included with other types, for the reason that they were too small to map.

The Clyde silty clay loam is generally distributed over the county, with the exception of the southern tier of townships, where only a few small patches occur.

The surface of the type is level or slightly depressed and the natural drainage is poor. In some cases the soil occupies depressed areas of irregular shape in the uplands where natural drainage is restricted. In texture these areas are practically the same as the dominant surrounding types. The soil represents mixed glacial and loessial material which has been markedly influenced by poor drainage, favoring the accumulation of dark colored organic matter. There has been considerable washing in of silty material from adjacent higher land. In the lowlying country bordering streams and in some of the larger areas formerly swamps or ponds is found the heaviest phase of this type.

The greater part of the type is under cultivation, being drained by artificial means. There still remain areas which would be greatly benefited by more complete drainage systems. Along some of the streams areas too wet to cultivate are devoted to grass. There remain in the uplands some good-sized areas which support a heavy growth of oak, hickory, and elm.

This type is especially adapted to corn and grass. The yield of corn is from 60 to 80 bushels, the average being about 50 bushels per acre. Clover is grown, but is frequently injured by heaving due to freezing and thawing. The yield is about two tons of hay per acre.

In favorable seasons oats produce 65 bushels, but 30 bushels per acre is about the average yield. Some rye is grown and 15 bushels per acre is considered a fair average yield. In the usual rotation oats, with which clover is sown, follows corn. The acreage planted to wheat is small and for this crop only is commercial fertilizer used.

The price of the Clyde silty clay loam varies from $125 to $200 an acre, depending mainly upon the improvements in drainage.

Fox Silt Loam.

The Fox silt loam consists of a light-brown silt loam to a depth of about 15 inches, where it is underlain by a brownish, heavy silt loam or silty clay loam. Below this material at an average depth of about 30 inches sandy clay of a slightly reddish-brown color is encountered. Beds of gravel from 4 to 7 feet below the surface insure good natural drainage. The surface is practically free from stone or coarse material.

The broad, high terraces north and west of Crawfordsville constitute the largest and most representative bodies of this type. These nearly level areas stand approximately a hundred feet above the channel of Sugar Creek. They represent material deposited by the stream when it was flowing at higher levels. The underlying gravel beds give evidence of having been laid down by swift currents, probably at the close of the glacial period. The soil covering of silt material may have been deposited contemporaneously with the silty material of the Montgomery silt loam. Besides the areas along Sugar Creek other bodies occur near Smartsburg and Shannondale on North Walnut Fork.

The Fox silt loam closely resembles the Crawfordsville silt loam, differing from that type chiefly in its topography.

Practically all the Fox silt loam is under cultivation, most of it being devoted to the general farm crops. The type is easily cultivated, and a loose, friable seedbed can be readily secured. It stands drought remarkably well. Corn will yield from 50 to 75 bushels per acre, and oats 35 to 60 bushels, with an average of about 45 bushels per acre. Rye is grown to some extent, the average yield being about 25 bushels per acre. The Fox silt loam is an excellent clover and timothy soil. Clover seeded alone yields from $1\frac{1}{2}$ to 3 tons per acre. The growing of alfalfa has not been attempted, but the soil is believed to be well suited to the production of this valuable hay crop.

West of Crawfordsville a large acreage of this soil is devoted to strawberries, lettuce, tomatoes, and other market garden produce. The tomatoes grown are said to be superior in quality to those produced upon the more sandy soils.

In fertilizing, the best results are obtained with a complete mixture containing 1.6 per cent. nitrogen, 8 per cent. phosphoric acid, and 6 per cent. of potash. The use of stable manure, in connection with green manuring, is considered one of the best methods of increasing and maintaining the productiveness of the soil.

Well-improved farms on the Fox silt loam range from $100 to $150 an acre.

Fox Sandy Loam.

The soil of the Fox sandy loam to a depth of 12 to 15 inches is a medium sandy loam to loam of a light to dark-brown color. Fine gravel in limited quantities is found on the surface and through the soil and in places the soil approaches closely the texture of a fine sandy loam. On the higher terraces the texture is heavier, approximating a loam. Below the soil is a light-brown, or yellowish-brown, heavy coarse sandy loam or sandy clay which contains considerable coarse sand and gravel. The gravel content increases with depth until at 3 to 5 feet a bed of nearly pure gravel is encountered.

The Fox sandy loam is not an extensive soil type in this county. It occurs along Sugar and Coal creeks, Walnut Fork, and other streams as terraces (or second bottoms), all of which are of small extent. The largest area occurs along Sugar Creek.

The soil represents alluvial material deposited by the several streams when they flowed at higher levels than at present. Its origin is probably similar to that of the Fox silt loam.

On account of its porous texture and deep gravelly subsoil, the natural drainage of this type is good. The subsoil, however, is sufficiently compact and retentive of moisture to prevent damage to crops during ordinary periods of drought.

The Fox sandy loam gives good returns when planted to any of the crops grown in the area. Corn yields from 35 to 50 bushels, oats 30 to 50 bushels, wheat 15 to 20 bushels, and hay about 2 tons per acre. Alfalfa would doubtless do well on this soil. Small fruits and vegetables are grown to some extent, and where conveniently situated to market this type should be more extensively used for these crops.

Land of the Fox sandy loam type varies in price from $100 to $125 an acre.

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

MECHANICAL ANALYSES OF FOX SANDY LOAM.

No.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
281317	Soil	5.2	15.2	16.4	15.5	9.2	28.8	9.5
281318	Subsoil	5.8	17.5	14.4	13.2	8.4	31.8	8.8

Genesee Fine Sandy Loam.

The Genesee fine sandy loam is an unimportant type of soil. It is found in the valley of Sugar Creek in the central part of the county and is derived from flood deposits of this stream. The soil is typically developed in the area northwest of Garfield, where the surface consists of a dark-brown fine sandy loam or loamy fine sand varying in depth from 10 to 20 inches, and the subsoil of a light brown sand, which usually becomes sticky below. In some cases the subsoil extends to a depth of 3 feet, without important change, consisting of a rather loose sand, while in other areas it is composed of alternately stratified sandy and silty layers. The small patch south of Yountsville which is really a fine sand was included with this type on account of its small size.

The largest area still farther south, is a rather heavy fine sandy loam. The portion of the type lying east of Sugar Creek, adjacent to the uplands, is also noticeably heavy. The Genesee fine sandy loam occupies first bottoms and is almost entirely free from gravel. It is subject to occasional overflows, but crops are seldom injured by floods. The surface of the type is gently undulating and the areas are all well drained, except for overflows.

The Genesee fine sandy loam is productive and easily cultivated. It is an excellent soil for the growing of watermelons and well adapted to early garden crops. Corn is at present the chief product, and where the sandy loam subsoil occurs within 3 or 4 feet of the surface an average yield of about 40 bushels per acre is secured.

Rodman Gravelly Sandy Loam.

The surface soil of the Rodman gravelly sandy loam is a dark or light-brown gravelly sandy loam or loam from 8 to 15 inches deep. The subsoil is a brownish sandy loam or loam containing varying quantities of gravel. Often the deep subsoil or substratum represents a bed of gravel with comparatively little fine material. This is frequently used for surfacing road beds. On the crests of hills and ridges gravel and small stones are more abundant than on the lower slopes. Much of the gravel consists of limestone.

The Rodman gravelly sandy loam covers only a small proportion of the county, the largest area occurring as a ridge north of Darlington. Other areas occur as isolated hills and ridges in this section.

The type is usually associated with the Montgomery silt loam and frequently represents elevations occurring within this type from which the silty covering has been partially removed.

The material corresponding with the subsoil of the Rodman gravelly sandy loam outcrops in many places beneath the Montgomery silt loam in the bluffs and slopes along Sugar Creek and smaller streams. The two areas north of Yountsville occupy hills of considerable elevation overlooking the valley of Sugar Creek.

The larger of these areas has suffered more from erosion than any of the others.

The physiographic position and structure of this type permit rapid and thorough drainage. On the more elevated areas drainage is excessive, and when crops do not receive the natural amount of rainfall during the growing season, yields are lighter.

The Rodman gravelly sandy loam is devoted to general farming. Corn, oats, wheat, and rye produce fair yields. Clover does better giving yields of $1\frac{1}{2}$ to 2 tons per acre. This soil should prove a very valuable one for the growing of alfalfa, on account of its high content of lime.

Steep Broken Land.

The classification steep broken land embraces all those areas which are so steep, rough or stony as to be of little agricultural value. These include the steep, stony hillsides and bluffs along the streams and the land thoroughly dissected by numerous small streams flowing into Sugar Creek.

From a point west of Alamo on Sugar Creek much of the steep broken land extending along this stream and its larger tributaries is precipitous, and bare walls of rock frequently over 100 feet high are exposed.

Some spots included with the steep broken land are cultivated, but these of course simply represent areas of other soils too small to be separated on a map of the scale used in the survey.

The irregular soil covering varies from a thin fine sandy loam on the slopes to a silty loam often as deep as 16 inches on the crests of ridges. In some places the buff or yellow silty clay subsoil is exposed. The soil of the more nearly level intermediate areas if mapped separately would be classed with the Montgomery silt loam.

This land should be largely used for pasturage and forestry.

Muck.

Muck consists of decaying vegetable matter, including some mineral matter or soil. The material is black in color, fluffy when dry, and it extends to a depth of about 2 to 3 feet. Peat, or poor organic matter, may be reached below the surface stratum of Muck. This mass of original material rests upon a deposit of stiff, blue clay which in turn is underlain by gray fine sand and gravel.

Owing to the thoroughness of decomposition the original structure of the plant remains is no longer distinguishable, except perhaps in some of that of the lower depths.

The largest area of Muck and the only one of any consequence in the county occurs about two miles east of Cherry Grove. It occupies what was formerly known as Lye Creek Swamp.

In character of material the Muck of the smaller areas is fairly typical, but the depth is usually shallow, sometimes being not more than eight inches.

No attempt has been made to show upon the map numerous areas of Muck occupying less than 20 acres, which occur in the Clyde silty clay loam type of soil.

On account of the flat surface of the Muck areas the natural drainage is poor. The large area referred to has been reclaimed by means of large open ditches, and is under cultivation. On the better drained areas corn is the principal crop grown, with yields of 50 to 75 bushels per acre, when fertilizer is applied at the rate of 125 pounds per acre. A mixture analyzing 8 per cent. of potash and 8 per cent. of phosphoric acid is used. Without fertilization corn yields about 20 bushels per acre. It is of an interior quality.

Commercial fertilizers containing a large percentage of potash salts are especially beneficial upon the Muck. A complete mixture analyzing 4 per cent. nitrogen, 8 per cent. phosphoric acid, and 10 per cent. of potash is recommended, where truck crops are grown on this land. From 500 to 1,500 pounds of this mixture per acre may be profitably applied.

Muck is adapted to the production of celery, lettuce, cabbage, carrots, onions and potatoes. Throughout the central States these crops, and in some localities peppermint, are extensively grown, and considering the profits to be derived from these special crops it is believed that the Muck of Montgomery County should be used in this way rather than in the production of the general farm crops.

MEADOW.

Areas of Meadow occur as narrow strips along nearly all the courses of the streams in the County, the exception being Sugar Creek. These areas are subject to overflow and represent the accumulation of water-transported material derived from the upland soils. The material varies widely in texture over small areas, the range being from sand to heavy clay loam. Satisfactory separation of the bottoms into types could not be accomplished owing to the intricate association of the non-textural material. Some of that along the upper reaches of a stream represents poorly drained Clyde silty clay loam with a coating of muck a few inches or more in thickness. As the streams increase in size and the channels deepen the areas of Meadow become broader and better drained, giving rise to a phase of predominantly sandy loam. This condition prevails along all the larger streams.

The areas of Meadow are not suitable for cultivation, but support sufficient grass for pasturage. The timber growth, which is usually quite heavy, consists of oak, hickory, elm, sycamore, and other hardwoods.

SUMMARY.

Montgomery County is situated in the west-central part of Indiana and comprises 508 square miles or 325,120 acres. The surface features vary. The northern part is gently rolling prairie, the east-central undulating, and the west-central part rolling to hilly. Below Yountsville the country bordering Sugar Creek and its tributaries is rough and uneven, being intersected by numerous small streams which occupy deep gullies and ravines.

Montgomery County was organized in 1823 and Crawfordsville was founded about this time. It is the county seat and at present has a population of about 10,000.

The mean annual rainfall is 36.71 inches. The absolute maximum temperature is 105°F., and absolute minimum –33° at Lafayette and –24°F. at Veedersburg. The average date for the last killing frost in spring is April 27 and for the first in fall October 21.

The county is well provided with steam, electric, and wagon roads, which afford ample transportation for all parts of the county.

Drainage of the area is principally through Sugar Creek. The main tributaries are Walnut Fork, Lye, Black, Offield, and Indian creeks. Coal Creek drains the northwestern portion directly into the Wabash, and the southern and southwestern parts are drained by Big and Little Raccoon creeks.

General farming is the type of agriculture followed in Montgomery County. Corn, oats, wheat, clover and timothy are the chief crops. Live stock is not raised extensively.

Alfalfa—an ideal forage crop and a splendid soil renovator—has been successfully tried on a small area. More attention should be given to this crop and to the clovers.

The average size of farms is about 80 acres. About 60 per cent. of the farms are operated by the owners. Many retired farmers live in the towns, and rent their farms.

The value of the farm ranges from $15 to $50 for rough, broken land, to $100 or $150 for "sugar tree land" and other light-colored soils, and from $150 to $200 for "black land" and prairie land.

Eleven types, including Steep broken land, Muck, and Meadow, are mapped. These have all been derived from glacial material. The light-colored types need organic matter. The dark soils having remained in a swampy or poorly drained condition for a considerable period, contain more humus.

Silt loams cover the greater part of the county, the Montgomery silt loam being the dominant type. It is well suited to all the crops grown in the county and may be said to be the general purpose soil of the area. A flat phase of the type occurs. This is one of the best corn soils in the county.

The Miami series is represented by one type, the silt loam. This is an extensive soil to the east, but occurs only in the eastern part of Montgomery County. It is a good grass soil and considered fair for general farming.

One Carrington soil, the silt loam, is found. This is a strong soil, containing a high percentage of organic matter and well suited to general farming. It is the prairie soil, with an undulating to rolling surface, and the highest priced soil in the county.

The Genesee series is represented by one type, a fine sandy loam, which occupies the flood plains of Sugar Creek and the other streams of importance. It is devoted principally to the culture of corn and grass. Melons and garden truck are grown in some localities.

The Fox series occupies the terraces. The sandy loam is found on the lower terraces; the silt loam on the higher. The latter closely resembles the Montgomery silt loam. Both the Fox soils are good general farming types, and in some places are devoted to small fruits and market gardening.

The Rodman gravelly sandy loam is of small extent. It occurs in morainic country. It is a fairly good soil for general farm crops, though somewhat droughty.

Steep broken land permits of some patchy farming with fairly good yields, but the greater part of the type is unfit for cultivation.

Muck has been drained, and when properly cared for and fertilized produces abundantly of corn and grass. Special crops, such as onions, celery, carrots and cabbage should prove remunerative.

Meadow land is usually too wet for cultivated crops and is best suited to pasturage.

Edward Barrett, State Geologist, Indianapolis, Indiana:

We herewith transmit the report and map concerning the soil survey of Putman County as a portion of the united efforts of the State Geologist and assistants in the development of the agricultural conditions and soil managements of Indiana.

N. CORYELL.
H. S. HESLER.

Soil Survey of Putnam County, Indiana.

By N. Coryell and R. S. Hesler.

DESCRIPTION OF THE AREA.

Putnam County is located in the southeastern part of Indiana. It lies 39 miles west of the city of Indianapolis, and about an equal distance east of the city of Terre Haute. Montgomery County bounds it on the north, Hendricks and Morgan on the east, Owen and Clay on the south, Clay and Parke on the west. The entire area lies west of the meridian 87° and north of parallel 39° 28′. The boundary between Putnam and Morgan counties follows the dredged and natural course of Eel River, as far as the southern end of Mill Creek Township. Here the river enters Putnam County and flows within five miles of Cloverdale. The stream enters Owen County on the south of Putnam three-fourths miles northwest of Wallace Junction.

The county is a perfect rectangle 27 miles north and south, by 17½ miles east and west, plus the township of Mill Creek located in the southeastern part. The total area of the county is 486 square miles, or 311,040 acres.

The surface of the land in the northeastern part is level and in some cases slightly undulating, but in the center and southwest it is somewhat rolling, and in the neighborhood of the streams, more precipitous and hilly. From a table of altitudes furnished by the county, it is shown that the highest point between the Ohio River at New Albany and Michigan City on the Monon railroad is one mile north of Bainbridge, being 955 feet above the sea level, and on the Vandalia railroad near the east line of the county the altitude reached is 897 feet, being but nine feet lower than at Clayton, the highest point on the road between the Wabash River and Indianapolis.

The watershed of the county is to the southwest. It is traversed by Walnut Fork of Eel River, from the northeast to the southwest, which has for its principal tributaries on the west Little Walnut, and on the east Warford's Branch and Deer Creek. The southeastern portion finds its drainage in Mill Creek, while the northern part is drained by Raccoon Creek. The country is divided into three geographical sections, but they are so similar in their general features that it is unnecessary to treat them separately here. Each of these streams draws supplies from almost every part of the county, thus furnishing to it a thorough drainage for the run off from the heavy rains. The surface of the county in the eastern portion is level or gently undulating, affording extensive fields for tillage and meadows. The flat lands, on the divide between the headwaters of Walnut and those of the tributaries of Sugar Creek, lying principally within Boone County, extend into the extreme northeast corner of Putnam. They sometimes require artificial drainage to render them productive. Bainbridge is located near the southern limit of the level portion of this divide. Here the tract is scarcely more than two to three miles wide, being broken by the adjacent valleys of the intermittent feeders to Walnut Creek.

The northern and northwestern portions of the county are rolling to gently undulating, affording some of the finest pasturage to be found even in the remarkable belt of pasture lands lying along the fortieth parallel of north latitude. Other level upland tracts are found northwest of Clinton Falls, on the county line north of Vivalia, about Fillmore and Delmar east of Greencastle, about Morton, Broad Park, and Bell Union, but in every case the extent is limited by the young valley of streams. The plains of Hendricks County extend into Putnam near the Vandalia and New York Central right of ways, and also in the northeastern part of the county about Barnard.

The surface of the county is agreeably diversified, consisting of a high plain and woodland, rich in interest to the economist, all uniting to tell a long story, recorded on rock and plain, of the earth's past, laden with promises of the future. Soils and surface deposits are formed by the disintegration and destruction of rocks. If derived from local rocks or a single bed, they are generally thin or obdurate, and the character of the production—even of a people—may be declared from their geological deposits. On the other hand, a region having a soil derived from the greatest number of strata is, as a rule, productive and desirable. The soils of Putnam County, although principally composed of local rocks which give the character to the different parts, are also enriched by materials imported from the Paleozoic strata and thoroughly crushed, mingled and incorporated by the mighty forces of the glacial age. The soil, therefore, is equal to the best.

The alluvial deposits of creek and river bottoms which belt the water courses are due to causes now in action. This material is derived from the adjoining banks, enriched by the wear of rolling pebbles and grinding sand and is cast out by overflows upon the flood plains of the streams. Rich in mineral plant food, it always contains a large amount of soluble organic matter, constituting a valuable and productive farm or garden land.

These deposits are characteristic of an epoch which occurred subsequent to the glacial. The arctic coldness had subsided. A great body or sea of fresh water covered most of the southern half of the State with gulfs, bays and lagoon arms which reached north in the line of the ice thrusts. A warm, almost tropical climate prevailed, giving life and sustenance to the monster animals now extinct, including the American elephant, whose remains have been found at several stations in the county. This deposit, an almost impalpable sand and clay, was slowly formed at the bottom of a quiet waveless lake, filling up the lowest inequalities in the surface; for the lake water did not cover the high lands. Good examples are seen in the level plain adjoining Mill Creek, in the southeast parts, and in the old railway cuts at and west of Oakalla. These loess loams produce sweet fruits, and being free from pebbles are well suited for the manufacture of bricks.

To the strange phenomena of the glacial epoch we are indebted largely for results which make this soil and surface configuration so desirable. Evidences of this violent water flow are seen in the ancient bed one hundred and nine feet below the present channel of Eel River in Clay County. In Putnam County the same developments are met in sinking wells near the southern boundary. At the fork of Croy's Creek, four miles west of Reelsville, A. O. Hough put down a bore for coal about 1865, finding the bottom rock one hundred and twenty feet below the present water bed. It seems possible that the ancient Walnut Creek flowed south eighty degrees west, or nearly west by Otter Creek from Oakalla to the Wabash in a channel now deeply hid.

Interesting specimens of glacial grooves, striæ and planations are seen in the rock cut north of Maple Grove, on the Monon Railroad, and in Section 28, Township 13, Range 4, two miles south of Putnamville. At the first locality, the glacier in its southward movement, filled the valley of the adjoining stream to the east, and was heaped against and ground down the sloping sides and banks of the valley. The planished surface, grooves and striæ are distinct and perfect.

The coal measures are the most recent rocks exposed and comprise the southwestern part of the county. Beginning at Portland Mills, they generally form the surface rock west of "Little" and "Big" Walnut creeks; south of Reelsville, they broaden to the east to near Cloverdale, and thence southwest by Doe Creek to the southern boundary.

The conglomerate coal occurs at intervals all over the district. At a few stations it attains a thickness, in small pockets, of two or three feet, but such pockets or pools are limited in width to a few yards or rods. As a rule, the seam is barren or only one or two inches thick and will not exceed an average of four inches. The product is at the same time sulphurous and inferior. In the vicinity of Morton, a depression in the underlying rocks gives an eastern extension of the coal measure rocks and many beautiful fossil ferns and trunks of plants indicate the horizon of coal. The superimposed sand rock have been chiefly eroded. Other outcrops of coal occur north and northwest of Reelsville, generally thin and unworked.

These outcrops are only opened for local use now, and will not pay to work, except by stripping; but in the future, when coal may possibly become scarce, seams eighteen inches thick, and even less, will be worked, as such seams are now sometimes worked in Europe.

During the petroleum excitement (about 1865) a prospecting bore was put down in east side of the village of Reelsville, commencing eighteen feet above low water in Big Walnut Creek. There resulted a strong flow of white sulphur water highly charged with sulphuretted hydrogen gas and containing chlorides of sodium, calcium, and magnesium sulphides of the same bases, with traces of bromide and iodine. It had a pleasant saline, sulphurous taste and a pungent odor, and was found to have great medicinal efficiency in cases of dyspepsia, rheumatism and ague. It was considered a specific in diseases of the liver and kidneys, and although the outlet was covered by the flood of 1875, its "magic cures" are still held in kind remembrance of this vicinity.

Six miles southwest of Cloverdale on the northeast quarter of Section 12, Township 12, Range 5, is a very considerable outcrop of rich band and kidney iron ore in a wild, deep ravine. It was mined in 1860 by the proprietor, and some thirty tons sold to the Knightsville furnace. It was found to be an excellent ore to mix as a flux with the Missouri or Lake Superior ore. But the expense of mining and hauling was fully equal to the market value and the enterprise was abandoned.

The St. Louis beds of limestone, from the surface rocks, is a well marked division from four to eight miles broad, extending from the extreme northwestern to the southwestern corners of the county, with demanded extensions in the valleys of the Chester and coal measure beds. These strata are known as the cavernous or concretionary limestones of the Western States and are remarkable in the southern part of this State for caverns, sunken valleys and subterranean rivers. South and east of Greencastle many funnel shaped sink holes, which receive and deliver the rainfall to hidden streams, indicate the probability of small caverns yet to be discovered here. The limestones vary much in quality. Some are pure carbonate; others are silicious, or aluminous, and beds of shale, clay, and argillite are interpolated.

About a mile east of Cloverdale, on descending from the limestone hills, a level flat clay district is found which extends east beyond Eel River and northeast towards Monrovia in Morgan County. This area has been deeply eroded during the glacial epoch, removing more than fifty feet of St. Louis limestone and along the eastern side of the county exposing rocks of the Keokuk and Knobstone groups. The excavation is now refilled with lacustral and fluviatile drift, indicating an abandoned river bed, which once was connected by Indian Creek with White River Valley.

Putnamville, located on the National Road, is famous for valuable quarries of paving curb and step stones. From it have been shipped large quantities of flags, bridge, dimension and rubble stone. The product from here has been in use, severely exposed to the extreme vicissitudes of our variable climate, including changes of many degrees of temperature in a single day for over forty years. It has shown capacity to resist the action of frost and ice. Samples taken from the exposed parts of the quarry when first opened in 1838-40, may be seen in piers of the bridges and culverts on the National Road, in the steps of the Terre Haute House at Terre Haute, and of the old university building at Greencastle.

Greencastle, the county seat, is situated on the high rolling tableland one mile east of Walnut fork of Eel River. Geologically, it rests upon the upper ledges of the Mitchell limestone. The conglomerate rock of the coal measures caps the summit of Forest Hill cemetery just south, as also the hills across Walnut just west of the city. Quarries are found at several points about town affording an abundant and cheap supply of stone which meets with the approval of the contractors and builders of roads and paved streets.

Going north from Greencastle, many outcrops and quarries of Mitchell limestone are observable, presenting ledges of rock so similar to those already given that repetition is unnecessary. The surface outlook is characteristic of this limestone and is plane on the plateaus, or gently undulating, in long rolls and slopes by the action of air and moisture.

At Fort Wayne, on September 30, 1809, Harrison concluded a treaty with the Delaware, Pottawatomie, Miami and Eel River tribes, by virtue of which the United States for a consideration of a permanent annuity of $500 each to the Delawares, Pottawatomies and Miamis, and $250 to the Eel River tribe, purchased from the Indians a section of the territory lying on the southwest side of a line beginning at the mouth of Raccoon Creek on the Wabash River, and extending in a southeasterly direction to a point near the present city of Seymour, Jackson County; the whole comprising an area of almost 3,000,000 acres.

About 20 square miles of the soil, which is now Putnam County, that lies in the southwest corner, was south of that line. The remainder of the county was left unexplored until the Indiana territory became a State in 1816.

Before the close of the year 1821, both Vigo and Owen counties were lessened in area by the formation of Putnam County.

Who actually recommended or first suggested the name Putnam, we probably never shall know, but, whoever he may have been, no name could have been chosen more illustrious, more honorable. Putnam County was formed December 21, 1821, by the Sixth Session of the General Assembly as stated on page 65 of the Law of the Sixth Session.

Location of County Seat.

Jacob Bell of Parke, Abraham Buskirk and Daniel Anderson of Monroe, Jacob Cutler of Morgan, and James Wasson of Sullivan, were by an act of the General Assembly given power to meet at John Butcher's home just northwest of Greencastle on an eminence that overlooks the Big Walnut Creek. As an inducement towards the location there, and in consideration thereof, Ephraim Dukes and Rebecca, his wife, conveyed to Amos Robertson, designated as agent of Putnam County, seventy acres of land in the northwest quarter of Section 21, Township 14 north, Range 4 west. The deed was executed September 27, 1823, and recites that the land is donated in consideration that the county seat is located at Greencastle. This tract includes that part of the city now lying between Indiana and Locust streets.

The original town site consisted of 150 acres, divided into 214 lots, and was bounded on the north by Liberty Street, on the west by Gillespie, on the south by Hill, and on the east by Locust.

Naturally the people of this generation would be glad to learn where the "town of Bedford" Putnam County, was, but alas for us, a careful search of the deed books, the plat books, and other records in various offices in the court house fails to reveal the slightest hint of the early competitor of Greencastle for county seat honors. Some years after the county seat question had been settled in favor of Greencastle, and after the National Road had been constructed, Putnamville, then a busy and important place on that great thoroughfare, began to agitate the question of the removal of the seat of justice from Greencastle, arguing that as Putnamville was more favorably located as to the great highway of travel it was the natural and logical location for the county seat. An irritating rivalry thus grew up between the two towns for years but never crystallized into any sort of organized action.

Principal Cities, Towns, Roads and Railways.

Putnam County enjoys unusually good transportation facilities, due to the railroads, interurban lines and improved public roads. The county stands at a high mark in agriculture and other lines of industry.

The railroads crossing this area are the Monon, C. H. & D., Vandalia, and New York Central.

The Monon enters the county about three-fourths of a mile directly north of Roachdale. From Roachdale the line runs almost due south to Carpentersville 3½ miles and to Bainbridge 8 miles. From Bainbridge, with several bends but with a general southwest trend, the Monon goes to Greencastle, the county seat of Putnam. After leaving Greencastle, the road passes through Limedale, where it has a junction point with the Vandalia, thence to Putnamville. From Putnamville, the road swings back again and in a southeast direction passes through Cloverdale, which is the last town in the County touched by the Monon.

This road has the greatest mileage of any other railroad in the county. The total number of miles covered by the Monon in the county is about 32.

Roachdale, located in the extreme north central part of the county, is a town of about 900 inhabitants. Considerable business is transacted here, there being a creamery, large veneering mills, and elevator, besides other smaller plants of various kinds. Much shipping is done from this town. It is the junction point of the Monon and the C., H. & D., and these direct connections with Chicago, Lafayette, Indianapolis, Crawfordsville and Greencastle make good markets easily accessible.

Carpentersville has only about 100 to 150 people. Most of the business plants in the place, which includes a sawmill and grocery store, are owned by a single individual.

Bainbridge has a population of about 600 to 700. A canning factory is located here bringing about practical truck farming with the tomatoes. This factory was built recently, but promises extensions as the demand increases.

Greencastle is the county seat, and in 1910 the U. S. census bulletin for Indiana gave the total number of inhabitants as 3,790, but in all probability this number has increased to 4,000 in the last two years. As a business center, Greencastle has a fair standing. Several lumber yards and sawmills are located there. This is also the location of one of the most important seats of learning in the State, DePauw University. This institution was established and maintained as a college by a denominational organization. At present it has an enrollment of 1,000 students, and is a rival of any college in the State in its thorough training in all branches of the liberal arts.

Limedale is at the junction of the Monon and Vandalia railroads. It has a population of about 200.

Putnamville has a population of about 300 to 350. This town in the early history of the county was an important contender with Greencastle for the location of the county seat. Putnamville claimed the important advantage at that time of being situated upon the National Road, the great national highway. From Putnamville have been shipped large quantities of paving, curb and step stones.

Cloverdale does considerable business, and has a population of about 750. Much of the land around Cloverdale is used for grass land, and its products are marketed in, and shipped from Cloverdale. There are several quarries near Cloverdale that furnish road metal for that locality.

The C., H. & D. railroad enters Putnam County from the east at a point about 1¼ miles from the northeast corner of the county.

It runs nearly parallel with the north boundary line across the entire county. It has seventeen miles of track in the county.

The first town from the west line touched by this railroad is Russellville. This town has a population of about 550. It has a grain elevator and also is a market for hardwood logs.

Raccoon is a small town near where the C., H. & D. crosses Raccoon Creek. It is about five miles east of Russellville and on the Crawfordsville-Bloomington road. It has a population of 150.

Barnard is on the C., H. & D. about three-fourths of a mile from the east boundary of the county. It has a population of about 150. It has a grain elevator, facilitating the marketing of the local crops.

The New York Central Railroad enters the county from the west at a point about nine miles north of the southwest corner of the county. It has a general northeasterly direction and covers about 19 miles in the county. It touches Greencastle at the north side, where it has a junction point with the Monon and goes directly to Indianapolis. It has a block system and double track across the county. A coaling station is located near Delmar.

The St. Louis division of the Vandalia Railroad enters the county from the west about five and one-half miles north of the southwest corner. It has the same general direction as the Big Four, and runs parallel with it at a distance of about one mile, from Greencastle eastward. It has about 21 miles of track in the county and its junction point with the Monon is at Limedale.

The only town touched by the Vandalia after leaving Greencastle is Fillmore, which has about 300 inhabitants. It has a grain elevator, lumber yards and sawmill.

The interurban line that enters Putnam County is the Terre Haute division of the Terre Haute, Indianapolis and Eastern Traction Company. It affords splendid passenger service to Indianapolis and intermediate points and also to Terre Haute and Brazil. The line also handles freight. It passes through Fillmore and Greencastle and has about 20 miles of track in the county.

The public roads of Putnam County are, on the whole, good. In the more undeveloped and hilly parts of the county, they are as yet in poor repair, but the most important highways and thoroughfares are in good condition. This is due largely to the fact that the farmers realize that good roads, properly constructed, are one of the most valuable assets of farming land. Much good road metal is quarried in the county for local construction as well as elsewhere in the State.

Three public roads of more than local importance cross this county. The National Road, constructed by the Government in the pioneer days of westward settlement, enters the county at the east, about the center of Section 29, Range 3 W., Township 14 North. It runs in a general southwest direction and leaves the county near the place where the Vandalia Railroad enters from the west. The National Road is much used by tourists and travelers and is becoming an automobile thoroughfare from Indianapolis to Terre Haute. It passes through Putnamville, about four miles south of Greencastle, and Manhattan, a small town of about 150 inhabitants, that is located about four miles southwest of Putnamville. The National Road is well constructed of crushed rock and was an important factor in the early development of the county.

The Crawfordsville-Bloomington road, so called because it furnishes a direct road between these two towns, is constructed of crushed rock the greater part of the way through Putnam County. The road runs the entire north and south length of the county and has an extent of about 27 miles. It passes through the central part and crosses the National Road about one mile east of Putnamville.

The Danville road, an east and west thoroughfare across Putnam County, passes through Bainbridge and affords a direct line for business and tourist traffic from Rockville to Indianapolis.

General Development and Use of Soils.

The adaptation of soils to crops has been recognized only in a general way by the farmers of the county. The "Clay" lands are quite generally in sod, either for mowing or for pasture, for which they are best suited. Corn, oats, wheat, and rye are generally planted on soils in both the valleys and uplands best suited to them. The dairy farming is usually carried on on farms suited to that system of farming; the more hilly and rugged fields of the farms with the thin soils being used for pasture. Many of the dairy farmers own or lease a second farm or tract of land illy adapted to cultivation, which they use for summer pasturage for dry cows and young stock. Again, many of the hilly rocky fields with thin soils are used as sheep pasture, about the only use to which they can be put. In fact, many of these fields should not be utilized for farm purposes at all, but for the keeping of a flock of sheep in conjunction with other forms of farm industry.

The importance of keeping sheep on the farms of Putnam

County to utilize the rugged hill pastures with thin soils should become recognizable as an addition to the proprietor's income, requiring as it does but little time and attention during the busy season of the year and will occupy that portion of the farm which is least convenient for tillage. Without increasing in any sensible degree its expenses, and without interfering with and hindering other operations, a limited number of sheep can be supported, mainly upon such portions of the farm as would otherwise be neglected and for the time valueless.

Rotation of crops is not as systematically followed by the farmers as it should be to secure the best results. The large amount of rough land interferes with or prevents the establishment of any system or of any adequate system in some cases. However, these facts should not influence the practice of rotating crops on farms where this is practicable. Permanent sods are the rule rather than exceptions on the clay lands and also on much of the thin soils of the uplands. The example of this almost universal practice seemingly influences the practices on these soils on which short term rotations could and should be worked out, and there are fields which have been left in sod until the tame grasses have practically disappeared and mowing no longer proves remunerative.

For the upland clay soils in the hilly portions the principal crop should be hay, either for feeding or sale, preferably the former, but at least one such crop as that of corn or wheat should be grown to prepare the soil for other crops. This necessity being taken into account, corn might be planted the first year, followed by spring grain, either oats or barley, and a seeding. For the seeding, alsike clover and timothy should be used, both being well suited to these heavy soils. The third, fourth, and fifty years the sod should be moved, or possibly used for pasture the fourth and fifth or the fifth year. Yet these soils should rarely if ever be kept in sod more than three years and never until the tame grasses have disappeared from the sod. They should be plowed while there is still a good sod to turn under, and they should not be continuously used for pasture on account of the close, dense soil, which will become still more compact by the tramping of the stock over it.

On the thin soils potatoes could well be grown the first year, rye the second year with seeding to clover and mixed grasses, the sod land to be used for mowing one, two, or perhaps three years. Following their use for the production of hay these soils may or may not be used as sheep pasture. If not grazed too closely, this practice could well be employed in the places of the second and third year mowing; the droppings of the sheep serving as a partial top dressing. Corn could be well used for the first crop.

The rotation for the light gravelly soils of the terraces might be potatoes or corn the first year; winter grain, rye sown in the fall of the same year, or spring grain, oats following the corn, and sown the second year. In either case a seeding to clover and timothy should be sown with or among the crop of grain. The field then can be used for meadow and hay. Following the mowing during the second or third year, a return to the first course of the rotation might be made or the sod land may be used as pasture either for dairy cattle or sheep. If the fields are used for pasture the seeding should be to clover and mixed grasses instead of the clover and timothy alone. Providing the sod is good on these soils, the tramping of the stock, so undesirable on the clay soils, is here desirable, helping to counteract the natural lightness and looseness of the soils and making them more retentive of moisture.

On the heavier of the first bottom soils corn might be the crop for the first course of the rotation, oats with a seeding to clover and timothy for the second, mowing for several years, but never until the sod becomes too poor and thin to produce a reasonably profitable crop. If the farm is operated as a dairy farm, a part of the corn should be used for ensilage and after mowing the seeded crops of clover and timothy a year or two the field can be used for pasture. In this system of farming a few acres could well be sown to oats and peas in the second year for feeding green to the milch cows during the late summer, when pastures are likely to be short owing to drought. However, these lands are too valuable in the production of intertilled grain and forage crops to be extensively used for pasture, unless they be subject to overflow. In which case if the flood is frequent, they would probably be better suited for pasture, and should be used permanently as such. If sheep are kept, a portion of the land otherwise planted to corn should be used for root crops to furnish succulent feed during the winter months.

On the heavier soils of the upland the first year clover sod could be turned under for a planting to corn, with some of the corn used as ensilage if it is a dairy farm. If sheep are kept, a few acres otherwise planted to corn should be sown to some root crop, as rutabaga turnips or mangel-wurzels, and an acre or so of cabbage. The second year oats could be sown as a nurse crop for a seeding of clover and timothy, and a few acres could well be sown to oats and peas for feeding green to the dairy stock. The following year the timothy and clover fields should be mowed for hay. The next or fourth year the fields can be used for hay, pasture, or turned back to the first course of the rotation—corn or potatoes. In any case it will be unwise to keep the land in sod for more than two years. After the corn is harvested the first year rye may be sown as a winter cover crop and plowed under the following spring in time to sow and plant staple food crops. The rye furnishes a profitable green manure for loosening and enriching the soil.

These rotations, it will be observed, are not suitable for all soils and soil conditions existing within the different divisions of the county. Each farmer should work out from experience the rotation which is suited to his system of farming, his soils, and his climatic, market and soil conditions. Care should be taken in all cases to provide a place in the rotation, which usually should cover no more than four years, for a legume of some kind as a means of improving the soil, and also for the production of grain and root crops to lessen the expense where such foods are purchased. Alfalfa should find a place on all farms having soils which are adapted to growing it, thus accomplishing both objects—soil improvement and the production of protein food for the stock. Another item of importance in this region, where a great amount of land suitable for sheep pasture exists, is the growing in each system of rotation of roughage and succulent feed for the wintering of the flocks.

The character and condition of the soils, the markets, the transportation facilities, and the adaptation of the different soils to crops should be considered in determining the system of farming and the rotations to be followed, and consequently the kinds, varieties, and relative proportions of the different crops, the fertilizer treatment, the tillage methods, and the systems of farm management to be followed. This leads to a consideration of the drainage, the adaptation of crops to soil, the systematic rotation of crops, improvement of tillage methods, rational manurial and fertilizer practices, the improvement of permanent sods, and the improvement of seeds and stock.

The question of drainage is of fundamental importance, as no other improvement can be made permanent and efficient without tile as well as surface drainage. The close structure and fine texture of some of the soils of the county make drainage somewhat difficult but all the more important. It is certain that much is lost annually on these soils through low crop yields and partial or complete crop failures as a result of poor drainage conditions alone. Therefore thorough drainage, both surface and sub-surface, is essential on some of the soils, and desirable on others, before any stable improvement in their producing capacity can be brought about.

Many crops are grown on soils that are ill adapted to producing them, almost always with discouraging results. If these, as well as all crops, were planted on soils adapted to their production, the yield and quality would without question be improved, the cost of production lessened, and the profits therefore increased. In connection with this question of the adaptation of soils to crops comes the also important subject of crop rotation. It is an established fact that no permanently successful system of cropping or farming can be established and maintained without a rotation in the kind and character of the crops grown, if the very best results are to be obtained. Different types of soil require different suitable rotations.

Another important item in the betterment of the agriculture of the county is the question of tillage methods. As a matter of fact, the first and most essential operation—plowing—is too often poorly performed on the land that requires the most careful cultivation. Perhaps the most important part of tillage for any crop is the preparation of the seed bed, and this can not be properly accomplished if the plowing is poorly done. Some of the soils can be plowed in the fall of the year, while others ought never to be bared to the erosion of winter conditions by the late seasonal breaking. Again, some of the soils can be plowed and a seed bed prepared only within a narrow range of moisture conditions. More careful cultivation of the intertilled crops should be practiced, especially with a view to maintaining the most favorable moisture conditions.

The fertilizer practice is another matter for consideration in the improvement of Putnam County agriculture. Much of the commercial fertilizer, for lack of definite information, is used without reference to its composition or to the soil and crop requirements. It is probable that in many cases as much benefit could be brought about in some other way, without such a cash outlay, as is required by the use of "phosphate." In the consideration of this problem, more economical handling of the stable manure from the dairies and flocks of sheep deserves attention. Many of the soils of the county are low in organic matter. This condition could be helped by a careful saving of the stable manure. In addition to this husbanding of the refuse of the barns some crop should occasionally be grown and plowed under as green manure. For this purpose clover sod is desirable, but if the crop is to be grown especially for this purpose, rye, buckwheat, or field peas are suitable. In such practice, rye can be used to advantage, as it can be sown in the fall after some other crop has been harvested and plowed under in the spring before the time for planting another crop, thus losing no time or crop in the rotation. This practice will be found particularly desirable if the soils are such, or the fields so located, that washing takes place during the late fall, winter, and early spring. In this connection more leguminous crops should be grown, peas for green feed, forage, and grain, the clovers for hay and clover sod for plowing under, and alfalfa for protein feed. All of these crops except rye are legumes and enrich the soil in nitrogen, the most costly of all the ingredients of commercial fertilizers.

In working out the scheme of fertilizer practice, and especially where the growing of leguminous crops is practiced, the use of lime is often essential and may be the controlling factor between success and failure. In recent years the yields of clover have been unsatisfactory in most cases, yet with the proper care there are few soils in the county which will not produce clover successfully. The unsatisfactory yields are due largely to the soils having become acid or sown through poor cultural methods. This can be overcome by acreage applications of from one to five tons of un slacked lime or crushed limestone. When clover has not been grown on a soil, it should be inoculated with the proper bacteria. This can be done by sowing broadcast about 100 to 150 pounds per acre of soil from a clover field. By following this method, alfalfa could also be grown on the well-drained limestone soils, especially the loam and clay loam types. In places, the cowpeas and soy-beans are coming into favor both as forage crops and soil renovator. Vetch would also prove profitable for this purpose. The country is a little far north for the growing of vetch and cowpeas for hay as the plants have a tendency to mature early and produce seed rather than grow into tall succulent stems, because of the moderately early appearance of cool nights that checks the vigorous growth and permits advantages for early ripening.

A large percentage of the lands of the county are in permanent pastures; therefore the improvement of sod land is not to be neglected. This work is new, but nevertheless important. These lands, unless in forest or land too rough and rocky to deserve even the name of pasture land, should be re-seeded at intervals of a few years and if possible harrowed to distribute the droppings of the stock and to disturb the mosses and weeds. Some of this sod land should also receive an occasional light top dressing of stable manure.

The improvement of seed by selection and breeding should be considered by every farmer. If this were done the yield of crops could be materially increased in the course of few years at an insignificant and unnoticed cost. The herds of cattle and flocks of sheep are being improved by introducing new and better strains of blood and by the general upbuilding through care in crossing and breeding, using in every case only sires of the best constitution and blood obtainable. Besides improving the quality of the live stock, the number both of cattle and sheep could be increased in order to utilize all the rough pasture lands much of it now producing no income, and all of the forage grown, thus avoiding the sale of hay and straw and increasing the quantity of manure returned to the soil.

Agriculture of Putnam County.

Putnam County on the whole is a prosperous agricultural area. However, the north part of the county is more fertile and better adapted to purely agricultural purposes than the south half. This is due primarily to the effect of later glaciation.

During the four or five decades following the first settlement of the county, agricultural developments were slow. With no near available market for produce, there was no incentive for people to clear and cultivate land. In the absence of a market, fine beech, hickory, oak, walnut, yellow poplar, ash and hard maple trees were felled and burned in heaps. These trees were also used extensively for fuel, and thus the county was almost stripped of one of its important and beautiful natural resources—lumber. Even up until the last few years, the forest trees have been an important source of income to the county. This is true more particularly in the north part of the county, where the topography permits more easily the removal of large logs to the near points of railroad transportation. In the south part of the county where the topography is very much diversified, many specimens of hardwood trees, mostly second growth, are found growing upon and protecting the previously cultivated slopes from continued erosion.

The first settlers of the county produced almost all of their necessary food supplies. Corn was usually the first and most important crop and almost always preceded wheat. The fields were protected by rail fences and much of the stock, as cattle, hogs, etc., were permitted to roam in the woods and forage for themselves.

Along with the construction of roads and their improvement came also an advance in the agricultural development of the county. More lands were cleared and more settlers came into the country. Yellow corn was more extensively raised and wheat was tried. Corn in most places in the county did very well. The best crop of corn in the county averaged 100 bushels, but this was far above the general average. A more conservative estimate of the average crops is placed at 25 to 30 bushels per acre for the upland in the hilly districts, while for the stream bottoms and the level districts in the north part it is from 60 to 70 bushels. Wheat is not raised extensively.

In the south part of the county, where the region is undulating to hilly, practically all of the higher upland is used as grass land. Timothy is raised here with much success. Clovers, especially alfalfa, have not been given the attention that they should have, although several fields have been tried and some good results obtained. A study of the conditions under which these plants grow and the fundamental food materials which they demand is made available by the experiment station at Lafayette, Indiana, and the Department of Agriculture at Washington, D. C. Corn is grown to an advantage only in the bottom lands in the southwestern part of the county. The yields are usually good, but the amount of available land does not permit large averages, and almost all corn raised is used for stock feeding on the local farms.

Railroads had an important effect upon the agricultural development of the county. The market places were increased from one to many. Small towns that had before only afforded a place of procuring the staple necessities now became good markets for everything that the farm could produce. The corn crops were increased. Stock was raised for marketing. An increase in the acreage of wheat was made. Wheat in most places averages about 15-18 bushels per acre. The wheat acreage is decreasing as is also the yield of wheat per acre. Oats, on the other hand has been increasing in acreage. The yield averages from 35 to 40 bushels per acre. Much attention is given to the smaller truck crops. Tomatoes are grown near Bainbridge, and found profitable. A factory located there furnishes an ample local market. Potatoes are not grown extensively for market. The small fruits are raised principally for local consumption. But apples, peaches and pears have been receiving careful culture. Several orchards of both peaches and apples are bearing well and furnish the owners with a good source of revenue. Many of the slopes in other districts of the county will be turned to this horticultural use and realize handsome profits. Fruit growing is one of the coming industries of the State, and many places that were thought practically useless have become the location of splendid orchards.

According to the 13th Agricultural Census of the United States, the Bulletin of Indiana gave the following data concerning the crops of Putnam County for 1910.

	Acres.	*Bushels.*
Corn	61,898	2,175,110
Oats	15,772	377,280
Wheat	18,559	228,310
		Tons.
Clover	3,978	4,711
Timothy	18,117	20,400
Timothy and clover	4,838	5,630

In 1910, there were 2,962 farms in Putnam County with a total acreage of 292,399 acres over against 2,883 farms in 1900 with a total of 301,039 acres. This would tend to show that the principle of extensive rather than intensive farming was being practiced in the agriculture of the county. Of the farms in the county in 1910, there were 23 of under 3 acres, 158 of 3 to 9 acres, 156 of 10 to 19 acres, 621 of 20 to 49 acres, 919 of 50 to 99 acres, 671 of 100 to 174 acres, 240 of 175 to 259 acres, 151 of 260 to 499 acres, and 23 of 500 acres and over.

The average value per acre of land in the year 1900 was $26.83. In 1910, the average value per acre of land was $49.41, showing an average increase per acre of $22.58.

Of the value of live stock raised in Putnam County, horses are in the lead. The total number of all horses in the county in 1910 was 11,046, with a total value of $1,069,539; 16,554 cattle, but the total value was only $581,899; 58, 088 hogs, with a total value of $393,749. Mules were valued at $160,739, and sheep $116,411.

Climate.

The general temperature conditions of Putnam County are in every respect typical according to the fluctuations subject to a district located within an inland State. The winters are cold but not excessively severe; the summers are warm and usually accompanied by sufficient rainfall to stimulate a good forage growth. Droughts are unknown, though occasionally a few weeks pass with out perceptible precipitation other than the heavy dews in summer or frosts of the colder seasons. The rains are distributed over the growing season, and assist in making the district one most favorable for staple crops.

The following data taken from the United States Climatological Bulletin for southern Indiana shows the most important facts about the climate of the county. Putnam County has no U. S. Weather Station—Terre Haute, Vigo County, and Rockville, Parke County, are the nearest available stations to the area from which data can be taken. The average date of early and late killing frosts over a period of 16 years is follows:

Station.	*First in Autumn.*	*Last in Spring.*
Rockville	October 7	April 27
Terre Haute	October 22	April 17

The temperature and precipitation taken over a period of 22 years are as follows:

Mean temperature and average precipitation at (1) Rockville:

Month.	*Mean Temperature, Degrees F.*	*Average Precipitation, Inches.*
January	28.0	2.50
February	28.6	2.42
March	40.4	3.64
April	52.4	3.38
May	62.4	4.21
June	71.2	4.15
July	74.8	3.25
August	73.0	2.88
September	67.3	2.92
October	54.6	2.27
November	41.8	3.50
December	32.1	2.56
Annual	52.2	37.68

Mean temperature and average precipitation at (2) Terre Haute:

Month.	*Mean Temperature, Degrees F.*	*Average Precipitation, Inches.*
January	29.5	2.64
February	30.2	2.43
March	43.6	4.12
April	53.9	3.68
May	65.1	4.08
June	73.7	4.14
July	77.6	3.12

Month.	Mean Temperature, Degrees F.	Average Precipitation, Inches.
August	75.9	3.11
September	69.5	2.71
October	57.3	1.96
November	44.1	3.19
December	34.3	2.63
Annual	54.6	37.81

Maximum and Minimum Temperatures.

Highest temperature recorded for a period of 22 years at Rockville up to 1910, 104°, in July. At Terre Haute, 104° in July.

Lowest temperature recorded for the same length of time, at Rockville, —22°, in February. At Terre Haute, —17°, in February.

The preceding data can be used to apply to Putnam County, since there is very little variation between Vigo and Parke counties, and as Putnam County lies in the same latitude north and adjacent to the latter.

Glaciation.

A brief survey of the glaciers and glacial erosion will be found beneficial here in reference to the local soils. For this general information I am indebted to the works of Dr. Charles Dryer, Dr. T. C. Chamberlain, Prof. Rollin D. Salisbury, Frank Leverett and the late publication of C. W. Shannon, all of whom have made special investigations of the glacial deposits of Indiana.

"The work of the glaciers in Indiana has been attracting the attention of geologists and other investigators for a number of years. Both the State and the United States Surveys have done a great amount of work, and are at present engaged in the investigation. A careful study of the glacial deposits in Indiana will throw much light on the results of glaciation in general. 'It is in Indiana that we find about the first recognition in America of the boulders as erratics and striæ as products of ice action. So long ago as 1828, granite and other rocks of distant derivation were observed by geologists near New Harmony, in the southwestern part of the State; at nearly as early a date (1842) striæ were noted near Richmond, in the eastern part of the State.' But even with these observations, very little attention was given to the deposits until within the past twenty-five or thirty years.

"About four-fifths of the State lies in the glaciated area. In the south central part of the State is a driftless area comprising all or a part of twenty counties.

"Two distinct periods of glaciation are recognized and in addition much material derived from a third in which the advance of the sheet did not reach this county, but produced many important surface features by the wind and water action upon the outwash material.

"The various stages producing glacial deposits are spoken of as (1) The first ice invasion, a lobe of the Illinoian sheet which reached even to the eastern side of Indiana. (2) The loess depositing stage, coordinate with the flow of the Iowan sheet. (3) The Wisconsin State."

The Illinoian Glacial Invasion.—The State was invaded by ice which had its center of dispersion in the elevated districts to the east and south of Hudson Bay. From the region to the north of Lake Huron there was a movement to the west of south over the basin of Lake Michigan, Illinois and Indiana. From a part of this sheet the part known as the Illinoian lobe was formed. The deposit left by this invasion constitutes the surface (aside from the covering of loess) over southwestern Indiana and an area of almost equal size in the southeastern part, that is, it covers the entire area between the glacial boundary and the line of the Wisconsin drift. Many wells and drillings have shown that this drift is also present farther to the north underlying the Wisconsin. The thickness of this drift over the area of its exposure is in general about twenty-five feet, except in filled valleys. In places the ridges carry but a thin coating, while adjoining valleys may be filled 100 feet or more. At the southern limit the coating of material is very thin in most places, and while the boundary is not well marked by a well defined ridge, the character of the soil and the natural vegetation mark approximately the limits of the drift.

In general the material is of a yellowish brown color to a depth of fifteen feet or more, beneath which the color is a gray or blue gray. There is every transition from the brown to the gray; it is therefore probable that the brown is an altered gray till, the oxidation of the iron having produced the color. In the filled valleys sand and gravel are often found, and in the northern part of the area the drift becomes more variable. The underlying rock formation in most of the area appears to have contributed largely to the material of the till. Where the underlying rocks are of a friable nature, the material has been reduced to sand or clay and few if any pebbles remain in the till, the coarse and pebbly constituents of the till thus vary with the character of the underlying rocks. The locally formed pebbles and rock fragments are chiefly sandstone, but numerous foreign rocks and boulders of large size are occasionally found near the limits of the drift. The region presents a fair, even topography. In places, knolls and ridges with undulating surfaces occur, but only in the region of the young streams do they reach any great height. Striæ are found in several places in the county. They occur along Ramp Creek, Little Walnut, Deer and Mosquito. The markings are chiefly upon the sandstone exposures of the Mansfield formation.

The Loess Depositing Stage—The Iowan Drift.—Prior to the invasion by the Illinoian ice lobe there was a marked interval of deglaciation and a similar interval occurred at the close of the Illinoian period. These intervals were marked by leaching and oxidation of the drift, the accumulation of muck and soil, and the processes of erosion. The interglacial interval following the Illinoian invasion is known as the Sangamon Stage.

The surface of the Illinoian drift outside the limits of the Wisconsin drift is covered with a fine grained, yellowish silt or loam to which the term loess has been applied. Loess is a deposit which, like sand or gravel, may be laid down wherever the conditions are favorable, but since the great bulk appears to have been deposited at a definite stage in the glacial period, the time of deposition may be referred to as the Loess Stage. This loess may be different ages, but since the materials contained are such as occur in glacial drifts it must have been derived from the drift. The source is supposed to be from the Iowan drift, which moved south and westward over the States of Minnesota, Iowa and a portion of Nebraska and Kansas. The distribution was due to the combined action of the wind and water. The loess of Indiana varies from a fine silt of a loose, floury texture to a compact mass, held firmly by a calcareous cement. In some places small pebbles are found imbedded, also fossil remains of fresh water mollusks, and some insects and bones of mammals are found. The color varies from yellow to almost white, due probably to modified forms of the same material. The thickness varies from a thin coating to twenty-five feet or more. Where exposures of loess material occur the faces are vertical and compact, and any markings upon the surface remain well preserved indefinitely.

The Wisconsin Stage.—Considerable time elapsed between the main deposition of loess and the invasion of the Wisconsin ice sheet. This time is designated as the Peorian Stage. Erosion produced many changes in the surface of the loess and the underlying drift. In places, extensive deposits of muck and humus have been found. Following the Peorian Stage there occurred one of the most important stages of glaciation in the entire glacial period. "It is marked by heavier deposits of drift than those made at any other invasion. Throughout much of its southern boundary in the United States, a prominent ridge or drift is to be seen rising in places to a height of 100 feet or more above the outlying districts on the south, and merging into plains of drift on the north, which are nearly as elevated as its crest."

The southern border of this drift sheet is less conspicuous in Indiana than in the States to the east and west. The ridge on its southern border in western Indiana rises scarcely twenty feet above the outer border tract, and it is no more conspicuous in central Indiana. The limits cross the country, enter it a little north of Vivalia and extend southwestward to Limedale, thence south to Manhattan and then eastward and south to the eastern county line.

Here it is determined by the concealment of the loess beneath a thin sheet of bouldery drift.

Thickness of the Drift.—Throughout the State the thickness of the drift varies surprisingly. The portions of the older drift exposed to view have an average of about thirty feet. The additional 100 feet of the later drift, however, is deposited very irregularly. In the belt of thick drift which leads from Benton County to Marion, lies only the northeast portion of Putnam. The average thickness in the State ranges from 485 feet at Kendallville to only a few inches and in places leaving the residual rock formations bare, as in southwestern Pulaski, southern Jasper and northwestern White.

The work of glaciation divides the soils into two classes, one of which forms the foundation of the soil types of Putnam County, while the other appears in a highly modified form, being affected by the the loess depositions. The latter is the residual soils. These are the soils that have not been removed from the parent rock. Such soils, in common, appear in the driftless area. They vary much in color, texture, structure, and natural fertility, according to the formation from which they have been derived. The poorer soils are those derived from the shales and sandstones. Those from limestones are rather fertile, but will soon become depleted. The residual soils are not very deep as a rule, and do not withstand drought very well. Muck is also defined as sedentary, as it is derived from the local material congregated.

Transported Soils.—Those which have been transported by the power of water, wind and ice. These are known as colluvial, alluvial and glacial drift soils. The two latter classes are most important. All of the alluvial soils are fertile both in the glaciated and unglaciated areas. A large part of the river bottom soils are low-lying and difficult to drain. These soils vary from sand and gravel to the stiffest clays, but in general they are good clay loams. Corn is the principal crop.

The drift soils are composed of a great variety of types, and mostly of good to fair fertility. The black loam of the drift has made Indiana take first place among the States in the production of corn and other staple crops. The glacial drift deposits are varied in the arrangement of clay, gravel and sand, so that what is true in one locality may be entirely different in another. But in general it consists of a confused mass of material derived from many sources and is usually rich in all the necessary plant foods.

The loess soils are easily cultivated; much of the surface of a well tilled field is frequently a loose, floury dust, and when small clods occur they can be easily broken. Some of the soil may be plowed wet and yet easily be worked to a pliable condition. There is a marked deficiency of organic matter from the virgin soil in comparison to the soil that has withstood long periods of continuous cultivation. This amount often becomes less and less until the soil reaches a poor physical condition that is sometimes difficult to manage. A systematic rotation of crops and good application of stable manure are necessary to keep the soils in good condition for cultivation. Much of the land is used for pasture, but when left uncultivated for a few years the ground becomes covered with a growth of briers.

The principal alluvial soils of the State are those of the White River, Wabash and Ohio valleys. The valleys of these streams and their tributaries are the results of stream erosion, and chiefly by the streams which now occupy them. During the glacial period they were largely choked with drift, only a small part of which has been removed; deep ravines exist in great numbers along the tributaries.

Terraces are the results of stream erosion in the glacial debris. Between these terraces are the bottom lands, almost in every case an entirely productive type. A large percentage of the drift soils are better suited for cultivation than those of the driftless area, but there are, however, large areas of the former which are either too rough for agriculture purposes, as in the maturely eroded area of the older glacial deposition, or too wet, as exists in the marsh areas and low districts along Walnut and Mill Creek.

Geological Table.

The following table will aid in arranging the local formations in reference to the preceding and succeeding one. The outcrops in Putnam County are *underlined.*

Paleozoic	Permian	
	Pennsylvanian	*Merom sandstone.*
		Coal measures, shale, limestone.
		Mansfield sandstone.
	Mississippian	*Huron limestone and sandstone.*
		Mitchell limestone.
		Salem (Indiana Oölitic) limestone.
		Harrodsburg limestone.
		Knobstone, sandstone, shale.
		Rockford Goniatite limestone.
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	

SOILS.

Miami Silt Loam.

The surface soil of the Miami silt loam consists of 4 to 10 inches of heavy gray to a dark chocolate colored silt loam. The subsoil is a heavy plastic clay of dark drab or rich chocolate color, mottled freely by streaks of reddish yellow, oxidized iron. Both soil and subsoil have a dense, close structure, as well as a fine texture. A clay phase of the type is often found together with the silt loam and is not deemed advisable to a separate classification, being of such limited extent, and, greatly influenced in character and available plant food by the adjacent silt loam.

The predominance of clay and silt may vary as to the location and freeness of erosion by the runoff. In such places the soil is shallow; the upturned furrows upon exposure become light gray to white and give rise to the term "white-faced clay" and "white slash." Where the section has not been disturbed by tillage or by plant roots, the clay has a horizontal, laminated structure, due to the processes involved in its formation. There are also structure planes across these laminæ.

This soil is the most difficult to till in the whole region. The fine texture and the dense, close structure precludes the handling of this soil, except within a very narrow range of moisture condition. If plowed only a little too wet or a little too dry, the result is a mass of clods, which no amount of subsequent tillage can reduce to a good seed bed. Fall plowing for tillage crops is inadvisable, as the surface then puddles and makes the preparation of a seed bed almost impossible without replowing. Even after the fundamental operation of cultivation (plowing) has been performed, all other operations of the soil stirring must be carefully timed as to moisture conditions in order to secure beneficial rather than harmful results.

The Miami silt loam by perfect management can be reduced to a powdery seed bed; however, a rain causes a compact crusting upon the surface which often prevents a good stand of intertillage crops even when the proper care has been taken in all other preparatory necessities.

The soil is the most extensive type of the county, occupying the level uplands, the apparent high terraces and hill portions to an extent. It alone is the problematic type for local management both as to the retention of a sod and to the growing of staple crops of grains.

The physiographic position and topographical features are such that drainage over practically the entire area is inadequate. Most of the cultivated fields are plowed in very narrow "lands," the "dead furrows" serving as an open ditch to remove excess surface water. By other farmers the tile drainage is alone used. Besides, the internal movement of water is slow and cannot be readily improved on account of the dense, close structure and the extreme fineness of the soil particles. All these factors make the drainage of this soil exceedingly poor, giving the soil a wet "soggy" nature that increases the acidic character and tends to check and even kill the plant growth. Care should be taken to improve the surface drainage as much as possible, and artificial underdrainage should be installed in all cultivated areas. This would lessen the acidic composition and have a tendency to give a better areation. Liming of the land is an immediate remedy for "sour lands." To do this would be expensive, but not more so than the results would warrant. The great benefit of underdrainage would be not merely the removal of the excess water but would also lengthen the period in which the proper cultivation could be performed. This would result in more thorough tillage methods, and consequently better control of the moisture conditions in time of drought as well as excess.

The method of derivation of this soil type from the weathering of glacial and lacustrine deposits, as well as the action of the wind in depositing the loess over this area is given in another part of this report under the head of glaciation and its results.

The native forests of original type have been mostly cut away and for the most part the land is ''cleared'' for cultivation or is covered with second growth of maple, oak, hickory, elm, poplar, and trees of shrubbery-like growth.

The Miami silt loam is especially adapted to the production of hay, of which it yields from 1 to 2½ tons per acre. The best yielding fields are usually of timothy and alsike clover, the soil being much better adapted to this species of clover than to red clover; however, the latter does well in places. In taking the entire area the great number of fields are easily killed by the freezes of winter, especially if moisture is abundant. Though this type cannot be considered a corn soil in its natural state, excellent crops of that grain can be grown. The average yield of corn, however, is not over 30 bushels per acre. Oats usually give a good yield, about 40 bushels per acre. While these yields are on typical soil, the better managed and well located tracts do considerably better, corn yielding from 60 to 80 bushels, oats from 40 to 50 bushels, rye from 25 to 30 bushels, and hay seldom less than 2 tons per acre.

Farming practices on this soil are not as good as they should be. This, taken with the natural physical properties of the soil, curtails production not a little. The large area of the type and its agricultural possibilities make its improvement one of the important factors in the agriculture of the county. At present there is no definite systematic rotation practiced, or the rotation is so long that the soil is not much benefited. As before stated, plowing should be done when the soil has just the right moisture content, so that clodding may be reduced to a minimum. More organic matter should be introduced into the soil, with a view to improve both its structure and its ability to hold moisture during droughts. This will give better tilth, reduce clodding and make cultivation practicable under a wider range of moisture conditions. Increasing the organic matter content will also reduce the liability of puddling where the land receives a fall plowing. Such improvements can be brought about by using the land for different forms of animal husbandry, instead of producing forage crops and hay for sale as such, by establishing shorter rotations, including more leguminous crops, such as alsike clover for hay and field peas for grain or for feeding green, and by turning under some green manuring crop. In addition to the practice of stock raising or dairying and the practice of rotation and green manuring, greater care should generally be taken in all the farm operations, particularly in the preparation of the seed bed and subsequent cultivation, which because of the difficulty in handling this heavy soil are apt to be inadequate. Careful restrictions of the soil to those crops for which it is adapted will also tend to make farming upon it safer and more profitable. Agricultural conditions on these areas are variable. As a whole they are poor to fair, though on individual farms and in the better localities, they are often excellent. The improvement of the soil, as indicated above, would materially improve conditions, and there is no reason why all the poorer farms should not approach in crop yields and profitableness the best now found.

The values of this type range from $20 to $40 an acre for that in the poorer condition, and from $75 to $100 an acre for land having the better improvements, buildings, and being better tilled.

Below are given the results of mechanical analysis of the Miami silt loam:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
3 miles east of Mt. Meridian on south side of National Road	Soil	0.25	1.4	0.8	3.1	1.9	73.35	19.2
	Subsoil	0.3	1.	.6	1.5	2.1	68.8	25.7
Center of East ½ Sec. 26, T. 14 N., R. 4 W.	Soil	1.	.4	.8	2.5	.8	74.6	19.8
	Subsoil	.5	.2	.7	2.	1.2	71.7	23.7

Miami Silt Sandy Loam.

This type consists of all of the characteristics of the Miami silt loam otherwise than the variation caused by its location upon the Mansfield sandstone. This geological formation has given to this type a sandy nature and a reddish color in addition to the gray-chocolate coloration. Lying as it does in the southwest part of the county, it follows arbitrarily the boundary of the Mansfield except in the district south of Vivalia where the writer did not deem the variations great enough to run the boundary upon the later glacial drift. The depth of the drift prevents the alternation of the surface by the residual weathering to any such extent as to require a change of plant adaptation for perfect qualification to the avail able plant food.

Corn, wheat and oats produce good to fair crops except where the silica component of the soil is so great as to cause frequent intermittent periods of rains to verge upon the character of a drought.

Grasses for pasture prove a good means of obtaining an income from the soil, and for hay wherever the surface is level and not damaged by the wash of heavy rains.

The following is the result of mechanical analysis of the Miami silt sandy loam:

LOCATION.	DESCRIPTION.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Center of Sec. 18, T. 12 N., R. 5 W	Soil	0.3	3.8	5.2	11.1	15.2	46.2	18.2
	Subsoil	.4	3.1	9.2	8.6	20.5	31.5	26.7

MIAMI LOAM.

The Miami loam consists of dark-brown to a gray loam, 8 to 10 inches deep, underlain by a subsoil of gray mottled silt loam, to a partially unweathered glacial till. The subsoil often contains layers of gray sand or gravel in pocket formation. While the subsoil varies considerably, the surface soil is relatively uniform. Some small areas of the type contain large quanities of rock fragments.

This soil occurs in only small areas, mainly along the boundary of the Genesee sandy loam and Genesee loam phases. It resembles them much in character but is derived from the glacial debris directly instead of alluvial deposition, though portions may be partially the product of high water sedimentation.

The Miami loam has a rolling to hill topography and is used principally for pasture and woodland; however, the leveler tract responds readily to tillage and produces good yields of corn and truck crops. Because of the damage done to this soil type by run-off directly, it is usually kept under cover of a good sod of blue grass or timothy. In many places the location of the type has the appearance of terraces perhaps as high as second or more. However, the derivation disproves this classification, allying it closely to the silt loam type of the same glacial and loessial deposition.

The following is the result of the mechanical analysis of the Miami loam type:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
N.W. ¼ of Sec. 35 T. 14 N., R. 5W	Soil	.1	.1	.7	9.0	15.6	58.0	19.2
	Subsoil	.2	.2	4.8	9.1	11.4	59.4	15.7

Genesee Sandy Loam.

The soil of the Genesee sandy loam contains a very high per-cent of silt. It is light-brown or grayish soil, 8 to 10 inches deep. The subsoil consists of a yellow silt which often carries an appreciable amount of fine to very fine sand in the third foot. The entire three foot section is compact, but especially so in the lower part. The surface soil is easily tilled, and can be worked to form a mellow, friable seed bed.

The Genesee sandy loam is one of the most important soils, but is of limited area, the largest areas being along Little Walnut and the eastern tributaries of Walnut Creek. The remainder is distributed along other small stream courses of the county.

The topography is uniformly level as would be expected from its position and mode of formation. The drainage is very poor, unless assisted artificially.

This soil is alluvial in orgin and consists of wash of materials from the uplands deposited along the stream in the position of first bottoms. Underdrainage is difficult because no outlet can be secured that will be open throughout the year. The base of these soil deposits are principally the work of glacial streams, which deposit has more recently been covered by the sandy loam. Periodic inundation is still an active factor in the accumulation of soils of this type along the younger stream courses. The floods are irregular and may occur at any time of the year and for a number of years in succession, or again a number of years may pass without these bottoms being inundated.

The area mapped as Genesee sandy loam includes the true river bottom deposits where the river has cut a well-defined valley into the upland and spread a plain of sandy loamy sediment over its floor, and also a large area of irregular shape where the river floods have spread out over a low area that antedated the birth of the river. The river work within the latter has been a work of construction only, not preceded by the destructive work of valley cutting, as has been the case where the valley is a clear cut one. The same river-borne sediment has been spread over the lowland area and also over the valley floor, so that from the point of view of the origin of the material the soils are identical, in both positions.

The level area deposits are usually underlain by a more firm clay subsoil than that of the irregular bottom areas, where the subsoil has a larger per cent. of sand. This does not change the surface soil to any great extent because of the recentness of deposition, except a variation in underdrainage and a tendency to a better aeration.

A small proportion of the Genesee silt loam is wooded. Some oaks and elms occur along the streams.

The crop to which the Genesee sandy loam is best adapted, especially in the narrower deposits, is probably grass for both pasture and mowing. The yield of blue grass sown for pasture is abundant and of good quality. The type also yields good crops of hay, either clover or timothy. Neither of these crops is in so much danger of injury from flooding as are tilled crops. When, however, the danger from floods can be avoided, general crops, such as corn, wheat, and oats yield extremely well, and such special crops as sweet corn, beans, peas, tomatoes and beets for canning can be successfully grown.

Besides the danger from floods, the difficulty of keeping the fields free from obnoxious weeds is another drawback in the growing of tilled crops. At times of flood, weed seed are scattered over the fields and as a result there is a superabundance of weeds that require much hard labor in order to keep crops clean.

The principal improvement to be suggested for this type is the quicker removal of the flood waters, by surface as well as under drains. In spite of the difficulties in farming the Genesee sandy loam, it is one of the most valuable soils of the country wherever properly handled. Prices for the land of this type range from $75 to $125 an acre.

The following table gives the result of the mechanical analysis of the Genesee sandy loam:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
N. E. ¼ of Sec. 9, T. 14 N., R. 4 W	Soil	0.4	4.3	10.8	27.1	15.6	30.5	11.3
	Subsoil	6.1	5.2	9.7	30.2	9.8	26.8	12.2

Genesee Loam.

The Genesee loam consists of dark-brown to gray loam or silt loam, 8 to 16 inches deep, underlain by a gray mottled silt loam. The subsoil, like that of all alluvial deposits, is stratified, the predominant silty material containing some thin layers of gray sand and fine gravel. The subsoil being the product of deposition with little or no modification by weathering, varies considerably in color as well as in texture. The soil on the other hand is relatively uniform in both, the former being due to weathering, the latter to mixing by the roots of plants, by animals and by cultivation.

This soil occurs along the narrow valley bottom. It is usually only moderately drained. At a depth of 3 to 4 feet, a substratum of loamy gravel is encountered which serves as a means of under drainage, yet lying below the water level except in the dryer seasons, it lends no beneficial aid to crop production. Artificial drainage by tile and open ditches is necessary to insure the best results. In the higher valley the type is not subject to overflows, and is considered a superior soil for staple products. Corn, wheat, grasses, and oats are the principal crops in this county.

Corn yields from 40 to 80 bushels per acre, oats from 40 to 60 bushels, hay from 1 to 3 tons. Onions, cabbage, and carrots are well adapted to this soil, the first producing from 500 to 800 bushels per acre, and carrots giving a splendid yield of 1,000 bushels per acre. Potatoes, tomatoes and celery have been grown and have given exceedingly good returns. The industry of truck farming on extensive and intensive scale finds this soil a valuable respondent by favorable yields. The soil will react for commercial fertilizer. Organic matter is furnished by overflow of the streams and inwash from the adjacent uplands; nevertheless crop rotation with a legume gives marked increase in yields.

The following table shows the results of the mechanical analysis of the Genesee loam:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
S. ½, Sec. 27 T. 15 N., R. 5 W....	Soil................	.4	5.3	12.8	23.6	8.2	39.0	10.7
	Subsoil............	3.6	14.2	14.1	17.9	5.3	30.1	14.8

Carrington Black Clay Loam.

This soil, which is a black clay loam, is very high in organic matter content, is underlain by a dark gray subsoil. Due to insufficient drainage outlets, the depressions now occupied by this type have become exceedingly wealthy in plant food. The whole represents residual material derived from glacial till, which, being subject to poor drainage has become a very dark to black soil by the constant accumulation of the remains from decayed water plants.

Soils of this type form some of the best agricultural lands of the county. When well drained it is exceedingly productive, and proves to be one of the best corn soils of the glaciated area.

It occurs upon the leveler uplands and is easily differentiated in the spring by topography and coloration, in the summer by the rank growth of the crops. The texture and constituents are changed by long continuous tillage, but have so far been no great problem to the progressive farmer. Grains, during a favorable growing season, make such a rank growth that lodging is caused by the winds. The damage caused in this way has been a chief factor in limiting the tillage crop of corn to this soil. Splendid results are also had with grasses and clovers. Fertilizers are seldom if ever used.

This type is limited to three principal districts. The largest portion lies to the north central and eastern parts of the county. It forms the bases for the wealthy farm lands and timothy fields extending north and eastward from Carpentersville.

The Carrington black clay loam yields readily to seeding preparation, a quality that proves an advantage in its proficiency.

During the freezing of an open winter, with a scanty supply of snow winter grain crops suffer greatly, especially on this type. The soil never packs thoroughly, is readily pervious to water, and by freezing the roots of the winter crops are torn loose and killed.

Forage crops make abundant yields.

The following table gives the result of mechanical analysis of the Carrington black clay loam:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
E. ½ Sec. 2, T. 16 N., R. 3 W....	Soil...............	0.1	2.4	2.1	3.5	2.7	38.9	50.3
	Subsoil...........	.08	1.7	1.5	5.4	3.2	40.1	48.02

Coloma Sandy Loam.

This soil is a sandy loam of grayish color, loose, heavy with loam, ranging in depth from 8 to 16 inches. The subsoil is of a more reddish yellow, heavy sandy loam of coarser quality. At the depth of several feet a stratum of yellow, coarse sand is encountered which frequently merges into a heavy plastic bolder till. The subsoil is generally a light yellow loamy sand containing some gravel; however in deep deposits a substratum of gravel is found. This lower stratum furnished a splendid underdrainage, becoming in periods of slight rainfall a detriment to crop yields.

The surface configurations vary from gently rolling to hillocky, or even sharply rolling. The type is moderately well suited to sugar beets, corn, oats, wheat, grass, and potatoes. Vegetables give fairly good results. Green manuring should be practiced in order to maintain a proper supply of organic matter.

The following table shows the results of mechanical analysis of the Coloma sandy loam:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cnet.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
S. W. ¼ Sec. 23, T. 13 N., R. 5. W.	Soil...............	0.5	2.4	10.3	30.6	19.1	26.2	10.9
	Subsoil...........	0.3	2.1	15.7	27.2	18.3	28.0	8.4

Coloma Sand.

The sandy soils of this type are used to produce the early summer vegetables. The quality, flavor, and keeping qualities are not so good as on the heavier soils, which mature the crops earlier.

The soil ranges in depth from 6 to 15 inches, of a light brown color, stained to a brown black by the humus, wherever it has been left uncultivated for a few years. The subsoil is of a coarse loamy sand to sand with occasional gravel beds at a depth of 3 to 4 feet. The topography is rolling to steeply hilly. The areas lie near streams and glacial moraines. It represents residuary material, resulting from the reworking of glacial till by wind and water.

The area is principally in pasture land. As a general farming soil the Coloma sand is by no means a superior soil, but is considered well adapted to fruit raising. It is not retentive of moisture and to produce a good yield a liberal supply of organic manure and frequent rains are necessary. On the higher elevation of the hills a drought is caused by the intermission of rain for a few weeks, at such time the sand is easily shifted about by the wind wherever there is a lack of vegetation or sod. In the lower areas alfalfa has been grown quite successfully. The general dryness prevents a successful seeding.

Because of the loose texture of the soil, and the freedom with which water penetrates it, commercial fertilizers produce no cropping advantage. As long as moisture is constantly retained in the fertilized soil the results are beneficial, but the heavy rains and intermittent dryness leach away the food material.

The following table shows the result of mechanical analysis of the Coloma sand:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
	Soil	0.2	0.6	6.7	40.1	36.1	12.2	4.1
	Subsoil	0.9	2.1	8.2	30.6	32.8	7.1	18.3

Chenango.

The soil of the Chenango type is a gravelly sandy loam and is of a brown color, usually ranging in depth from 4 to 8 inches. The subsoil is a light brown to a yellowish brown or gray material, somewhat more sandy than the soil and extending to considerable depth. The gravel content of both soil and subsoil is generally high, the fragments consisting of even, coarse gravel. The soil of this type is easily cultivated, even immediately aften heavy rains.

The area of Chenango in Putnam consists of small scattered tracts along various streams of the county. The surface is relatively level, and the loose, open structure and coarse texture give good drainage, both surface and underground.

Like the other alluvial soils the Chenango, which has been formed by stream action, occurs as terraces along the stream courses or where streams flowed into glacial lakes.

Owing to the loose, sandy, gravelly nature of this soil type it is not suited to general farming, but its open structure, permitting ready drainage, and the fact that it warms up early in the spring makes it well adapted to truck crops, such as melons, cucumbers, small fruits, and especially strawberries.

Corn, clover, oats and wheat have been the customary crops in the county on this type. The clover does well when the difficulty of securing a good seeding has been mastered. Corn yields 20 to 35 bushels, oats 20 to 40 bushels, rye 10 to 15 bushels, buckwheat 5 to 15 bushels, and hay ½ ton to 1½ tons per acre. South of Fincastle and north of the stream near that place is a small plot of alfalfa upon this soil which does well with exception to the higher portions. An increase in these green crops should be made and turned under, thus increasing the organic soil constituents and making it possible for the soil to hold more moisture. With this plan and the liberal use of stable manure, yields of such crops as are adapted to the type could be secured annually instead of one in two, three or four years. Where these methods have been applied to the soil with the intention to conserve organic matter and improve the moisture-holding power, good yields are obtained.

Below are given the results of mechanical analysis of the Chenango type:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
S. W. ¼ Sec. 16, T. 14 N., R. 4. W.	Soil	1.1	8.2	9.4	45.3	6.3	17.4	12.3
	Subsoil	3.9	6.1	10.2	57.1	8.2	4.2	10.3

MUCK.

When the ground and terminal moraines were laid down by the melting glacial sheet they presented an uneven topography. This left shallow lakes of large and small sizes scattered promiscuously and with underlain or no drainage. The depressions were shallow and presented conditions favorable to the rank growth of water plant, the accumulation of aerial deposits, and as receptacles for the sedimentary deposits of surface run-off. In time the depressed area became practically firm, being filled with a disintegrated peat soil, still occupying damp and low surface. The vegetable mold generally reaches to the depth of several feet. When drained, muck becomes a fertile soil and well adapted to the production of cabbage, onions, celery and other truck crops.

The area of muck in Putnam County is rather limited and is used for tillage and pasture. The portion tilled yields only moderately, being hindered from maximum productivity on account of the poor drainage. The pastured portion proves to be very profitable, the greatest difficulty being in the retention of a tame grass sod in the place of the native swamp grasses. Cattle and sheep were the principal stock upon this limited area.

WAVERLY LOAM.

The Waverly loam occurs as first bottom land along the creeks. It contains more organic matter of decayed plant stems and roots than the Wabash loam. When dry the soil is rather mellow, dark brown to a whitish brown soil, but becomes plastic when wet. The dark color is due to the presence of the organic matter.

There is an intimate relation between the origin, physiography and drainage of the Waverly loam. The soil is part alluvial but the principal constitutent is the glacio-loessial loam, deposited by glaciation and graded partly by stream erosion. The areas mapped in this county resemble old lake bottoms and shallows of stagnant water, which, similar to muck formations, gave favorable conditions for swamp and bog vegetation. Together with the organic accumulations in this way, the surface wash was deposited here. This accounts for the fact that, from the average depth of the soil, being 8 to 10 inches, the same coloration and composition may exist for a depth of 20 to 30 inches as if found near the surface.

The subsoil, a brown yellowish to whitish yellow clay loam, underlies the whole type except where local pockets of loamy gravel and sand of small extent are found. In many borings the exact division of the subsoil was difficult to distinguish, the texture being the only differentiating factor.

The original Waverly loam gives favorable conditions for the growth of trees adapted to wet soils, as gum, sycamore, water oak, beech and willows. The surface topography is level, though a portion is somewhat slightly rolling. Open ditches are used to provide adequate drainage. Some parts are subject to overflow during the rainy seasons. A few tracts are not sufficiently drained to allow the highest efficiency of the soil to be realized.

When this type of soil is thoroughly drained and protected from overflows, it is one of the best soils for corn, wheat and forage crops. It also produces large yields of grasses and proves to be well adapted for the heavier truck crops, especially to cabbage and onions. It is not so well adapted to canning crops. In case of the tomato, a plant disease known locally as "blight" prevents the development of the blossom. The leaves die and blossoms fall off. The wet non-aeriated condition of the soil decays the thread roots and limits the nourishment.

Considerable ditching and tile drainage is the first practical development of this soil, and good results will become evident the first year. The legume crops and clover can be grown then, with good crop advantages as well as giving splendid beneficial returns to the soil.

After several years of continual cropping with non-legumes this type becomes lighter in color, more stiff in texture and presents a pale whitish colored soil. The crops of corn become less productive and many plants will be void of an ear. Such lands could well be called "sick lands" of which Putnam County has but very little. Immediate results can be obtained by a dressing with stable refuse, a thorough drainage and prevention of overflows.

The Waverly loam stands high in agriculture importance where well tilled and drained. The average yields for this county are as follows: Corn, 40 to 50 bushels; wheat, 15 to 20 bushels; timothy, 1 to $1\frac{1}{2}$ tons per acre.

The texture of this soil is shown by the mechanical analysis given in the following table:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
S. E. ¼ Sec. 29 T. 14 N., R. 3. W.	Soil...............	0.2	1.0	1.3	3.6	7.2	57.8	28.9
	Subsoil............	0.2	.3	.4	2.8	6.4	52.7	37.2

Wabash Loam.

The soil consists of a dark brown to a reddish brown sandy loam of a rather coarse texture, becoming lighter in color with depth. Mill Creek's lacustrine deposits and glacial lake fall in this type. The soil to a depth of 15 inches is of a brown color lightly tinged with a yellowish red, but the same soil in cultivated fields is darker from the increase of vegetable mold, while farther from the stream local portions are lighter or darker, due to the wash from the Miami silt loam or from some accumulation of organic matter.

The topography is level and the hills near are low, gentle slopes and generally at a mile or so from the stream. The soil is a heavy clay loam containing a large per cent. of loam, a little grit, but is free from sand.

The subsoil at a depth of two to three feet is more reddish. The clay is mottled with darker red stains from oxidized iron. Spots of lighter bluish clay exist throughout the subsoil at this depth. There is less grit than above in the soil.

At a depth of 4 feet the principal constituent is a bluish clay with an increase of sand. The iron stains become less with depth but are large and resemble what is locally known as "iron pipes". Blue clay and sandy gravel stratum is encountered at a depth of 5 to 7 feet, and at 12 feet the sand becomes the predominant constituent.

This gives a key to the previously ponded nature of Mill Creek along the eastern boundary of Mill Creek township. Since the dredging and deeping of the channel, this has become one of the wealthiest soils of the county, and leaves only one principal drawback, inundation. Small limited areas of alkali soil are found in this type, which can be improved by tiling thoroughly and mulching heavily with stable manure.

The alkali must be washed from the soil, which process is assisted by artificial drainage; and the firm and compact nature made friable and easily cultivated by the introduction of organic matter.

Corn is the principal crop and produces from 60 to 80 bushels per acre.

The following is the result of the mechanical analysis of Wabash loam:

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
S. E. ¼ Sec. 36, T. 13 N., R. 3. W.	Soil	0.3	0.9	2.1	9.3	20.8	48.7	17.9
	Subsoil	.2	0.4	14.3	10.6	27.5	35.1	12.6

Wabash Sandy Loam.

Along the lower portions of Mill Creek on the southeastern boundary of Putnam County is a type classed as Wabash sandy loam. It is of a light brown loam 10 to 20 inches deep, and cantaining a good proportion of fine sand and some larger gravel.

The subsoil is a brownish yellow clay loam intermingled with a coarse sand and locally containing much organic matter, which produces a dark color. The substratum of gravelly loam and of gravel furnishes a good under drainage. The type lies along stream on the first bottoms and is subject to overflow. Artificial drainage is used in extensive flat portions where the percent of sand is low and excessive surface water has a tendency to stand for a longer period than that of the time of inundation.

The principal crop is corn. The soil is well adapted to melons, sweet potatoes, cabbage, and other truck crops.

Stony Phase.

Some land upon the most broken and hilly portions of the county have been classified as Stony land. The soil in thin and contains either heavy, coarse glacial till, or numerous isolated portions of the underlying rock formations. The vegetation is scanty. The surface is gullied deeply and so thoroughly that the drainage of a single acre may be very complex. The surface humus has been removed. The profitable fertility of the soil is at a minimum. Local owners have considered the situation unfit for cultivation, and have left much of the surface to the ravages of weathering, namely, erosion and transportation.

The reclamation of gullied soil is one of the problems lying open to agricultural science. The transportation and run-off must be reduced to a minimum.

Terracing is a successful method, but by many is considered too expensive for large landowners. It is used extensively in Europe, especially upon the hillsides of southern Germany.

Parallel walls of masonry, or ridges of heavy soil are made, transversely to the flow of run-off, at a distance of a few rods apart, according to the steepness of the slope, intended for reclamation. The intercepted gullies are then filled and the intervening surfaces are made approximately level. A humus is made of straw, manure, and other refuse from the feeding barns, and a sod of vegetation is obtained, either of clover or meadow grasses. After a few years the terraces reach a profitable fertility and in this county could be used to an advantage for the production of berries and small fruit. Where the owner has not the available means, he must direct his energies to decreasing the erosion of run-off by covering the surface with a firm sod, such as blue grass, or placing the land under other available vegetative growths.

The forestry department of the United States Bureau of Agriculture is making special attempts to reinstate such lands with forests and plant trees that develop rapidly, reaching a commercial valuation within a few years.

River Wash.

Under this head is placed the pebbly deposits of the streams. The formation is not in the least productive and its location is always considered a waste, usually left to support the meager vegetation that thrives in moist gravelly sand. For the most part, willow sedges and water reeds cover such surfaces, yet more generally these plants group themselves in patches, leaving the water-worn pebbles bare over the portions selected by the stream for its secondary currents, during a spring freshet or heavy rain. The inner curve of the meanders of the larger stream, and the angle of land lying between the junction of two streams are the usual locations for the deposit of river wash.

The extent of the deposit depends upon four principal conditions, namely, the rapidity of the current, the abundance of rainfall upon the head waters of the stream, a low first bottom, which is easily denudated, and a source of supply of rocks that can withstand in a measure the abrasive action produced by the moving water.

The speed of the stream must be sufficient to carry sand and large pebbles, during the flooding of the stream, if at no other time. When such heavy sediment is transported over the low bottom it is deposited. The momentum of the water is checked by the lessening of depth and obliquity of lateral spreading. Sediment has a general tendency to move in a more or less direct line down a stream, following the greater current. In straight stretches of the stream bed with a regular fall, the water gains speed. A curve in the bed causes a change in the action of the water and lessens the speed. The carrying capacity of the stream is decreased and necessarily the heavier portion of its load must be deposited. The inner curves of the stream current are composed of complexities of motion that impede the onward movement and give the available reasons for the location of the wash.

Artificial soil making on these deposits is not practical. The repeated inundation and strong currents remove all fine sediment that would contain productive soil advantages.

SUMMARY.

Putnam County is located midway between Chicago and Louisville, and 39 miles west of Indianapolis, and is divided in two parts by the divide of the Raccoon and Walnut creeks. Topographically there are two general divisions; the northern half is a moderately level plain, the southern half is rolling to hilly. The elevation varies from 600 to 950.5 feet above the sea level. There are no very marked differences of elevation within the county.

The drainage is entirely by Raccoon Creek and Eel River. Eel River and its branches, "Big" and "Little" Walnut carry most of the water. For the most part the present stream channels are part glacial.

The settlement is rather dense except in small hilly districts. The chief towns are Greencastle, Roachdale, Cloverdale, Bainbridge, Putnamville, Carpentersville, Fillmore, Delmar, Reelsville, Russellville, Barnard, Manhattan, Mt. Meridian, New Maysville, Portland Mills, Clinton Falls, Bell Union, Groveland, Broad Park, Brick Chapel, Fincastle, Raccoon, Limedale, Morton, Vivalia.

Transportation facilities for both local and distant markets are excellent. Shipments are carried by steam and electric railways. Passenger service is good to all points of the county traversed by the railways.

This region has a high reputation for the quarrying and preparing of road metal.

Corn has always been a leading crop.

The live stock industry is not prominent, but in certain localities good breeds are being raised.

Fruit production on a commercial scale became prominent about 1870 and has steadily increased since that date. Apples, peaches and pears are the leading orchard products. Berries, currants and gooseberries are also of importance.

The agriculture of the present day consists of fruit and grain farming, truck growing, general farming and dairying. Fruit growing is becoming more prominent in the southern part of the county.

The soils have been largely formed under glacial lake influence and are closely related to soils of other counties covered by glacial till.

There are fourteen types recognized and mapped in the county. Seven series are represented, besides a number of miscellaneous types.

The Miami, Genesee and Carrington series occupy most of the county and are of the most importance agriculturally.

The Carrington is the most important soil of the county, being suited to all general farm crops.

Miami loam and Miami silt sandy loam are the best for apples, pears and peaches.

The Genesee series is a series of very fertile soil, and is of great importance agriculturally. The sandy loam is the most valuable.

The Stony phase could be used for pasture and reinstating of forest trees.

Muck, when drained, is one of the most valuable soils.

The Wabash series is well adapted to corn raising. The sandy phase of this series is well suited to truck cropping.

The Coloma series is adapted to small fruit growing and pasture lands.

Waverly series, well drained and secured from overflow, is a good general farming soil, being well adapted to the staple grains.

Chenango soils are suited to truck raising and fruit growing.

The most important need for soil improvement is drainage. This should be carefully done and should receive early attention. Surface ditches so far as possible should be replaced by tiles.

Crop adaptation should be more carefully studied.

A systematic rotation should be carefully adhered to on each farm.

Lime is very generally needed for the improvement of the soils, especially the Miami series.

Farmers should study more closely the fertilizer needs of their soils and supply those needs so far as possible by the use of manure and crop rotation.

Organic matter is needed by all upland soils. They need it to loosen their structure and make drainage and tillage easier. Sands and sandy loams need it to prevent leaching.

A systematic rotation in which legumes are prominent should be employed on such farms, and the more general use of alfalfa and clover for forage is urged.

Soil Survey of Newton County

By N. P. Neill and W. E. Tharp.
U. S. Bureau of Soils.

LOCATION AND BOUNDARIES OF THE AREA.

Newton County lies in the northwestern part of Indiana, bordering the Illinois State line. It is bounded on the north by Lake

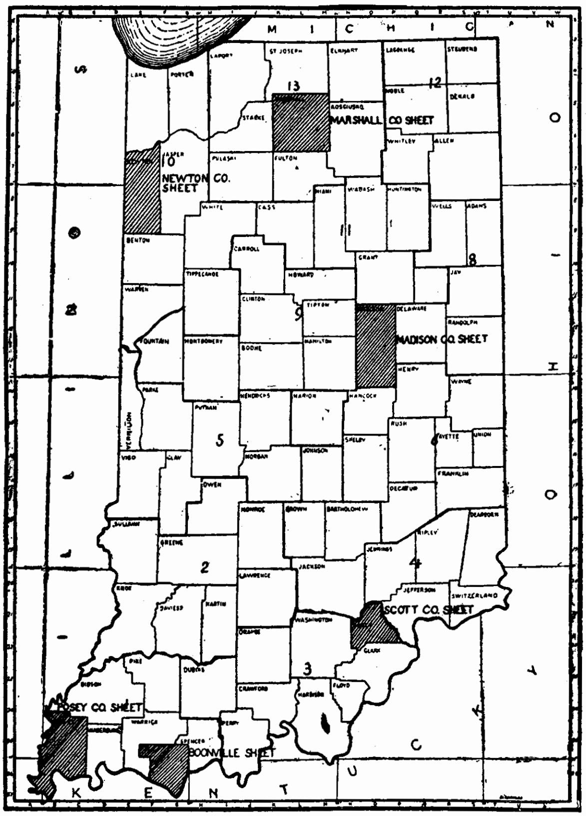

Fig. 1.—Sketch map showing location of the Newton County area, Indiana.

County, from which it is separated by the Kankakee River; on the east by Jasper County; on the south by Benton County, and on the west by the State of Illinois. Newton County is quite regular in outline. Its average length north and south is 30 miles and its average width east and west is 13 miles. The area included within these boundaries is 251,448 acres, or, approximately, 393 square miles.

Goodland, Kentland, and Morocco are the principal towns in the county.

History of Settlement and Agricultural Development.

The original county of Jasper, which was organized in 1838, formerly embraced the territory included within the present limits of Newton and Jasper counties. Owing to the large size of the county and the great distance of the outer portions, especially the western, from the county seat, it was divided. The separation was made in 1859, with the county seat of Newton County located at Kent, now Kentland.

It is quite difficult to determine who were the first settlers to come into this locality. The county was originally a wet, marshy country, covered for the most part with a heavy growth of prairie grass, with some timber along the streams, and inhabited by a large number of fur-bearing animals. These animals attracted the early hunters and trappers into this section of the State, and in some cases temporary settlements were made along the streams.

Prior to 1850 society had little organization. The population was small and scattered over considerable territory, except in one or two localities. The principal early settlements were made on timbered areas along the Iroquois River, in the eastern part of the county. The early settlers came principally from southern Indiana, but most of them were natives of Virginia, Kentucky, Pennsylvania, and Ohio. In later years, as the county became better developed, the immigrants came chiefly from New York, Maryland, and Illinois. The growth and development of the county was at first greatly retarded by trouble with the Indians and later by a class of outlaws who made this territory their field of operation.

Aside from these retarding influences the prairie fires were the most dreaded of all early contingencies with which the settlers had to deal. Various means were resorted to for protection against these fires, but often, when driven by high winds, they would leap any barrier that could be constructed, and buildings, crops, and all improvements would be destroyed, and the settler was often fortunate to escape with his life.

Prior to 1860 the county had no railroads, no newspapers, and but few inhabitants. About 1853, however, the county began to develop gradually, and the advent of the railroad in 1860 gave its growth a decided impulse.

The early settlers brought only the actually necessary outfits with which to begin farming operations in this new territory. They generally came in wagons drawn by horses or oxen, and as a rule followed old trails made by the Indians. The roads over which they passed were bad and at times almost impassable, and under such conditions only the necessities of life were brought with them. The farmers depended upon the near-by villages or settlements for such farming implements as could be obtained. The plow then used was a crude, ungainly implement and not capable of breaking up prairie lands. For this reason the early inhabitants settled on the timbered areas along the streams. Here the land had been heavily shaded and was free from the tough grass roots of the prairie, and when cleared was more easily cultivated. But as it became necessary to break up the prairie lands a heavy sod plow was developed, and while it was a crude, poorly constructed implement, nevertheless it revolutionized the farming of early days. The plow consisted of a beam 10 or 15 feet in length, a share that would cut about 2 feet in width, and a moldboard made of iron bars. It generally required six yoke of oxen to draw it, but the expenditure of all this labor was usually repaid the first year. The second year a "cary" or two-horse side plow was used, which together with the hoe, was the only implement used until harvest time, when the reap hook, cradle, scythe, and flail were employed.

Each settler brought his cattle and horses with him. Horses were used at first, but later oxen proved to be more serviceable in breaking up new land. A few hogs were raised, which furnished the farmer with meat and occasionally added a little to his income. The wild prairie grass furnished feed for most of the stock, and a small amount of corn was fed.

Corn was generally the first crop planted. It was dropped in the edge of the furrow while the sod was being turned under. The crop produced was small and of inferior quality. Wheat was occasionally grown, but not very successfully. It generally grew too rank or succumbed to attacks of insects or unfavorable climatic conditions.

The agricultural development of the county was at first greatly retarded by the lack of local markets and the great cost of transporting the produce to distant ones. Later, however, as public roads were improved and the towns and local markets were built up development became more rapid. Morocco, the oldest town in the county, was established in 1851. In 1860 the town of Kent, now Kentland, was founded, and in the following year Goodland was laid out.

In later years, as the prairie lands were being put under cultivation the settlers aimed to improve first such lands as possessed good natural drainage, avoiding wet and poorly drained areas. Corn, oats, wheat, and hay were the chief products. Wheat formerly produced good yields, but in later years its production proved unsuccessful. The great freeze of 1871-1873 was the deathblow to wheat growing in this county. Several attempt were afterwards made to produce this cereal, but they were generally unsuccessful.

In 1871 land was valued at $20 an acre, and in 1872 it was worth $25 an acre. During the five years following land advanced in price in proportion to the amount of improvement put upon it. The wet season, which covered a period from 1882 to 1886, brought the price of land down to about $10 or $15 an acre. The farmers then began tiling and draining the lands, and since that time land has gradually advanced in price.

Fifteen years ago cattle and hogs were raised more extensively than at present. The low price of beef and pork, together with the prevalence of hog cholera, was the cause of the decrease in their production. During recent years, however, the stock industry has been gradually improving and at present a large proportion of the county, particularly the northern, is devoted chiefly to stock raising and dairying.

Climate.

No data giving the normal monthly and annual temperature and precipitation of Newton County were obtainable. The appended table gives the weather records taken at Rensselaer, which is only a few miles east of the area, and Hammond, which is situated in the county north of Newton:

NORMAL MONTHLY AND ANNUAL TEMPERATURE AND PRECIPITATION.

Month.	Rensselaer		Hammond.		Month.	Rensselaer.		Hammond.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°*F.*	*Inches.*	°*F.*	*Inches.*		°*F.*	*Inches.*	°*F.*	*Inches.*
January	32.6	2.91	23.4	2.37	August	74.5	2.30	71.0	1.97
February	24.8	3.00	22.2	2.10	September	66.2	1.59	65.4	2.70
March	41.6	5.05	36.0	....	October	57.8	3.03	54.6	1.79
April	51.0	2.03	47.2	2.64	November	44.6	3.43	38.0	2.15
May	62.8	3.36	58.5	4.68	December	29.8	2.78	26.2	2.38
June	69.2	5.61	68.8	3.95					
July	76.4	3.88	73.7	2.64	Year	52.6	38.97	48.8	29.37

The climate of Newton County is humid. The rainfall is quite evenly distributed throughout the year. During the growing season it is greatest during the months of May, June, and July, averaging about 4.28 inches for each month, the heaviest precipitation occurring during the month of June, averaging 5.61 inches. The total yearly precipitation is 38.97 inches.

The average annual temperature is about 52.6° F. The coldest months of the year are December, January, and February, the average temperature for these months being 29° F. There are periods during the winter months when the temperature falls considerably below the average, but such cold periods seldom last more than a few days.

The warmest period of the year occurs from June to August, the average temperature being 73.3° F. During these months the temperature often rises as high as 90° F., but such warm periods only last for two or three days at a time.

A very important and characteristic feature of the climate is the occurrence of strong winds during the late spring and early fall months. Periods of strong winds often extend over a number of days and during the latter part of the growing season, especially if the rainfall is light, these hot, dry winds sweeping over the area rob the soil of considerable moisture and crops are more or less injured.

The average date of last killing frost in the spring is April 30 at Rensselaer and April 20 at Hammond; the average date of first killing frost in the fall is October 5 for the former place and October 23 for the latter. On the low wet lands of the area frosts generally occur later in spring and earlier in fall than is shown by the above dates.

Physiography and Geology.

The area surveyed lies north of the hydrographic basin of the Wabash River. It is separated from this basin by a low ridge, the northern slope of which embraces a small portion of the southern part of the county. The surface in this locality is slightly undulating and rolling and occasionally broken by small narrow valleys which have been formed by streams having a northerly direction. The general fall is to the north, and as the Iroquois River is approached the surface becomes more level. This portion of the area embraces a part of the typical prairie lands of the northwestern part of Indiana, and the surface for the most part represents a having a low elevation, occur in clusters or are grouped together in the form of a chain.

The land bordering the Kankakee River is somewhat lower than it is farther back from the stream and is under water a greater part of the year. A more detailed description of the surface features of the county will be given later in the descriptions of the various soil types.

The drainage waters of the southern part of the county, south of the Iroquois Ridge, empty into the Iroquois River. This stream flows in a southwesterly direction across the county about 4 miles north of Kentland. North of the ridge the greater proportion of the drainage water flows to the north and empties into the Kankakee River. However, a part of these lands is drained by the Beaver Creek ditch, which flows in a westerly direction and empties into the Iroquois River in Illinois. This stream formerly drained the old Beaver Lake district.

Later the old State ditch, which is now known as the Beaver Lake ditch, was built and the waters of this district were turned into the Kankakee. The Beaver Lake ditch is the largest stream emptying into the Kankakee in Newton County. A number of other smaller ditches have been constructed which drain into this river.

The glacial drift that occurs over the area south of the northern base of the Iroquois moraine is correlated with the late Wisconsin drift sheet.[1] The surface material consists of sand, sandy loam, and loam, except in cuts or on the more pronounced slopes of some of the ridges constituting the Iroquois moraine, where the unweathered till is exposed. The drift varies in depth from 60 to 150 or more feet, and is composed of a mixture of clay, sand, and gravel in varying proportions, with gravel generally increasing in size and amount with depth. Associated with this material are deposits of pure sand and gravel. Many of these gravel knolls have been opened and the gravel used for road building.

Large glacial bowlders also occur scattered over the surface of the greater part of the area, particularly on the prairie lands, and in a few areas on the Moraines. These bowlders, which consist chiefly of granites, occasionally occur so plentifully as to interfere with cultivation, but in most cases they have been removed from the fields.

[1] Monograph No. 38. U. S. Geological Survey.

Another but much smaller moraine extends east from Percy Junction to the eastern boundary of the area. This ridge, which is composed largely of sand, forms the most southern of the sand areas of Newton County. Other sand areas occur north and northwest of these ridges, but they have no definite connection with one another or with the one just described.

North of the Iroquois moraine the soils are largely of lacustral origin and belong to the Lake Kankakee period. The flat areas are largely composed of sand, and heavy peat beds are quite common. In some areas peaty material is found underlying the sand, which denotes a period or interval of emergence or exposure to the atmosphere between the withdrawal of the ice sheet and the deposition of the sand over these deposits.

In a few areas in the southern part of the county Niagara limestone is found at a depth of only a few feet. In section 25 of Jefferson Township limestone is quarried and used for road building. The limestone is covered over with glacial material and has played no part in the formation of the soils of the area.

SOILS.

Eleven distinct soil types were recognized and mapped in the area surveyed. Each of the types is quite distinct in its typical form, although, as in nearly all glacial areas, minor variations from the true type occur. The line of demarcation between the various soils is generally quite well defined, but in some cases the transition from one type into another is gradual and occasionally almost imperceptible. The typical prairie soils of the area are separated from the original marsh soils, which occupy the northern part of the county, by the Iroquois moraine. Covering this moraine and south of it four distinct types are recognized, while to the north of it and including the soils mostly of lacustral origin seven types are found.

The following table shows the extent of the several types:

AREAS OF DIFFERENT SOILS.

Soil.	Acres	Per cent.	Soil.	Acres.	Per cent.
Marshall loam	81,856	32.8	Swamp	3,648	1.4
Clyde fine sand	61,048	24.4	Miami black clay loam	1,792	.7
Marshall fine sandy loam	42,560	16.8	Clyde loam	960	.4
Miami fine sand	32.704	13.0	Kaskaskia loam	832	.3
Peat	10,368	3.9			
Marshall fine sand	9,792	3.9	Total	251,448	....
Newton fine sand	5,888	2.4			

Marshall Fine Sandy Loam.

The soil of the Marshall fine sandy loam consists of a medium to fine sandy loam, with an average depth of about 14 inches. It generally contains a very high percentage of organic matter, and to this is due its characteristic black or dark-brown color. As the depth of the soil increases the amount of organic matter gradually decreases and the color becomes correspondingly lighter. The texture of the soil is quite uniform, but the depth varies from about 8 to 20 inches, depending upon topographic position. On the crests of knolls and ridges it is generally of a more sandy nature and is more shallow than in the depressions, where, besides being usually deeper, the texture is somewhat heavier, in some cases approaching a silty loam. This is not always the case, however, and a few areas were found in which the soil on the higher elevations of the type was heavier than that occupying the lower areas. This latter variation generally occurs where the soil is quite shallow and rests directly upon bowlder clay. In this case considerable of the underlying clay has become more or less mixed with the soil, giving it a somewhat heavier character. The color of the soil in these localities is also somewhat lighter than it is in typical areas.

At a depth of about 14 inches the soil grades into a medium to fine yellow sandy loam subsoil, in which there is generally found considerable clay. The subsoil gradually becomes heavier with depth, grading into a mottled yellow sandy clay, which is quite sticky when wet and which usually extends to a depth of 36 inches. In some instances, however, the percentage of sand increases with the depth of the subsoil, and occasionally a layer of sand, seldom over 2 or 3 inches in thickness, is encountered. Such areas as these generally occur in the vicinity of sand ridges. These sandy layers are in turn underlain by a sandy clay varying in color from light or orange yellow to gray. The subsoil varies to a marked degree in different parts of the county. This fact is of considerable importance, inasmuch as it has a controlling influence upon the character and yield of crops grown. Generally till is encountered beneath this type of soil at a depth of from 3 to 4 feet. It consists of a mixture of clay, sand, and gravel of varying proportions, with gravel generally increasing both in size and quantity with depth. In the upper portions of this till the gravel is about the size of a pea, while at lower depths it varies in size from a fraction of an inch to 3 or 4 inches in diameter. Occasionally some fine gravel occurs on the surface of the type, but this is of little or no consequence. A few large bowlders are also found on the surface of this soil, but in most cases they are directly associated with the Marshall loam. In certain areas of the Marshall fine sandy loam, especially where the surface is very rolling or hilly and particularly on the crests of some of the moraines, the till is covered only to a depth of a few inches by fine sandy loam. This feature is especially noticeable in sections 32 and 33 of Jackson Township. Here the till, consisting chiefly of clay mixed with some sand and considerable gravel, outcrops on the slopes of the ridges. The color is generally reddish yellow, occasionally slightly mottled. The till found underlying the soil of lower levels is generally light yellow.

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

MECHANICAL ANALYSES OF MARSHALL FINE SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12780, 13127	Soil	0.4	2.2	8.6	40.7	13.3	21.8	13.0
12781, 13128	Subsoil	.3	3.0	8.0	41.7	13.8	20.3	13.0

The Marshall fine sandy loam occurs almost wholly north of the Iroquois River, being the chief type occupying the Iroquois moraine. In this locality it occurs in one body continuous across the county, though interspersed with many areas of other soil types. In no case is it found north of the northern base of this ridge. A few comparatively small areas occur as isolated patches south of the Iroquois River. They occupy the more elevated positions or ridges in the Marshall loam areas. The largest two of these bodies occur along the Iroquois River in Jefferson and Washington townships.

The surface of the greater proportion of the area occupied by this type is undulating and rolling. In only one or two instances is the surface level, and in these cases the level areas are comparatively small. The most conspicuous topographic features of this type are the two large ridges on each side of the Iroquois River in Jefferson and Washington townships. The isolated areas in the southern part of the county occur mostly as small ridges, seldom over 4 or 5 feet above the level of the surrounding country, while in sections 25 of Jefferson Township and 30 of Grant Township the type occurs as one large knoll.

The character of the surface of the Marshall fine sandy loam affords excellent natural drainage, but it is a generally recognized fact that artificial drainage greatly increases the productiveness of the soil, particularly where it is underlain by a heavy subsoil. The lighter areas, especially where the subsoil is sandy, are not so much in need of artificial drainage, but nevertheless it should be encouraged on both the light and heavier phases of this type, inasmuch as crops suffer materially from an excess of moisture during wet seasons.

The soil for the most part is derived directly from the glacial till, but some areas have been formed by the mixing together of the fine sand and loam types, forming in this case the transitional phase between the Marshall fine sand and the Marshall loam. In addition to this there has been incorporated in the soil a very high percentage of organic matter through decay of a luxuriant growth of vegetation.

The Marshall fine sandy loam is one of the most productive soils in the area and is adapted to a greater diversity of crops than is at present grown upon it. The type in this locality is devoted chiefly to the production of corn and oats, the staple crops of the county. Bluegrass grows very well, and timothy and clover are grown to some extent, but it is generally quite difficult to obtain a good stand of clover on account of the dry, hot winds and dry weather which often follow the removal of the nurse crop. Wheat is grown only on this soil. Its production, however, is limited, owing to poor and uncertain yields. Very few vegetables are grown, except for home use. Potatoes do fairly well, but their yield is uncertain. Only the early varieties of this crop are grown. Of the small fruits, berries do best on this type. Some currants are grown, but they do not yield well. Sour cherries and apples are the principal orchard fruits produced.

The average yields of the crops produced on this soil vary somewhat in different parts of the county, depending largely upon the character of the subsoil and climatic conditions. During dry seasons that portion of the type possessing a heavy subsoil generally gives the better results, inasmuch as it is able to withstand droughts better, while during unfavorably wet seasons the areas having a light subsoil and better drainage give the better results. In former years this type produced on the average about 50 bushels of corn and an equal quantity of oats to the acre. During recent years, however, there has been a gradual falling off in the yields of crops grown, until the average of corn and oats produced seldom exceeds

35 or 40 bushels. The yields, however, vary considerably with different seasons. The estimated yield of wheat is given at about 12 or 15 bushels, if grown under favorable conditions. Timothy and clover average from 1 to 1½ tons per acre. Potatoes vary considerably, and, although as many as 200 bushels have been produced, the average yield is about 50 bushels per acre.

The manurial requirements of this type were investigated, using a large sample from a field three-fourths of a mile south of Morocco. The soil is a black to dark-brown medium fine sandy loam and the field is well drained. It has been in cultivation for more than twenty years, corn and oats being the chief crops. Small to medium quantities of stable manure are used, but no other fertilizers. Yields of both corn and oats average about 40 bushels per acre.

The results of the examination of this sample by the wire-basket method indicate that stable manure has a large effect in increasing the growth of crops, and that sulphate of potash and nitrate of soda used either alone or in combination have very little effect. Lime and acid phosphate, either separately or in combination with the above-mentioned fertilizers, failed to give any appreciable increase in growth. These results were obtained under favorable climatic conditions for the crop and with the soil in the best possible physical condition. They indicate that the practice of the locality in applying barnyard manure is commendable.

Marshall Loam.

The Marshall loam, to an average depth of about 14 inches, consists of a dark-brown or black loam. The soil generally becomes heavier with depth, and under field conditions the texture appears rather silty, due in part to the presence of a very high percentage of organic matter which is everywhere found in this soil, and to which is also due its characteristic dark color.

The depth of the soil varies in different localities, depending largely upon topographic position. In the local depressions and in the more level areas the soil is much deeper than the average, ranging from 16 to 18 inches, and in some cases to 24 inches. In such areas the soil is generally of a somewhat heavier nature than that occurring on the more uneven places. On the low knolls and ridges the depth of the soil varies from 6 to 8 inches, and the texture is more sandy, occasionally approaching a heavy sandy loam. Near the main streams and over areas affected more or less by erosion the type is generally a heavy loam, with the color lighter than in the typical areas, the depth in this case being also less. This phase is particularly well developed along the Iroquois River.

The line of demarcation between the soil and subsoil is generally well defined. At a depth of from 12 to 14 inches the soil grades into a yellow light clay loam in which the clay content increases with depth. The color is often a mottled yellow in the lower portions, and occasionally this material extends to a depth of over 3 feet. In most cases, however, at a depth of from 25 to 30 inches it grades into a sandy clay in which the sand content is large, and finally, at from 30 to 36 inches, there occurs a layer of sand and fine gravel mixed with a sufficient amount of clay to give it a sticky consistency when wet. As a rule the deeper subsoil is a heterogeneous mass of clay, sand, and fine gravel, and this generally comes to within 36 inches of the surface. Occasionally some fine gravel is found on the surface and scattered through the soil, but this occurs in limited areas and does not affect the agricultural value of the land. Large glacial bowlders are found scattered over some areas of this soil, in some areas so plentifully as to interfere with cultivation, though in most cases they have been removed from the fields.

There are a number of unproductive spots in the Marshall loam that are locally called ''alkali spots.'' Their unproductiveness, however, is not due to the presence of alkali salts. Before this part of the county was drained these areas, which occupy depressions too small to be shown on the map, were known as ''sink holes'' or ''quicksand'' areas, and the soil is now generally somewhat more sandy than the neighboring productive lands, while the subsoil is largely composed of sand. Liberal applications of stable manure increase the productiveness, and large quantities of straw have been burned on them with good results.

The average results of mechanical analyses of typical samples of fine earth of this type are shown in the following table:

MECHANICAL ANALYSES OF MARSHALL LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12784, 13107, 13111	Soil	0.6	3.2	4.4	21.6	9.1	36.8	23.9
12785, 13108, 13112	Subsoil	.9	4.1	4.8	20.4	9.2	33.1	27.3

The Marshall loam occurs most extensively developed in the southern part of the county, embracing the greater proportion of the area south of the Iroquois moraine. It occurs as one continuous body over this part of the sheet, while north of this main body are found isolated areas covering the local depressions in the morainic ridge. Like the Marshall fine sandy loam, this soil does not occur north of the northern base of this ridge.

The surface of the Marshall loam is mainly a level plain sloping gradually toward the Iroquois River, which crosses the county from east to west. In the extreme southern part of the county the surface is gently rolling and occasionally broken by shallow valleys, formed by the small northward-flowing streams. As the river is approached the surface becomes more level. North of the river the surface is almost a dead level, with only a slight fall toward the south. In many areas the surface is broken by a number of low sand and sandy loam ridges, seldom exceeding an elevation of 6 or 8 feet above the surrounding levels. Where these ridges are of sufficient size they have been shown as different types of soil.

The drainage conditions of this soil vary in different parts of the county, depending to a marked degree upon the topographic features. On the more rolling areas the natural drainage features are well developed, while over the more level areas artificial drainage has to be resorted to in order to insure the production of good crops. Most of these lands can be economically drained, and already a large proportion of their area is tiled. There are a number of small ponds, sloughs, and depressions which have little or no outlet, and while some of these can be and have been economically reclaimed, it is doubtful if many can be profitably drained, as the cost of constructing outlets sufficient to secure good fall would probably exceed the value of the land.

The Marshall loam is derived from glacial material correlated by Leverett with the late Wisconsin drift sheet. Mingled with the soil and subsoil are many pebbles and bowlders. The bowlders, which consist chiefly of granites, are directly associated with this soil and in only a few cases were they found on any other type. To the material deposited by the glaciers large quantities of organic matter have been added by the decay of a luxuriant growth of prairie vegetation which formerly covered this region.

The Marshall loam is admirably adapted to the production of corn and oats, and up to the present time has been devoted almost exclusively to the cultivation of these crops. The yields vary widely with the season, but the average for corn is about 40 bushels and for oats from 35 to 45 bushels per acre. The yields were formerly higher than at present, having declined as a result of the almost continuous production of these two crops for the last twenty or thirty years. Timothy and clover are grown to some extent, but considerable difficulty is often experienced in getting a good stand of these crops. They are very frequently sown together and yield from 1 to 2 tons per acre. Bluegrass does very well and is often sown in connection with white clover and used for pasture. Fruits and vegetables are grown only for home use. Apples and cherries, with some of the small fruits, chiefly berries, produce the best results. Irish potatoes, as well as most of the early vegetables, can be successfully grown, but up to the present time have been raised only for home consumption.

A test was made to determine the manurial requirements of this type, using a large sample collected about 1½ miles west of Goodland. The soil here consists of a dark brown to black heavy silt loam, and the sample was taken to a depth of 6 inches. The land has been in cultivation for from twenty to thirty years, the chief crops being corn and oats with some grass. Moderate applications of stable manure are used, but no other fertilizers. Yields of both corn and oats average about 40 bushels per acre, while hay averages about 1½ tons per acre.

The results of the examination of this sample by the wire-basket method indicate that stable manure has a large effect in increasing the growth of the crop. Results obtained with nitrate of soda, sulphate of potash, acid phosphate, and lime, used separately and in various combinations with each other, were small, and were no greater when two or more of these substances were used in combination than when one was used by itself.

These results are held to be applicable only to the field from which the sample was taken, but it may be stated that they agree well with the experience of farmers upon this type of soil.

MARSHALL FINE SAND.

The Marshall fine sand, to a depth of from 10 to 20 inches, consists of a medium to fine sand, varying in color from light to dark brown, according to the proportion of organic matter present. The color generally becomes lighter as the depth increases, changing to yellow, but the texture of the subsoil remains about the same as that of the surface soil, though generally possessing less coherency. The loamy nature of the soil, particularly in the first 6 inches, is due in part to the presence of a small percentage of silt and clay, but chiefly to the presence of a relatively large amount of organic matter. The yellow subsoil generally extends to a depth greater than 3 feet, but occasionally at from 25 to 30 inches it becomes a mottled yellow, streaked with gray and white sand.

The Marshall fine sand is fairly uniform throughout its occurrence in the area, the chief variation being the presence of some fine gravel. It is seldom, however, that gravel is found upon the surface, though in some areas it is frequently encountered at a depth varying from 20 to 36 inches or more. The gravel is fine, seldom exceeding 3 or 4 inches in diameter, and is used quite extensively for road building.

The following table shows the results of mechanical analyses of typical samples of this soil type:

MECHANICAL ANALYSES OF MARSHALL FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12782	Soil	0.0	1.7	7.5	52.6	19.2	9.8	9.1
12783	Subsoil	Trace	1.6	9.0	53.3	18.3	9.1	8.7

The Marshall fine sand is confined to the hills and ridges, but occurs throughout the area surveyed. It is most typically developed in the eastern part of the county, where the ridges are low and narrow, seldom exceeding an elevation of from 10 to 20 feet above the lowest depressions in their immediate vicinity, and varying in breadth from 200 to 300 feet to nearly one-half mile. The type frequently caps the more elevated areas in the Marshall fine sandy loam. The natural drainage conditions are good. In some areas the drainage is excessive, and while it retains moisture well for a soil of this character, crops often show the effects of drought.

The Marshall fine sand is of glacial origin, but the exact manner of its formation is not understood. It is probable that the materials represent deposits of glacial outwash made during the recession of the ice sheet, which have since been modified to some extent by the action of wind.

Corn, oats, rye, and timothy are the principal crops grown on this soil. The yields are generally small and uncertain, but are larger in wet seasons than in dry. The soil is well adapted to the production of vegetables and melons, and their cultivation should be encouraged.

Miami Black Clay Loam.

The surface soil of the Miami black clay loam, which is the heaviest type found in the area, consists of a heavy loam or clay loam, carrying silt and clay in about equal proportions. The average depth of the soil is about 18 or 20 inches, but in some cases, especially in the central parts of the areas, the depth may be as much as 2 feet. Relatively large quantities of organic matter are found in the soil, and to this is due its prevailing black or dark-brown color. As the depth increases the percentage of organic matter decreases, and at 8 to 14 inches the color has a bluish or grayish tinge. The soil is very cohesive and when moist pulls up in large masses around the auger. If allowed to dry without stirring it has a tendency to puddle and bake, and cracks from 1 to 2 inches across and from 1 to 2 or more feet in depth intersect the surface in all directions. If plowed when too wet large clods form, which are difficult to pulverize until moistened again by rain.

At from 18 to 20 inches below the surface the soil grades into a heavy clay loam subsoil, in which the clay content increases with depth. The color of the upper part of the subsoil varies from light to dark gray, depending largely upon the percentage of organic matter present. Generally at a depth of about 20 or 25 inches the subsoil grades into a light-gray or mottled-yellow sticky, impervious clay, which extends to a depth of 3 feet or more.

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

MECHANICAL ANALYSES OF MIAMI BLACK CLAY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12969, 13131	Soil	0.1	7.3	6.6	17.9	5.8	34.4	27.8
12970, 13132	Subsoil	.1	.9	1.4	6.0	2.4	27.2	61.4

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12970, 1.83 per cent.

The Miami black clay loam occupies only a very small percentage of the area surveyed. It occurs as basinlike depressions between the low hills and ridges and is most typically developed north of the Iroquois River, occupying only limited areas scattered over that part of the county covered by the Iroquois moraine. The surface is generally level, but in some cases a few small shallow ponds and sloughs occur, the result of obstructed drainage.

Owing to the level character of the topography of this type and to the imperviousness of the soil and subsoil the natural drainage conditions are very poor. In a number of cases artificial drainage has been employed, and this should be done wherever practicable.

The material composing the Miami black clay loam is primarily of glacial origin, but since its deposition it has undergone considerable modification. Prior to the construction of drainage systems sufficient to carry off the surplus water the areas occupied by this type were covered with swamps and marshes. Through the growth and decay of a luxuriant vegetation a large amount of organic matter has been incorporated in the soil, the rapid oxidation of which was prevented by the moisture conditions. Some of the finer particles of soil have been washed into these depressions from the surrounding higher land, and this has had considerable effect on the texture of this type.

The Miami black clay loam is considered one of the best types in the area for the production of corn. When well drained and with favorable climatic conditions it produces on the average about 45 bushels per acre. Although there is danger from lodging, the average yield of oats is estimated at from 35 to 40 bushels per acre. This type is also well adapted to the production of clover and timothy, the latter yielding from 1 to 2 tons of hay per acre. Only the better drained areas are suited to clover, because in the low wet areas the clover heaves badly.

Clyde Loam.

The soil of the Clyde loam is a heavy loam or clay loam, varying in depth from 18 to 30 inches. It is of a decidedly black color, owing to the presence of a very large proportion of organic matter, which is generally well distributed throughout the soil profile. The quantity gradually decreases, however, with depth, and the color becomes correspondingly lighter. In some cases, at from 12 to 20 inches, the color is a dark-reddish or brownish yellow, due probably to the oxidation of iron. Iron occurs quite abundantly in the soil and subsoil of this type in irregular masses, varying in size from a fraction of an inch to 1 foot or more in diameter.

Variations in the texture of this type occur near the borders of the sand ridges, where the soil is mixed with varying amounts of sand and approaches a heavy sandy loam. The transitional zone between this soil and the sandy soil is generally quite narrow, and in some cases the line of demarcation is sharply defined.

The subsoil varies in different parts of the area. Near the outer margin it generally consists of medium to fine sand, the latter grade predominating. The upper portion of the subsoil is of a very sticky nature, due to its relatively high clay content, and the color is generally dark gray. With increase in depth the material generally becomes lighter, both in color and texture, grading into white or gray sand at 40 inches. In the central parts of the area the soil becomes deeper and the subsoil much heavier. Here the soil consists of a heavy clay loam to an average depth of about 24 inches, below which occurs a sticky impervious clayey subsoil, becoming heavier with depth. The color of the latter is generally somewhat lighter than that of the soil, although it contains a high percentage of organic matter. In general the subsoil upon drying breaks up into roughly cubical blocks, resembling in this particular an adobe soil. Where excavations for large drainage ditches have been made the walls remain almost perpendicular and are only slightly affected by erosion.

Underlying the subsoil proper at a depth of about 6 feet is a layer of peat. The layer is about 3 feet thick and is in turn underlain by an impure marl which contains small fragments of shells and some organic matter. This marl extends to an undetermined depth.

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

MECHANICAL ANALYSES OF CLYDE LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12971, 13135, 13137	Soil	0.1	6.2	5.6	19.0	4.8	38.8	25.1
13138	Subsoil	.0	2.6	3.8	9.8	5.2	49.5	29.3

Only one area of this type of soil occurs in Newton County It is found about 10 miles northeast of Morocco and lies almost wholly in the west central part of Colfax Township, a small extension reaching westward into McClellan Township.

The surface of the type is practically level, with only a slight fall toward drainage lines, and, as a result, the natural drainage is very poor and has to be supplemented by artificial drains in order to insure the production of good crops. A large proportion of the area is already reclaimed. All of the area can be economically drained, and large crop yields will be sure to follow the construction of a comprehensive drainage system.

The Clyde loam is of lacustrine origin. Prior to the construction of large drainage outlets for the surplus water the area embraced by this soil probably formed a small lake, and the accumulation of the finer material held in suspension by the waters feeding it has given rise to this peculiarly situated body of heavy soil. During low water or probably after there had been a sufficient filling in of this depression so that only a shallow pond remained, conditions were such as to favor the growth of a heavy vegetation, and through the decay of this vegetation a large amount of organic matter has been added to the soil.

The Clyde loam is very productive, and when properly drained and cultivated produces even larger crops than the Miami black clay loam. It is well adapted to the production of oats, rye, timothy, clover, and bluegrass, and is considered one of the best corn soils in the area, to which crop it is largely devoted. The average yield of corn is variously estimated from 40 to 50 bushels per acre. Forty bushels of oats is given as the average yield per acre, but, as on the Miami black clay loam, the growth of straw is heavy, and the grain often lodges. Rye is grown only in limited areas, yielding from 20 to 25 bushels per acre. Clover and timothy are grown to some extent on this soil, and the yields compare favorably with those produced on the Miami black clay loam. Bluegrass makes a thrifty growth, and is used largely for pasture.

Clyde Fine Sand.

The Clyde fine sand is the prevailing type in the northern part of the county. The soil consists of a dark-gray to black medium to fine sand, in which the latter grade predominates. The depth varies from 4 to 20 inches, depending upon the depth to which the organic matter extends. Along the boundaries of the type, and especially next to areas of Peat, organic matter is found in large proportions and in some cases occurs to a depth of more than 3 feet. The presence of this high percentage of organic matter gives the soil a loamy texture, and areas are occasionally referred to locally as "semimuck." As the more central parts of the areas are approached the percentage of organic matter becomes proportionally less and the depth to which it extends decreases, until in some cases it is confined to the upper 5 or 6 inches. From this point the soil gradually passes into the Newton fine sand, in which there is practically no organic matter in the surface soil.

At varying depths, as above mentioned, the soil grades into a subsoil having about the same texture as the soil, but containing a much smaller percentage of organic matter. In areas where the soil extends to a considerable depth the subsoil is generally a dark-gray fine sand, which usually becomes lighter in color as the depth increases. Where the soil extends to a depth of only a few inches the subsoil is generally gray in the upper portions but grades into light-gray and occasionally white or yellow-mottled sand at an average depth of about 15 or 18 inches. In areas where considerable iron is found in the subsoil the color generally has a reddish-yellow or brownish tinge and is occasionally mottled. In other areas, at a depth of about 25 or 30 inches, the subsoil is composed of a brownish-colored Peat in which the vegetable fiber is quite easily distinguished. This peaty layer generally extends to a depth of over 3 feet, although occasionally it is only a few inches in thickness and is in turn underlain by a dark-colored sand in which the amount of organic matter is very large.

The following table shows the average results of mechanical analyses of typical samples of this type:

MECHANICAL ANALYSES OF CLYDE FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand. Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12973, 13139	Soil	0.0	1.8	10.6	60.0	9.2	12.6	5.8
12974, 13140	Subsoil	.0	1.7	12.4	69.1	6.7	5.5	4.6

The Clyde fine sand is found throughout the northern half of the county, occurring practically as one continuous body, although much broken by bodies of other types, extending north from the northern base of the Iroquois moraine to the Kankakee River. The surface is practically level, the elevation seldom varying more than

5 or 6 feet. A few low undulations occur, and in some cases small ponds or swampy depressions are found, but the surface is generally flat.

In general the type possesses poor natural drainage. Considerable difficulty is often experienced in the construction of artificial drainage channels, both on account of the level character of the surface and the filling of the ditches by sand, which underlies the greater part of this territory, and by material washed in from the lateral drainage ditches. This last difficulty can, however, be largely overcome by the construction of culverts across the mouths of the lateral drains, thus preventing the banks from being washed away at these particular points. In some localities it is practicable to turn the drainage waters into existing channels. In the northwestern part of the county the upper end of the Houseworth and Riner ditch is connected to the upper end of a branch of the old Beaver Lake ditch, and here the drainage waters flow in either direction. Lower down from the headings of these ditches the fall becomes greater and the drainage is generally much better. The Clyde fine sand is generally improved by drainage. In fact it is necessary to drain this soil before successful agriculture can be practiced. The cost of constructing a comprehensive drainage system will necessarily be large; but the land, if properly managed, should yield a profitable return on the investment.

The Clyde fine sand represents areas which have been formed by the action of water. While primarily of glacial origin, the sand composing this type has probably been transported by stream currents to its present position from sand areas to the north and east, and deposited while this part of the area formed a lake. As the lake was gradually filled up or drained, conditions became such as to favor the formation of a large amount of organic matter.

The crop value of the Clyde fine sand varies in different parts of the area, depending largely upon the proportion of organic matter present. Areas in which the organic content is small are devoted chiefly to pasture, while those in which the proportion is greater and where the soil is impregnated to greater depths produce the staple crops of the county with a fair degree of success. The average yields are gradually decreasing from year to year, and will continue to do so as the organic matter in the soil is consumed. The yield of corn, which ten or twelve years ago was as high as 50 bushels, is now estimated at from 10 to 30 bushels per acre. The yield of oats, which was formerly much higher, is now on the average about 20 or 30 bushels per acre. Potatoes do well during favorable seasons, but unless the land is well drained the crop is often waterkilled or rots before coming up, during wet seasons. The average yield of this crop is estimated at from 125 to 200 bushels per acre. Some rye is grown, and yields from 10 to 20 bushels. It is generally sown as a nurse crop for timothy, which does very well on the heavier areas, yielding from three-fourths to 1½ tons per acre. Clover is not grown to any extent, inasmuch as it is generally winterkilled. Sugar beets have been successfully grown on this soil, but at present no attention is given to their production. Small fruits do well, and it is considered an ideal soil for strawberries. It is also a fine truck soil, but up to the present time little attention has been paid to this industry. The greater part of this type is devoted to pasturage. The poorly drained areas are generally covered with "sour grass," which is seldom eaten by stock, unless other grasses are short. Near the Miami fine sand areas and occasionally on the low knolls the vegetation consists of a natural growth of different varieties of oak. Bluegrass is generally found growing quite luxuriantly on the better drained areas.

In order to obtain an idea of the manurial requirements of this type a large sample was collected about 2½ miles north of Morocco. The soil in this particular field consists of a black sand, containing a large admixture of organic matter, but so incoherent that when dry it blows and shifts to some extent. The surface is very level, and it holds considerable water despite its porous texture. The field from which the sample was taken has been in cultivation for from fifteen to twenty years. Corn and oats are grown in regular rotation, and form the sole crop interests. Small amounts of stable manure are used chiefly on the corn, and no other fertilizers. Yields of both corn and oats average about 30 bushels per acre.

The results of the examination of this sample by the wirebasket method indicate that stable manure has a moderate effect in increasing the growth of crops; that nitrate of soda and sulphate of potash give a small increase, and that nitrate of soda, sulphate of potash, acid phosphate, or lime used alone or in combination (except as above), have little or no effect. These results were obtained under favorable climatic conditions for the crop and by having the soil in the best possible physical condition, and, while held to be strictly applicable only to the field from which the sample was taken, they substantiate the general farm practice on this type of soil in Newton County, where considerable barnyard manure is applied to the fields with beneficial results and practically no mineral fertilizers are used.

Newton Fine Sand.

The Newton fine sand resembles the type just described to a remarkable degree, the chief difference being in the percentage of organic matter. The organic content is generally very small and in most cases is not sufficient even to color the soil, while in the case of the Clyde fine sand, as we have seen, the organic content is generally large.

The soil of the Newton fine sand, to a depth varying from 10 to 36 inches or more, is composed chiefly of fine sand. Around the outer margin of the areas the soil generally extends to a depth of over 3 feet. The color is a light gray, grading into mottled yellow in the lower depths. Occasionally some organic matter is found in the first 3 or 4 inches, but the amount is generally so small as to have practically no effect upon the soil. In the more central parts of the soil bodies, at a depth varying from 10 to 20 inches, a layer of sand is encountered which contains a high percentage of organic matter, and in some cases this layer consists almost entirely of Peat. The layer varies in thickness, but seldom exceeds 6 inches, and it is not unusual to find two and sometimes three such layers in the subsoil, in which case they are generally much thinner and occur from 6 to 15 inches apart. The subsoil underlying these layers is generally a black fine sand containing considerable organic matter and very similar in character to that underlying the Clyde fine sand.

Along the range line between McCellan and Colfax townships the type occurs in the form of dunes, and the texture of the soil in this case is fine sand to a depth of over 3 feet. It is much finer than the sand composing the level areas, and the color is also much lighter, varying from light gray to white.

The boundary between this type and the Clyde fine sand, as a rule, is difficult to establish, inasmuch as the types grade almost imperceptibly from one into the other. Generally in areas in which the organic matter extends to a depth of over 4 or 5 inches the soil is classified with the Clyde fine sand, while if less it is mapped as Newton fine sand. In some cases, however, the line of demarcation between the two types is sharply defined, being marked by a slight rise of 2 or 3 feet.

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

MECHANICAL ANALYSES OF NEWTON FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13040, 13151, 13152	Soil	0.0	0.8	4.1	87.7	5.5	0.6	0.9
13153	Subsoil	.0	.8	3.3	79.3	9.5	5.0	1.8

The Newton fine sand occupies only a small percentage of the area surveyed, occurring most typically developed in one large area, about 7 miles north of Morocco, in the northeastern part of McClellan Township. Another but much smaller area is found in the north central part of Lake Township, bordering the swamp area along the Kankakee River. The type represents a part of the floor of an old glacial lake. The surface is a few feet below that of the Clyde fine sand, and, while it is generally level, it is broken by numerous ponds and swampy depressions, and occasionally cut by old drainage lines. A number of old beach lines which cross this part of the county from northeast to southwest are quite easily distinguished, and in some cases rise to an elevation of 2 or 3 feet above the general level of the surrounding lands. In the eastern part of the area occurring in McClellan Township, and particularly along the range line between this and Colfax Township, where the dunes already mentioned occur, the area has a desertlike appearance. These dune areas have an elevation of from 3 to 20 feet above the mean surface level of this part of the county.

The natural drainage conditions, as in case of the Clyde fine sand, are poor, and over a greater part of the area the water table seldom exceeds a depth of 3 feet, while at the time this part of the county was surveyed, water was found on the surface over a considerable area.

The Newton fine sand owes its origin to the same agencies as the Clyde fine sand. As evidenced by the layers of peaty deposits, it is quite probable that prior to the deposition of the sand now constituting the surface soil, this territory was only partially submerged at different periods, during which there was a heavy growth of vegetation. Subsequently the water of the lake rose again and completely submerged this territory, and layers of sand were deposited over this vegetation.

None of this soil is at present under cultivation, and its only use is as pasture. It is for the most part covered with water-loving grasses, willow, and birch. The higher and better drained areas are either almost free from vegetation or covered only with a sparse growth of bunch grass. Wherever the native vegetation dies out or is removed the sand drifts badly.

Miami Fine Sand.

The Miami fine sand consists of a loose, incoherent medium to fine sand, with a minimum depth of more than 3 feet and a maximum depth of over 100 feet. It varies in color from light brown in the upper portions of the soil to yellow at lower depths, the former color being due to the presence of a very small amount of organic matter, which is found especially in the local depressions between ridges and on some of the more level areas. On the more rolling areas there is practically no organic matter in the soil, and this and the absence of gravel are the chief features distinguishing this type and the Marshall fine sand.

The average results of mechanical analyses of typical samples of this type are given in the following table:

MECHANICAL ANALYSES OF MIAMI FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cnet.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
12975, 13154, 13155, 13156.........	Soil................	0.0	2.4	15.5	65.4	10.2	3.2	3.2

The Miami fine sand is distributed over the northern portion of the county. The areas vary from a few acres to over 3 square miles in extent and occur as islandlike bodies in the level sand areas. The surface is very irregular, consisting of rounded hills and ridges, from 2 to more than 150 feet in height. Owing to the physical character of the soil and its rolling topography, natural drainage over most of these areas is excessive, and vegetation often suffers from lack of moisture.

The origin of this soil is largely due to the action of winds, though it is probable that during the early stages of development wave action also played an important part in its formation. On account of the loose, open character of the soil and the unstable or drifting nature of this material it has little agricultural value. It is for the most part covered with a native growth of timber, chiefly scrub white and black oaks, hazel brush, black gum, sumac, and a few quaking aspens. On some of the lower, moister areas bluegrass is found. Only a few areas of the Miami fine sand are farmed. Sorghum is grown to some extent for home use and melons and early potatoes do well. Some rye and corn are produced but the yields are very small. Fruit is grown to some extent and is said to do fairly well.

Kaskaskia Loam.

The surface soil of the Kaskaskia loam is a brown loam or silty loam, with a depth varying from 18 to 24 inches. The texture of the soil is quite uniform, although it is heavier in some of the depressions farthest from the river than it is on the higher areas or near the present channel. The soil is generally quite friable and readily cultivated.

The subsoil is generally a loam, although some sections exhibit but a slight difference between the soil and subsoil. In most cases, however, the sand content increases with depth. The percentage of organic matter in both the soil and subsoil is less than is usually found in alluvial types. A large amount of iron is usually present, which sometimes gives the subsoil a mottled appearance.

The average results of mechanical analyses of typical samples of this type are given in the following table:

MECHANICAL ANALYSES OF KASKASKIA LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13103, 13105	Soil	0.2	0.7	0.7	9.2	13.9	53.1	22.0
13104, 13106	Subsoil	.1	.5	.5	9.1	18.6	51.7	19.4

This type occupies only a limited area along the Iroquois River in the eastern half of the county. It constitutes the flood plain of this stream and is confined to the oxbows and to narrow strips along some of the less crooked parts of the channel. It is seldom more than a few feet above low water and is subject to overflow. Numerous depressions and sloughs occur, which mark the course of former stream channels, having been deposited by the river during high water. The current is here too sluggish to transport any but the finer materials, so that the type is remarkably free from coarse sand and pebbles.

The Kaskaskia loam is largely devoted to pasture. Some of the areas are planted to corn and during favorable seasons yield from 40 to 50 bushels per acre. Oats and potatoes can be successfully grown, though there is always danger from overflow.

Swamps.

The classification of Swamp is based upon topographic position and drainage conditions rather than upon the physical character of the materials of which it is composed. The texture varies in different parts of the areas from a light sandy soil to a heavy clay loam, though the greater proportion is a black sand, very similar in character to that of the Clyde fine sand. A constant feature is the extremely large admixture of more or less decayed vegetable matter.

With the exception of one small body occurring in the western part of Beaver Township the Swamp is confined to a strip from one-eight to over 1 mile wide along the Kankakee River, in the extreme northern part of the county. It is low-lying and generally level, though somewhat broken by old stream channels and small lakes, or lagoons, and is poorly drained and under water most of the year. Owing to its slight elevation above the river it can not be drained economically.

The areas are largely the result of poor drainage. Along the river it has been slightly modified by the deposition of fine material brought down during high water. Through the growth of a heavy vegetation a large amount of organic matter has been added.

Except along the streams where there is a heavy growth of timber, chiefly birch, oak, poplar, and willow, the native vegetation consists of a host of moisture-loving plants, such as reeds, rushes, sedges, etc. None of the Swamp is under cultivation. When the river is low some areas become dry enough to allow the cutting of hay, and such areas are also used to some extent for pasturage.

Peat.

A very important and characteristic feature of the northern part of the county is the frequent occurrence of quite extensive Peat deposits. They consist of brown peaty material, in which the percentage of combustible material is extremely high. In consistency the soil varies from a coarse, raw, fibrous Peat through all stages of decomposition to that of Muck. The Muck areas occur, however, to a limited extent around the outer margins of these deposits. The soil in this case consists of more thoroughly decomposed vegetable mold mixed with varying amounts of mineral matter and extends to a depth seldom exceeding 3 feet. The typical Peat is much deeper, generally extending to a depth of 10 or 12 feet.

The texture of the subsoil varies from a medium to fine sand in which the percentage of organic matter is quite low. It varies in color from dark to light gray, and in some cases is slightly mottled. In a few localities the underlying material is a light-blue or gray clay, while in others it is a marl. Such areas as these are, however, quite limited and occur only as local variations.

The Peat occurs most typically developed northeast of Morocco, in Beaver, McClellan, Colfax, and Lincoln townships. A few small areas occur west and southwest of this town on the Iroquois moraine. The general character of the surface of these tracts is level, with only a slight fall toward drainage lines. Over some areas the surface has a hummocky appearance, due to the presence of small tufts or bunches of grasses and other vegetation. The hummocks seldom exceed 12 inches in height. Large holes and depressions often occur, especially in areas which have been burned.

The Peat has been formed by the gradual accumulation of organic remains in low wet places. During depositions the materials were more or less under water, which has retarded decomposition, and the vegetable fiber in most cases is yet easily distinguished.

The drainage of the areas of Peat is an important problem to the land owners in this section of the county. The areas usually have a fall of from 2 to 5 feet per mile toward the main drainage lines, and while a large amount of water accumulates in the spring, both from the melting of snow and from spring rains, it is practicable to remove this by the construction of wide deep ditches. It is believed that open ditches even for the lateral drains would prove more effective than tile. The little drainage channels in the soil would form more quickly and the excess water would be removed more rapidly. After the land is once thoroughly drained tiling would undoubtedly prove effective. Large tracts of the Peat have been drained, dredges being used to dig the main ditches across the lowest depressions of the areas or along such lines as would give the greatest possible fall. These ditches vary in width from 12 to 15 feet and in depth from 10 to 12 feet. A few laterals have been constructed which are as large as the main channels and into which sublaterals are run, but in most cases the laterals are much smaller and irregularly placed, generally at intervals too great to be effective. A glance at the map accompanying this report will show the main drainage channels of the county as well as of the Peat areas.

The cost of constructing the existing drainage systems has been great, so it is most desirable that immediate returns be secured on the capital invested. In some cases the results obtained from growing crops on the Peat have been most gratifying; in others they have been most discouraging. It has been the experience of most of the farmers that the Peat generally produces fairly well for two or three years after being reclaimed, when its productiveness begins to decline, each succeeding crop being poorer than the one preceding. On the other hand, some of the areas improve with cultivation, although the improvement is gradual. There are also areas that have never produced well, the crops being generally small and frequently failing to mature. It has also been observed that the productiveness of the Peat areas is correlated in some way with the state of the organic matter present and that as soon as the marsh sod, leaves, trash, etc., plowed under, become thoroughly decayed or consumed the yields of the crops grown cease to be profitable.

Corn is most extensively grown upon these soils the first few years. The yields of the first crop or two are quite large, though the corn produced is of poor quality. The kernels do not generally fill well and are often chaffy. The yield and quality of the succeeding crops are generally poorer, the ears are smaller and do not fill well, and the stalks are small. Later crops frequently do not produce any ears, and during the growing season the stalks turn yellow and growth is checked. In some areas the first crop grown is of this character, and spots giving like results occur even in the best areas, where no difference in drainage conditions or other cause can be assigned for the difference in the growth of the plants. A very few farmers have built silos, and thus utilize the inferior products of the Peat, but such a method can hardly be practiced to good advantage except on a dairy farm.

Very frequently this soil produces a rank growth of stalk or straw, as the case may be, in which the grain does not fill out well. Timothy and bluegrass may be grown wherever the drainage is reasonably good, but neither of these grasses is so profitable as corn. Special truck crops will do well on the Peat, but few landowners have either the inclination or experience to attemp their cultivation. This has led to considerable experimental work on these soils with corn, but the results so far obtained have not proven entirely satisfactory, although somewhat larger yields have been produced.

The general conclusion reached is that these and similar soils in Illinois, Wisconsin, and other parts of Indiana are in need of potash,[1] and in some cases potash, phosphoric acid, and stable manure should be applied to make them productive.[2]

The results obtained last season on an experimental plot in the southeast corner of section 35, McClellan Township, under the direction of the Indiana experiment station, show that two plots upon which muriate of potash and sulphate of potash were applied, respectively, produced at the rate of 48.9 bushels and 40.5 bushels per acre. Where no fertilizer was added the yield was 36.4 bushels. Another plot, where 1 ton of coarse straw was applied, produced at the rate of 58.5 bushels per acre, or about 10 bushels more than the plot fertilized with muriate of potash.

It would seem from these results, together with the generally observed fact that these soils produce well until the marsh sod, etc., is destroyed, that the Peat of the area is not lacking in plant food, and that the low yields are due to some unfavorable condition, which was alleviated by the addition of coarse straw. While potash improves these soils it seems quite probable that the beneficial results are not due to the plant food thus added, but to some other effect it has upon the soil.

While this type of soil is less extensive than many in the area, its peculiar condition after a few years' cultivation, as discussed above, made it advisable to select this as one of the types for investigation as to manurial requirements. For the purpose of carrying on this line of work, several samples of the soil were collected from sections 1 and 2, township 29 north, range 9 west. The soil here consists of brown mucky peat, varying from 30 to 40 inches in depth and usually underlain by sand. Where the samples were taken the water table varied from 2 to 3 feet below the surface.

The results obtained upon this soil by the above-mentioned method indicate that both stable manure and green manure are

[1] Buls. Nos. 93 and 95, Illinois Exp. Sta.

[2] Twenty-first annual report, Wisconsin Exp. Sta.

decidedly beneficial. Sulphate of potash gave a large increase in growth, whereas lime, nitrate of soda, and acid phosphate had little or no effect. These results are in accord with the conclusions of the experiment stations cited above.

When thoroughly reclaimed the Peat should be well adapted to corn, potatoes, onions, celery, cranberries, and similar crops. Owing to the high percentage of nitrogen present it has a particular adaptation to corn, rape, and the grasses. It is an ideal timothy soil, producing from 1 to 1½ tons per acre, and bluegrass does exceedingly well and is used for pasture. The chief difficulties encountered in farming the Peat areas, aside from the conditions already discussed, are wetness in the spring, danger of frost, and the accumulation of excessive amounts of nitrates. Even when well supplied with open drains the soils are often too wet to allow early sowing of crops, and it frequently happens that crops have to be planted two and occasionally three times, before a stand is secured. This necessarily so shortens the growing season that there is danger of frost before the crops mature. The excess of nitrates, which tend to stimulate stalk and leaf growth, often causes oats and other grains to lodge badly, and this makes the type in general unsuited to these crops, although under the most favorable conditions they often do well.

Agricultural Methods.

The cultural methods generally practiced in the area pertain largely to the production of corn and oats. In the preparation of the soil for corn, which generally follows oats, the land is plowed deep in the fall, generally as soon as the oat crop is removed. Nothing more is done with the soil until spring, when, as early as the season will permit, it is disked and harrowed. The corn is then planted, generally with a check planter, in rows about 3 feet 6 inches apart, later leaving three of four stalks in each hill. Very frequently the ground is harrowed after planting, and, in addition, is cultivated three or four times during the season. Implements with small shovels and other attachments adapted to shallow cultivation are preferred by most of the farmers to those which do deeper work or leave the land in ridges.

The corn is generally planted in May, although corn planted as late as June 10 will yield well, providing the season is favorable. A small part of the crop is cut with binders and subsequently shredded or husked from the shock, but the greater part is gathered from the standing stalks. Since a very few farmers in the southern part of the county feed cattle or have much stock of any kind, the greater part of the corn produced is sold at the nearest elevators. Occasionally some of the corn stover is harvested for feed, but the practice is not general.

In growing oats the seed is generally sown broadcast on land that has been in corn the previous year without any preparation of the soil. The disk is then used to pulverize the surface and cover the seed. The crop is sown as early as the season will permit, and is harvested the latter part of July. The grain is seldom stacked, but is thrashed from the shock soon after it is cut.

In seeding lands to grass and clover it is the general practice to use oats as a nurse crop, but the success of this method depends almost wholly upon climate conditions. Upon the removal of the nurse crop the young plants are exposed to the hot sun and winds, and growing in a soil already largely exhausted of its moisture, can make but feeble growth unless moisture conditions remain favorable. If these crops become fairly well established they will endure very unfavorable conditions, which frequently occur during the winter months. There is, however, considerable danger of the clover heaving, and this condition is largely responsible for the small acreage of this crop.

Rye is sown in the fall on land that has been in corn during the growing season. The usual date of sowing is about September 20, and of harvesting about July. It is quite generally used in the northern part of the county as a nurse crop for timothy. Timothy in this section is occasionally sown in the fall without a nurse crop, and the first cutting of hay is harvested the following spring.

A large proportion of the soils in the northern part of the county are in pasture or hay. Most of this grass is utilized in cattle feeding, which is conducted on an extensive scale by companies and a few wealthy landowners. Light-weight cattle are purchased on the Chicago markets, shipped in here, and fed for a few months. This method has proven more profitable than raising calves. The cattle feeders purchase all the corn produced in this section of the county, and in addition import a considerable quantity of cottonseed meal for feeding purposes.

Aside from the use of stable manure and the occasional plowing under of a green manure crop, the soils of the area receive practically no fertilizers. A few farmers in the east-central part of the county and a few of those farming areas of Peat buy some commercial fertilizers, but as a rule the quantity used is very small.

No systematic rotation of crops is practiced in the area. The general system followed is to plant corn one year and sow to oats the following year, then back to corn again. In some cases the farmers do not alternate corn and oats from year to year, but plant to one crop, generally corn, for a period of years. Occasionally a clover crop is grown and plowed under for green manure. It is generally recognized that this crop will keep up the fertility of the soils if not sown at too great intervals. The growing of this crop for green manuring should be encouraged wherever it is possible to secure a fair stand, and it should be introduced into the rotation once every three or four years at least.

Under the present system of farming the soils have decreased in productivity and are gradually becoming poorer from year to year. Land which formerly produced 60 or 70 bushels of corn is now producing 30 or 40 bushels per acre. And it is not exceptional to find even lower yields if climatic conditions have been unfavorable.

This matter is of great importance to the landowners of the area, and the necessity of methods less exhaustive to the soils is generally recognized. The trouble can easily be obviated by a proper system of farm management, which should be installed before the lands become poorer in crop-producing power. More stock should be raised to consume all the products of the farm and make more manure to be applied to the lands, a systematic rotation of crops should be practiced, and leguminous crops should be raised to supply nitrogen and increase the organic content of the soil. If this were practiced, the soils would not only at once produce better crops than can be grown at present, but they would gradually increase in productivity from year to year.

Agricultural Conditions.

The resources of Newton County are almost wholly agricultural. The soils, although not as productive as formerly, give good yields, and from the general appearance of the country the farming class is in prosperous circumstances. During the last decade the price of land has steadily advanced. The valuation of all farm lands, according to the State assessor's report for 1904, is $5,396,360, while that of buildings is placed at $705,180. These figures represent less than 40 per cent of the actual value of the farms of the county.

Very few farmers are in debt, and in 1903 there were only 80 farm mortgages on record. The farm houses, especially upon farms operated by the owners, are well built, and in many cases are handsome residences. The barns are large, substantially built, and painted, while the other outbuildings are usually well kept. Most of the lands are inclosed by fences or hedges, wire and osage orange being most commonly used.

More than one-half of the farms of the area are operated by tenants, who are usually compelled by the lease to grow certain specified crops. The larger estates are generally divided up into a number of farms which are rented. These estates are usually looked after by a manager or foreman, whose duty it is to supervise the work of the different farms and see that the terms of the leases are carried out.

The usual rent for good land varies from two-fifths to one-half of the grain delivered at the nearest elevator, and when a cash rent is asked from $3.50 to $5 an acre for pasture and hay lands. In a few cases renters have to pay house rent, which is often as high as $50 a year. On the larger estates, especially on those where stock is raised, the usual rent is two-fifths of the crop delivered at the home place. In some cases the landowners have the tenants feed cattle for them, buying the tenant's share of the crops for feeding purposes and paying him from $30 to $50 a month for feeding and caring for the stock.

Most of the farms are the property of men who have moved to the towns, and there are also a good many which represent investments or inheritances.

There are four estates in the county which have more than 5,000 acres under one management, and a number of others which include more than 3,000 acres. Small farms of 20 or 40 acres are comparatively few, and the greater number vary in size from 160 to 240 acres.

The value of the land depends almost altogether upon the drainage conditions and the character of the soil. The Marshall loam and Marshall fine sandy loam have the highest value, frequently selling for $125 an acre. The Clyde fine sand and Clyde loam sell for about $50, while the Miami fine sand and Newton fine sand are worth much less. Poorly drained areas of Swamp and other soils, used mostly for pasture, vary greatly in price, but seldom exceed $25 or $35 an acre.

There is no particular scarcity of farm labor in the county, but many farmers complain of the difficulty of securing permanent help, inasmuch as few young men seek farm employment except as a temporary occupation. The usual wages are about $25 a month, with board. Day labor, especially during harvest, commands $2 or more a day.

The principal products are limited in variety, but there is considerable difference in their quality. The best corn, grown on the Marshall loam and Marshall fine sandy loam, is usually graded as "No. 3" on the Chicago market, but that grown on the more sandy soils is much inferior in weight and feeding value. A similar difference is observed in the oat crop, but very often the quality of the best grain is materially reduced by being thrashed from the shock instead of from the stack after being allowed "to go through the sweat."

In 1904 this county produced 2,247,965 bushels of corn and 1,462,269 bushels of oats. The land devoted to these two crops was 119,630 acres. The total acreage of clover for the same year was 1,748, while that devoted to timothy was about 12,000 acres. The production of wild grass on the poorly drained lands is a very important item. The quality is rather poor, but the native varieties are gradually giving place to bluegrass, wherever the water table is permanently lowered.

The live-stock interests are confined chiefly to the feeding of cattle on the cheaper lands of the northern part of the county. There are very few farmers who do not have two or more milch cows and fatten a number of hogs each year, but the income from these sources is far less than the county is easily capable of producing. A large number of excellent draft horses are raised, which usually bring a good price on the market. At the present time the price of horses is high, good draft types selling for $150 to $200, and a good team, well mated, bringing from $300 to $400. In only a few cases is special attention given to the production of any kind of high-grade live stock.

The fact does not seem to be generally recognized that the soils of the area are adapted to a wider diversity of crops than is at present grown upon them. Neither is the fact appreciated that certain crops are grown upon soils which are unsuited to them, and that the poor yields almost invariably secured are not so much due to the natural unproductiveness of the soil as it is to the fact that the soil is not adapted to their production.

The Marshall loam is well adapted to corn and oats. Timothy and clover can be raised on this type, but the climatic conditions are generally such as to make the production of these crops uncertain. Barley, flax, and millet have been produced on this soil type in other areas, but the success of growing these crops in this county would depend largely upon climatic conditions. The same can be said of the Marshall fine sandy loam and the Clyde loam, but in addition wheat can be grown upon the former under suitable conditions. The Miami black clay loam is generally recognized as a corn and grass soil. Clover will also do well on this type, particularly on the better drained areas.

Corn and oats are also grown upon the level sandy soils of the northern part of the county, but these soils are not well adapted to these crops and the yields are generally very poor. Hay and rye are grown on these soils, but the yields are generally light except on areas in which the soil contains large amounts of organic matter. These sandy soils are particularly well adapted to small fruits and truck crops. Wherever drainage conditions are favorable the Clyde fine sand offers exceptional advantages for small fruit and truck growing. Newton fine sand probably offers the same advantages, but a large amount of organic matter must first be incorporated in this soil to make it produce well. A few farmers have already engaged in the small fruit and truck business with encouraging results.

Locations may be selected where grapes, plums, and pears will do well. A fruit farm in the Clyde fine sand has averaged during the last two years over 3,000 quarts of strawberries per acre under ordinary field conditions, and large yields of early potatoes, cabbage, and other vegetables have also been reported.

The sandy soils of the area are also well adapted to pasture, and a large percentage of them in the northern part of the county is devoted to grazing. The Miami fine sand areas have at present little agricultural value, but they can be made to produce successfully such crops as small fruits, early potatoes, and truck.

While there are no large towns within the borders of the county, transportation facilities to Chicago and other cities east and west are very good. There are three railway lines direct to Chicago, which is about 80 miles distant. In addition to the small towns, there are a number of grain elevators located along the railroads, so that the farmers have only a short distance to haul the grain to a shipping point. The public roads are generally kept in good repair, and many miles of these have been covered with gravel or crushed stone.

Soil Survey of Tippecanoe County.

By N. P. Neill and W. E. Tharp.
U. S. Bureau of Soils.

LOCATION AND BOUNDARIES OF THE AREA.

Tippecanoe County is situated in the west central part of Indiana. It is bounded on the north by White and Carroll counties; on

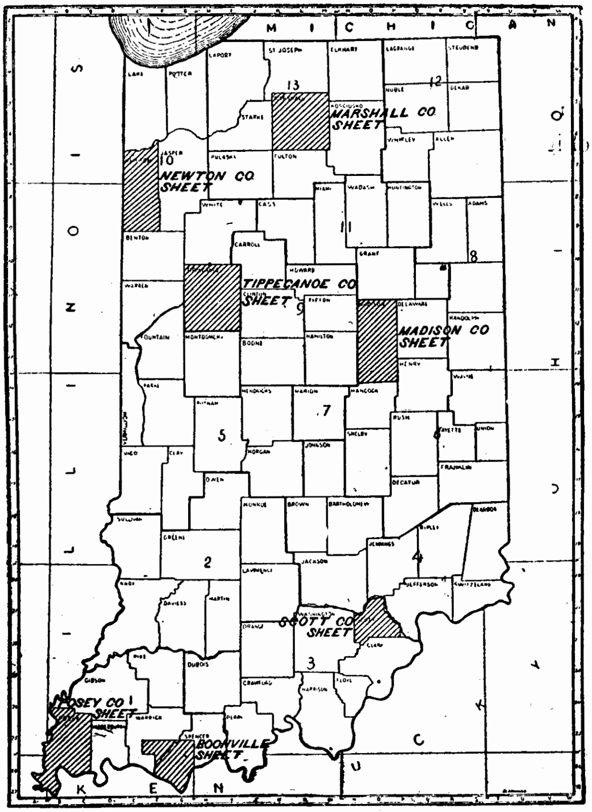

Fig. 1.—Sketch map showing location of the Tippecanoe County area, Indiana.

the east by Carroll and Clinton counties; on the south by Montgomery County, and on the west by Fountain, Warren, and Benton counties. The county comprises approximately 320,000 acres, or 500 square miles. It is nearly square in shape, its width east and west being 21 miles and its length north and south about 24 miles. Lafayette, the county seat, which is quite centrally located, is the principal town and has a population of about 20,000. Purdue University and the Indiana State experiment station are located at this place.

History of Settlement and Agricultural Development.

A little over three-quarters of a century ago Tippecanoe County was inhabited by hostile Indian tribes belonging to the great Algonquin family. The defeat of the Indians in 1811 by General Harrison at the battle of Tippecanoe broke their power and rendered the country available for settlement. By an act of the general assembly of the State of Indiana Tippecanoe County was formed out of Wabash County in 1826, the latter then embracing all of the territory lying north of Montgomery County as far as Lake Michigan. Lafayette was chosen as the county seat.

In the latter part of 1822 or early in 1823 Peter Weaver settled in the lower end of Wea Plains, on the south side of the Wabash River. Other pioneers settled around him, and early settlements were also made near Clarks Point, in the neighborhood of Westpoint and on Little Wea Creek. The early settlers came principally from eastern and southern Indiana, the majority of them being natives of Ohio, Virginia, Kentucky, and Pennsylvania. In later years, as the county became better developed, immigrants came from Illinois, New York, Maryland, and West Virginia.

In taking up the new land the settlers generally selected timbered areas. The open prairie lands, which were considered poor and unproductive, were swampy and poorly drained, and were covered with a tough, thick sod which could not be broken with the tools possessed by the settlers. The timbered areas, when cleared of their forest growth, offered little resistance to cultivation and possessed good natural drainage. In course of time, when newcomers were unable to locate claims, except on the prairie lands, a heavy sod plow was invented with which the tough sod could be broken. While it was a crude, poorly constructed implement, requiring several yoke of oxen to draw it, it nevertheless served its purpose, and the farmers were well repaid for the labor expended in breaking up the prairie soils. They were found to be more productive that the timbered areas, yielding larger and better crops on the well-drained areas.

Corn and potatoes were the first crops planted on the newly cleared timbered lands, while corn was generally the first crop grown on the virgin prairie soils. In planting corn on the prairie soils it was the practice the first year to drop the grain in the furrow as the sod was being turned under. This was called "sod corn" and was not worked during the growing season, it being impossible to cultivate the crop without tearing up the sod and pulling out considerable of the corn. The corn thus produced was generally of poor quality. In the fall the land was plowed and put in wheat, which was sown broadcast. Wheat was generally the second crop grown on the new soil, but in some cases corn was grown for two or three years before the land was sown to wheat. The wheat was at first cut with a sickle and later the cradle came into use. It was either thrashed out with a flail or spread on the barn floor and trampled by horses until the grain was separated from the straw. Reapers and thrashing machines did not come into use until some time during the sixties. The early settlers also raised some flax and wool, from which they made their clothing.

Little progress was made in agriculture prior to the completion of the Erie and Wabash Canal in 1840. Most of the grain produced had to be consumed at home. Occasionally a load of grain or other produce would be taken west to Chicago or east to Louisville or Cincinnati and salt and other provisions brought back. It took several weeks to make the trip, and only small loads could be hauled, because of the bad roads. Produce of all kinds was very cheap at this time. Some traffic between Lafayette and other small cities to the south and east was carried on by steamboats and other smaller crafts on the Wabash River. While navigation of this character figured quite extensively in the earlier growth of the county, it was not until the completion of the Erie and Wabash Canal, which furnished direct communication with the Ohio River, that more rapid progress was made in the agricultural development of the county. With these increased shipping facilities produce of all kinds could be sent to the south and east, where it was more in demand and brought higher prices.

Following the introduction of canal navigation the county began to develop rapidly. Large areas of timber lands were cleared and put under cultivation. Soon afterwards large tracts of prairie land were broken and converted into productive fields. Many improvements rapidly followed. The settlers began draining their land, open drains being most commonly used. A great deal of fencing was done, osage orange hedges being used generally. In later years these hedge fences have been largely replaced by wire.

Late in the fifties the first railroad was built in the county and aided greatly in its development. Other railroads were soon afterwards constructed, and as they afforded better and more rapid transportation facilities they secured most of the shipping trade, finally forcing the abandonment of both the canal and the river as means of transportation.

Climate.

There are no marked peculiarities in the climatic conditions of the area. The climate is humid and is about the same as that of the Middle States lying in the same latitude. Extreme temperatures seldom occur during either the summer or winter months, and the rainfall is well distributed throughout the year. The following table, compiled from the records of the Weather Bureau station at Lafayette, shows the normal monthly and annual temperature and precipitation:

NORMAL MONTHLY AND ANNUAL TEMPERATURE AND PRECIPITATION.

Month.	Lafayette.		Month.	Lafayette.	
	Temperature	Precipitation.		Temperature	Precipitation.
	°F.	*Inches*		°F	*Inches.*
January	25.1	2.19	August	72.7	3.16
February	27.7	2.78	September	65.9	2.66
March	36.9	3.01	October	53.0	2.45
April	51.0	3.20	November	38.9	3.24
May	61.2	4.59	December	30.1	2.49
June	71.2	4.50			
July	74.8	3.52	Total	50.7	37.79

As appears from the foregoing table, the average annual precipitation is about 38 inches. The greatest amount of rainfall occurs during May, June, and July, and the lowest precipitation comes during the month of January. The average annual temperature is about 51° F. The growing season comprises about six months of the year, during which time crops are safe from frosts. It is seldom that crops are injured by frosts on the uplands, but occasionally those grown on the bottoms are injured if sown late in the spring.

The following table shows the dates of first and last killing frosts for years 1898-1904 inclusive:

DATES OF FIRST AND LAST KILLING FROSTS.

Year.	Lafayette.		Year.	Lafayette.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1898	Apr. 6	Oct. 15	1902	Apr. 5	Sept. 14
1899	Apr. 16	Sept. 27	1903	May 1	Sept. 18
1900	May 10	Oct. 17	1904	Apr. 21	Oct. 23
1901	Apr. 21	Oct. 5	Average	Apr. 20	Oct. 4

Physiography and Geology.

Tippecanoe County lies wholly within the drainage basin of the Wabash. North of this river the general fall is toward the south, while south of it the fall is toward the north and west. The smaller streams flowing into the Wabash have cut channels from 10 to over 175 feet deep, which as a rule carry off the surface water quickly and afford excellent outlets for artificial drains. The Wabash River enters the county at the northeast corner, flows in a general southwesterly direction, and leaves the county about the center of the western boundary line.

The Tippecanoe River enters the area about 4 miles west of the northeast corner, flows in a southerly direction, and empties into the Wabash about 3 miles south of the northern boundary line. This stream drains only a small portion of the northeastern part of the county. Pine Creek, Indian Creek, Burnett Creek, and their tributaries drain that part of the county north and west of the Wabash River, the eastern half of the area south of the Wabash is drained by Sugar Creek, Buck Creek, and Wildcat Creek and its tributaries, while the southwestern section of the area is drained by Big and Little Wea creeks and Flint Creek.

The general altitude of Tippecanoe County is about 750 feet above sea level. The high bluff lies about 4 miles north of Lafayette and the uplands between Wildcat and Sugar creeks have an elevation of a little over 800 feet. It is quite probable that these are the highest points in the area.[1]

Along the margin of the Wabash River and its principal tributaries the surface is generally broken and hilly, while back from these streams the topography of the county is slightly undulating and rolling, gradually extending into plains or level tracts. In the northwestern part the surface varies from level to slightly undulating, but eastward the surface becomes more or less undulating and rolling in character, and in the northeastern part, where

[1] Fifteenth Report, Indiana State Geologist.

Burnett Creek, the Tippecanoe River, and the Wabash River approach one another, it is quite uneven and somewhat broken. That part of the uplands east of Tippecanoe River and north of the Wabash is level or only slightly rolling.

In the western part of the county, north of the Wabash River and extending east to Lafayette, the surface is slightly undulating. Pine Creek has formed only a small, shallow valley in this section, but near the margins of the valley formed by Indian Creek, particularly along the southern half of its course, the surface is more or less broken. The valley formed by this stream is narrow and is marked by rather steep bluff lines.

The valley of the Wabash is quite narrow, considering the size of the stream. The valley floor varies in width from a few rods near Lafayette to perhaps a mile at other points and is generally marked by prominent bluff lines. In some cases the bluffs have been worn into well-rounded contours or gently sloping descents, while in other cases, particularly near Lafayette and in the northeastern part of the county, they are precipitous and from 50 to 100 feet or more above the level of the valley floor. The surface of the low bottoms of the Wabash varies but little along its course, and its height above the low-water mark is between 10 and 20 feet. These bottoms are subject to overflow during periods of high water.

West of Lafayette, on the south side of the river, a second terrace is developed. This has an elevation of from 40 to 80 feet above the bottom lands and extends back from 2 to 5 miles from the river. This comparatively level tract, known as Wea Plains, was originally a prairie, and is composed of a mass of sand and gravel from 125 to 200 feet in depth, covered by a mantle of soil of varying thickness.

South of Wea Plains the surface becomes more rolling and is crossed by a number of ridges of varying height which have a general trend from east to west.

On the opposite side of the river from Wea Plains a gravelly terrace is developed, with about the same elevation as the plains. This is really a third terrace, as a lower or second terrace occurs from 25 to 30 feet above the bottoms. About 4 miles below Lafayette this second terrace is well developed, but it gradually merges into the higher or third terrace as the city is approached. This second terrace varies in width from a few rods to over 1 mile.

The surface of the uplands of the eastern half of the county south of the Wabash River varies from level to slightly rolling. Near the stream courses the surface becomes more or less broken and hilly. The valley formed by Wildcat Creek is marked by steep, precipitous bluffs ranging in height from 50 to 100 feet or more. The bluff lines are most prominently developed near the point where the South Fork enters the main stream, but as the source of the stream is approached the bluff lines become more rounded and possess more gentle slopes. The bluffs along the South Fork are not so prominently developed. The valleys formed by these streams are narrow and the surface irregular, being broken by low hills and ridges, old stream channels, sloughs, and swampy depressions. Second bottoms, generally quite narrow, are developed along certain parts of these stream courses.

North of Wildcat Creek the uplands are broken by the deep, narrow valleys formed by Buck and Sugar creeks.

The entire region is covered with glacial débris, the thickness of which varies greatly in different parts of the county. The greatest depth of this drift, so far as is known, is about 150 feet, but it is thought that careful measurements in some parts of the county would show it to be deeper, possibly from 200 to 250 feet.[1]

Prior to the deposition of the glacial material a great depression or basin was formed in the central part of the county by erosion. Immediately following this period of erosion the basin was filled with glacial drift. Subsequent to the deposition of the glacial material a large proportion of the county was covered with loess. The loess varies in thickness from a few inches to 3 feet or more and has resulted in the formation of the most extensive soil types in the area. Generally a few feet below the surface the soils grade into bowlder till consisting of clay, sand, and gravel mingled in varying proportions. In some cases the underlying material consists of yellow or blue clay, which extends to an undetermined depth, while in other cases it consists chiefly of sand and gravel.

SOILS.

Seventeen soil types were recognized and mapped in the area surveyed. Of these, 8 occur as upland types, 5 as alluvial or river bottom types, and 4 as second bottom or terrace types. The various soils are quite distinct in their typical formations, each possessing its own physical peculiarities. Although each soil type is easily recognized when typically developed, yet in some parts of

[1] Fifteenth Report, Indiana State Geologist.

the county the transition from one to the other is often so gradual that it is difficult to draw accurate boundaries between them. This is especially so in the case of the lighter areas of the Marshall silt loam and the darker areas of the Miami silt loam, and also of the Marshall loam and the Marshall silt loam. Although frequently occurring in limited areas, the bottom land types are generally quite easily distinguished.

The following table shows the extent of the different types of soil found in Tippecanoe County:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	140,166	43.9	Wabash sandy loam	2,624	.8
Marshall loam	72,320	22.6	Miami loam	1,920	.6
Miami silt loam	44,288	13.9	Muck	1,664	.5
Wabash fine sandy loam	11,712	3.7	Miami gravelly sandy loam	1,024	.3
Marshall fine sandy loam	11,584	3.6	Sioux loam	896	.3
Wabash silt loam	9,408	2.9	Riverwash	832	.2
Sioux sandy loam	9,216	2.8	Sioux silt loam	570	.2
Miami fine sandy loam	4,608	1.6			
Miami black clay loam	3,840	1.2	Total	319,488	
Miami fine sand	2,816	.9			

Marshall Silt Loam.

The Marshall silt loam is the most important and extensive soil found in the area. It consists generally of a dark-brown to almost black silt loam in which the percentage of silt is extremely high. In some cases the color is much lighter, varying from light brown to dark gray. On the more rolling areas the depth of the soil is about 12 inches, while on the more level tracts and in some of the shallow depressions it is much deeper, occasionally extending to 20 inches. Over the prairie regions occupied by this type the depth is fairly uniform, averaging from 16 to 18 inches. The percentage of organic matter in the soil is generally quite large, giving the type its prevailingly dark color. The color of the soil generally becomes much lighter with depth. As the depth increases the soil gradually becomes heavier, and below 16 or 18 inches it grades into a heavy silt loam subsoil having some of the properties of a clay. This material generally extends to a depth of 3 or 4 feet, but in some cases it grades into a clay loam or clay at a depth of from 28 to 30 inches. Sometimes this clay loam subsoil lies directly beneath the soil. The color of the subsoil is yellow, sometimes slightly mottled or streaked with red or yellow iron stains in the lower sections. Generally below 3 or 4 feet the subsoil consists of a yellow sticky sandy clay, which grades into bowlder till at lower depths. As the Wabash River is approached the underlying material contains more sand and gravel, and near this stream it is composed largely of coarse sand and gravel more or less stratified. An occasional bowlder or small pebble occurs on the surface, particularly upon the morainic ridges.

The following table shows the results of mechanical analyses of a typical sample of Marshall silt loam:

MECHANICAL ANALYSES OF MARSHALL SILT LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13991	Soil	0.2	1.1	1.3	3.9	5.7	67.2	20.0
13992	Subsoil	.3	.9	1.1	2.9	4.5	64.8	25.6

The Marshall silt loam is most typically developed southeast of Lafayette, and is the chief type, occupying the uplands on both sides of the Wabash River. The type occurs in every part of the county, but is not extensively developed north of township line 24 north, nor is it found to any great extent in the southwestern part of the area.

The surface of the greater part of this type is level, although in certain localities it is slightly undulating and rolling. Near the streams and along the morainic ridges which cross the county in a generally east and west direction the surface is somewhat broken. The topographic features of the greater part of this type afford good natural drainage. In the swales and local depressions and over some parts of the more level areas the natural drainage is poor, and artificial drainage is necessary to successful crop production.

This soil has been formed by the deposition of loess over glacial drift. To this have been added large quantities of organic matter from the growth and decay of grasses and other prairie vegetation. The type embraces a part of the typical prairie lands of the county. Some areas, however, especially near the streams, were originally timbered, the forest growth consisting chiefly of oak, ash, walnut, hickory, and maple.

Corn, oats, wheat, and clover are the principal crops produced on this soil. Of these corn is by far the most important. The crop yields vary with the seasons and methods of cultivation, but are always larger than those secured on typical areas of the Miami silt loam. On the well-managed farms corn yields from 50 to 60 bushels per acre, but the average for the type will probably not exceed 40 bushels. The average yield of oats is estimated at 50 bushels and of wheat from 20 to 30 bushels per acre. Clover when cut for hay will average about 2 tons per acre, and when cut for seed from 1 to 1½ bushels per acre. The Marshall silt loam is well adapted to the crops at present grown upon it. It is generally recognized that wheat does better on the lighter than on the heavier phases of this soil. The best results from corn are generally secured on the heavier and darker-colored areas.

In order to study the manurial requirements of this soil, a large sample was collected from the southeast corner of Sec. 22, T, 23 N., R. 4 W., and an examination made by the paraffined wire-pot method. The soil at this place is a black or dark-brown silt loam, containing a large percentage of organic matter.

The land from which the sample was taken was originally timbered, but has been under cultivation for the last thirty years. During the last seven years it has been cropped continuously to corn, the average yield being about 45 bushels per acre. It has never been sown to clover, neither have fertilizers of any kind ever been applied. Of the various fertilizer ingredients applied to this soil, none produced any appreciable increase in the growth of the plants. The plants grown on the untreated soil were of good size, thus indicating that thorough cultivation rather than fertilizers is needed on this soil.

In these tests wheat plants were used as an indicator, and the results are held to be applicable only to this crop and to the particular field from which the sample was taken, but in a general way they are believed to apply to a large part of this soil throughout the area, and in this agree with the common farm practice.

Miami Silt Loam.

The soil of the Miami silt loam consists of a light-brown or dark-gray to almost white silt loam with an average depth of about 16 inches. In some localities it is streaked with red or yellow iron stains. Iron concretions are frequently found on the surface and through the soil, and in a few cases some small gravel is found, but the amount is too small to have any appreciable effect upon the texture or agricultural value of the soil. The soil has a loose, flour-like feel, and the amount of organic matter it contains is generally very small. On the ridges and slopes of the bluffs the soil is somewhat more sandy than in the typically developed areas.

There is no sharp line of demarcation between the soil and subsoil. At a depth of 16 inches the soil generally grades into a heavy silt loam subsoil, which gradually becomes heavier with depth. The color varies from gray to yellow and is often streaked with red and yellow iron stains. Below 30 inches the subsoil generally grades into a yellow clay loam, which extends to a depth of 3 or 4 feet. Below this the underlying material consists of a sandy silt or clay, in which the percentage of sand increases with depth. This material is underlain by bowlder till, consisting of clay, sand, and gravel in varying proportions, but in some localities, especially near the Wabash River and a few of its principal tributaries, this underlying material is composed largely of sand and gravel. Over that portion of the type underlain by sand and gravel the soil grades at a depth of about 18 inches into a yellow or mottled yellow, sticky, sandy clay in which the percentage of coarse sand and fine gravel increases with depth, grading eventually into sand and gravel.

This soil type resembles the Marshall silt loam to a marked degree in texture, but is easily distinguished from that type by its lighter color, more hilly surface, and lower crop value. The following table gives the result of the mechanical analysis of a typical sample of this soil type:

MECHANICAL ANALYSES OF MIAMI SILT LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
14003	Soil	0.4	1.8	1.0	2.2	7.3	68.4	18.9
14004	Subsoil	Trace	.9	.7	1.6	6.5	73.6	16.2

The Miami silt loam is most typically developed over a portion of the uplands bordering the valleys formed by the Wabash River and its principal tributaries. It occupies the best-drained areas of the county. It is found in a long, narrow strip north and west of the Wabash River, widening out into broader areas along the lower courses of Indian and Burnett creeks. Another large area occurs east of the Wabash, from Wildcat Creek northeast to the county line. Between the Middle and North forks of Wildcat Creek is a third area of Miami silt loam. The only area of any considerable size lies in the southwestern part of the county, in the vicinity of Flint Creek.

A few areas of this type are level, but the greater proportion is rolling, and near the streams it is quite hilly. In many places deep V-shaped gullies have been cut in the steeper slopes by erosion. Owing to the rolling and hilly topography, which characterizes the most of this type, the rainfall runs off readily, and artificial drainage is seldom necessary. The more level tracts, however, could be improved by tile drains.

This type owes its origin to the deposition of loess over glacial material. Because of the good natural drainage, the moisture conditions have been unfavorable to the growth and preservation of a heavy vegetation, and as a consequence a soil has been formed in which the amount of organic matter is extremely low. For this reason the type is less loamy and less productive than other soils of the area in which considerable organic matter has been incorporated through the growth and decay of grasses and other vegetation. This type embraces the greater part of the original timbered areas of the county, and at present considerable timber, consisting chiefly of oak, ash, hickory, walnut, and maple, is found growing upon it, especially in the more hilly and nonagricultural sections.

The Miami silt loam is devoted to about the same crops as the Marshall silt loam, but the yields are generally much smaller. The yields are largest during wet seasons, as the crops grown on the more rolling and hilly areas are frequently injured by drought. Corn and oats average from 35 to 40 bushels per acre, wheat from 15 to 20 bushels, and clover from three-fourths to 1 ton. This soil type is not well adapted to corn, although a considerable proportion of the cultivable tracts is devoted to this crop. Oats do fairly well, and moderate yields of wheat and clover are secured. It is an excellent soil for pasture, and a large proportion of the type, particularly in the hilly sections, is used for this purpose. Some fruit is grown, chiefly apples, pears, and peaches, but the yields are generally light and the fruit is not of the best quality.

The manurial requirements of this soil were studied, using a large sample collected near the center of Sec. 23, T. 23 N., R. 3 W. The field from which the sample was taken has been in cultivation for about twenty years, having been planted to corn a larger part of the time, and although no manure or fertilizer of any kind has been used the average yield has been about 30 or 35 bushels per acre.

The results obtained with plants grown in wire baskets indicate that an excellent increase in productiveness may be obtained by the use of stable manure; that nitrate of soda with either sulphate of potash or acid phosphate will give a large increase, and that cowpeas and lime, acid phosphate alone, or nitrate of soda alone will give a fair increase. Sulphate of potash or lime gave only a small increase.

In these tests wheat plants were used as an indicator, and the results are not held to be applicable to other and unrelated crops or to fields which have received treatments essentially different from that from which the sample was taken.

Miami Black Clay Loam.

The Miami black clay loam is the heaviest soil type in the county. The soil consists of a heavy loam or clay loam with an average depth of about 14 inches, the depth varying in different parts of the same area, generally being deeper near the center of the area than near its outer margins. The soil contains a very high percentage of organic matter, and to this is due the characteristic black or dark-brown color. As the depth of the soil increases the percentage of organic matter proportionately decreases, and the color becomes much lighter, generally becoming bluish or grayish at from 10 to 20 inches below the surface. The soil is very cohesive, with a tendency to puddle, and if stirred when too wet or too dry it breaks up into large clods which are difficult to pulverize. If allowed to dry without cultivating, it cracks badly, often forming cracks 1 or 2 inches wide and several inches deep.

The soil gradually becomes heavier with depth, and below 14 or 16 inches grades into a silty clay, the clay content increasing with depth. Below 20 or 24 inches the subsoil generally consists of a heavy, tenacious, impervious silty clay. The color of the upper section of the subsoil varies from light to dark gray, depending upon the depth to which the organic matter extends. It rapidly becomes lighter with depth, finally grading into light-gray or mottled yellow.

While the surface soil is fairly uniform throughout the area, the subsoil varies somewhat in different parts of the county, especially where the type occurs along stream courses. In such localities the subsoil consists of a yellow heavy silty clay grading at a depth of about 30 inches into a heavy sandy clay containing some fine gravel. Occasionally some fine gravel is found on the surface, but the amount is generally small.

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

MECHANICAL ANALYSES OF MIAMI BLACK CLAY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13600	Soil	0.3	1.3	1.9	5.1	6.2	59.1	25.3
13601	Subsoil	.1	1.1	.5	1.9	5.1	71.1	19.7

The Miami black clay loam occupies only a small proportion of the area surveyed. It occurs as small isolated bodies over the county, and is found most typically developed south and east of Lafayette. It occupies shallow, basinlike depressions on the uplands and is occasionally found along some of the smaller streams. The soil has resulted from the washing of the finer material from the higher levels into these poorly drained depressions, where through the growth and decay of rank grasses and other kinds of vegetation much organic matter has accumulated. The surface is practically level, with only a slight fall toward the main drainage lines. In some cases it is slightly broken by old sloughs and swampy depressions. On account of the level surface and the heavy imprevious subsoil the type is poorly drained. To produce good crops artificial drainage is necessary over all this type, except in the small areas occurring along the streams. Some of these lands have already been supplied with tile drains. The soil is rich and productive, and when well drained and properly managed it is capable of producing large crops of corn, oats, grass, and other products.

The Miami black clay loam is one of the best corn and grass soils in the area. Good crops of oats have been produced, but there is danger of the grain lodging, because of the rank growth of straw induced by the high organic matter content of the soil. The average yield of corn is from 50 to 60 bushels, while that of oats in good years is about 35 bushels per acre. The yield of hay varies from 1 to 2 tons per acre. Some clover is grown on this type, mostly for pasture and green manure. When grown for hay, it yields about 1½ tons per acre. It is sometimes allowed to ripen and is cut for seed, 1 bushel per acre being the average yield. Trouble is frequently experienced in growing this crop on account of its heaving from the freezing and thawing of the soil. This can be largely overcome by a more thorough system of drainage.

Marshall Loam.

The suface soil of the Marshall loam, as typically developed, consists of a black or dark-brown loam with an average depth of 8 or 10 inches. Below this the soil grades into a somewhat heavier-textured and lighter-colored loam, which extends to an average depth of 14 inches. The soil contains a small amount of sand, which is most apparent on the surface after beating rains. The type in some localities, although of a loamy appearance, when examined closely is seen to have the characteristics of a silt loam, and in some cases it is difficult to separate this type from the darker-colored Marshall silt loam. Organic matter occurs in this soil in large quantities, and to this is due the prevailing dark-brown or black color. As the depth of the soil increases the percentage of organic matter decreases, and the color becomes correspondingly lighter.

The depth of the soil varies considerably in different parts of the area, depending largely upon the topographic position occupied by the type. On the crest of the low knolls and ridges it varies from 8 to 10 inches and is generally more sandy than the typical soil. On the more level areas and in the local depressions the soil is generally much deeper, averaging 16 or 18 inches. The organic matter content of the soil in these areas is generally much larger than in the more uneven or elevated areas, and the texture is also somewhat heavier.

The line of separation between the soil and subsoil is generally well defined. At a depth of from 14 to 16 inches the soil grades into a yellow clay loam subsoil, in which the percentage of clay increases with depth. In some sections the clay loam extends to a depth of over 36 inches, but generally at about 24 inches the subsoil grades into a yellow heavy sandy clay. In some cases a depth of 30 or 33 inches is reached before this coarse sandy material appears. Below these depths, however, the subsoil becomes lighter, the sand content increasing, and below 36 to 40 inches the subsoil is a light sandy clay. Occasionally at a depth of 36 inches a thin layer of medium to coarse sand is encountered. The type is underlain by bowlder till. A small amount of gravel and a few large bowlders occur on the surface. In some areas the bowlders are so plentiful as to interfere with cultivation, but in most cases they have been removed from the fields.

The average results of mechanical analyses of typical samples of this soil are shown in the following table:

MECHANICAL ANALYSES OF MARSHALL LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13594, 13979	Soil	0.2	1.2	1.1	3.4	7.1	66.2	20.5
13595, 13980	Subsoil	.2	1.0	.8	1.9	4.4	70.0	21.5

The Marshall loam occupies a part of the prairie lands of the county. It occurs as a large, irregular-shaped area in the northwestern corner of the county, extending eastward along the northern boundary line nearly three-fourths the width of the area. A second large area is found between Flint Creek and the Wabash River, northeast of Westpoint. In the southwestern part of the county are other large areas of Marshall loam. A smaller area of this soil occurs in the southeastern corner of the county, near Clarkshill.

The surface of the Marshall loam is nearly level or only slightly undulating. The surface is sometimes broken by small, shallow valleys, formed by streams flowing across the type and by a number of low sand and sandy loam ridges, which seldom exceed an elevation of more than 6 or 8 feet above the level of the surrounding country. Owing to the practically level surface of the greater part of this type, the natural drainage is poor and artificial drainage has to be employed in order to insure good crops. When this land was first put under cultivation open drains were mostly used, but in later years these have been largely replaced by tile drains.

The Marshall loam is of glacial origin. Directly associated with the type are large massive bowlders, consisting chiefly of granite, which are found most abundantly in the southern part of the county. In addition to the material deposited by glaciers, there has been added to the soil a large quantity of organic matter from the growth and decay of prairie vegetation.

This soil is well adapted to the production of corn and oats, which are the principal crops grown on it. Clover does fairly well, but considerable difficulty is sometimes experienced in getting a good stand. It is generally sown with oats, and if the season is dry the clover may die after the nurse crop is removed. The average yield of corn is about 40 bushels, while that of oats varies from 35 to 45 bushels per acre. Clover will yield during successful years from 1 to 2 tons of hay and from three-fourths to 1½ bushels of seed per acre. Fruit and vegetables are grown only for home use. Of the large fruits, apples and pears are most extensively produced, but the yields are light and the fruit is not of the best quality. Irish potatoes and some of the early vegetables can be successfully produced, but up to the present time they have been grown only for home use.

Miami Loam.

The soil of the Miami loam, to an average depth of 16 inches, is a light-colored loam, in which the percentage of silt is relatively high. When wet or newly plowed it has a light-brown color, which on drying out becomes light or dark gray, and in some cases almost white. In general the soil resembles the Miami silt loam, but upon careful examination it is found to contain considerable medium to coarse sand. When thoroughly moistened, the soil is quite sticky and the presence of sand and small iron concretions gives it a gritty character. The soil is loose and light and is easily tilled, but is very deficient in organic matter.

The subsoil is a heavy, sticky loam, the upper section of which has a mottled yellow color, changing to deep yellow at lower depths. Some iron concretions occur in the first 6 or 8 inches of the subsoil, but below this depth they are not generally found. In some localities the soil at a depth of 14 inches grades into a sticky, gravelly subsoil, which resembles that of the Miami gravelly sandy loam. The gravel, however, is generally much smaller, and as a rule does not occur so abundantly as in the case of the Miami gravelly sandy loam subsoil.

There is usually found a slight quantity of small pebbles or gravel on the surface of this soil, and occasionally a few small bowlders, but not in sufficient quantity to interfere with cultivation.

The Miami loam covers only a small percentage of the area surveyed. It occurs as one continuous body on the uplands southwest of Lafayette, in the vicinity of Elston. The surface of the type is comparatively level, with but a slight fall toward the drainage channels. In some parts of the area the surface is slightly undulating, but the low knolls and ridges seldom exceed an elevation of 5 or 7 feet above the mean level of the type. Near the streams the surface is more broken and the boundary between this type and the valleys is often marked by a steep scarp from 80 to 100 feet high.

The natural drainage features of the type are poor, except on the more undulating areas and over that portion underlain by a gravelly loam at a depth of from 14 to 20 inches. Originally the soil was cold and wet, but this condition has been greatly improved by artificial drainage. A few low, wet areas needing drainage are still to be found.

The Miami loam is of glacial origin. It is composed of the weathered products of a mass of ground-up rocks deposited upon the surface during Glacial times.

Corn is the principal crop grown upon this soil. Wheat and oats are also grown to a limited extent, and some areas are devoted to pasture. The yields vary considerably, according to the seasons and the drainage conditions of the soil. Corn will average from 35 to 45 bushels, oats about 40 bushels, and wheat about 20 bushels per acre. The type is well adapted to the crops at present grown upon it. It is quite probable that tobacco would do well, since this crop is successfully grown on soils of similar character in other sections, particularly in Ohio.

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

MECHANICAL ANALYSES OF MIAMI LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13618, 13977	Soil	0.8	12.1	8.1	5.8	3.6	52.5	16.9
13619, 13978	Subsoil	.9	10.0	8.8	13.1	8.9	34.3	23.2

Miami Fine Sand.

The soil of the Miami fine sand consists of a loose, incoherent, medium to fine sand, in which the percentage of fine sand is extremely large. The color of the soil varies from light-brown to yellow, depending upon the amount of organic matter present, which is generally very small. The color usually becomes lighter with depth, and below 10 or 12 inches the soil grades into a light-yellow or gray subsoil having about the same texture as the soil. In the lower section of the subsoil the color is often mottled with brown and yellow, and in some cases pockets of gray sand are found.

There is a small area of the type northeast of Battleground in which the soil contains a larger percentage of organic matter than is generally the case, and the color is consequently somewhat darker, varying from light to dark brown. It rapidly becomes lighter with depth, and below 12 or 14 inches grades into a subsoil similar in character to that underlying the typical areas.

The following table gives the results of mechanical analyses of a sample of this type:

MECHANICAL ANALYSES OF MIAMI FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13624	Soil	0.0	2.9	13.3	52.0	11.5	13.8	6.4
13625	Subsoil	.0	3.0	13.3	49.6	13.4	13.5	7.1

The Miami fine sand is found bordering the Wabash River and as well-defined ridges on the uplands some distance back from this stream. The largest body is found south of Battleground, occupying a part of the second bottoms on the north side of the river. One or two small areas are also found along Wildcat Creek and its principal tributary.

The Miami fine sand has a topography similar to sand dunes, consisting of well-rounded hills and ridges varying from 5 to over 20 feet in height. Owing to the uneven surface and the open, porous nature of the soil, the drainage is generally excessive and crops are frequently injured by lack of sufficient moisture in the soil.

This type has resulted from the drifting of sand from the valley of the Wabash and its principal tributaries and its deposition in its present location by the action of winds.

Corn, melons, and sweet potatoes are the principal crops grown. The yield of melons and potatoes is generally good, but that of corn depends upon climatic conditions entirely. A few areas are covered with timber, consisting chiefly of oak, hickory, and walnut. It is a good truck soil and is also well adapted to small fruits.

Miami Fine Sandy Loam.

The soil of the Miami fine sandy loam consists of a light to dark brown fine sandy loam, averaging about 4 inches in depth. The sand content varies in texture from fine to medium, with the finer material occurring in the upper part of the soil. The soil generally becomes slightly sandier and somewhat coarser with depth. Below 14 or 16 inches the soil grades into a medium sandy loam, which extends to an average depth of 30 inches. This section of the subsoil is very compact, the clay content being sufficient to give it a sticky character when wet. The color varies from light-brown to yellow. At a depth of 30 inches the subsoil grades into a brown coarse sandy loam containing considerable fine gravel and extending to an undetermined depth. Outcrops of the underlying material along road cuts and stream bluffs show this fine gravelly, sandy loam subsoil extending to a depth of from 4 to 6 feet, underlain by alternating layers of coarse sand and gravel. As the distance back from the streams increases, particularly near the Miami silt loam areas, the soil becomes heavier, in some cases approaching a loam, and the subsoil varies somewhat from that described above. In such localities the subsoil generally becomes heavier with depth, grading into a heavy fine sandy loam or light loam in which the silt content is high. The color is also somewhat lighter, varying from light gray to mottled yellow. This phase of the type is usually underlain by material similar in character to that underlying the typical Miami silt loam, although a few areas occur in which the subsoil grades at a depth of 3 feet into a layer of fine sand.

On some of the higher elevations and near the bluff lines the soil is sandier and the sand is somewhat coarser than is the case where the soil exists in its typical formation. The color of the soil, however, remains practically the same. This type, like the Miami silt loam, is markedly deficient in organic matter.

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

MECHANICAL ANALYSES OF MIAMI FINE SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13693, 13999, 14001	Soil	0.6	6.1	8.1	22.0	8.5	40.6	13.5
13694, 14000, 14002	Subsoil	1.2	7.5	8.0	23.1	7.9	31.1	21.0

The Miami fine sandy loam is confined exclusively to the northeastern part of the county, north of the Wabash River. The largest body occurs north and northeast of Battleground. Another area occupies that part of the upland between the Wabash and the Tippecanoe rivers.

Near the streams the surface of the type is somewhat broken and hilly, but farther back on the uplands it is rolling or slightly undulating. A few level areas occur, but these are generally quite small. The natural drainage of the Miami fine sandy loam is good, and in only a few cases has it been necessary to construct artificial drains. Over a considerable proportion of the type the drainage is excessive and crops frequently fail to mature on account of an insufficient moisture supply in the soil. The type has probably been formed by the deposition of loess, to which has been added the fine sand which has drifted upon the uplands from the valley of the Tippecanoe River.

The Miami fine sandy loam is well adapted to the crops grown in the county, with the exception of timothy, which requires a greater amount of moisture than this soil can retain during a dry season. Corn, oats, wheat, and some clover are the principal crops. Ordinarily corn will average 45 bushels per acre. The yield of wheat is about 20 bushels and of oats from 25 to 35 bushels per acre, depending upon the moisture supply. The yield of clover averages three-fourths of a ton per acre. Potatoes do well on this type, but it is difficult to estimate the yield, inasmuch as they are grown only in small patches for home use. Apples and peaches are grown to some extent, and some small fruits also, but the quantity produced is seldom sufficient for home use. The soil is well adapted to truck crops.

Marshall Fine Sandy Loam.

In its typical formation the soil of the Marshall fine sandy loam to an average depth of 18 inches consists of a medium to fine sandy loam. It generally contains a large percentage of organic matter, and to this is due its prevailing black or dark-brown color. The soil usually becomes heavier as the depth increases, and at 16 or 18 inches below the surface it grades into a light-brown, sticky, sandy loam extending to a depth of about 30 inches. The subsoil generally becomes lighter in the lower section, grading into a light-brown medium sand extending to a depth of over 3 feet. In some cases this sandy layer is only a few inches thick and is underlain by bowlder till, while in others it is totally absent, the type resting directly upon glacial débris. The depth of the soil varies in different localities, depending largely upon its topographic position. On the slopes and crests of some of the ridges it has an average depth of about 10 or 12 inches, and the soil is of a more sandy nature and the sand is coarser, while at the base of the ridges, on the more level areas, and in the depressions it is much deeper, occasionally exceeding 22 inches. The soil in the depressions is generally heavier than the typical soil, approaching a loam in some cases. In some areas, especially on the crests of the ridges, fine gravel is found, but the amount is generally too small to have any effect upon the agricultural value of the soil. Occasionally a few large bowlders are found.

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

MECHANICAL ANALYSES OF MARSHALL FINE SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13622, 13985	Soil	0.1	7.1	18.1	22.4	10.4	23.3	18.7
13623, 13986	Subsoil	.6	17.2	17.6	23.1	8.3	16.8	16.0

The largest body of Marshall fine sandy loam occurs in the western part of the county, immediately south of the Wabash River. A smaller area occurs northeast of Battleground, and a few areas are found in the northwestern part of the sheet. Other small, isolated areas occur in the county, principally in the southern and western parts.

The surface of the greater part of the type is slightly rolling. In some parts of the county the type occurs as low knolls and ridges, running approximately parallel with the Wabash River. The natural drainage of the Marshall fine sandy loam is excellent. Owing to the uneven surface of the greater part of the type water runs off quickly, and artificial drainage is seldom necessary except on the more level tracts and in local depressions. On the lighter areas, particularly those underlain by a light subsoil, the drainage may be excessive, but in most cases the soil withstands drought well.

This soil type is for the most part of glacial origin. A few small areas have been formed by the mixing together of the Miami fine sand and the Marshall loam, forming a transitional zone between the two types. There have been added to this soil large quantities of organic matter through the growth and decay of prairie vegetation.

Corn, wheat, oats, and clover are the principal crops grown on the type. During wet seasons those areas of the soil underlain by sand produce better crops than those having a heavy subsoil. The latter, however, give better results than the former during a dry season, being better able to withstand drought. Corn averages about 40 bushels, wheat 20 bushels, and oats from 35 to 45 bushels per acre. Clover yields about 1½ tons when cut for hay and from three-fourths to 1 bushel per acre when grown for seed. Potatoes do well on this type, but are at present grown only for home use. Some fruit is raised, but is not of good quality and the yields are small.

Riverwash.

The Riverwash consists chiefly of coarse sand and waterworn gravel. It occurs as narrow strips, seldom exceeding one-quarter of a mile in width, along the Wabash River and its principal tributaries. It has been formed by the deposition of material along stream courses during periods of high water. The surface is low and flat and occasionally broken by old stream channels. It is generally dry during the summer months, and during wet periods it is covered with water. Owing to the small amount of fine material in this soil it is unproductive and has no agricultural value. Cottonwoods and willows, with some water-loving shrubs, are about the only vegetation found on this type.

Wabash Sandy Loam.

The soil of the Wabash sandy loam consists of a sandy loam in which the percentage of coarse sand is extremely high. The average depth of the soil is about 12 inches, but this varies in different localities, the soil being deeper as well as slightly heavier in the depressions. On the ridges the soil is of a more sandy nature and is frequently covered with considerable fine gravel. The gravel is generally less than 1 inch in diameter and is more or less irregularly distributed throughout the soil profile. The prevailing color of the soil is dark brown, but it is sometimes slightly reddish, becoming lighter colored with depth. At about 12 inches the soil grades into a coarse, slightly sticky, loamy sand subsoil which extends to a depth of over 3 feet. Small gravel is also found in the subsoil. The color varies from yellow in the upper part of the subsoil to pale yellow at lower depths.

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

MECHANICAL ANALYSES OF WABASH SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13604, 14021	Soil	5.2	27.5	14.9	25.6	8.9	12.0	5.4
13605, 14022	Subsoil	3.7	25.0	15.5	28.9	9.4	12.1	4.6

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 14022, 1.3 per cent.

The Wabash sandy loam occurs only in limited areas along the Wabash River and its principal tributaries. It usually borders the bluff lines where typical second bottoms have not developed. The type has resulted from the washing of material from the uplands and coarse sand and gravel from the exposed bluff lines, together with material deposited by streams, its formation being due entirely to stream action.

The surface is generally uneven, consisting of low knolls and ridges and shallow depressions. A few level areas occur, but these are not very extensive. Owing to the open, porous structure of the soil the drainage in most cases is excessive, but this depends upon the relative position of the soil with respect to the streams. While not occupying the flood plain proper, it is nevertheless partly overflowed during excessively wet seasons. During the growing season the streams are generally low and the crops are seldom injured by floods.

Corn and melons are the principal crops grown on this soil. The yield of melons is generally good, but that of corn depends largely upon the quantity of rainfall during the growing season. In favorable seasons the average yield of corn is about 30 or 40 bushels per acre.

Wabash Fine Sandy Loam.

The Wabash fine sandy loam varies to a marked degree in different parts of the area. Where typically developed, the soil consists of a fine sandy loam having an average depth of 16 inches. The fine sand content is quite large and generally increases with depth. The color varies from light to dark brown, the latter predominating. As the depth increases the soil becomes lighter both in color and texture, grading at about 18 inches into a light-brown fine sandy loam or loamy fine sand. The loamy material gradually decreases with depth, and at about 30 inches a gray fine sand is encountered which extends to a depth of more than 36 inches. Very frequently at this and lower depths the fine sand grades into gray coarse river sand and finally into gravel. In some localities the type, particularly the subsoil, is stratified. The soil in such cases is a light fine sandy loam, of a light to dark brown color, to a depth of about 14 inches. This is underlain by a fine gray sand, with an average thickness of 4 or 5 inches, which in turn is underlain by a brown fine sandy loam containing considerable silty material. This layer is about 5 inches thick, and beneath it is a medium gray sand extending to a depth of over 3 feet and becoming coarser with depth. In the depressions or over areas where the velocity of the stream was greatly retarded, thus permitting the deposition of the finer material carried by the streams, the type is much heavier, consisting in some areas of a light loam and in others of a silty loam. The color of the soil throughout these variations is the same as where the soil is typically developed. The organic matter content is generally small, but a few areas are found where considerable organic matter has been added to the soil. In such areas the color is a very dark brown and in some cases almost black. Some fine gravel is occasionally found on the surface, but the quantity is too small to have any effect upon the agricultural value of the soil.

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

MECHANICAL ANALYSES OF WABASH FINE SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13606, 14023	Soil	Trace	0.5	2.2	19.9	24.4	44.6	8.3
13607, 14024	Subsoil	0.1	1.1	2.1	20.3	26.5	40.3	8.9

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 13606, 7.8 per cent; No. 14024, 1.5 per cent.

A few small areas of this type are found along the Wabash River in the western part of the county. It is most typically developed along the more important tributaries of the Wabash, especially along Wildcat Creek, Sugar Creek, and Tippecanoe River. It occupies the first bottoms or flood plains of these water courses and has a width seldom exceeding three-fourths of a mile.

The surface of this soil is fairly level, with a gentle slope toward the main stream channels. A few low sandy and gravelly knolls and ridges occur, but they seldom exceed an elevation of 3 or 4 feet above the mean level of the type. The surface is also broken by sloughs, swampy depressions, and old stream channels.

The Wabash fine sandy loam is of alluvial origin, having been deposited in recent times by the streams which it borders. Because of its low-lying position the type is frequently flooded, but the sandy texture of the soil allows the water to drain off quickly, so that it is possible to plant crops quite early in the spring. Occasionally crops are injured by late floods and have to be replanted; but as a general rule crops on this soil are earlier than on the uplands.

Corn is about the only crop grown on this soil, and the average yield in favorable seasons is 45 bushels per acre. Some clover is grown, particularly on the higher and better drained areas, and yields fairly well. During dry seasons, especially when the streams are very low, the crops suffer from drought and the yield is very small. This soil is well adapted to truck crops.

Wabash Silt Loam.

The soil of the Wabash silt loam consists of a heavy silt loam or clay loam, with an average depth of 18 inches. It contains only a small percentage of decayed organic matter, and the characteristic color is light or dark brown. The soil is quite sticky when wet. If allowed to dry without stirring, it has a tendency to bake and crack, and if plowed when too wet or too dry it forms clods which are difficult to pulverize unless moistened by rain.

The Wabash silt loam is remarkably uniform in character over most of the area. Where found along the smaller stream courses, the color of the soil is generally much darker, the amount of organic matter is larger, and more fine gravel occurs on the surface than is the case where the soil is typically developed. These areas resemble somewhat the Miami black clay loam, but the color of the soil is generally much lighter.

As the depth of the soil increases the percentage of clay also increases, and below 18 or 20 inches it grades into a heavy silt loam subsoil, which gradually becomes heavier, grading in turn into a silty clay, which extends to a depth of over 3 feet. Over the greater part of the type the color of the subsoil is much like that of the soil, but in some localities it is slightly mottled. There is no distinct line of separation between the soil and subsoil, and the change from one to the other is marked only by the gradually increasing clay content.

The following table gives the results of mechanical analyses of a typical sample of this soil type:

MECHANICAL ANALYSES OF WABASH SILT LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13626	Soil	0.0	Trace	0.3	2.7	2.1	66.1	28.4
——	Subsoil	.0	0.0	.2	2.7	3.2	62.2	31.9

The Wabash silt loam occupies the first bottoms or flood plains along the Wabash River. A few small areas are also found along its principal tributaries. The surface is fairly level, with gentle slope toward the stream beds. The elevation of the type varies in different parts of the valley, in some places rising gradually from the streams to the bluff line, while in other localities it occurs in the form of broad, flat terraces or steps. Often as many as three of these step-like elevations occur between the river and the bluff line, each having a rise of from 2 to 3 feet. In some parts of these bottoms the surface of this type is cut by old stream channels, sloughs, and swampy depressions. In general the natural drainage of the type is poor. During wet seasons in the spring the greater part of the bottoms is flooded, and it not infrequently happens that early-sown crops are destroyed. As a rule, however, the bottom lands are late in drying out in the spring, so that by the time crops are planted the danger of floods is past. It is seldom that a crop is destroyed during the growing season.

This soil type owes its origin to the deposition of material brought down by the river during periods of high water. Corn is about the only crop grown, and the type is admirably adapted to this crop, yielding in favorable seasons from 50 to 60 bushels per acre. Occasionally, if the crop has been late in getting started, it is injured by early frosts. Clover does well on the higher and better-drained areas, yielding from 1 to 2 tons of hay per acre.

Muck.

Muck consists of more or less thoroughly decomposed vegetable mold mixed with varying amounts of mineral matter. Over most of the Muck areas in this county the vegetable matter is thoroughly decayed, but in a few areas it is only slightly decomposed. These latter areas could be more properly classed as Peat, but on account of the small extent of the type a separation was not made. The peaty areas consist of coarse, raw, fibrous matter in which the vegetable tissue has been only slightly decomposed. Over these areas the soil is light and chaffy, contains some fragments of shells, and gives a slight effervescence when tested with hydrochloric acid. The color of the soil varies from dark-brown to black, being darker in those areas where the vegetable matter has been more thoroughly decomposed. The depth of the soil varies from 2 to several feet. The sub-soil of those areas occurring along the streams consists of all grades of light-colored sand and gravel, while that underlying the type on the uplands is composed largely of dark-gray to mottled yellow clay loam or clay, the color here depending upon the depth to which the organic matter extends.

This soil type is not extensively developed in Tippecanoe County, and occurs as small, isolated areas, mostly in the southern and southwestern parts of the county. Along some of the streams the type marks abandoned channels that have passed the lagoon stage, where the soil has been formed by the long-continued growth and decay of aquatic vegetation. Some of the areas occur at a considerable elevation above the present stream channels, so that it is probable that the moisture necessary to the growth of muck-forming vegetation was supplied by seepage from the bluffs.

The natural drainage is poor. When artificially drained the type is adapted to the production of corn, potatoes, onions, and celery. It is also well suited to rape and timothy and other grasses. Corn is the principal crop grown. On some areas of the type good yields are secured, but on those areas where the soil is light and chaffy, resembling Peat rather than Muck, the crop is poor both in yield and quality and very frequently fails to mature. Oats and other small grains can not be successfully produced, because the large organic-matter content forces the growth of straw at the expense of the grain, and the crops lodge badly.

Miami Gravelly Sandy Loam.

The soil of the Miami gravelly sandy loam to a depth of 12 or 14 inches consists of a sticky, heavy coarse gravelly sandy loam. The color varies from light to dark brown, and in some cases is a reddish-brown. The surface is generally covered with considerable gravel, which is seldom more than 1 or 2 inches in diameter. Gravel also occurs distributed through the soil, and as a rule increases in quantity with depth. The greatest quantity is found on the crests of hills and ridges and gradually decreases on the lower slopes.

The soil grades at about 14 inches into a light-brown heavy sandy loam in which there is considerable coarse sand and fine gravel. Small gravel is also found in the subsoil, the size and quantity generally increasing with depth. From 30 to 36 inches below the surface a layer of gravel is encountered which extends to an undetermined depth. Very frequently pockets of coarse sand and gravel occur in the hills and ridges, but these are seldom over a few rods across. On such areas the soil consists of a dark-brown coarse sandy loam to a depth of 10 or 12 inches, below which it grades into sand and small gravel. Below this material the subsoil is composed of alternating layers of sand and gravel, with the gravel gradually increasing in size with depth. Near the base of ridges and along the foot of terrace lines the soil generally becomes sandy and less gravel is found. The sand is also much finer.

The average results of mechanical analyses of fine earth of this type are given in the following table:

MECHANICAL ANALYSES OF MIAMI GRAVELLY SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13598, 14013	Soil	4.0	22.4	15.1	18.3	7.4	19.9	12.3
13599, 14014	Subsoil	2.7	20.9	12.6	16.7	9.2	20.0	17.7

The Miami gravelly sandy loam is found on the uplands, principally in the southwestern part of the county, and on well-developed terrace lines along the streams. While occupying different topographic positions, there is little variation in the texture or the crop value of the soil, so far as could be observed in the field.

The soil is of glacial origin. The low hills and ridges which occur to a limited extent were probably formed by the action of ice and probably were at one time covered with loess, which has since been removed by erosion. The soil of the terrace lines is composed of glacial material which has been slightly modified and reworked by stream action. The surface of the type on the terraces is level or gently rolling, while on the uplands occur low, well-rounded hills and ridges. The type in general possesses good natural drainage. In some cases, especially on the more elevated areas, the drainage is excessive and crops do not do well unless there is an abundance of rainfall. The soil has, however, the power of retaining moisture exceptionally well, considering its coarse, gravelly texture. The crops produced do not as a rule suffer from drought as much as those grown on the Sioux sandy loam.

Corn, clover, oats, and wheat are the principal crops. The yields are generally best when the rainfall is quite evenly distributed throughout the growing season. The yield of corn is about 30 bushels, oats 25 bushels, and wheat from 10 to 15 bushels per acre. Clover will yield from 1 to 1½ tons of hay and from three-fourths to 1 bushel of seed per acre.

Sioux Sandy Loam.

The surface soil of the Sioux sandy loam consists of a medium to coarse sandy loam with an average depth of about 16 inches. The sand content is quite high and usually increases with depth. The color varies from light to dark brown and in some areas where the soil contains more organic matter the color is somewhat darker.

Fine gravel is found on the surface and through the soil. There is no sharp line of demarcation between the soil and subsoil, but the change from one into the other is gradual. At a depth of from 14 to 18 inches the soil grades into a sticky coarse sandy loam or sandy clay subsoil containing considerable coarse sand and gravel. The gravel content generally increases with depth, and at a depth of 33 to 36 inches a bed of coarse gravel is encountered which extends to an undetermined depth. The color of the subsoil is brown, but it has more of a reddish tinge than the soil. Northeast of Lafayette the soil varies somewhat from its typical formation, containing a smaller amount of gravel and the gravel being finer than is generally the case.

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

MECHANICAL ANALYSES OF SIOUX SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
13602, 14019,	Soil	2.2	9.8	10.2	28.5	10.3	27.1	11.2
13603, 14020,	Subsoil	3.5	11.5	10.2	30.4	11.6	18.8	13.4

The Sioux sandy loam is an old alluvial soil and is found only where second and third bottoms are developed along the streams. It is most typically developed along the Wabash River and Wildcat Creek and their tributaries. The soil owes its origin to stream action. The coarse material which forms the subsoil was deposited at times when the streams had sufficient velocity to transport coarse sand and gravel. Following the deposition of this coarse material the finer and more loamy material was deposited as the velocity of the streams diminished, thus forming a sandy loam. The surface varies from level to slightly undulating. The level areas generally occur along the border of the terraces and uplands, while near the outer margins of the areas the surface becomes more uneven. In some areas the surface is broken by shallow abandoned stream channels and by streams flowing from the uplands.

Owing to the topographic position of the soil, its open, porous texture, and the fact that it is underlain by sand and gravel, the natural drainage conditions are good. In most cases it is even excessive, and except during seasons of unusually heavy rainfall crops suffer from lack of moisture. The type is never overflowed.

Corn, wheat, oats, and clover are the principal crops grown on this soil. The crop yields are heaviest during wet seasons. The average yield of corn is about 35 bushels, oats about 30 bushels, wheat 12 to 20 bushels, and clover about $1\frac{1}{2}$ tons per acre when raised for hay and 1 bushel when raised for seed. The Sioux sandy loam is well adapted to these crops and is generally recognized as one of the best wheat soils in the county.

Sioux Loam.

The soil of the Sioux loam consists of a dark-brown to black loam about 15 inches deep, containing a large percentage of silt, some coarse sand, and a few pebbles or fine gravel. The dark color is due to the large amount of organic matter present. The subsoil is a brown or reddish-brown loam of about the same texture as the soil and is underlain at an average depth of 2 feet by a bed of gravel many feet in depth, which constitutes the chief material of the river terraces. In some places this gravel comes to the surface, and these small areas are of low agricultural value.

The only area of this type occurs upon the high terrace immediately southwest of West Lafayette. The State University farm is located upon it. The surface is nearly level, but the underlying gravel bed gives thorough underdrainage. In fact, the lower subsoil is so open and porous that water readily passes through it, causing crops to suffer quickly from drought. The large amount of organic matter present in the soil assists greatly in the retention of moisture, thus diminishing the damage from this cause.

This soil type consists of glacial material reworked by the swollen streams at the close of the Glacial epoch. The sand and gravel were laid down by swift currents, but when the water began to subside finer material was deposited, giving rise to the thin layer of loam over the coarser sand and gravel.

The yields upon this type depend very largely upon the rainfall and the depth to the underlying gravel. Where the layer of loam is 2 feet or more deep large yields are secured in seasons of abundant rainfall. A drought at the critical period in the growth of a crop causes a very decided decrease in the yield.

A sample of this soil taken from the university farm, 20 rods south of the experiment station building, was studied by the paraffined wirepot method to learn something of its manurial requirements. The soil is a dark-brown or black loam. It contains some coarse sand, and a few pebbles and fine gravel are found on the surface, while the subsoil is of a gravelly nature. The field from which the sample was taken has been in corn continuously for the last twenty-five years without the use of manure or other fertilizer.

The results obtained indicate that a large increase in production may be obtained by the use of stable manure; that nitrate of soda and sulphate of potash will give a small increase; while only a very small increase may be obtained by the use of any other form of fertilizer tried. Lime alone or with cowpeas or acid phosphate slightly diminished the yield.

In these tests wheat plants were used as an indicator, and the results are held to be applicable only to this crop and to the particular field from which the sample was taken, but they are believed to apply in a general way to this soil throughout a large part of the area.

Sioux Silt Loam.

The soil of the Sioux silt loam consists of a dark-brown or black friable silt loam with an average depth of 15 inches. It contains a very large percentage of organic matter which gives the dark color. The subsoil consists of a yellowish heavy silt loam or clayey silt, containing brown iron stains and some iron concretions. At a depth of from 3 to 6 feet the silty deposit is underlain by coarse sand and gravel, which extends to a depth of many feet.

The Sioux silt loam occupies only a small percentage of the area, the only occurrence being found upon the high terraces along the Wabash River and is covered almost entirely by West Lafayette. The surface features of the type are gently rolling or undulating. The underlying gravel bed insures good drainage.

The soil was probably formed at the same time that the loess or silt was deposited upon the uplands. The underlying gravel beds were laid down by the swollen streams at the close of the Glacial period.

The Sioux silt loam is a strong, fertile soil, easily cultivated and capable of large yields of general farm crops. The greater part of the type, however, is covered by West Lafayette, and very little therefore is under cultivation.

Agricultural Methods.

The cultural methods generally practiced in the county apply almost exclusively to the production of corn, oats, and wheat. On many farms, particularly those on the Marshall loam areas, no wheat is grown, and corn, oats, and some clover are the principal crops.

In the preparation of the land for corn about 5 inches is the usual depth for both spring and fall plowing. In some cases, especially if the land has been in corn the preceding season, the disk harrow is used to stir up the ground, after which the peg-tooth harrow is used for pulverizing and leveling the soil. Some farmers drill their corn, but the general practice is to plant with a check rower and cultivate both ways. Shallow cultivation is the general rule, although deeper cultivation is frequently necessary in wet seasons when weeds are especially troublesome. On a few farms a part of the corn crop is cut for ensilage, while on a larger number it is cut, usually with a corn binder, shocked, and husked by hand. These methods are not widely practiced, however, as probably more than 90 per cent of the corn is husked from the standing stalks.

Oats are generally sown broadcast over the corn land and a disk harrow used to loosen the surface and cover the seed. In some cases the land is harrowed after disking. When the oats mature they are cut with self-binders and thrashed from the shock.

Winter wheat is a somewhat uncertain crop in regard both to yield and quality. Many farmers, particularly those located on the light-colored soils, continue to grow this grain, because it alternates easily with either corn or oats and clover, making an excellent nurse crop for clover and affording a needed change in the crop series. Some farmers drill their wheat in the cornfield between the rows of stalks, using a one-horse drill for this purpose. This method is satisfactory if the ground is free from weeds and the seeding is done somewhat earlier than if sown on open land. A large proportion of the wheat grown is sown on land that has been in oats the previous season. Soon after the oat crop has been removed the stubble land is plowed to a depth of 4 or 5 inches and well harrowed. The seed is drilled in, usually during the last two weeks in September. It has been observed that the best fall growth is obtained when the seed bed is prepared as early as practicable. This is probably due to the fact that the soil moisture is thus conserved, usually a very necessary factor at this season of the year.

Timothy and clover are quite extensively grown for hay. On the typical prairie soils, particularly the Marshall loam, clover is sown with oats, as wheat can not be grown on this soil; but on the lighter soils wheat is preferable with clover, because it draws less upon both the moisture content and the available plant food of the soil, and consequently there is less danger of the clover doing poorly after the nurse crop has been removed. The first crop of clover is cut for hay, but if the second crop promises a good yield of seed it is allowed to ripen and is thrashed.

There are practically no farms upon which a systematic rotation of crops is practiced. In certain parts of the county, however, it has been found unprofitable to grow the same crop continuously for any considerable length of time upon one field. In such cases the rotation considered by the farmers as best adapted to the soil is one or possibly two years of corn and one year of oats or wheat. If oats are grown, they are followed by wheat, used as a nurse crop for clover. In some cases the oat crop is omitted and the rotation practiced is one year of corn, one year of wheat, and one year of clover. On the heavier soils corn and oats, with an occasional crop of clover, is the rotation generally practiced. Many farmers grow corn as long as possible, the land being planted to this grain for three or four seasons, and then one crop of oats is raised. In some cases the farmers alternate corn and oats from year to year. In either case clover is generally introduced once in four or five years. The limited quantity of barnyard manure on hand is usually applied to land intended for corn. Commercial fertilizers have been tried in some parts of the county, but their use is not becoming general.

Agricultural Conditions.

During the last five years there has been a marked increase in the valuation of farms in the county. This is due in part to the advance in the average price of agricultural products and the comparatively high rents which good lands readily command. The valuation of farm lands and implements according to the census of 1900 was $16,023,930. The majority of the land owners are in prosperous circumstances, but as much can not be said of the tenant class, who enjoy a comfortable living, but are not, as a rule, acquiring much property other than their teams, farming implements, and a limited number of cows and hogs. In the last fifteen years many of the farmers have moved to town and now live upon the rent received from their land. In every neighborhood the number of tenant farmers is increasing. A good many men who own and live upon large farms rent most of their tillable land, and thus avoid the employment of hired help and the details of farm management. More than one-half of the individual farms and a large proportion of the cultivated lands are operated by tenants. According to the census of 1900 only 44.6 per cent of the farms of the county were operated by owners.

The usual rent paid is one-half the crop, and in most cases the tenants deliver the grain at the elevators. Some landlords also exact a fixed cash payment for the use of the house and other buildings. The cash rent for good land varies from $4 to $5 an acre. The average size of farms for the county is 118.7 acres. In those parts of the county which were formerly timbered the farms are generally smaller than on the prairies. There are a few large holdings of 1,000 acres or more, but these consist of separately managed farms.

How to secure necessary farm labor is a very serious problem with the farmers of Tippecanoe County, and the difficulty of solving it is largely responsible for so many of them renting their lands and moving to town to live. About $270,500 is paid out annually for labor. A farm hand receives from $22 to $25 a month, with board for himself and a horse if he wishes to keep one. Three cents a bushel is paid for husking corn, and wages for other kinds of work are seldom less than $1.50 a day.

There is considerable difference in the agricultural value of the different soil types. The Marshall loam and the Marshall silt loam are the best corn soils and are worth from $90 to $125 an acre. The level areas of the Marshall fine sandy loam approach these heavier soils in value, but some of the sandy phases of this type and those which have a gravelly subsoil are rated somewhat lower on account of their susceptibility to drought.

The topography of the Miami silt loam usually determines its agricultural value. Broken areas along streams are commonly used for pasture, and some areas are in timber. The level areas have a market value somewhat lower than similarly improved farms of the Marshall loam and Marshall silt loam.

On the Miami fine sand and the Wabash fine sandy loam melons, small fruits, and early truck are successfully grown for the home market. Some of the Miami gravelly sandy loam and much of the Miami silt loam is adapted to apples, pears, and peaches. The poorer quality and lower yields of these fruits, compared with those reported a few decades ago, are doubtless due to causes other than those which may be attributed to the soil. The orchards are usually located without regard to the slope of the land or protection from wind, while the study of varieties adapted to this locality and the necessary care of the trees are almost wholly disregarded.

The variety of soils in the county affords opportunity for a diversity of products, but the tendency toward the exclusive production of grain is shown by the fact that the annual acreage of corn —approximately 100,000 acres—is 30 per cent greater than it was twenty years ago. The area now devoted to oats is about 50,000 acres, or nearly five times as much as it was two decades ago. The acreage of wheat varies from year to year, but is steadily decreasing.

With the exception of wheat, which often fails to mature well, the quality of the grain is generally good. Much of it, however, fails to grade well on the market on account of being damaged before leaving the farm. Oats and wheat usually remain in the shock until they are thrashed, and a great deal of corn, especially on the rented farms, is carelessly cribbed.

All of the wheat and nearly all of the oats are shipped out of the county. Of the 3,250,000 bushels of corn annually produced, about 65 per cent is sold at the elevators.

The comparative ease with which these cereals can be grown and harvested with the aid of machinery and the sure returns they afford commend them to both the landowners and the tenants. This system of farming is recognized as exhaustive of the soil, but clover is considered an easily introduced restorative. Too much dependence, however, is being placed upon this legume. Generally the first crop is cut for hay and the second is harvested for the seed, so that most of the vegetable matter above ground is removed from the field. While the nitrogen supply is reasonably well maintained, very little humus is added to the soil. The physical condition of all the upland types, excepting recently drained areas, is not so good as formerly. More labor and better methods are required to keep the soils in good condition during the growing season.

On the average farm the amount of manure produced is small as compared with the acreage of land cultivated. This is due to the small number of cattle usually kept. Cattle feeding has greatly declined of recent years, and dairying has not been developed to any extent except in the neighborhood of Lafayette. The number of cows a tenant can keep is restricted by the high rate of rent for pasture, while the farmers living on their own land usually sell most of the young stock. This limits the acreage of clover, which can be utilized profitably for pasture. The total acreage of this crop in the county has decreased during the last ten years. Since there is a good market at Lafayette for oat straw, a great deal of this roughage is sold direct from the farms.

Under present conditions there is an increasing tendency to adopt methods of farming which make slight returns to the soil. The results are already apparent in the case of many rented farms. The most of the farmers living on their own land would adopt more diversified lines of farming, especially dairying and stock raising, were it not for the high cost and unreliable nature of most of the hired labor which can be secured. This is a serious difficulty, with apparently no prospect of immediate improvement.

Stock raising is a profitable business wherever the owner gives it his personal attention. Most of the corn now consumed in the county is fed to hogs. On most of the farms the income from this source is greater than that received from the sales of all other kinds of live stock. There are a number of farmers who devote much attention to stock breeding. Some well-bred herds of cattle and flocks of sheep are to be seen, and some excellent horses are raised.

Lafayette furnishes a good market for most of the produce grown in the county. The Wabash, the Lake Erie and Western, the Chicago, Indianapolis and Louisville, and the Cleveland, Cincinnati, Chicago and St. Louis railroads pass through the county and afford good shipping facilities to Chicago, St. Louis, and the East. The Toledo, St. Louis and Western Railroad crosses the southeastern corner of the county. There are 17 elevators in the county, located at various points on these lines. There are also two interurban electric railroads now in operation. The county roads are excellent. All of them are well graded, and more than 1,000 miles of roadway have been surfaced with gravel.

Soil Survey of Marshall County.

By Frank Bennett and Charles W. Ely.
U. S. Bureau of Soils.

LOCATION AND BOUNDARIES OF THE AREA.

Marshall County lies in the north-central part of the State of Indiana, only one county—St. Joseph—separating it from the

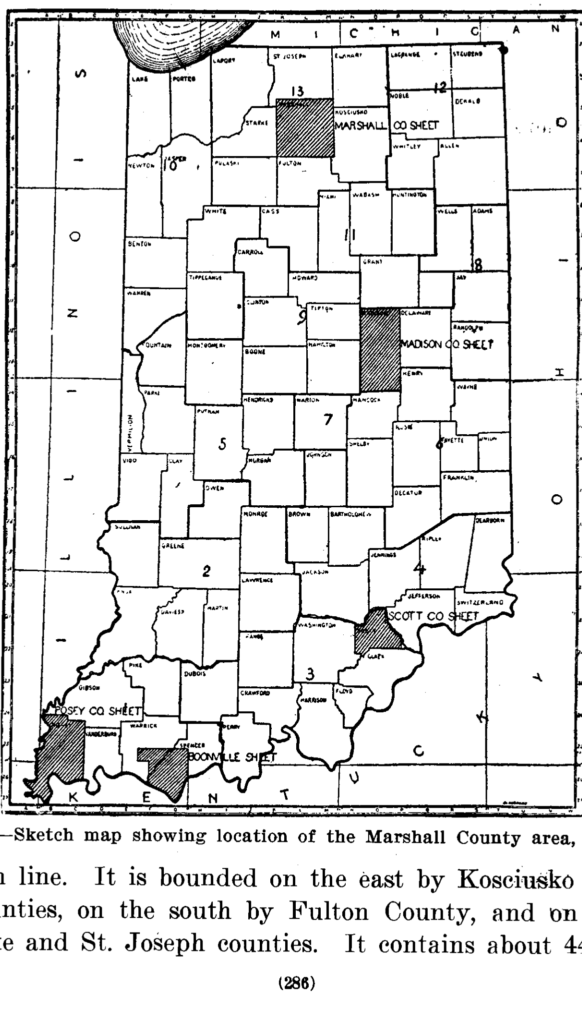

Fig. 1.—Sketch map showing location of the Marshall County area, Indiana.

Michigan line. It is bounded on the east by Kosciusko and Elkhart counties, on the south by Fulton County, and on the west by Starke and St. Joseph counties. It contains about 445 square miles. Plymouth, the county seat, situated a little to the west of the center, is 84 miles southeast of Chicago by rail, and 108 miles north of Indianapolis.

History of Settlement and Agricultural Development.

Prior to the organization of Marshall County this region was inhabited almost exclusively by Potawatomi Indians, who were very numerous here. The first cession of lands now embraced in Marshall County was made by the Indians at a treaty near Rochester, whereby they gave up a strip of land 1 mile in width through the present limits of the county to enable the whites to establish the Michigan road, a highway extending from Indianapolis to Michigan City via Logansport and South Bend. These road lands were offered for sale in 1832 and the proceeds were devoted to the building of the Michigan road, which extends through the center of the county in a north and south direction, following the boundary between the level and the rolling topography of the county.

A few years after the sale of the Michigan road lands most of the lands within the present limits of the county were given up by the Indians, who, after 1838, ceased to be an important factor in the history of Marshall County.

At this time immigrants from Ohio, Pennsylvania, and other Eastern States were rapidly coming into the county, and as the Michigan road was the first one opened, they naturally established themselves in its vicinity. Many of the settlers were Germans, some of whom came direct from the mother country.

The greater part of the county was originally covered with a heavy growth of timber, consisting principally of walnut, oak, and poplar. This timber, except the little that was used for building material, was either burned or destroyed in any possible way to clear the land. As the country became more thickly settled and transportation facilities improved, the lumber business became an important industry in the development of the county. The period from 1860 to 1870 was the most prosperous for this industry.

The first crops grown in Marshall County were corn, wheat, oats, rye, and beans. The soil was prepared by what was known as a "jumping plow" or "breaking shovel," drawn by several yoke of oxen. Grain was sown broadcast and dragged in with a brush. Corn yielded from 25 to 50 bushels per acre. Wheat was frequently a failure, but in favorable years produced from 14 to 18 bushels.

Oats were not a great success. Rye was used principally for feed and pasture, rarely being thrashed. Potatoes gave a large yield, and seemed to be of better quality than those produced at the present time. The sandy soils were best adapted to this crop. The early settlers grew a little tame hay, but depended mostly upon marsh hay or corn fodder for their stock feed. When hay was scarce the stock often lived on the buds of the basswood for long periods. Flax was also grown for many years and manufactured into homespun clothing.

About 1865 the farmers began to realize that the soils were becoming less productive, and began to grow clover to maintain their productiveness. Timothy was also introduced about the same time.

When first settled a large part of the county comprised swampy areas, but as it became more thickly settled some attention was given to drainage, though no well-planned system was inaugurated until 1876. Since that time more or less drainage work has been in progress every year, and a great many open ditches and tile drains have been constructed, while the Yellow River, in the northeastern part of the county, has recently been dredged. Many open ditches, into which tile drains empty, are seen in the eastern and northeastern parts of the county. Some of the most productive lands in the county have been made available for agricultural purposes by artificial drainage, and at the present time there is little land that is not well drained, aside from the Muck areas, and in some of the latter drainage work is now in progress.

Climate.

The following table, taken from the records of the Weather Bureau stations at Syracuse and South Bend, shows the mean normal monthly and annual temperature and rainfall. South Bend is about 24 miles north and Syracuse 26 miles northeast of the center of the county.

NORMAL MONTHLY AND ANNUAL TEMPERATURE AND PRECIPITATION.

Month.	Syracuse.		South Bend.		Month.	Syracuse.		South Bend.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*		*°F.*	*Inches.*	*°F.*	*Inches.*
January	25.2	2.47	29.2	2.99	August	72.4	3.19	72.8	3.12
February	24.0	2.32	22.8	2.14	September	63.8	2.76	65.7	2.90
March	34.2	4.00	35.6	2.99	October	54.8	3.55	54.2	2.44
April	50.7	1.93	50.4	1.77	November	40.2	3.74	39.7	3.12
May	62.6	3.77	60.8	3.09	December	27.4	3.07	27.8	3.07
June	69.3	3.60	70.5	2.45					
July	75.4	4.71	74.1	3.57	Year	50.0	39.11	50.3	33.65

The figures show a fairly uniform distribution of rainfall throughout the year, with the maximum during the growing season. The temperature is characterized by sudden changes during the period from October to April, and by alternate freezes and thaws, which sometimes seriously damage crops.

The average date of the last killing frost in spring is April 20, and of the first in fall October 10, giving a growing season of approximately 172 days.

Physiography and Geology.

The entire area of Marshall County is covered to a great depth by the deposit of drift of the Glacial period. No outcrops of stratified rock are seen, nor have they been reached by any of the many borings. The character of the surface material varies with the topography.

Generally speaking, a line running north and south through the center of the county separates the sandy soils from the clay soils. What are known as the "clay soils" have been mapped as the Marshall loam, which is found principally east of this line. The sandy soils include the Marshall sandy loam, Miami sand, and Marshall sand, and occur west of the dividing line. The topography of the western part of the county is quite rolling, with intervening depressions or slight valleys. Going westward from central points in the county the country assumes a more rolling topography, the bowlder clay being found at greater depths, while the amount of sand increases until finally the "sand barrens" are reached. These barrens, which have been mapped as the Miami sand, seem to be wind-blown deposits and to have some of the characteristics of sand dunes, though in a few places they have the appearance of old beach lines. Some of this sand at the present time is subject to wind action. This sandy region is said to be very similar to that bordering Lake Michigan. The topography of the country along the Yellow River and the lakes is usually very rolling, very little marsh and bottom lands being found. That part of the county lying east of the line above described is level or gently rolling, though there are small areas of a more rolling topography.

There are many basins or depressions in all parts of the county that are locally known as marsh, and have been represented on the map as Muck.

The beds of the streams are usually in the gray or the bluish till, and are covered by a stratum of washed gravel, sand, and bowlders. In many parts of the county bowlders are scattered over the surface. These are chiefly of granite, gneiss, and other metamorphic rocks. From the borings made these rocks seem to be more abundant on the surface than at lower depths.

Many rounded knolls, composed of both stratified and unstratified drift material, appear in different part of the county. These are most numerous in the Marshall sandy loam.

In many of the gravel pits the stratification is clearly outlined, the material being rounded gravel, clay, and sand, which is extensively used for road construction. Good tile and brick clays are plentiful.

There are many lakes in Marshall County, which are fed from springs that may either flow from the lake basins or along the shore line. The largest and most important of these are Lake Maxinkuckee and Lake of the Woods. The lake bottoms consist of an impervious blue clay, and below this is a mass of sand and gravel from which the springs flow. Marl is sometimes found in the lake beds. There is a large number of flowing wells in the county, these being especially numerous around Lake Maxinkuckee. These have the same source as the springs, being fed from the sand and gravel underlying the blue or gray clay.

The county is drained principally by the Yellow River, which flows across it in a general southwesterly course, though it flows directly west for a distance of about 7 miles just before it leaves the county. Yellow Bank and Pine creeks drain the northwestern corner, while the Tippecanoe River drains the southeastern corner.

SOILS.

The soils of Marshall County have been classified into nine types, including Muck and Meadow. They range in texture from sand to clay loam, and thus offer opportunity for the production of a diversity of crops.

The following table shows the extent of each type, and the map accompanying this report gives the distribution:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall loam	121,216	42.7	Meadow	6,784	2.5
Marshall sandy loam	77,184	27.3	Miami clay loam	3,392	.8
Miami sand	27,840	9.8	Miami black clay loam	1,536	.5
Muck	24,768	8.7	Miami gravelly sandy loam	1,216	.3
Marshall sand	20,672	7.4			
			Total	284,608	

Marshall Loam.

The Marshall loam, to a depth of 14 inches, consists of a brown loam containing much sand, underlain to a depth of 18 inches by a yellowish-brown loam, which is slightly more tenacious than the surface soil. The subsoil, from 18 inches to 3 feet, is a yellow, sticky sandy loam, often containing some gravel.

A few bowlders, sometimes measuring 3 or 4 feet in diameter, and some smaller stones are occasionally scattered over the surface, but the greater part of these have been removed. Large piles are often seen in the fields, and they are sometimes used in constructing fences.

The soil is often heavy enough to form clods, but these are easily broken by the harrow and roller. When put in a good state of tilth the soil becomes a very mellow loam.

There are some small areas where the soil is heavier in texture and darker in color than the typical phase, and often extends to a depth of 18 or 20 inches. The subsoil in such places is a yellowish-drab sandy clay. A small portion of this phase had to be artificially drained before cultivation was a success.

The Marshall loam occupies the largest and most uniform areas of any soil type in the county, though frequently small areas of the other types are found scattered through it. It occupies the greater part of the eastern half of the county, while west of the central dividing line it occurs in comparatively small areas, except in the extreme northwestern corner, where a spur of the main body of the type extends beyond the line.

The Marshall loam is generally level or undulating in topography, though it is found to a slight extent upon rounded knolls and narrow ridges, in which position the soil is often quite gravelly, and stones are scattered here and there over the surface, while the subsoil is a mass of gravel, sand, and clay, which is often used for road material. This phase is not so productive, nor is the soil so deep as that found occupying a more level topography. The average depth of the soil would probably not exceed 8 inches. These knolls and ridges are found chiefly in the small areas of the type occurring in the southwestern part of the county.

In many places along the boundary line between the Marshall loam and the Marshall sandy loam the former has a tendency to become more rolling.

The level areas frequently contain a small amount of gravel, but in no case in sufficient quantities to cause any serious trouble in cultivation. This was most noticeable in German township. Along the northern boundary of this township, which forms part of the county line, the soil had the lighest color of any of the types encountered in the area, and had the survey extended farther north it might have developed into some other type.

The Marshall loam was originally covered with a heavy growth of black walnut, and is still locally known as the "black walnut land." Occasionally a small patch is seen with its original timber, which has been kept as a small forest reserve.

All of this type at the present time has adequate drainage, though tile drainage and other artificial aids were necessary before some of it could be cultivated. The small forest reserves or woodlots are about the only spots not at present under cultivation.

The Marshall loam is generally recognized as the best soil in the county for general farming, being well adapted to nearly all crops grown in the area, and producing larger yields than any other soil type. It is especially adapted to corn, wheat, clover, and timothy. Corn yields from 35 to 70 bushels per acre, clover and timothy from 1 to 2 tons, and wheat from 15 to 18 bushels.

The following table shows the results of mechanical analyses of typical samples of the fine earth of the Marshall loam:

MECHANICAL ANALYSES OF MARSHALL LOAM.

No.	Locality.	Description.	Fine Gravel, 2 to 1 mm. Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm., Per Cent.
11970	SE. 40 of NE. ¼ sec. 7, T. 33 N., R. 4 E.	Brown light loam, 0 to 12 inches.	1.1	5.4	9.8	27.6	11.0	28.8	16.2
11972	SE ¼ sec. 19, T. 33 N., R. 3 E.	Brown light loam, 0 to 14 inches.	1.4	12.5	14.9	26.2	4.1	21.6	19.2
11971	Subsoil of 11970......	Yellow sticky sandy loam, 12 to 36 inches.	1.9	5.2	8.4	31.1	11.3	25.2	16.5
11973	Subsoil of 11972......	Yellow sticky sandy loam, 14 to 36 inches.	2.2	12.5	15.2	27.4	4.5	19.3	18.9

Marshall Sandy Loam.

The soil of the Marshall sandy loam to a depth of 10 inches is a dark or light-brown sandy loam, underlain by a yellow sand to a depth of 20 inches. Immediately below this is found a yellow sandy clay, or in some cases gravelly clay.

This type has usually a rolling topography and generally occurs as irregular ridges composed of rounded knolls. The soil in the intervening depressions is a heavy, black sandy loam, often 18 inches deep, while the subsoil is darker in color than that found on the higher elevations and contains less gravel. Occasionally the subsoil, from 18 to 36 inches, is a heavy, bluish-gray sandy loam. On the rounded knolls the soil is often quite gravelly, and there are many spots of only a few acres which would have been classed as a gravelly loam had they been large enough to represent on the map. The subsoil in these cases often contains such a high percentage of gravel that it is very difficult to make a boring 3 feet deep, and in other places it is almost pure sand and gravel. A few comparatively level areas are seen near the streams, where both the soil and subsoil become quite gravelly. Bowlders, chiefly of granite, are found scattered on the knolls and ridges, and to some extent over all the type, but they are much more plentiful on the knolls. Many small spots of the Miami sand are also found, usually occupying the tops of the ridges, similar to the position of the gravelly phase just described. These spots of sand and gravel are clearly defined during the growing season, as the crops upon them frequently suffer from lack of moisture. The most typical Marshall sandy loam is found on the sides or slopes of the ridges, where the topography is only gently rolling.

The depth of the clayey subsoil varies somewhat, being often 25 inches, which of course accounts for some variation in crop yields.

Probably three-fourths of the Marshall sandy loam is found west of the line heretofore described. The largest area of the type extends north and south through the town of Plymouth, and touches the western boundary of the county in only one place. In the eastern half of the county the greater part of the type lies along the Yellow River and in the southeastern corner of the county.

The Marshall sandy loam, while occurring in broad and somewhat uniform areas, is frequently spotted with the other soil types. It also occurs in small areas in the Marshall loam, which are easily detected by their slight elevation above the adjacent soil.

This type occupies about one-fourth of the area surveyed and is next in importance to the Marshall loam. It is especially adapted to the growing of cucumbers for pickles, and to beans, peas, Irish potatoes, and small fruits. The average yield of cucumbers is about 100 bushels, though 200 bushels per acre have been produced. Corn yields from 25 to 55 bushels, wheat from 12 to 18 bushels, and potatoes from 80 to 170 bushels per acre. Clover and timothy also give fair yields, especially the former.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

MECHANICAL ANALYSES OF MARSHALL SANDY LOAM.

No.	LOCALITY.	DESCRIPTION.	Fine Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm., Per Cent.
11962	SW. 40 of NW. ¼ sec. 11, T. 32 N., R. 2 E.	Dark light sandy loam, 0 to 5 inches.	0.5	5.3	17.4	48.0	8.8	11.7	7.8
11968	SW. ¼ sec. 29, T. 32 N., R. 1 E.	Brown sandy loam, 0 to 12 inches.	1.7	8.5	14.4	32.2	8.4	21.0	13.6
11963	Subsoil of 11962......	Yellow sticky sandy loam, 15 to 36 inches.	2.1	7.0	13.0	37.5	12.2	14.1	13.6
11969	Subsoil of 11968......	Yellow sandy clay, 12 to 36 inches.	1.4	5.6	7.3	21.0	9.8	28.5	25.8

MIAMI BLACK CLAY LOAM.

The soil of the Miami black clay loam, to a depth of 8 inches, is a black clay loam having the characteristics of a clay when wet. It is apt to break up into large clods, but unless handled when too wet or too dry can be put into a good state of tilth, becoming quite loamy. The subsoil, from 8 to 36 inches, is a stiff, mottled yellow and blue, or blue clay. Occasionally a considerable amount of sand is found in both soil and subsoil, and a few small gravel are sometimes seen scattered over the surface.

The greater part of the type is under cultivation, though most of it had to be artificially drained to a certain extent before it could be farmed, and there still remains a small portion too wet to give good crop yields. The soil is heavy in texture, and is one of the last to warm up in the spring, yet when well drained it is probably the best corn-producing soil in the county.

The Miami black clay loam is quite limited in extent in Marshall County. It is found only in Bourbon and German townships, most of it in the former, and is distinctly level in topography. Though especially adapted to corn, it is used to some extent for hay and pasture. In good seasons corn yields from 40 to 75 bushels, and hay from 1 to 2 tons, per acre.

The following table shows the results of mechanical analyses of typical samples of this soil:

MECHANICAL ANALYSES OF MIAMI BLACK CLAY LOAM.

No.	Locality.	Description.	Fine Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm., Per Cent.
11984	SE. 40 of NW. ¼ sec. 2, T. 34 N., R. 3 E.	Black loam, 0 to 12 inches.	0.7	8.4	19.8	30.2	5.0	14.7	20.7
11986	NW. 40 of NE. ¼ sec. 35, T. 34 N., R. 3 E.	Black clay, 0 to 8 inches.	.1	2.2	4.6	12.2	4.3	36.0	40.6
11985	Subsoil of 11984......	Gray sandy clay, 12 to 36 inches.	.4	9.5	19.7	27.8	4.6	12.5	24.9
11987	Subsoil of 11986......	Mottled clay, 8 to 36 inches.	.3	2.8	6.2	12.2	2.9	24.5	50.6

Miami Clay Loam.

The soil of the Miami clay loam, to a depth of 10 inches, is a yellowish-white loam containing between 30 and 40 per cent. of sand and the same quantity of silt, underlain to a depth of 16 inches by a yellowish loam containing a lower proportion of sand, beneath which is a yellow silty, sandy, or gravelly clay. The material from 10 to 16 inches is usually somewhat more tenacious than the surface soil. When dry the soil is almost white in color, but when damp it becomes a dark gray.

Most of this type has more or less gravel scattered over the surface and through both soil and subsoil, and in some places it partakes of the nature of a gravelly loam.

The type occupies narrow ridges, usually near lakes or around Muck areas, and is rather rolling in topography, though occasionally a comparatively level area is found. Near the lakes both soil and subsoil are more silty in character, and as a rule there are fewer stones than is the case farther away.

The Miami clay loam occurs in small areas in the western part of the county, only one area being found in the eastern half, near the southern boundary. Erosion has been greater on this soil than on any other within the area.

The type at present is of low agricultural value, but on account of its physical properties it should produce fair crop yields. Some of the more level areas, when carefully cultivated, produce from 25 to 40 bushels of corn per acre, from 14 to 18 bushels of wheat, and good yields of hay. The more hilly portions should produce good bluegrass for pasture and would very likely prove excellent for fruit.

The following table shows the results of mechanical analyses of the fine earth of typical samples of the Miami clay loam:

MECHANICAL ANALYSES OF MIAMI CLAY LOAM.

No.	Locality.	Description.	Fine Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm., Per Cent.
11976	SW. ¼ sec. 13, T. 33 N., R. 2 E.	Gray silty loam, 0 to 10 inches.	1.6	4.8	6.9	22.9	8.0	36.2	19.1
11974	½ mile S. of Lapaz...	Gray silty loam, 0 to 15 inches.	1.9	5.4	5.3	19.7	10.3	34.9	21.6
11977	Subsoil.............	Yellow silty clay, 10 to 36 inches.	1.4	3.5	3.3	12.0	7.4	39.0	33.0
11975	Subsoil of 11974......	Yellow silty clay, 15 to inches.	1.4	3.0	3.4	18.0	7.6	32.4	34.1

Miami Sand.

The Miami sand, to a depth of 9 inches, is a slightly loamy grayish or yellowish sand of medium texture. The subsoil, from 9 to 36 inches, is a yellow or orange-colored sand of about the same texture as the soil. Practically the only difference between soil and subsoil lies in the organic matter, which gives the former a darker color and more loamy texture, but there are places on the tops of some of the hills where even this difference does not exist. In the depressions the soil is more loamy, much darker, and extends to a greater depth, hence is more productive, than that on the hills.

Practically all of this type is found in the western half of the county, and most of it along the central western border and along the Yellow River and Lake Maxinkuckee. The few small spots found in the eastern half do not cover more than 1½ square miles.

The Miami sand is very rolling in topography, and much of it resembles sand dunes in form and appearance. In all probability a large portion was formerly old sand dunes on which plants have obtained a foothold and checked the action of the wind. Some of it is even now shifted about by the winds.

Probably one-third of the Miami sand is not under cultivation, and some that was once cultivated has apparently been abandoned and left to grow up in weeds. It is the most unproductive soil in the county, but the smaller areas scattered through the more productive types do fairly well, as they have received more attention than the farmers were able to give to the broader areas. Heavy applications of barnyard manure and a careful rotation of crops are absolutely necessary to secure even fair yields from this soil.

More of this type is covered with timber, in proportion to the total area, than of any other soil type in the county. The trees are chiefly scrub oaks, with a few other trees of fair size scattered here and there. The type is locally known as the "sand barrens," and in its extreme phases little agriculture is attempted.

The following table shows the results of mechanical analyses of the Miami sand:

MECHANICAL ANALYSES OF MIAMI SAND.

No.	Locality.	Description.	Fine Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm., Per Cent.
11978	NE. ¼ sec. 9, T. 33 N., R. 1 E.	Gray sand, 0 to 8 inches	0.4	6.5	25.2	56.6	5.5	2.1	4.4
11980	SW. ¼ sec. 21, T. 33 N., R. 1 E.	Gray sand, 0 to 10 inches.	.8	5.8	18.6	59.9	4.7	4.5	5.0
11981	Subsoil of 11980......	Yellow sand, 10 to 36 inches.	.4	5.3	18.9	65.0	4.1	2.7	2.9
11979	Subsoil of 11978......	Yellow sand, 8 to 38 inches.	.6	6.2	23.0	59.1	5.3	1.8	3.7

Miami Gravelly Sandy Loam.

There is a great variation in the material that forms the Miami gravelly sandy loam, though the soil to a depth of 8 inches is generally a light or dark brown sandy loam, containing a high percentage of gravel and frequently small stones. The subsoil is a gravelly or sandy clay with numerous small stones scattered through it.

The type is found bordering lakes or old lake basins as a chain of rounded knolls or hills, which are generally composed of stratified and unstratified sands, clays, and gravel. One of these knolls may consist almost entirely of sand and gravel, while another near by may be composed of loam or clay; but the brown sandy loam described above predominates, and along the slopes and slight depressions it is comparatively uniform.

The Miami gravelly sandy loam covers only a small portion of the county, the largest area being on the eastern side of Lake Maxinkuckee. Its surface is very rolling and often badly washed. A considerable portion is not cultivated, and on the remainder the crop yields are only fair.

The following table gives the mechanical analyses of the fine earth of this soil:

MECHANICAL ANALYSES OF MIAMI GRAVELLY SANDY LOAM.

No.	LOCALITY.	DESCRIPTION.	Fine Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm Per Cent.
11954	SW. ¼ sec. 23, T. 32 N., R. 1 E.	Brown gravelly sandy loam, 0 to 10 inches.	4.2	13.4	17.9	35.6	7.5	9.8	11.3
11952	SE. ¼ sec. 30, T. 33 N., R. 3 E.	Gray gravelly sandy loam, 0 to 9 inches.	2.2	10.3	12.7	32.4	9.7	19.2	13.2
11953	Subsoil of 11952......	Yellow gravelly sandy loam, 9 to 36 inches.	3.5	11.9	13.1	26.5	7.7	17.4	19.3
11955	Subsoil of 11954......	Brown gravelly sandy loam, 10 to 36 inches.	6.5	17.3	15.7	28.2	4.9	7.0	20.2

MARSHALL SAND.

The first 10 inches of the Marshall sand varies from a gray to an almost black loamy sand underlain, usually to a depth of 3 feet or more, by an orange-colored sand or, in places, a sand of lighter color.

Gravel often occurs in both soil and subsoil, and was found in greater quantities in the areas in the southeastern and northwestern corners than in other parts of the county. In the former instance, where the type borders the Tippecanoe River, the presence of gravel has probably been influenced to a certain extent by the river, though at the present time the soil is elevated above all danger of overflow.

The Marshall sand occurs in five comparatively large areas and a few smaller ones. In extent it is about equally divided between the eastern and western sides of the county, and does not occur through the central portion at all. Some spots of the Miami sand, too small to represent on the map, are found in areas of this type, usually as small knolls or sand mounds elevated a few feet above the surrounding soil. A few areas are seen in this type of soil that are lower and flatter than the general type, and here the soil is deeper, darker, and usually more loamy and more productive than the more elevated portions. The subsoil in these cases rests on almost white sand. Frequently at a depth of 8 or 10 feet a blue clay is encountered. As the topography becomes more rolling the soil assumes a lighter color and is of lower agricultural value. The most productive portion of the type is that found in the northwestern corner of the county, but this is more likely due to better cultivation, to more liberal applications of manure, and to a more careful rotation of crops than to any natural difference in the soil itself.

In the western part of the county the type is found associated with the Miami sand, and the line between the two is at times rather indefinite. There is not a great deal of difference between the Miami sand and the Marshall sand so far as texture is concerned, but the latter occupies a more level topography, and there is more organic matter in the soil, making it darker and more loamy. The crop yields are from 10 to 25 per cent. higher. The Marshall sand is always lower lying than the Miami sand, and does not have such excessive drainage as the latter; consequently there is less leaching, and the organic matter is retained longer. It is nearly always possible to find water at from 6 to 12 feet below the surface.

The greater part of the Marshall sand is under cultivation. It is best adapted to cucumbers for pickles, beans, and Irish potatoes, though corn, timothy, and wheat are extensively grown, but with only fair yields. Corn yields from 25 to 35 bushels per acre, Irish potatoes from 80 to 150 bushels, and other crops in proportion.

The following table shows the results of mechanical analyses of typical samples of the Marshall sand:

MECHANICAL ANALYSES OF MARSHALL SAND.

No.	Locality.	Description.	Fine Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0 mm., Per Cent.
11958	NW. ¼ sec. 28, T. 33 N., R. 1 E.	Brown loamy sand, 0 to 12 inches.	0.4	8.6	30.7	47.4	1.3	5.5	5.8
11956	NW. ¼ sec. 8, T. 34 N., R. 1 E.	Gray medium sand, 0 to 10 inches.	.7	10.7	28.5	45.1	4.2	3.4	6.9
11957	Subsoil of 11956.......	Yellow medium sand, 10 to 36 inches.	.4	11.7	27.4	48.7	4.6	2.5	4.1
11959	Subsoil of 11958......	Yellow sand, 12 to 36 inches.	.2	6.4	28.9	54.9	1.3	1.8	6.1

Muck.

The Muck in this area usually represents deposits of partly decayed organic matter, sometimes mixed with particles of earth. The Muck areas occupy low, wet places, and are locally spoken of as "marshes." As a rule the Muck is more than 3 feet deep, and there is little change to that depth. Sometimes, however, the surface soil has reached a higher state of oxidation and is a deep black in color, with few, if any, fibers distinguishable, which material gradually changes to a reddish-brown mass, in which the fibers and sometimes the forms of leaves can be made out. In other cases there is no change to a depth of 3 feet. Sometimes the surface is red, especially before cultivation, but becomes black after being plowed and exposed to the air for some time. A few spots are seen in which the mass is very compact or peaty. Around the edges and in other shallow places a whitish sand or sandy clay is found underlying the Muck, but most of that mapped in this county is more than 3 feet deep, though the sand or clay may be found at greater depths.

This type is found in spots from a few acres up to 2 or 3 square miles in extent. It is also seen in narrow strips along streams or at the head of streams, and is always lower than the adjacent soil types, and comparatively level. These small areas of Muck occur in various parts of the county, but the greater portion of the type is seen in the eastern half.

Owing to the position of some of the Muck areas, it is supposed that they are old lake beds, which have gradually become filled with decaying organic matter. A few instances are seen where Muck entirely surrounds a lake, which is much smaller now than it was at one time. Sometimes where the ground is springy and wet on the slopes the Muck extends a short distance up the slopes; otherwise it is very level. It is naturally covered with swamp grass, goldenrod, huckleberry bushes, and cottonwoods, with occasional larger trees. Before cultivation small mounds 1 foot in height are often seen thickly scattered over the surface.

In its natural condition water is always near the surface, and artificial drainage is necessary before cultivated crops can be grown, except in some instances around the edges. Drainage has been accomplished to some extent by constructing large, open ditches into which tile drains empty, and much work is being done at the present time along this line. About 75 per cent. of the type is yet undrained.

Until drained the Muck can be used only for pasture and for hay, but when drained it is an almost ideal soil for onions and celery, and good crops of corn can also be secured. Some onions are grown at the present time. Corn is the most common crop on the drained area, the yields ranging from 40 to 75 bushels per acre. Marsh and timothy hay are the chief crops on the undrained areas, yielding from 1 to 3 tons per acre, generally of a poor quality. The greater part of the type is used chiefly for pasture.

MEADOW.

The term Meadow represents poorly drained areas along streams and in depressions, which are not usually cultivated. The soil may consist of a heterogenous mass of material, though it is usually a heavy black sandy loam, rich in organic matter. The subsoil varies from a tenacious blue clay to a white sand.

The material composing the type is much more variable along streams than in depressions, this being due to stream action. The soil bordering the streams is often almost pure sand and gravel, but in other places the first few inches is muck. When found in depressions, the soil is rather uniform and usually has the characteristics of the sandy loam described above.

Most of the cultivated areas of Meadow are found in these depressions, which have been wholly or partially drained. Corn is the principal crop, but these areas are rarely cultivated, except around the edges. The type is used mostly for grazing or hay.

AGRICULTURAL CONDITIONS.

The farmers of Marshall County are in a fairly prosperous condition. In the eastern half of the county, which is largely occupied by the Marshall loam, nearly every acre of which can be cultivated, the farmers as a rule are more prosperous than those living on the sandy soils in the extreme western portion. The houses, though often small, are nearly always painted, and the barns are of sufficient size to shelter all the live stock and machinery. Many silos are also seen. As a rule, the houses are smaller and not quite so good on the more sandy soils, and a good dwelling with no barn is frequently seen.

The value of farm land ranges from $20 to $100 an acre. The Marshall loam is generally held at from $65 to $100, the Marshall sandy loam at from $65 to $75, the Marshall sand at from $30 to $40 when in cultivation, and other lands at from $20 to $60 an acre. Muck undrained sells at from $20 to $30, and when drained at from $40 to $70 an acre.

About 75 per cent. of the land in this county is under cultivation or in condition to be cultivated. The remainder consists of sand, marshes, timber land, and rough broken land, and, aside from the marshes, the greater part of this land lies in the western half of the county. Much of this uncultivated land can be used for pasture, so that there is comparatively little land in the county from which some returns can not be secured.

About $2,000,000 in mortgages is held against the farms of Marshall County, which is between 15 and 25 per cent. of their value. While these farm mortgages apply generally throughout the county and are not confined to any one soil type, yet they are fewer in proportion to the total number in the northern and northeastern parts of the county than in other sections. A great many German farmers live in those parts of the area, and, being of industrious and prudent habits, they have maintained a better financial standing.

About 60 per cent. of the farms are operated by the owners. The remainder are cultivated by tenants, who pay a rental of from two-fifths to one-half of the crop made, or, very rarely, a cash rent, which ranges from $3 to $4.50 an acre. The proportion of grain paid varies in different sections. For corn lands one-half of the crop is more often paid, while for wheat and rye either two-fifths or one-half is paid, according to the amount of seed furnished and the proportion of the thrashing bill paid by the owner and tenant, respectively.

About 90 acres is the average size of farms in this county. Where onions and potatoes are grown the farms are below the average in size, but where much live stock is kept they are usually larger. There are several farms of 640 or more acres, but as a rule these large holdings are divided up and rented in smaller tracts.

The smaller farms are generally operated by the owner or tenant and his family, assisted to some extent by labor hired by the day or week during harvest and other pressing seasons. The wealthier farmers usually hire by the month, paying from $20 to $25 and board, and employing the men from the 1st of March to the 1st of November. The harvest season is from June 15 to August 15, during which time there is a great demand for laborers, and efficient men receive from $1.75 to $2 a day. At other times day laborers receive $1.25 a day and dinner. During the corn-husking season labor is much in demand, and at times farmers find difficulty in getting the crop out as fast as they desire. The labor is exclusively white and is usually efficient, but the supply is often inadequate.

Corn and wheat are the principal products of Marshall County. From 15 to 25 per cent of the cultivated lands is planted to each of these grains. The average yield of corn in the county is 35 bushels per acre and of wheat 10 bushels. Winter wheat only is grown. Owing to severe damage to wheat by freezing and by the Hessian fly, there has been a tendency in recent years to reduce the acreage somewhat and to give more attention to the growing of rye, but as yet rye is an unimportant crop. The corn is planted in checked rows and cultivated with two-horse machinery. A great part of it is cut for fodder, both by hand and by corn binders and binders and shockers. The fodder is sometimes shredded, and thus prepared it may be substituted for hay. A part of the crop is put into the silo and utilized in that way. Wheat is generally sown in drills, and is thrashed either in the field or at the barn. Clover is an important crop, about 15,000 acres being cut every year. It is generally sown with wheat or oats, and produces two crops, one of hay and one of seed, a considerable proportion of the seed being shipped out of the county. Timothy is grown on all soils except the sand, and will thrive in low, damp places where clover or corn does not do well. Both clover and timothy hay are baled and shipped to eastern markets. Oats are grown largely for home use, but some are shipped.

Among the minor crops cucumbers are probably the most important. They are grown chiefly on the more sandy soils and are sold at the salting stations, of which there are seven within the area. The managers of these stations contract with the farmers, giving them 60 cents a bushel and providing the seed. Cucumbers are rarely grown in large fields, the patches ranging from 2 to 5 acres. Onions are grown chiefly on the muck and potatoes on the more sandy soils. On nearly every farm there is an orchard, which supplies the needs of the owner. A great many apples are made into cider, to be sold later as vinegar.

Except on the most sandy land every farmer keeps one or more milch cows. A great many sell milk to the creameries, of which there are several within the area. According to the census of 1900 the value of dairy products in Marshall County was $163, 028. A great many beef cattle, hogs, and sheep are kept also, this being more particularly true in the eastern half of the county. The Shorthorns, Angus, and Herefords are the chief breeds of cattle, and the Chester Whites, Poland Chinas, and Berkshires are the breeds of hogs most in favor. Almost the entire grain crop produced in some sections of the Marshall loam is consumed upon the farm. The raising of live stock is to be commended, for the more manure produced the more productive the lands should become. Increased interest is being shown in the live-stock industry.

The farmers of Marshall County have a fair understanding of the adaptation of soils to crops. The Marshall loam is generally recognized as the best soil in the county for general farming and the more sandy soils as best for the special crops. The possibilities of the Marshall sandy loam and the Marshall sand for Irish potatoes, however, are not fully appreciated, especially in the case of the latter type of soil, which produces fair yields of corn and rye, but is excellently adapted to potatoes, which, with liberal applications of manure, give very large yields. It is suggested that where the type lies near Muck areas a dressing of the Muck would prove very beneficial.

Marshall County is well supplied with railroad facilities. The Baltimore and Ohio crosses the northern part of the county in an east and west direction; the Pittsburg, Fort Wayne and Chicago the central part; the New York, Chicago and St. Louis the southern part; the Lake Erie and Western the western half in a northwest and southeast direction, and the Logansport division of the Terre Haute and Indianapolis passes through the southwestern, central, and northern parts of the county. Few points in the area are more than 7 miles by wagon road from a station. The three east and west lines are trunk lines from Chicago to the East, so that all produce can be quickly shipped either way from any point in the county.

Good dirt roads are found on nearly every section line, and many of them have been graveled. Except in the most sandy areas there is rarely any difficulty in getting products to market.

Plymouth, the largest town in the county, had a population in 1900 of 3,656. Other smaller towns are Bremen, Bourbon, Argos, and Culver. Only a comparatively small portion of the produce can be consumed within the county, so that it is necessary to seek larger markets. Plymouth is only 84 miles from Chicago by rail; but as this large western market is supplied with enormous shipments from all over the northern part of the Mississippi Valley, the farmers of Marshall County find better markets elsewhere. Some of the products are shipped to the larger towns around the State, while a great deal of live stock, hay, etc., is shipped to Pittsburg and Buffalo. Nearly every railroad station in the county has an elevator, and the exceptionally good railroad facilities enable the farmers to send their products wherever they may desire.

Soil Survey of Allen County.

By Grove B. Jones and Cornelius Van Duyne.
U. S. Bureau of Soils.

DESCRIPTION OF THE AREA.

Allen County is located in the northeastern part of Indiana, and is bounded on the north by Dekalb and Noble counties; on the

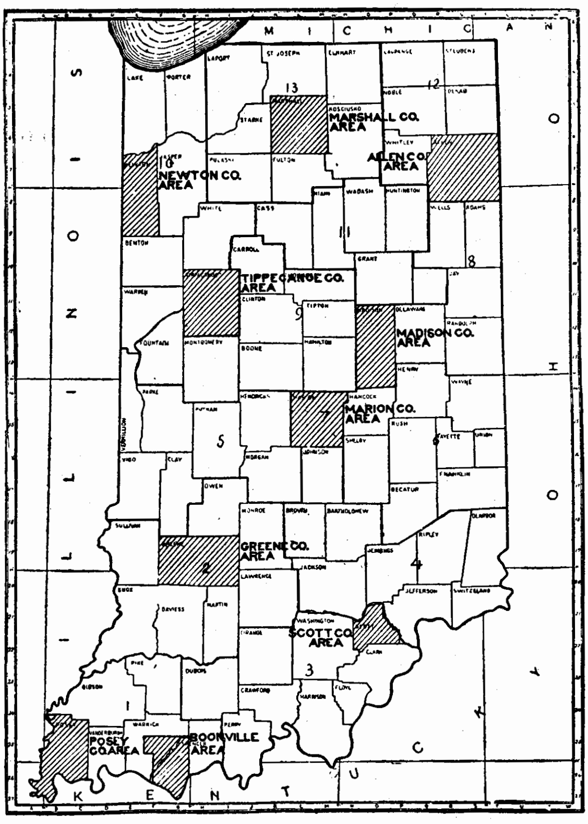

Fig. 1.—Sketch map showing location of the Allen County area, Indiana.

east by the State of Ohio; on the south by Wells and Adams counties; and on the west by Whitley and Huntington counties. The county is included within meridians 84° 50′ and 85° 20′ 25″ west from Greenwich and parallels 40° 50′ 30″ and 40° 18′ north latitude. It is the largest county in the State, and embraces an area of 667 square miles, or 426,880 acres.

The surface features of the county are those characteristic of a glaciated region, varying from low, level, or depressed areas—the sites of ancient lakes—to rolling and hilly, the latter being the usual surface features of moraines. The morainic belt extends in a northeasterly-southwesterly direction across the county. It passes through Fort Wayne, where it is intersected by the St. Joseph and St. Marys rivers, which at this point unite to form the Maumee River. From Fort Wayne a lobe of this moraine extends southeast to the county line. The extreme northwest corner of the county is also crossed by another morainic strip.

These morainic belts present a varied topography and give to the county its most rugged scenery. Though their general elevation is much above the surrounding country and their surface for the most part is rolling to hilly, there occur many small, level to gently undulating areas. Between the morainic hills and ridges numerous swamps, saucerlike depressions, and small lakes form a salient feature of the landscape everywhere. In the northern part of the county the hills and kamelike eminences occur particularly well developed, especially in Perry and Cedar Creek townships. The highest point in the county is located upon "Dutch Ridge," in Perry Township. This ridge is a broken, gullied strip of country, with an average height of about 50 feet above the surrounding lowlands. The sides of the ridge are badly dissected and eroded by deeply cut, steep-sided, irregular valleys, varying in width from one-eighth to one-fourth mile. Some of the valleys in the morainic country have the appearance of having carried much larger volumes of water in former times and of having later become partially filled with glacial débris. These valleys vary in width from one-eighth to one-fourth mile.

Generally speaking, the southern half of the county consists of intermorainic stretches having a gently undulating to fairly level topography. The exceptions are found in the southwest corner and along the east side of the St. Marys River, where the moraines give rise to gently rolling to hilly country.

The Maumee Lake Bottom, which embraces over 100 square miles of country in the eastern part of the county, is the largest level area. The surface features are level to gently undulating, with an occasional knoll or ridge. This tract was known as the Black Swamp, but has been reclaimed by artificial drainage.

Another level semiswampy area is found extending southwest from Fort Wayne to the western boundary of the county. This formation represents an abandoned channel which at one time conveyed the waters of Lake Maumee into the Wabash River. It is locally known as Little River Prairie.

The St. Joseph and St. Marys rivers rise in Ohio and flow through the eastern portion of Allen County to Fort Wayne. The St. Joseph flows in a general southwesterly direction, the St. Marys in a northwesterly direction, until they unite at Fort Wayne, forming the Maumee River. The eastern and central parts of the county are therefore drained by these three rivers and their tributaries.

The western part of the county is drained by Eel River, Aboite Creek, Little Prairie Creek, and the tributaries of these streams. This drainage is in a southwest direction to the Wabash River. The county thus forms a watershed, part of whose waters discharge through the Maumee, the Great Lakes, and the St. Lawrence into the Atlantic, and the rest through the Wabash, Ohio, and Mississippi into the Gulf of Mexico.

Fort Wayne, the only city of the county, has an estimated population of 61,195. It is situated nearly in the geographical center of the county and is sometimes called the "Summit City," because it is at about this point that the east and west railway lines cross the divide between the waters which flow into the Mississippi and those which flow into Lake Erie. Fort Wayne is the county seat and is a progressive and prosperous city. It covers an area of 9 square miles and has a number of manufacturing plants.

There are a number of small towns and villages in the county. In the northern half are Dunfee, Arcola, Huntertown, Ari, Leo, Cedarville, Grabill, Maysville, Harlan, and Woodburn, named in order from west to east. In the southern half and named in the same direction are Zanesville, on the southern margin, Ninemile, Yoder, Poe, New Haven, Hoagland, Maples, Monroeville, Townley, Baldwin, Dixon, and Edgerton.

General Anthony Wayne, on September 18, 1794, selected the present site of the city of Fort Wayne, at the junction of the St. Marys and St. Joseph rivers. This early white settlement was known as Fort Deposit, and furnished protection to the pioneers. Much interesting history is linked about this spot. It was called by the Indians Ke-ki-on-ga, meaning "Central City."

Under the treaty of St. Marys, 1818, lands ceded by the Indians came into possession of the United States. In 1822 Fort Wayne was laid out, and in 1823 the county of Allen was organized out of Randolph and Delaware counties.

The first settlers came in by way of the St. Marys River, from Ohio, New York, and other eastern States. They selected the timber lands along the St. Joseph and St. Marys rivers for their first settlements. The tide of immigration, however, did not begin until the decade of 1840-1850.

The county roads as a rule are in good condition. The principal roads leading into Fort Wayne are macadamized or graveled, and in the eastern and southeastern parts of the county there are many miles of permanent macadam roads. Much of the material used for road construction is a durable blue limestone, but upon about half of the roads of the county the gravel deposits, which are so common in the morainic sections, have been utilized. This material is often too fine for good results, and in all cases is less durable than the limestone. Where the Clyde clay and other heavy soils are crossed by roads not graveled they become, in wet seasons, almost impassable from deep, stiff mud.

Allen County is well supplied with railway lines. With the exception of the extreme northeastern township, Scipio, every township is traversed by one or two lines of railway, and shipping points are easily reached from all parts. The following railroads enter Fort Wayne: The Pennsylvania (main line), the Grand Rapids and Indiana, the Wabash (two lines), the Lake Erie and Western, the Lake Shore and Michigan Southern, the New York, Chicago and St. Louis, and the Cincinnati, Hamilton and Dayton. The Vandalia Railroad crosses the northwest corner of the county and furnishes an outlet for that section. In addition to the steam roads the following electric lines center at Fort Wayne: The Fort Wayne and Wabash Valley Traction Company's lines run southwest from the city along the northern edge of the "prairie" to Huntington, Indianapolis, and Lafayette. Another line runs south to Bluffton. The Ohio Electric Railway Company's lines pass east through New Haven and Monroeville to Van Wert and Lima, Ohio. The Fort Wayne and Springfield Railway runs southeast to Decatur, and the Toledo and Chicago Interurban Railway runs north through Huntertown to Waterloo. A proposed electric line running northwest from Fort Wayne will, when completed, connect it with South Bend, Indiana.

Fort Wayne is the market for all of the products of the county, and considerable produce is shipped in from outside districts.

CLIMATE.

The climate of Allen County is healthful and well suited to carrying on general farming. No ~~official weather records are available for the county~~; those which ~~appear in the accompanying~~ table were taken from the records ~~of the Weather Bureau station at Angola, two counties to the no~~rthward. It is ~~believed, however~~, that the data given represent ~~approximately the conditions which prevail over Allen County~~.

The winters are rather long and cold, and are usually accompanied by considerable snow. The mean temperature for December, January and February, covering a period of eighteen years, is about 26° F., while that for the three following months for the same period is about 48° F. The mean temperature for the months of June, July, and August, covering a period of eighteen years, is about 72° F., while that for the three following months for the same period is about 51° F. The mean annual temperature is about 49° F. The temperature seldom reaches 100°, and zero weather seldom lasts for more than one or two days at a time.

The mean annual precipitation for a period of eighteen years is about 39 inches. The mean snowfall for December, January, and February covering this same period is about 29 inches. During these same months, however, a considerable precipitation—about 2½ inches monthly—occurs in the form of rain. For March, April, and May the mean rainfall is about 10 inches, while the snowfall is also about 10 inches. During the summer months of June, July, and August the average rainfall is about 3½ inches per month, while that for the following three months is about the same. In general, the rainfall is quite evenly distributed throughout the growing season. Crops seldom suffer from extreme drought or from excessive moisture.

The length of the growing season is about five and one-half months, the average dates of the last killing frost in the spring and the first in the fall for a period of fifteen years being April 27 and October 14, respectively. During this same period the very latest date of a killing frost in the spring was May 21, and the earliest in the fall was September 21. The climatic conditions of the county are representative of those over a large portion of the northeastern United States.

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT ANGOLA.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute mixi-mum.	Absolute mini-mum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow average depth.
	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	29	65	—13	2.6	2.0	1.5	8.7
January	24	64	—20	2.4	1.8	2.4	10.8
February	24	62	—25	2.8	2.2	2.0	9.7
Winter	26	....	....	7.8	6.0	5.9	29.2
March	34	76	—10	3.0	2.7	3.1	7.8
April	48	90	15	2.8	2.1	5.9	2.7
May	61	100	26	4.0	6.6	4.4	0.2
Spring	48	....	....	9.8	10.4	13.4	10.7
June	70	104	38	3.9	1.8	3.6	0.0
July	74	104	45	4.0	1.1	12.8	0.0
August	71	101	44	3.2	0.9	7.6	0.0
Summer	72	....	....	11.1	3.8	24.0	0.0
September	64	100	28	3.5	5.2	5.9	0.0
October	51	90	18	2.9	3.0	0.8	0.1
November	38	76	7	3.6	2.7	2.1	5.1
Fall	51	....	....	10.0	10.9	8.8	5.2
Year	49	104	—25	38.7	31.1	52.1	45.1

Agriculture.

The development of agriculture in the early days was necessarily slow, for the country was heavily forested with oak, hickory, elm, maple, beech, and other hardwoods. Corn was the chief crop planted in the partially broken new ground. This crop was usually followed by wheat, while another area was cleared for corn the following year. On account of the absence of ready markets the most of the grain produced was consumed at home. Occasionally ox teams hauled small loads of grain to Chicago or Cincinnati and returned with other provisions. On account of the distance and the poor condition of the roads such trips usually required several weeks.

Upon the completion of the Erie-Wabash Canal in 1843, which furnished direct communication with the Ohio River, the development of agriculture became more rapid. Large areas were cleared, better farming implements were used, and higher prices were paid for the products.

After immigration became active in the forties and fifties, the development was steady. About twenty years after the completion of the canal—that is, in 1863—the Wabash Railroad was constructed and other lines soon followed, forcing the abandonment of the canal in 1881. About this time large areas of swamp land lying south of the canal were cleared, drained, and put in cultivation, and today only a small percentage remains unreclaimed. These drained swamp lands are the strongest corn soils in the county, command the highest price, and are an important factor in the county's wealth.

The general character of agriculture has not greatly changed since the beginning. Corn and wheat constituted the first crops, but the yield of wheat has gradually decreased because of continuous cropping, and more attention has been given to oats and hay. During the last twenty years the acreage devoted to corn and oats has greatly increased, owing to the draining of the swamp lands. According to the census of 1900 the number of acres in corn was 70,840, in oats 50,715, and in wheat 3,765. This year, 1908, it is believed the wheat acreage is not over 2,000 acres, though this small showing is due partially to the very dry fall, which prevented seeding. The average yield per acre of hay for the county is about 1½ tons. The first crop of clover is cut for hay and the second generally harvested for the seed. By this method little or no humus is added to the soil and the grass lands of the county are generally deficient in organic matter. Alfalfa can be successfully grown on the upland soils and should be more extensively planted. It will prove a valuable feed, a splendid soil renovator, and of importance in the system of rotation. Buckwheat, rye, rape, and sugar beets are grown to a limited extent. The sugar beets are produced upon the Clyde clay in the eastern part of the county, the yields ranging from fair to good. The beets are shipped to Fremont, Ohio, where is located the nearest sugar factory.

The soil and climatic conditions are well suited to sugar beets, and there would seem to be no reason why the acreage of this crop should not be greatly increased. Many of the beets now produced are grown under contract, the price paid being $5 a ton. The cost of seed per acre is $2.50, for the hire of the company's tools 55 cents, and weeding and thinning $18 per acre. The yield this year ranged from 8 to 10 tons per acre. Comparatively little commercial fertilizer is used.

Stock raising has never been of great importance and at present is confined chiefly to the production of pork. Dairying has never been extensively carried on and provides only for the local demand.

With the growth of Fort Wayne into a large manufacturing city and the resulting increase in demands for fruit and vegetables, more attention has been given to these special crops. The city furnishes a splendid market for such products, all of which do well on the sandy soils just east and west of town. Apple and peach orchards planted upon the Dunkirk sandy loam and given proper care will doubtless prove remunerative. Potatoes grow well upon the lighter soils and upon the lighter phases of the Muck and Peat areas. The supply of vegetables and fruit is even yet inadequate, and many carloads are shipped in annually.

The importance of crop rotation is recognized and quite generally practiced upon the Miami clay loam. The common practice consists of plowing sod land for corn, following this with oats, and then with wheat. If wheat is included in the rotation, timothy is usually sowed in the fall and clover in the spring; otherwise both are sowed in the spring with the oats. The land is allowed to remain in grass for two or three years, the period depending usually on the ability of the clover to withstand the heaving of the soil and on the relative prices of hay and corn. On the Miami black clay loam wheat is usually omitted from the rotation and corn is planted for two or more years. The Clyde clay is planted to corn for several successive seasons, followed by oats, seeded, and allowed to remain in clover only one year.

The matter of drainage is an important problem for the farmer of Allen County, and especially is this true in the eastern and northwestern parts of the county. Most of the farms of the upland are equipped with effective systems of tile drains. In the large level tracts of land the main open ditches become partially filled with sediment and plant growth and require frequent cleaning. Ditching machines for constructing the small lateral ditches are in common use. Tile is manufactured in several places in the county and can be secured at reasonable prices.

Eel River ditch, completed in 1887, is 11 miles long and drains over 3,000 acres of land. Little River ditch, completed in 1889, with all its branches, is 40 miles in length and furnishes an outlet for the water which falls upon 200,000 acres.

In 1900 the value of farm lands and improvements of Allen County, exclusive of buildings, was $14,565,350, and the value of farm buildings amounted to $4,707,320. The farms contain a total area of 397,235 acres and have an average extent of 90 acres. The value of farm land ranges from $50 to $150 an acre. The corn and truck soils command the highest price. Drained Muck sells for about $80 an acre, and much of this soil could be improved by more complete drainage systems.

About 60 per cent of the farms are operated by the owners. Where tenanted, share rent is the common plan, although a money rental is coming into more general use. The usual rent on the share basis is two-fifths of the products, the renter furnishing everything. When the owner furnishes the seed, etc., he gets one-half of the products. Money rents range from $2 to $5 an acre, depending upon the kind and condition of the soil and the character of the improvements. Day laborers receive $2 and $2.50, and those hired by the month from $15 to $30, with board.

The agriculture of Allen County is of a progressive and advanced type. Farm machinery of the latest designs—corn planters, shredders, harvesters, wheat drills and harvesters, manure spreaders, ditching machines, in fact everything needed to handle the soil and the crops in the most economical way—is found upon the farms. The soils being strong and fertile, but little resort is had to commercial fertilizers. On the other hand, the great value of barnyard manure is thoroughly appreciated, and large quantities are used, mainly on the corn and wheat.

SOILS.

Indiana lies within the region which during comparatively recent geological time was subjected to glaciation, the ice having invaded the country a number of times. This great snow-covered ice sheet, 1,000 feet or more in thickness, covered the country as far south as the Ohio River and in some places beyond that river, just as Greenland is covered to-day. During its slow advance southward great quantities of earth and rock which were carried on the ice, pushed along beneath it, crushed and mingled, were upon the melting of the ice sheet left as a thick mantle over the surface of the country, in many cases entirely obliterating the then existing surface features. Geologists believe that there were four or five successive invasions of the ice over this section, each adding to the vast deposits found today—an earthy mass of heterogeneous material covering the northern three-fourths of the State, in some places to a depth of 500 feet. In Allen County the depth of the deposits ranges from 40 to 280 feet.

As far as Allen County is concerned, the most important period of glaciation was the Wisconsin stage, a period marked by heavier deposits of drift than those of any other ice invasion.

Ridges of drift material, known as terminal moraines, form important topographic features of the county. These moraines are varied in constitution and in the arrangement of the different grades of material, like clay, sand, and gravel, and give rise to several soil series. One of the most important of these ridges is the St. Marys Ridge, named from the St. Marys River. The course of the river in the eastern part of Allen County is determined for a distance of about 20 miles by this ridge, and in like manner the course of the St. Joseph River is controlled for nearly the same distance.

Another moraine of less importance is known as the Van Wert Ridge, which crosses the Maumee River about half way between Fort Wayne and New Haven. Other smaller moraines are found in different parts of the county.

Another topographic feature of the county, important both in area covered and its influence on the soil formation, is the extensive depression now known as the Maumee Valley, which during Glacial times was a great inland lake receiving the waters of the St. Marys and St. Joseph rivers. The outlet of this lake was to the westward through the Little River and Wabash Valley to the Gulf. Large amounts of reworked glacial débris were carried into this inland lake and spread out over its bottoms as sediments. Later, when the level of Lake Erie was lowered, the waters of this inland body broke through one of the lower moraines hemming it in on the north and thus established the present drainage toward Lake Erie.

Evidently the former river flowing westward from Maumee Lake was a very large one, as is indicated by the large river valley which it occupied. This valley extends from a point east of the city of Fort Wayne to the southwest, joining the present Wabash River Valley near Huntington. The old channel or valley is known as the Erie-Wabash gap and the materials found there give rise to a number of soil types.

In connection with the description of Maumee Lake another interesting feature should be mentioned. This is the abandoned channel which crosses Adams Township, from the St. Marys River to a point 2 miles southwest of New Haven. This channel was probably used during interglacial times by the St. Marys River, which evidently made a cut-off and emptied into the interglacial Maumee Lake at a point just south of where New Haven now stands. The banks are well defined, rising in height from 15 to 25 feet above the intervening lowlands, and the old stream bed is occupied by the Clyde clay, which is the predominating soil of the glacial lake bed itself.

Further evidence of the interglacial position of the St. Marys River is seen in the delta formed at its supposed mouth. This delta, known as the New Haven delta, has a length east and west of 4 miles and a width north and south of about 1 mile. It is composed largely of sandy types of soil, several small sand knolls occurring in its eastern extremity.

No rock outcrops occur within the county, but from deep well borings the underlying formations have been determined. As these in no way influence the soils they may be dismissed with the merest comment. In the borings of the artesian well in the court-house square at Fort Wayne the drift was found to extend to a depth of 88 feet, where it rested on limestone. The limestone in the southern half of the county is the Niagara of the Upper Silurian and in the northern half Corniferous of the Devonian. South of Maysville, near the northern border of Maumee Lake basin, flowing water is found 35 to 45 feet below the surface. These wells are fed by reservoirs in the gravel beds of the moraine to the north.

All the soils of Allen County are of glacial origin. The upland soils are derived directly from the glacial deposits, while the glacial lake and swamp types are derived from the drift merely reworked by streams and laid down in more or less quiet waters. Such material and processes of formation give the Clyde series of soils. The alluvial lands are similarly derived. They belong to the Wabash series.

In all fourteen soil types, representing five soil series, were mapped. Two types are members of the Miami and three of the Dunkirk series, the Clyde has three representatives, the Wabash series two, and the Waverly series one. Muck, Peat, and Meadow, of the organic and miscellaneous soil groups, were also mapped.

The name and the actual and relative extent of each soil are shown in the following table:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami clay loam	244,480	57.3	Dunkirk fine sandy loam	4,096	1.0
Clyde clay	65,920	15.4	Dunkirk fine sand	2,944	.7
Miami black clay loam	51,840	12.1	Waverly silt loam	2,240	.5
Clyde loam	12,800	3.0	Wabash Fine sand	1,536	.4
Muck	11,392	2.7	Clyde fine sandy loam	1,408	.3
Wabash silt loam	11,136	2.6	Peat	640	.1
Dunkirk sandy loam	10,240	2.4			
Meadow	6,208	1.5	Total	426,880	

Miami Clay Loam.

The soil of the Miami clay loam consists of a light-brown or gray silty loam from 8 to 12 inches deep, beneath which to a depth of about 24 inches is a heavy yellowish-brown silty clay. The silt content of the subsoil decreases with depth and at an average of 2 feet gives way to a stiff, impervious brown clay. Frequently in the rolling areas of the type a layer of silt 1 to 3 inches in thickness is found immediately beneath the surface soil.

Glacial bowlders and rock fragments, consisting of granite, quartz, syenite, greenstone, and siliceous slate are sometimes present on the surface and disseminated through both soil and subsoil, but these are seldom numerous enough to interfere with cultivation. A few small gravel pits occur in steep banks adjacent to stream courses at a depth of 15 to 25 feet below the surface.

Where the Miami clay loam occurs bordering large depressions and also as knolls and ridges within such depressions, there is nearly always present in the soil varying amounts of fine sand in excess of the typical soil. This is particularly true in Lake Township.

Land of this type of soil is found in every township and covers a greater proportion of the county than all the other types of soil. The largest and most typical areas occur in the northern and western parts of the county. Slight local variations due to the varying drainage conditions occur throughout the type, but generally it possesses marked uniformity in texture. The surface features range from gently rolling to hilly, and in the northern part of the county it occupies some of the most broken and roughest areas. When the Miami clay loam is found in fairly level hummocky country the small knolls possess the texture and color of the Miami clay loam, while the intervening spaces are the Miami black clay loam. It should be borne in mind, therefore, that the boundary lines as indicated on the map between these two soils do not always denote an abrupt change from the one soil to the other, and some few areas were found in which the Miami clay loam and Miami black clay loam were so mingled that they could not be shown as separate and distinct soils upon a scale of 1 inch to 1 mile. In such cases the map shows the predominating soil. These hummocky areas support an uneven crop growth, owing principally to the difference in the productiveness of the Miami clay loam on the hummocks and the Miami black clay loam in the depressions.

The Miami clay loam is the best drained of any of the heavy soils, but it is somewhat more deficient in organic matter than the Miami black clay loam, because it has never passed through the swampy conditions of the latter type. Upon the rougher areas, where the drainage is sometimes excessive, considerable washing and gullying has taken place on the slopes. The soil in these eroded areas is more deficient in organic matter than elsewhere and has an ashy appearance. Usually artificial drainage is not necessary, but there are some rather low, flat interstream areas and draws which have been greatly improved by tiling. The type is of glacial origin and is derived from the weathering of the mantle of glacial till. The original tree growth consisted of oak, ash, hickory, elm, sugar maple, and a few sycamore and beech, and many fair-sized wooded areas still remain.

The Miami clay loam is the general-purpose soil of the county, and upon it all the varieties of farm crops are produced. If handled at the proper time it is not a difficult soil to cultivate. If plowed when either too wet or too dry it has a tendency to clod. By disking before plowing it is claimed a more desirable seed bed may be secured. Wheat, oats, corn, and hay are the principal crops. The yield per acre of wheat ranges from 18 to 30 bushels; of oats, 30 to 50 bushels; of corn, from 25 to 50 bushels; and of hay from 1½ to 2½ tons. For wheat the Miami clay loam is considered one of the best soils in the county, but for corn it is excelled by other soils and the yields are below those secured from the darker colored types.

A common rotation on this type is to turn under the sod and keep the field in corn for two years; the following year a liberal application of barnyard manure is given and the field sown to oats; wheat follows in the fall, and at the same time the land is seeded to timothy and in the spring to clover. In growing wheat some farmers advise plowing clover or corn-stubble land in June, and if there has been abundant rainfall a later plowing or disking before sowing. Green manuring is a very valuable means of restoring organic matter to the soil and should be practiced more generally. The Miami clay loam sells for $50 to $100 an acre.

The following table gives the average results of the mechanical analyses of fine-earth samples of this soil:

MECHANICAL ANALYSES OF MIAMI CLAY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19975, 19977	Soil	0.5	3.0	2.9	6.1	5.6	54.9	26.8
19976, 19978	Subsoil	.0	1.5	1.6	4.9	5.9	50.1	35.7

Miami Black Clay Loam.

The surface soil of the Miami black clay loam is a heavy dark-brown or black loam or clay loam with an average depth of 12 inches. Near the margin of the areas the depth of the soil is usually considerably less than this. The prevailing dark color is due to accumulations of organic matter, and in the lower depths of the soil, where the organic content naturally decreases, the color gradually becomes lighter. The soil gradually becomes heavier with depth and at about 14 inches below the surface grades into the subsoil, a light-brown or mottled yellow and brown clay or heavy clay loam, which at a depth of about 24 inches changes into a yellow or light-brown, heavy, impervious clay continuing to a depth of 3 feet and more. When wet the soil is sticky and gummy and if worked in this condition it bakes and clods badly, but when dry it is usually friable and loamy and can be handled with comparative ease.

Large areas of this type of soil occur in the southern tier of townships and in the region north and west of Arcola. Other small isolated areas, many too small to be shown upon the map, occur in all parts of the county outside of the Maumee Lake Basin and the Erie-Wabash channel.

The Miami black clay loam occupies shallow, saucerlike basins and depressions in the uplands and narrow strips along some of the smaller streams. The upland areas are often large and irregular and are sometimes connected with each other by a narrow strip of the same soil. Owing both to the level, depressed surface of the type and the impervious nature of the subsoil the drainage is naturally poor. The greater part is drained by open ditches and tile drains, and is under cultivation. The undrained and uncultivated areas support a heavy growth of oak, hickory, and elm.

This type of soil owes its origin to an accumulation of fine material washed from the uplands into the depressions. The impervious character of the subsoil prevented underdrainage from these depressions and the decay of vegetation which grew luxuriantly under the existing swampy conditions resulted in the accumulation of large quantities of organic matter. Near the margins of some of the areas of Miami black clay loam small elevations locally known as "clay knobs" occur. The soil here was not subjected to the same swampy or poorly drained conditions and therefore carries less organic matter and is lighter colored. When large enough to be mapped they were classed as Miami clay loam. The type as it occurs along the small streams and in draws usually contains a larger amount of sand and silt, the result of recent wash, and is therefore more friable and loamy, and easier to work.

When thoroughly drained this type becomes very productive, capable of producing large yields of corn, oats, and hay. The best results seem to have been secured in the production of corn, which yields from 40 to 75 bushels an acre. Oats often produce too heavy a growth of straw, but under favorable conditions may yield from 30 to 40 bushels per acre. Hay yields from 1½ to 2 tons per acre. Clover frequently fails to survive the second winter on account of the heaving to which this type of soil is prone. The type is usually permitted to remain only a short time in sod. The price of the Miami black clay loam varies from $50 to $100 an acre, depending mainly upon the improvements in drainage, the most important factor in the cultivation of this type.

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

MECHANICAL ANALYSES OF MIAMI BLACK CLAY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19971	Soil	0.2	2.3	3.1	12.6	10.2	51.1	20.1
19972	Subsoil	.5	1.6	2.0	11.0	9.4	52.1	22.7

Clyde Fine Sandy Loam.

The Clyde fine sandy loam consists of 10 to 15 inches of a dark-gray or black material, varying in texture from a fine sandy loam to a fine sand, underlain to 36 inches or more by a dark-gray or black fine sandy loam or loam. The relatively high percentage of organic matter present renders the type a loamy, mellow soil, very productive and easy to cultivate.

The type is of limited extent, the largest areas being found near New Haven and in the prairie southwest of Fort Wayne, with a few other scattered patches in the northern part of the county. It is closely associated with the Dunkirk fine sand, being practically the same in origin. These two types were deposited at the same time, but the material forming the Clyde fine sandy loam fell in deeper water, and these lower places afterwards remained longer in a swampy condition than the shallower portions of the former lake bottom. These long-continued swampy conditions were favorable for the accumulation of organic matter, and hence the reason for higher organic content of Clyde fine sandy loam. The surface is slightly undulating and for the most part the natural drainage is good.

The Clyde fine sandy loam is admirably adapted to the production of small fruits and vegetables, and areas near markets are mostly devoted to these crops. It is also a good corn and grass soil.

The results of mechanical analyses of the soil and subsoil of this type are shown in the following table:

MECHANICAL ANALYSES OF CLYDE FINE SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19957	Soil	0.3	1.7	4.7	50.1	14.4	21.6	7.4
19958	Subsoil	.6	1.5	3.8	33.9	17.5	27.6	14.7

Clyde Loam.

The Clyde loam consists of a dark-brown or black loam or clay loam, from 8 to 12 inches deep, underlain to 36 inches or more by a gray, drab, or yellowish clay or clay loam. There is usually no coarse material in either the soil or subsoil, but in section 18, Jackson Township, there is a small area which consists of a heavy, medium, black sandy loam with numerous small shells strewn upon the surface, and underlain by a sticky, gray coarse sand. It represents a reclaimed swamp area and is a little darker colored than the remainder of the type.

The Clyde loam is most extensively developed in the northern part of the Lake Maumee Basin. It forms an almost continuous strip of varying width, immediately south of the north shore line of this glacial lake bed. Other smaller areas occur as depressions in the prairie and elsewhere in the county. The natural drainage is poor, but most of it has been improved greatly by the construction of large open ditches and tile drains.

The formation of the Clyde loam has taken place under practically the same swampy conditions as the Clyde clay. The wash from the sandy beach line and the finer material brought down by the streams from the uplands have become mingled with the soil, giving it a loamy texture. It is therefore more easy to cultivate than the Clyde clay, does not clod or heave as much, and is better adapted to small grains. Most of the type is drained and under cultivation, all the varied farm crops of the county being grown to greater or less extent. Corn, the leading crop, gives yields of 40 to 75 bushels, wheat 15 to 30 bushels, oats 30 to 60 bushels, and hay 1 to 2 tons per acre. Cabbage, onions, sugar beets, and potatoes are grown successfully, but only in a limited way. The poorest drained areas are still uncleared and support a heavy growth of elm, ash, oak, and hickory.

The results of mechanical analyses of the soil and subsoil of this type are shown in the following table:

MECHANICAL ANALYSES OF CLYDE LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19953	Soil	0.4	3.8	5.6	20.8	15.5	34.1	19.6
19954	Subsoil	1.3	5.6	6.3	18.9	14.3	33.5	20.1

Clyde Clay.

The Clyde clay consists of 6 to 10 inches of drab, black, or dark-brown clay, underlain to a depth of 3 feet or more by a drab or yellow, often mottled, plastic and impervious clay. There is only a very small percentage of fine sand present in the soil and its tough, waxy character makes it a difficult type to work. When wet the soil is plastic and tenacious, but when dry the surface breaks into small cubical blocks about one-fourth inch in diameter, and deep cracks, 2 to 4 inches wide, sometimes extend several feet below the surface. The soil contains a large amount of organic matter and where well drained after cultivation for a time becomes more pulverulent, appearing more like a clay loam. Near Muck areas there is usually a few inches of mucky material overlying a heavy drab clay; this phase supports a luxuriant growth of Bermuda grass.

The Clyde clay stands second among the soils of Allen County. It is found principally in the eastern part of the county, where it occupies the large glacial lake depression known as the Maumee Lake Bottom. It is therefore lacustrine in origin, consisting of reworked glacial till laid down in quiet lake waters and after the recession of the lake subjected to wet, swampy conditions for a long period. The lake bed embraces about 100 square miles of territory in Allen County and extends east into Ohio. It is V-shaped, with the apex at New Haven. Good-sized areas also occur in the level prairies southwest of Fort Wayne, to the southeast of Hoagland, and in Adams Township. Smaller bodies occur in the northern part of the county. The surface features are flat or slightly undulating, broken here and there by a low sand or gravel ridge or by a stream depression.

Owing to the general level topography and the heavy texture of the soil, together with its low-lying position, artificial drainage is necessary to cultivation. Large open ditches usually parallel the roads and carry off the water conveyed to them by numerous tiled laterals. The natural drainage in the northern part of the Maumee Lake Bottom is slightly better than in other parts, and having been cultivated longer the soil in this section is in a better state of tilth than the rest of the type.

More care is required in handling the Clyde clay than any of the other soils of the county. If plowed when too wet or too dry it breaks up into large irregular clods which can be pulverized with difficulty. During a very wet season crops suffer from excessive moisture, but with an average amount of rainfall or less, large yields of corn, oats, and hay are secured.

Corn is the principal crop grown and the type is the recognized corn soil of the county. The average yields in favorable seasons range from 60 to 75 bushels per acre, while 100 bushels is not an uncommon yield. On well-drained fields oats yield from 30 to 50 bushels. Wheat is seldom grown, on account of injury from the heaving of the soil in winter. The type is well adapted to grass, and from 1½ to 2½ tons of hay per acre are sometimes secured. Sugar beets are being successfully grown in the eastern part of the county, the yield ranging from 8 to 12 tons per acre. It is well adapted to this crop, but on account of the scarcity of suitable labor sugar beets are not grown extensively at present.

The Clyde clay is the heaviest and strongest soil of the area, and taken as a whole commands the highest price. Condition of drainage has especial influence on the value. Land having well-established systems of drains range in price from $100 to $150 and more an acre.

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

MECHANICAL ANALYSES OF CLYDE CLAY.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19961	Soil	0.3	4.9	3.2	12.5	4.4	46.4	27.9
19962	Subsoil	.7	1.7	2.7	7.1	5.2	46.5	35.5

Dunkirk Fine Sandy Loam.

The Dunkirk fine sandy loam consists of 8 to 15 inches of light-brown fine sandy loam, underlain to a depth of 36 inches by a brown or yellow silty loam or fine sandy loam. It is closely associated with the Dunkirk fine sand, and near the contact of these types the soil is a loamy sand, deeper and much lighter in texture than the typical soil.

Of limited extent, this soil is found principally along the shore lines of the ancient lakes. It occurs as long, narrow ridges from 2 to 10 feet high, and also in a small way as gently rolling areas. In the northern part of the county, along the northern edge of the Lake Maumee bottom, numerous other areas occur which have the form of eskers. It is derived mainly from reworked glacial material piled up in the old lake beaches. Since that time it has been somewhat modified by wind action and shifted about so as to form low sand dunes. Owing to its texture it is naturally well drained.

With an average amount of rainfall this porous, easily cultivated soil gives good yields of the general farm crops, but during very dry seasons the crop yields are cut short for lack of moisture. Corn averages from 40 to 50 bushels, oats from 25 to 30 bushels, and wheat 15 to 25 bushels per acre. It is splendid clover soil. Alfalfa has been successfully grown, and the acreage of this legume could be profitably increased. Several fine orchards were noticed, and besides the tree fruits, small fruits are successfully grown. Potatoes and all vegetables adapted to the climate do well.

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

MECHANICAL ANALYSES OF DUNKIRK FINE SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19969	Soil	0.7	4.4	9.4	25.7	12.3	34.1	13.4
19970	Subsoil	1.2	3.6	5.9	14.9	14.3	43.0	16.7

Dunkirk Fine Sand.

The soil of the Dunkirk fine sand consists of a light-brown loam or yellow fine sand, with a depth ranging from 6 to 10 inches. The subsoil is a yellow, loose, incoherent fine sand, which extends to a depth of 36 inches. In the few inches at the surface there is enough organic matter, together with fine material, to make the soil loamy in texture and somewhat more coherent than the subsoil. It is an easy soil to plow and cultivate.

The Dunkirk fine sand is limited in extent, the largest bodies being situated in the vicinity of New Haven, around Fort Wayne, and in the southern half of the "prairie" lying southwest of the city. It also occurs along the larger stream courses in the northern half of the county. The type is developed as ridges, rounded hills, and knolls from 2 feet to more than 30 feet in height, and possesses excellent natural drainage. These islandlike bodies vary in size from knolls containing a few acres to long, narrow ridges many acres in extent.

In origin this soil is traced directly to reworked glacial débris, carried into the old lakes and assorted by wave action and piled up along the shores as beach lines. Later these beaches have been considerably modified in extent and shape by wind action and the resulting sand dunes are often found some distance from the original position of the material.

Owing to its limited extent, the type is of little agricultural importance in Allen County. Its open, porous nature and thorough drainage, however, make it a typical early truck soil, and this is the class of farming usually followed. In the vicinity of Fort Wayne it is devoted almost exclusively to market gardening, and all kinds of vegetables, melons, and small fruits are successfully grown. Peaches and apples produce a fine-flavored fruit. Any crop requiring a light sandy soil will do well upon the Dunkirk fine sand. The native timber growth is oak and the greater part of the type supports a good growth of grass. The subsoil is valuable as a building sand and is used considerably for construction purposes.

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

MECHANICAL ANALYSES OF DUNKIRK FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19967	Soil	0.1	0.8	5.1	70.0	10.5	8.7	4.6
19968	Subsoil	.0	.7	5.6	73.4	9.0	8.8	2.4

Dunkirk Sandy Loam.

The Dunkirk sandy loam to a depth ranging from 10 to 15 inches consists of a medium to fine sandy loam varying in color from gray to brown or reddish brown. This surface material is underlain to a depth of 3 feet by a reddish-brown sandy loam or sandy clay which acts as a cement or matrix holding together a large quantity of coarse sand and fine gravel. Frequently fine gravel is found strewn upon the surface, but not in quantities great enough to interfere with cultivation.

Immediately underlying the subsoil beds of gravelly clay varying from 2 to 4 feet in thickness often occur, and below these are frequently found beds of a purer gravel, usually from 4 to 10 feet in thickness. Nearly all of the sand and gravel used in the county for road material and railway ballast have been taken from these gravel pits, and the exposures thus made afford an excellent opportunity for studying the arrangement of the deeper strata underlying this soil.

The texture of the Dunkirk sandy loam varies greatly in different parts of the county, but the subsoil possesses great uniformity. In Perry and Cedar Creek townships, for example, the soil contains a larger proportion of medium to coarse sand than in other parts of the county, while south of Fort Wayne the soil is composed of a compact fine sandy loam or light-textured loam. In the eastern half of the county the type is composed largely of a medium-textured sandy loam.

The Dunkirk sandy loam occurs as gently rolling country, terraces, isolated knolls, and detached ridges, and possesses excellent drainage. It is typically developed in the ridges which represent the old beach lines of Lake Maumee. The ridge running northeast from Fort Wayne, along which the Maysville wagon road extends, formed the north shore of this glacial lake, and the Van Wert wagon road follows a ridge which represents the south shore of the lake.

The general farm crops of the region are grown upon the type, but wheat is given preference, as the soil is recognized as one of the best in the county for that crop. Corn, oats, and hay are also grown. The yields of wheat range from 20 to 30 bushels, of corn from 50 to 75 bushels, oats from 30 to 40 bushels, and hay from 1½ to 2 tons per acre.

All kinds of market-garden crops and small fruits do exceptionally well. It is considered the best orchard soil of the area, peaches, apples, and cherries producing fine, well-flavored fruit. It is also an excellent potato soil.

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

MECHANICAL ANALYSES OF DUNKIRK SANDY LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19979, 19981	Soil	1.8	9.8	18.4	40.8	5.8	17.6	6.0
19980, 19982	Subsoil	5.1	12.7	12.4	30.5	4.1	21.5	13.2

Wabash Fine Sand.

The Wabash fine sand to a depth of about 15 inches consists of a brown fine sandy loam or loamy sand. The subsoil is lighter than the surface soil both in color and texture, and at a depth of 2 feet frequently grades into a gray or yellow fine sand. The soil is friable and easily cultivated.

Most of this soil, which is of only limited extent, is found along the St. Joseph River in Cedar Creek Township and along Cedar Creek in sections 19 and 20 of the same township. A few scattered areas also occur along the Maumee River between New Haven and Fort Wayne. It is of alluvial origin and confined to the flood plains of the larger streams. The most typical areas occur upon the inner bends of the streams and adjacent to the stream courses. The type is frequently overflowed, and each successive flood leaves a thin deposit of fine sand and organic matter upon the surface. The areas consist of low, sandy knolls, ridges, and old stream channels, and except in flood times they are fairly well drained.

Corn is the principal crop, and in favorable seasons the average yield ranges from 40 to 75 bushels per acre. On the higher, better drained areas some oats and wheat are grown and fairly good yields are produced. Truck crops also do very well on this type of soil.

The following table shows the results of mechanical analyses of the soil and subsoil of Wabash fine sand:

MECHANICAL ANALYSES OF WABASH FINE SAND.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19987	Soil	0.0	0.4	3.9	59.4	12.8	18.2	4.4
19988	Subsoil	.0	.2	4.9	61.7	12.7	14.5	5.0

Wabash Silt Loam.

The Wabash silt loam is usually a brown silty loam, about 10 inches deep, underlain to a depth of 36 inches or more by a lighter-colored material of the same texture as the soil. The texture of the type as a whole, however, is quite variable, depending upon distance from the stream channel and the character of the soils upon the hills of the surrounding country. Near the present stream channel there is usually increased sand content, while in some of the depressions farther from the stream there is enough clay present to approximate the standards of a clay loam.

Little of this soil is found in Allen County. It occurs mainly along the bottoms of St. Joseph, St. Marys, and Maumee rivers. It is an alluvial type, and owes its origin to material washed into the streams from the hills and deposited along the bottoms at times of overflow. It is found principally in the oxbows of these larger streams, although narrow strips are found along both the main and the smaller streams where the channels are less crooked. The type is subject to overflow, and occupies the level or flat first and second terraces or bottoms. The underdrainage is good, so that crops do not usually suffer from excessive moisture, except at times of high water, and the fields are soon in condition after the floods subside.

The Wabash silt loam contains a large percentage of organic matter and is a strong, productive type. Corn is the principal crop, and during favorable seasons yields from 50 to 75 bushels per acre. Higher lying, better drained locations are often planted to wheat, and have yielded as high as 30 bushels per acre. Oats yield from 25 to 40 bushels and hay 2 tons per acre.

The results of mechanical analyses of soil and subsoil of this type are given in the following table:

MECHANICAL ANALYSES OF WABASH SILT LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19983	Soil	0.0	0.9	0.8	4.8	8.4	64.8	20.0
19984	Subsoil	.0	.5	.7	5.7	9.7	62.1	20.9

Waverly Silt Loam.

The Waverly silt loam consists of a light-gray or brown silt loam from 8 to 12 inches deep, resting on a subsoil of yellowish-brown silty clay, becoming somewhat heavier as the depth increases, but extending without material change below the limit of the borings, which are made to a depth of 36 inches.

The type is of very limited extent and is rather variable in texture. It occupies narrow strips or small areas along the Maumee River, from 10 to 12 feet above the present flood plain, and seldom extends back more than one-fourth mile from the stream. The most typical area occurs north of New Haven, along the north bank of the Maumee River. The other areas were mapped southwest of New Haven, in what is known as the New Haven delta. These areas contain more fine sand and coarse silt in the surface soil than is usual for the areas adjacent to the river, and the color of the soil is also darker, owing to the presence of slightly more organic matter.

In surface features the Waverly silt loam is nearly level, with a gentle slope back from the stream, where the silt gives way to heavier material. It is usually deficient in organic matter, and the soil when wet becomes quite sticky. The soil is best suited to grass, and is seldom planted to corn on account of small yields. Wheat and oats do fairly well.

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

MECHANICAL ANALYSES OF WAVERLY SILT LOAM.

Number.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
19985	Soil	0.0	0.7	0.8	2.1	7.6	64.7	23.8
19986	Subsoil	.0	.7	.7	2.4	7.3	62.1	26.4

Muck.

The Muck consists of a mass of dark-brown to black more or less decomposed vegetable mold, usually 3 feet or more in depth, though in places it may be only a few inches deep. The color of the material sometimes becomes reddish brown at some distance below the surface, and at this and lower depths coarse and fine vegetable fibers often become noticeable. Beneath this mass of organic material there is found a light-blue or drab clay, which in places is somewhat sandy. Along the margins of the larger areas and bordering the banks of the open ditches considerable fine sand and silt have become incorporated with the Muck. In the northeastern part of the county a number of the Muck areas have a reddish-brown fine fibrous substance with which there is mingled but a small amount of mineral matter. This phase represents the transition stage between Peat and true Muck. As these areas are closely associated with the more typical Muck areas and become darker with cultivation and more thoroughly oxidized when exposed to the air, they have been mapped as Muck. Other areas of Muck occur as isolated patches from one to many acres in extent in the intermorainic plain which extends diagonally across Lake, Eel River, and Perry townships. Long, narrow strips of Muck also occur along what were probably small stream channels during glacial times, and all of the present lakes of the area are surrounded by narrow fringes of the type.

Occupying depressions the Muck areas are level and flat and possess poor natural drainage. They receive the drainage from higher ground, and often, even in times of drought, the water table is very close to the surface. Artificial drainage is therefore necessary before cultivated crops can be successfully grown. A great deal of good has been accomplished by the construction of large open ditches, into which lateral tile drains and open ditches empty, but much yet remains to be done in this direction. Muck areas represent depressions of various kinds in which there has been a great accumulation of organic matter resulting from the decay of the plants which have grown in these wet places. The degree of the decomposition is the distinguishing feature between Muck and Peat, the former representing a more advanced state of decomposition than the latter. Along the margins of the larger areas and bordering the banks of the open ditches a considerable amount of silt and fine sand is mixed with the organic matter. This is either a result of overflow in the ditches or of wash from higher ground.

Many of the Muck areas support excellent pasturage, but the greater part of the type is covered with a dense-growth of goldenrod, coarse grasses, and willows. Corn is grown on the better drained areas and when not injured by rains or early frosts yields from 60 to 100 bushels per acre. The quality of corn, however, is inferior to that grown upon the other soil types. Large yields of potatoes are secured on the Muck areas, but they are usually inferior in quality. The areas having considerable sand and wash material mixed with the mucky surface produce larger yields and a product of better quality. Cabbage, onions, celery, and peppermint are grown to a limited extent and considering the abundant yields it is surprising that these crops are not grown more extensively.

In handling Muck soils it has frequently been found that they can be considerably improved by the use of coarse barnyard manure, and also by the use of straw or other coarse litter, which should be thoroughly incorporated with the Muck. Throughout the central States it has been found that commercial fertilizers, containing a large percentage of potash salts, are especially beneficial upon Muck and Peat soils. A fertilizer establishment located near Ft. Wayne uses Muck as a filler in the mixing and preparation of its fertilizers.

Peat.

Peat consists of 3 feet or more of coarse brown vegetable fiber more or less permanently saturated with water. When thoroughly drained and tilled the fibrous material readily breaks up into a fine powder closely resembling snuff both in texture and color. It contains practically no mineral matter and when dry burns readily, often to a depth of several feet.

Only a few typical areas of Peat occur in Allen County, but where possible these were separated from Muck. The largest body of the type occurs southwest of Fort Wayne in the "prairie." A portion of this area is under cultivation, potatoes being almost exclusively grown. In favorable seasons, when the rainfall is below the average, potatoes yield from 150 to 300 bushels per acre, though over 400 bushels have been grown on an acre. The quality, however, is generally poor. Less than a half dozen other small patches of Peat occur and these are all confined to the northern part of the county. They are not cultivated, but support a dense growth of weeds, bushes, and aquatic plants, and also a few elm trees.

MEADOW.

The Meadow of this area includes the usual type of wet, low-lying narrow strips of waste land along the smaller streams, and also a few low-lying areas in the uplands.

The soil of the Meadow strips is variable, but for the most part is a dark-colored clay or clay loam. Where the Meadow is swampy there is usually found a coating of Muck, a few inches in thickness. In depressions the soil is a heavy black clay upon which water stands the greater part of the year. These areas if reclaimed by proper drainage would in time become similar to the Miami black clay loam. Most of the Meadow areas are unfit for cultivation at present and are left in timber and grass.

SUMMARY.

Allen County is located in the northeastern part of the State of Indiana. The surface features vary from the nearly level prairie-like areas of the glacial lake beds to the gently rolling and hilly country of the terminal moraines.

The average elevation above sea level is about 800 feet. The county has an area of about 667 square miles or 426,880 acres.

Allen County was organized in 1823, but not until the decade of 1840-1850 was there a marked influx of settlers.

The yearly rainfall ranges from 31 to 52 inches, with a mean of 38.7 inches. The absolute maximum temperature is 104° F., absolute minimum –25° F., and annual mean 49° F.

The drainage is principally into Lake Erie through the Maumee River and its tributaries. The western part of the county drains into the Wabash through Eel River, Aboite and Little Prairie creeks, and their tributaries.

The agriculture of Allen County is in a prosperous condition. Corn, wheat, oats, clover, and timothy are the principal products. Dairying and live-stock raising are practiced only in a limited way.

The importance of crop rotation is recognized, though no system is strictly adhered to. Stable manure is widely used. Farm labor is paid $15 to $30 per month, with board.

The average size of farms is about 90 acres and over one-half of them are operated by the owners. Most of the land in the county is improved. Value of farm land ranges from $50 to $100 an acre for the clay uplands to $100 or $150 an acre for the best drained and improved bottom land.

A number of steam and electric railways give ample transportation facilities for all parts of the county.

Fourteen soil types were recognized in this survey. These are all composed of glacial material and range from sand to clay. The light-colored soils represent the well-drained drift materials, while the dark soils are those which have remained in a swampy or poorly drained condition for a considerable period. The Miami series with two members and the Dunkirk series with three represent the light-colored soils. The Clyde series embraces the dark-colored glacial lacustrine soils with three members. Of the alluvial soils two belong to the Wabash and one to the Waverly series. Muck, Peat, and Meadow are the three remaining types.

The Miami clay loam is the predominating type. It is the general-purpose soil of the county, and constitutes more than one-half of the area of the county.

The Miami black clay loam when properly drained produces large yields of corn and grass.

The Clyde soils are best suited to corn. They require artificial drainage, and deep plowing in the case of the clay would increase the crop yields. Clyde clay is a very desirable soil for sugar beets, and their acreage could be profitably extended.

The Dunkirk soils are best suited to crops requiring a light, sandy soil. The fine sand is an ideal soil for early truck. Most of the market-garden produce consumed in Fort Wayne is grown upon this type. The sandy loam is the best wheat soil, and apples do exceptionally well upon it. The gravel subsoil of this type is used for road-surfacing material.

Of the alluvial soils, the Wabash fine sand and silt loam are subject to frequent overflow, but in favorable seasons produce large yields of corn and grass. The Waverly silt loam is deficient in organic matter and is best suited to grass.

Peat and Muck when thoroughly drained produce abundantly of corn and potatoes, but the yield of corn is usually light and chaffy in quality. Special crops, such as celery, onions, and peppermint, should prove remunerative. Meadow land is best suited to pasturage.

The light-colored soils are in need of humus. Manure and catch crops turned under for green manure should be more extensively used. Much clover is grown for hay and seed, but more of it should be fed on the farm and returned to the soil as manure. Alfalfa has been successfully grown upon the Miami clay loam and the Dunkirk sandy loam. It is an ideal forage crop for all stock and a splendid soil renovator. It should be more extensively grown.

Soil Survey of Madison County.

By R. T. Avon Burke and LaMott Ruhlen.
U. S. Bureau of Soils.

LOCATION AND BOUNDARIES OF THE AREA.

Madison County is located in the central part of Indiana, northeast of Indianapolis. The county is a rectangle, with a width

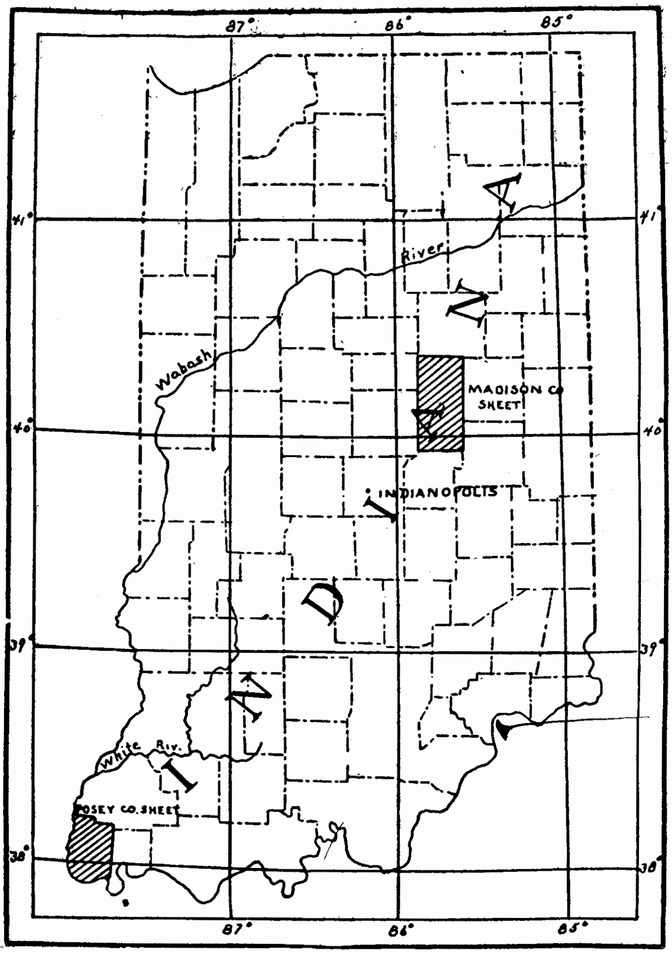

Fig. 1.—Sketch map showing position of the Madison County area, Indiana.

east and west of 15 miles and a length north and south of 30 miles, comprising an area of 450 square miles. It is bounded on the north by Grant County, on the east by Delaware and Henry counties, on the south by Hancock County, and on the west by Hamilton and Tipton counties.

CLIMATE.

In the area surveyed the climatic conditions are about the same as the average mean temperature and precipitation for the State. The following table is taken from the report (1903) of the Weather Bureau Station at Anderson, near the center of Madison County:

NORMAL MONTHLY AND ANNUAL TEMPERATURE AND PRECIPITATION.

Month.	Anderson.		Month.	Anderson.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	Inches.		°F.	Inches.
January	29.3	2.37	August	74.0	4.15
February	27.9	1.97	September	67.5	2.75
March	38.4	4.02	October	55.6	2.08
April	51.9	2.68	November	41.9	3.98
May	62.5	3.49	December	30.7	2.65
June	71.6	2.86			
July	75.2	3.89	Year	52.2	36.89

The records at Anderson for the past several years show the average dates of the last killing frost in spring and the first killing frost in fall to be April 18 and October 19, respectively.

PHYSIOGRAPHY AND GEOLOGY.

Madison County has an average elevation of about 800 feet above sea level. The surface features in general consist of a gently undulating plain, with broad, level, interstream areas more or less rolling as they near the water courses.

A belt about 3 miles wide, with the features of a dissected ridge and consisting of a heterogeneous mass of bowlders, sands, and gravels typical of glaciated regions, occurs along Kilbuck Creek. It passes through Anderson, following the southeast side of Prairie Creek, and extending to Lick Creek, 3 miles southwest of Pendleton, and is cut by White River, just north of Anderson.

The meandering of White River has built up two distinct terraces, the higher terrace being bordered by rounded bluffs of low elevation, while along the smaller streams are usually found narrow overflow bottoms. With the exception of Kilbuck, Fall, and

Lick creeks, the streams flow in shallow channels, sloping gradually to the uplands.

The north fork of White River, which flows slightly north of west through the county, receives the greater part of the drainage waters beyond the county line. Pipe Creek rises in Delaware County, flows southwest, and empties in to White River about a mile beyond the western boundary, draining the northern and northeastern parts of the area surveyed. Kilbuck Creek rises in Delaware County and drains the eastern part of Madison County, flowing into the White River near Anderson. Duck Creek rises on the "Black Flats," flows southwest through Elwood, and empties into White River in Hamilton County. This creek is nothing more than a series of public drainage ditches, converging into one main ditch, constructed for the better drainage of what was once a great marsh. Fall Creek and Lick Creek flow in nearly parallel courses, coming together in the extreme southwestern part of the county, and there emptying into the White River. The area between these two creeks is more rolling than the northern uplands. The country drainage passes by way of White, Wabash, Ohio, and Mississippi rivers to the Gulf of Mexico.

The underlying rocks in Madison County,[1] as exposed along streams that have cut through the glacial drift, belong to the Silurian and Devonian rock systems. The Upper Silurian occupies the eastern and northern parts of the county, and is represented only by the Niagara group. The limestones of this series occur at several points along White River in its course through the county, and are overlain in most places by soft, crumbly shales. It has also been exposed along Prairie Creek, about 2 miles south of Anderson, and outcrops also in several places along Pipe Creek.

The Devonian strata, consisting of the Corniferous limestones and Oriskany sandstones, underlie the glacial drift in the southwestern corner of the county, embracing all of Green Township and parts of Fall Creek and Stony Creek townships. The largest and boldest outcrop in the county occurs at the falls near Pendleton, where the rock, which is a sandstone said to be closely related to the Oriskany, is exposed. The caliciferous strata of the Oriskany series appears in the stream bed a mile above Pendleton, on Fall Creek. It also outcrops near the Hamilton County line, near Fishersburg. The Corniferous limestone, the upper member of the Upper Silurian in this county, outcrops at Fosters Branch, 4 miles

[1] Facts relating to the geology of Madison County are drawn largely from the report of the Indiana State Survey, 1884, by Ryland T. Brown.

below Pendleton, at a point near the county line. The rock at this point is a compact, crystalline limestone, and makes good foundation stone.

The underlying rocks of Madison County have such a limited exposure as to have little influence on the soils. The greater part of the county is covered with a deep deposit of glacial drift, laid down during the advance and retreat of the ice sheet. A belt extending from the northeast corner of Richland Township to Anderson, and thence down the valley of Prairie Creek past Pendleton to the southern boundary of the county, covers a region of eroded valleys bordered by hills of washed gravel. This gravel was deposited by streams beneath the melting glacier, the finer sediments being carried on to form the surfaces of areas to the south. The southeastern side of the glacial river bed, which stretches from White River to Fall Creek, along what is now known as Prairie Creek, is bordered by a distinct lateral moraine, composed largely of gravel and bowlders. This moraine often reaches a height of 40 or 50 feet above the level of the old river bed.

This valley of erosion is about a mile in width, and is depressed about 30 feet below the general surface of the county. The valley crosses Fall Creek, and narrows as it approaches Lick Creek near the Hancock County line. At the point where it crosses Fall Creek the surface is profusely strewn with bowlders of granite, gneiss, and trap rock. Southeast of this ancient valley gravel hills are very numerous, but these are usually covered with a deposit of clay loam. North and west gravel beds are rare, and entirely disappear as the northern county line is approached.

SOILS.

The soils of Madison County are largely made up of clay loam, with smaller areas of muck and sandy loam. Altogether there are four types of soil, exclusive of Meadow.

The following table gives the extent of each of these types and the part which each forms of the whole area:

AREAS OF DIFFERENT SOILS.

Soil.	Acres.	Per cent.
Miami clay loam	232,640	83.6
Miami black clay loam	31,360	11.3
Meadow	10,816	3.9
Madison loam	2,240	.8
Muck	1,152	.4
Total	278,208	

Miami Clay Loam.

The Miami clay loam consists of a loam or silty loam varying in depth from 6 to 12 inches, grading into a clay or clay loam of a stiff, heavy character which has a depth of 3 feet or more, and is, in turn, underlain by gravel or gravelly clay. The color of the soil varies from light to dark gray, although the lighter color is more general, while the subsoil is of a dark-yellow or mottled color, becoming lighter as it approaches the underlying gravelly clay.

The depth of the material from which the soil is derived is variable. Near Pendleton the underlying rock is only about 3 feet below the surface, but in general, between the subsoil and the rock there are strata of gravelly and bowlder clays. In the subsoil, at depths varying from 12 to 36 inches, are found in a number of places pockets of cross-bedded gravels and sands. Where these occur near the surface they have resulted in a phase of the Miami clay loam which can be described as a gravelly loam, underlain by a gravelly clay or gravel. This phase occurs in very narrow streaks, rarely exceeding a width of 40 feet, particularly along the river bluffs and the watersheds of the larger streams, and is the result of general surface washing and erosion. The proximity of such pockets to the surface causes a more or less droughty condition of the soil. The more important of these areas are indicated on the map by the gravel symbol.

The Miami clay loam occupies about 83 per cent of the entire area of the county, and extends for many miles beyond the limits of the present survey. It occurs with remarkable uniformity in different parts of the county, with the exception of such changes as attend the varying drainage conditions of local areas.

The surface features of this type are gently rolling, becoming more rolling and broken as it approaches the water courses.

The Miami clay loam is derived from the mantle of drift which was laid down subsequent to the deposition of the bowlder clay in the waters in front of the great ice sheet during its recession. Over the type occurs a scattering of erratic bowlders, supposed to have been brought from remote regions by the agency of icebergs. These erratics are not so numerous as to interfere with cultivation.

At the time of the early settlements the Miami clay loam was generally in a poorly drained condition. Tiling and surface ditching have done much to improve its condition, although at present there are many small areas of local importance—particularly in the large, level, interstream areas—which are badly in need of more perfect drainage.

The original timber growth on this type consisted of oak, ash, hickory, elm, beech, and sugar maple. These forests have gradually disappeared, and now only a few scattered woodlots are encountered.

The soil of the Miami clay loam is easy to cultivate; the subsoil, upon drying, breaks up into small cubes, the soil becomes loose and friable, and is a very productive soil type. It is used for general farming purposes, producing chiefly such crops as corn, wheat, oats, and grass. Some garden truck is grown, and orcharding is also carried on to some extent. No system of crop rotation is generally followed. Corn may be grown one or more years in the same field, then wheat or oats, followed by grass for two years. The fields are then left in pasture for a period of three or four years. Many farmers sow corn continuously for four or five years. and follow it with wheat for about the same number of seasons. This is in turn followed by timothy and clover, which run two years, and the fields are then used for pasturage for indefinite periods.

In good seasons the average yields of the field crops are given as follows: Corn 60 bushels, wheat 20 bushels, oats from 15 to 40 bushels, and hay from 1 ton to 1½ tons to the acre.

Orchards are few in number, and the acreage in tree fruits could be profitably increased. Apple and pear trees and grape vines were found to be of good growth and thrifty where the soil was well drained.

Mechanical analyses of the fine earth of the soil and subsoil of this type are given in the following table:

MECHANICAL ANALYSES OF MIAMI CLAY LOAM.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., per cent.	Clay, 0.005 to 0.0001 mm., Per Cent.
9462	3 miles NE of Anderson..	Silty loam, 0 to 12 inches.	1.46	0.96	1.88	2.12	7.60	7.54	59.86	19.90
9464	6 miles W. of Anderson.	Silty loam, 0 to 11 inches.	2.38	.70	2.50	2.46	6.54	5.70	59.50	22.30
9466	3 miles SW. of Alexandria.	Loam, 0 to 8 inches..	2.80	.88	2.48	4.62	23.22	10.30	35.80	22.66
9467	Subsoil of 9466...	Stiff clay loam, 8 to 36 inches.	2.58	.58	1.86	2.94	21.30	12.82	36.12	24.30
9465	Subsoil of 9464...	Stiff clay loam, 11 to 36 inches.	.75	Tr.	1.34	1.78	5.82	6.36	59.90	24.90
9463	Subsoil of 9462...	Stiff clay, 12 to 36 inches.	.52	.60	2.24	2.24	9.50	8.52	47.62	29.36

MIAMI BLACK CLAY LOAM.

The Miami black clay loam consists of a clay loam having a depth of 10 inches, grading into a stiff, silty clay.

When wet this type has a characteristic dark-gray or black color, which, as the soil dries, turns to an ashy gray. The immediate subsoil is very darkly mottled, but at depths exceeding 24 inches it generally becomes lighter, assuming the same color as the subsoil of the Miami clay loam.

The Miami black clay loam occupies slightly more than 11 per cent of the area of the entire county. It is found in a large tract of irregular outline in the northwestern corner of the county, in the vicinity of Elwood. Another area is found along the northern county line, in Boone Township, while a few isolated areas occur east of Alexandria. There are also many areas too small to map, occurring in depressions throughout the Miami clay loam.

The level or troughlike depressions occupied by the Miami black clay loam were formed upon the recession of the great ice sheet at the close of the glacial epoch. These lands became swamps or ponds, and to the later accumulation of decaying vegetable matter with the wash from surrounding soils is attributed the formation of this type.

In its natural condition the Miami black clay loam is wet and cold, the result of imperfectly established drainage. The greater part of the type originally swampy has been completely or partially reclaimed by the use of tile and surface ditches, but there are still considerable areas that could be reclaimed in this way. This type is usually difficult to till. It breaks up into clods and the surface becomes cracked and broken during hot weather. Where the drainage is good and the soil receives the necessary care and attention, it is slightly more productive than the Miami clay loam.

Like the Miami clay loam, this soil is used for general farming purposes, largely for the production of corn, wheat, oats, and grass. Corn yields about 60 bushels, oats about 50 bushels, wheat from 15 to 20 bushels, and hay from $1\frac{1}{2}$ to 2 tons to the acre.

The lack of definite methods of crop rotation is as marked on this type as on the Miami clay loam.

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

MECHANICAL ANALYSES OF MIAMI BLACK CLAY LOAM.

No.	Locality.	Description.	Organic matter. Per Cent.	Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0.0001 mm., Per Cent.
9478	6 miles NE. of Elwood.	Clay loam, 0 to 8 inches.	5.56	0.40	1.50	2.00	7.88	12.12	56.82	18.40
9480	4 miles SE. of Elwood.	Black clay loam, 0 to 11 inches.	3.93	.86	3.18	3.76	11.68	9.92	48.96	21.50
9481	Subsoil of 9480...	Stiff silty clay, 11 to 36 inches.	.78	.72	1.78	1.86	6.16	7.08	59.16	23.24
9479	Subsoil of 9478...	Stiff silty clay; 8 to 36 inches.	2.75	.32	1.62	1.64	5.54	7.78	57.10	25.88

Madison Loam.

The Madison loam consists of loose, friable, brown or yellow loam or fine sandy loam, from 8 to 14 inches deep, resting upon a heavy loam or clay, which usually becomes heavier below 24 inches.

The lighter variations in this type are usually found as it approaches the water courses, while the heavier phases occur near the uplands. Throughout the soil and subsoil is a scattering of well-rounded gravel, while many local variations occur in the subsoil, which sometimes consists of alternating layers of sand and clay, with an occasional lens of cherty gravel.

The Madison loam has a very limited distribution in the area surveyed, occupying less than 1 per cent. of the area of the county. It occurs in the second bottoms. The surface features are level or slightly inclined toward the water courses. The type is an alluvial deposit, laid down by the river and stream when they flowed at much higher levels than at present. The soil materials are derived from the wash and erosion of the valley slopes, and the differences in texture are the result of the varying velocity of the water currents in which the deposition took place. The Madison loam is poorly drained in places, owing to seepage of the drainage from the hills through the gravel strata in the river and stream bluffs.

The soil is used largely for the production of corn, wheat, grass, and truck. It yields good crops of corn and hay, but poor crops of wheat. In the vicinity of Anderson it is used more largely for the production of truck. Cabbage, tomatoes, and all kinds of berries do well on this soil, and it is even better adapted to potatoes and the root crops.

The following table gives mechanical analyses of samples of the fine earth of the soil and subsoil of this type:

MECHANICAL ANALYSES OF MADISON LOAM.

No.	Locality.	Description.	Organic matter. Per Cent.	Gravel, 2 to 1 mm., Per Cent.	Coarse Sand, 1 to 0.5 mm., Per Cent.	Medium Sand, 0.5 to 0.25 mm., Per Cent.	Fine Sand, 0.25 to 0.1 mm., Per Cent.	Very Fine Sand, 0.1 to 0.05 mm., Per Cent.	Silt, 0.05 to 0.005 mm., Per Cent.	Clay, 0.005 to 0.0001 mm., Per Cent.
9484	1 mile W. of Anderson.	Light loam, 0 to 16 inches.	5.10	0.52	2.64	2.36	9.78	12.70	44.60	26.70
9482	2 miles N. of Anderson.	Fine sandy loam, 0 to 18 inches.	1.33	1.40	4.60	4.44	17.00	11.12	34.14	27.30
9483	Subsoil of 9482...	Loam, 18 to 36 inches.	1.16	1.08	3.80	3.70	14.80	10.36	42.60	23.60
9485	Subsoil of 9484...	Loam, 16 to 36 inches.	3.59	.70	2.34	2.48	16.06	17.16	36.48	24.60

Muck.

Muck is a term given to that class of soils known as cumulose deposits, in which organic matter in various degrees of decomposition is the dominant characteristic.

The largest area of such deposits in this survey, and the one chiefly described, lies along the county drainage ditch between Anderson and Pendleton, east of the turnpike and the Cleveland, Cincinnati, Chicago, and St. Louis Railroad. The type also occurs throughout the county in many isolated areas of insignificant extent.

The soil is usually of a black color, less often a rich brown, and contains very little material other than organic matter. The depth of the deposit is variable, ranging anywhere from 8 to 36 inches, although exceptional spots occur where it exceeds a depth of 5 feet. There is a gradual change in the color and texture of the material as the depth increases, the black giving way to a yellowish-brown where the deposit has been subjected to but little oxidation, the tissues of the mosses and grasses being very plainly seen. Beneath this mass of partially decomposed vegetation there is a deposit of blue clay, of a stiff, heavy character, practically impervious to water. Interbedded with this are thin layers of lime marl, which rarely exceed 1 foot in thickness. No layers occur near the surface, although one boring showed indications of such a deposit at a depth of 8 feet.

The muck areas generally occupy poorly drained depressions, and are supposed to have been at one time shallow lakes or ponds. The depressions were first taken by aquatic vegetation of swimming types, followed by water ferns, coarse sedges, heaths, and sphagnum mosses, with willow, alder, and birch around the edges.

The area along the Pendleton ditch is troughlike and is supposed to have been a glacial river bed, which afterwards became a swamp through obstructed drainage. A portion of this swamp adjoining this area shows the condition of this type at an earlier stage of its development.

In the Pendleton ditch area drainage conditions vary considerably. In the southern part, where the deposit is narrow and the slopes steeper, the type is fairly well drained, but in the northern part it is imperfectly drained. In this section the main drainage ditches should be lowered and the number of laterals increased. The main can be lowered sufficiently for all practical purposes just below the McCulluch tract, or, if a greater fall is desired, the cut could be deepened at Pendleton Falls. This type, where cropped at all, is used for the production of corn and grass, and a little truck. The first two grow luxuriantly where perfect drainage has been established.

During the survey numerous local spots were seen throughout the areas of high water table where corn had been killed. When the surface of these spots dried after a rain they were usually characterized by the formation of a very thin white crust.

Samples of this soil taken from a corn field near Anderson were collected by Prof. F. H. King, who made analyses of the water-soluble constituents dissolved by treating 100 grams of soil with 500 cubic centimeters of water. The results are given in the following table:

CHEMICAL ANALYSES OF THE WATER-SOLUBLE CONSTITUENTS OF MUCK.

[Parts per 1,000,000.]

	K.	Ca.	MgS.	NO_3.	HPO_4.	SO_4.	HCO_3.	Cl.	SiO_2.
Under poor corn	46.18	306.0	93.84	519.20	12.8	520.0	114.0	30.0	50.8
Under good corn	60.96	160.0	65.28	354.40	32.0	178.0	124.0	44.0	98.9
Corn killed	29.84	160.0	46.92	52.60	20.0	240.0	282.0	16.0	59.7

The figures show the largest amounts of potassium and phosphoric acid under the good corn, but this fact probably has no especial significance, since the amounts of all the essential plant-food constituents (presumably in a readily available, because readily soluble, form) are in excess of what is known from experience to be sufficient for cultivable crops. Indeed, the figures show that the soluble salts are present in sufficient quantity to prove dangerous to many crops, and this warning is the more important because of the white crust sometimes observed on the surface of this soil after a prolonged drought. The soil from the spot where the corn was killed does not contain quite as much soluble material as the other spots show, and it seems that other causes were operative there, probably the rank growth of weeds observed when the sample was taken. It is obvious that it will be essential to the development of this type for cropping purposes that the water table should be lowered to 3.5 or 4 feet below the surface. For this purpose tile drainage is preferable. Similar soils have been profitably treated in this way in Illinois, Wisconsin, Michigan, and other areas of Indiana. A very instructive and detailed bulletin[1] on the treatment of such soils has been issued by the Indiana State Experiment Station. A description of the successful handling of similar soils in Michigan, where the soil has been found especially adapted to onions, cabbage, peppermint, and celery, has been described by the Bureau.[2] The application of potassium salts, after drainage, as a temporary corrective on these soils, has proved effective, as reported by several investigators, and the Indiana station reports that straw was nearly as effective. Chemical analyses by the usual method of digestion with concentrated hydrochloric acid have generally shown that these soils contain what would normally be considered ample quantities of lime, large quantities of phosphoric acid, and very large quantities of nitrogen. The amounts of potash usually reported are rather below what is obtained from productive soils. A thorough aeration and ventilation of these soils, which can be obtained by cultivation and underdrainage, would probably make them very valuable in the course of a few years, though possibly not immediately so.

No mechanical analysis of this type is given, since it is made up almost entirely of organic matter.

MEADOW.

In this report Meadow is a term used to indicate the poorly drained areas adjacent to water courses or lands subjected to overflow or seepage, irrespective of soil texture or vegetation. The Meadow occupies only about 4 per cent of the area of the county. It now forms a portion of the permanent pastures, but with the establishment of better drainage it can be made to produce a good quality of hay.

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[1] Purdue University Agricultural Experiment Station, Unproductive Black Soils, Bulletin No. 95, Vol. XII, March, 1903; Lafayette, Ind.

[2] U. S. Department of Agriculture, Field Operations of the Bureau of Soils, 1901. Soil Survey of Allegan County, Mich., by Elmer O. Fippin and Thomas D. Rice; p. 118.

Agricultural Development and Conditions.

In 1818 the Delaware Indians, who occupied a portion of the county, by the treaty of St. Marys ceded their territorial rights to the United States, and in 1823 withdrew from the county. At this time Madison County was organized from Marion County. The first permanent settlement in the county, however, antedated its organization about five years, having been made in Fall Creek Township in 1818. The early settlers came from Virginia and Kentucky. They found the county heavily timbered, with large tracts of poorly drained lands. The original timber growth consisted of oak, ash, walnut, hickory, and sugar maple. The first town to be founded was Pendleton, followed by Anderson and Chesterfield. The county did not grow very rapidly, being outside the line of travel, but with the building of railroads, between 1851 and 1891, the county made great strides and its progress has continued rapid to the present time.

Madison County is now one of the most prosperous counties of Indiana. There are three incorporated cities within its boundaries, and the total population is over 70,000. The manufacturing and agricultural interests are in a flourishing condition, presenting a wide range of industrial pursuits, and supplementing each other in the general development of the county. The great growth of manufacturing interests is attributable to the discovery of gas and oil, the use of which lessens the cost of production and enables the manufacturers more easily to compete with kindred industries.

The chief agricultural interest is stock raising. This is carried on in connection with general farming. Some roughage and grain are sold direct to local buyers, but the more enterprising farmers convert a great part of their field crops into beef or other meats.

The stock consists of horses, mules, cattle, sheep, and swine. Large numbers of horses are raised, more particularly in the southern part of the county. These are chiefly road and draft types, grade mares being bred to Percheron, Clydesdale, English Shire, and trotting stallions. The few mules raised are used mostly to supply the local demand for work animals of this type. The cattle are raised for dairy and beef purposes. The dairy cattle are few in comparison with the beef cattle, and consist of Jerseys and Holsteins. The dairy herds are usually found in the neighborhood of cities or large towns where dairy products can be readily disposed of. The beef cattle consist of graded Shorthorns and Herefords, the former predominating. Some herds of 25 or 30 cows are kept to produce beef calves, although the greater number of calves in the county are raised by farmers with only two or three cows. These animals, when matured, are either fattened by the owner or are bought up by farmers who make a business of feeding. A great number of young steers are imported from areas which have large tracts of cheap pasture lands. These are turned out on the pastures and during the fall and winter fattened on corn or ensilage. The latter is not used extensively at present, but its use is growing constantly. The hogs consist of graded Poland-China, Berkshire, Chester White, and Duroc-Jersey. The first and the last are most numerous. There are few pure-bred hogs in the county, but the graded stock is very good. Hogs form the main product of many of the farms and consume the greater part of the corn produced in the area.

Sheep are very scarce, but those seen consist of good grades, with a predominance of Shropshire blood. The farmers in general favor the grades and crosses, as they are considered more hardy than the pure-bred animals.

The farm houses of the area are usually two-story frame structures of very simple design. The outbuildings consist of a large barn, a corn crib, and a shelter for stock. The barns are mostly of the large, rectangular type, though "bank" barns are gradually displacing the older ones, owing to their better facilities for storing and feeding the crops. There are a few round barns, and these are generally regarded as the best type, considering economy of space and cost of construction. The cattle sheds are commonly of the straw type. The timbers are put up and the wheat straw blown over them from the thrashing machine.

The best general conditions in the area are found in the vicinity of Pendleton, west and north toward Anderson, and then east; and also in the vicinity of Alexandria, Elwood, and Summitville. The worst conditions occur on the poorly drained areas, more particularly on the areas of Miami black clay loam.

The farms are usually well fenced, and equipped with improved types of modern machinery. Insufficient care is given these tools, and they are often left exposed to the weather throughout the winter.

The farms vary greatly in size. There are 71 farms of less than 3 acres, and only 1 of over 1,000 acres. There are 1,090 farms containing between 50 and 100 acres, and 705 containing between 100 and 175 acres. The average size for all farms in the county is

81.9 acres. The value of the farm lands ranges from \$60 to \$100 an acre, depending upon location and improvements.

Of the 3,346 farms in Madison County, as given by the Twelfth Census, more than half are operated by the owners. About one-third are cultivated by tenants, by far the greater number of which are share tenants. On the share basis the owner receives one-half the crops, the tenant furnishing the seed. The cash rental ranges from \$2 to \$6 an acre. The leases are usually made out for periods of from one to five years. Landlords prefer the system of crop rent, as the tenant in this case usually takes better care of the land.

Farmers usually have considerable trouble in securing help during harvest, but the character of the labor employed is reliable and efficient. The use of labor-saving machinery has cut down the number of hands required, and very few men are now employed by the year, the farmers doing most of their own work, often exchanging service with others in the same community. Where labor is hired by the month or year, \$20 a month is a fair average wage, while during harvest from \$1.50 to \$2.50 a day is the customary rate.

The farming practiced in Madison County is of a general character, and there has been little development of special interests. This is one result of the remarkably uniform soil areas. The crops produced consist of corn, wheat, oats, and grass, and a very limited quantity of truck and orchard products.

Corn is the main crop, and the production is large, but little of it goes to the markets, the greater part being converted into beef and pork. Some corn is raised for ensilage and used largely for fattening cattle. There are few silos in the county, but to judge from interviews with farmers using them, they would seem to be a profitable investment.

The larger part of the wheat and oats is sold as soon as thrashed, small quantities being retained for home use.

Of the hay crops, clover seems to be the most important. The feeding and manurial value of the hay, combined with the low selling price, as compared with timothy, causes the use of large quantities of it as a stock feed in this area. The second cutting of clover is harvested for seed.

As already stated, there are in the area surveyed four types of soil, not including the lands grouped as Meadow. To emphasize some of the more salient features and adaptations of these different types, a brief review will be given here.

The Miami clay loam has the greatest area and is used almost entirely for the production of grass and grain. It produces fair crops of corn, wheat, and hay, although oats do not do so well as on the Miami black clay loam. In the description of this type it was pointed out that little systematic rotation of crops was practiced, and it is not surprising that there has been a marked decrease in the yields, the result of continued cropping to corn and wheat. The type is generally deficient in organic matter, and there are many local spots in need of drainage.

It is suggested that the productiveness of this type would be increased by the practice of a judicious rotation, the establishment of better drainage, and the incorporation of humus through the use of stable manure and green manuring crops. In many places the application of lime would be most beneficial, more particularly in the depressions where the soil is cold and wet. The Miami clay loam is well adapted to the field crops at present grown. It also produces a good quality of apples, pears, and grapes, which, though now grown only to a limited extent, might be made an important feature of the agriculture on this type.

The type Muck, commonly known as "black prairie," or "chaffy soil," is a peculiar type of soil. With the ground water very near the surface, the soil is never too wet to work. It is apparently very rich, and yet at present largely unproductive; so much so that stable manure and wood ashes are necessary to produce profitable crops.

The most noticeable feature of this type is its poor underdrainage. The impervious nature of the underlying subsoil keeps the water table too near the surface, as a general rule. Better drainage could be established with a system of tile drains, provided the main ditch (Prairie Creek) be lowered, which seems practicable. In areas where the valley slopes are steeper and there is good natural drainage, the type is well adapted to corn and timothy. In such positions, also, this is a good soil for growing the general truck crops, particularly celery, onions, potatoes, and cabbage. In some parts of the United States very similar soils are used in the production of peppermint.

The relatively low productiveness of the Muck, as has been stated, is largely due to imperfect drainage, which has prevented aeration and consequent oxidation of the organic matter forming the greater proportion of the soil materials. In addition to a more thorough draining the process of oxidation can be hastened by incorporating strawy manures or litter, and this can best be added to the soil by the use of disk plows or harrows.

The Madison loam occupies the least area of the soils of the county. It is well adapted to light farming and the production of general truck and fruit crops, for which it is largely used at present.

The Miami black clay loam, under good general conditions, is more productive than the Miami clay loam. The production of oats is more successful on this type than on the Miami clay loam, although wheat does not do so well.

In Madison County the question of drainage is very important. Those areas of Madison loam which are subject to seepage from the bluffs could be greatly improved by a tile or open drain paralleling the bluffs. Reference has already been made to the drainage of the Muck areas. On the Miami black clay loam and Miami clay loam there is room for extension of the present drainage systems. Tile drains are, on the whole, most satisfactory, but frequently surface ditching to the underlying gravel is possible and answers very well. In some instances the kettle holes and small depressions have been drained by placing 6-inch tile in abandoned gas wells, where the pipes have been removed. It has been necessary to tile these wells only to the underlying gravel.

The use of commercial fertilizer is not very common in Madison County. The census report of 1900 gives $5,730 as the total expenditure in the county for that purpose. In general, the only attempt to maintain the productiveness of the soils is made by turning under clover and timothy sod or worn-out pastures. The intervals between such renovation are in general too long.

A growing custom is that of feeding the cattle around the straw piles and saving the barnyard manure, a great deal of which formerly went to waste. It was not uncommon to see from three to six straw stacks around the barns on the best improved farms.

There was formerly an extensive system of toll roads in Madison County. The last of the companies operating these roads was bought out in 1889. At the present time the county owns 450 miles of well-kept turnpikes. In addition to these there is a complete system of dirt roads.

The railroad facilities of the county are excellent, many trunk lines traversing it in all directions. There is no part of the county where the distance to the nearest railroad exceeds 8 miles.

With the exception of manufactured products, cattle form the chief export of the county. They are shipped mainly to Chicago and Indianapolis, although some shipments go to Eastern markets.

Report of State Natural Gas Supervisor.

OFFICE OF STATE NATURAL GAS SUPERVISOR, FORTVILLE, INDIANA.

Prof. Edward Barrett, State Geologist of Indiana:

Sir.—I hereby transmit to you the twenty-first report of this Department, the same being my second report. I endeavor to report conditions as found by me in my visits to both the oil and gas fields. Also I will quote from some of the best authorities when and where the first gas and oil was found and the origin of the same, and in closing this my second year's work, I am pleased to acknowledge the very cordial support and valuable suggestions that I have received from you from the beginning.

Very respectfully,

W. E. MORSE,
State Natural Gas Supervisor.

Report of State Natural Gas Supervisor.

In all previous reports, the gas has been discussed at length and the waste of the same, but there has been but little effort to have laws made to correct this evil until this year, when I hope the Legislature will remedy all laws so that the waste can be stopped entirely.

The impression prevails among the people that this Department has nothing to do with the oil wells which produce as much wealth to the operator as gas, and much more to the one who owns the farm. I look after the oil as closely as the gas. The trouble which I come in contact with mostly, and which has been given the least attention in the past, is the fresh and salt water. The fresh water does more damage than the salt water. Casings become bad by remaining in use so long, and allow the fresh water to leak down into the gas and oil bearing rock, which destroys the gas and oil. A stream of fresh water the size of a lead pencil will destroy hundreds of dollars worth of oil; salt water will destroy the gas when such water is allowed to stand in wells which are abandoned and not properly plugged. The gas bearing rock becomes flooded, driving the gas back in the rock until the pressure becomes so great that it will counteract the pressure of the salt water, thus preventing the utilizing of the gas and oil.

However, I have had but little trouble to convince the people that it is their duty to remedy all such evils, as soon as I get information that such wells are in bad condition. The waste of gas is not giving as much trouble now as it has been in the past, as nearly all oil companies have provided ways of husbanding the extra gas.

OLD FIELDS.

In the old fields there seems to be some excitement. In some localities the operators are looking after old leases which had been returned to the owners of the farms, and more drilling has been done in the last six months than in the three years previous, wells having been found that will produce from 15 to 250 barrels of oil, with enough gas to operate them, and when spring weather comes there promises to be much more drilling done. This is brought about by the price of oil, which is at this writing $1.23 per barrel.

Greene County.

Greene County is at this time very promising to become an oil field. Four wells, ranging in production from 5 to 35 barrels per day, with a very fine grade of oil, have been drilled the past year. The Ohio Pipe Line Company has laid a line to the wells and are now taking care of all oil.

Sullivan County.

Sullivan County has not been very active, but still has some production there. It seems that one company has taken very nearly all the leases and is holding same for a larger price than the operators wish to pay.

Pike and Gibson Counties.

These counties are still holding up to about their usual production of both gas and oil, and there is some drilling being done, but very few wells have been plugged within the last year.

Harrison County.

Harrison County has come forward with both gas and oil. There has been gas produced in Harrison County for some time, the same being piped to Louisville, Kentucky. Both the gas and oil wells vary in depth from 60 to 900 feet, and six oil wells range in depth from 135 feet to 700 feet, with a production of from 5 to 30 barrels per day. It is the opinion of the writer that this county will develop into a good gas and oil field, as gas and oil are found in various sands.

The Stratigraphy and Paleontology of the Tanner's Creek Section of the Cincinnati Series of Indiana.*

By E. R. Cumings and J. J. Galloway.

INTRODUCTION.

The present report is the result of three continuous years of study in the laboratory of collections and notes taken in the field by Professor Cumings and students of the Department of Geology of Indiana University during the summers of 1910 and 1911. The collections were made from the eighteen new railroad cuts on the Big Four Railroad from Weisburg to Guilford, Indiana, and at Section 5.9A, and consist of about a ton of clean fossils, mostly Bryozoa.

The fossils were collected zonally, great care being taken to locate exactly the horizon of every specimen. The laboratory work has involved the preparation and study of 1,550 microscopic slides with sections of Bryozoa from this collection alone.

We are under obligations to Mr. Lyle Shank and Mr. Robert Payton, who assisted in the field work, and to Dr. R. S. Bassler, of the United States National Museum, for kindly furnishing specimens for comparison. Mr. H. N. Coryell has been of inestimable service to us. He has assisted in the preparation of slides, charts and plates and has been of great assistance in many other ways. Dr. J. W. Beede has kindly given suggestions and advice on many points.

PART I. STRATIGRAPHY.

The most complete section of the Cincinnati Series so far known is the section exposed in the eighteen railroad cuts on the Chicago and Cincinnati Division of the C. C. C. & St. L. Railroad along Tanner's Creek, Dearborn county, Indiana, from Guilford to Weis-

* The present report is supplementary to the senior author's work on "The Stratigraphy and Paleontology of the Cincinnati Series of Indiana", published in the 32d Annual Report of the Department of Geology and Natural Resources of Indiana, 1907.

burg. The railroad cuts were opened in 1902-3, and expose the strata from the middle Eden to near the top of the Whitewater division of the Richmond, with the exception of ten feet in the upper Liberty. The section exposed is 505 feet thick. Since the westerly dip is five feet to the mile the difference in elevation between the base and top of the section is 460 feet.

Many of the cuts overlap stratigraphically, that is, the same strata are exposed in several cuts, so that the chances of getting the entire fauna of a stratum are greatly increased by collecting from the same horizon in different cuts. The elevation of the railroad track at every point is accurately known, so that it would scarcely be possible to find a section where more accurate stratigraphic measurements could be made, or the horizon of specimens and range of species determined with more exactness.

When the cuts were first opened and the strata were freshly exposed, accurate zonal collecting would have been a simple matter, but it is becoming more and more difficult to collect in these cuts on account of the slumping, and overgrowth of vegetation. In the spring of the year, however, before the weeds get started, it is still an easy matter to find the fossils in place. Great quantities of fossils in a fine state of preservation may be picked up from the talus and dumps, but such collections are of little value for stratigraphic studies.

The following classification of the Cincinnatian rocks is applicable to the Tanner's Creek Section:

Cincinnatian	Richmond	(Elkhorn)
		Whitewater (*Homotrypa wortheni* zone)
		Saluda (*Tetradium minus* zone)
		Liberty (*Strophomena planumbona* zone)
		Waynesville (*Dalmanella meeki* zone)
	Maysville	Corryville-Arnheim (Harmon) (*Rafinesquina fracta* zone)
		Bellevue (*Rafinesquina ponderosa* zone)
		Mt. Hope-Fairmount (Fairview) (*Plectorthis plicatella* zone)
	Eden	McMicken (*Heterotrypa ulrichi* zone)
		Southgate (*Hallopora onealli* zone)
		(Economy)

Explanation of Faunal Charts.

At the left of each chart is given an alphabetical list of all the species identified in the 1910 and 1911 collections from Tanner's Creek. The occurrence of each species is indicated by a straight line, the weight of the line indicating the relative abundance of the species. Where the species is very abundant or dominant in the fauna the space is filled in solid black..

At the top of the charts the interval exposed by each railroad cut is indicated by a bracket. The elevations above sea level are also indicated, each space, reading across the chart, equaling five feet.

In these charts the dip is disregarded. This introduces an error of about eight per cent., that is, each formation is eight per cent. thicker than is indicated by the differences in sea level.

The 565 foot level of Section 5.9A (opposite the mouth of the Miami River, in the Kentucky bank of the Ohio River) corresponds to the 515 foot level of the Tanner's Creek section, since the dip between the two sections amounts to at least 50 feet.

The profile and map were taken from surveys made by the engineers of the C. C. C. & St. L. R. R. Co., and show the interval exposed by each cut, the dip and thickness of the strata, the elevation above sea level, etc.

The Eden Group.

The rocks of the Eden group consist largely of soft, blue, sometimes sandy shale with occasional thin beds of blue or gray limestone. The limestone layers are made up largely of fossils, but most of the shale is relatively barren, though occasionally containing large numbers of Graptolites, Trilobites, etc. About 160 feet of these shales are exposed on Tanner's Creek and at Section 5.9A, across the Ohio river from Lawrenceburg.

Southgate.—The lowest strata exposed in the Tanners' Creek section are seen in an exposure about a mile and a half down the creek from Guilford. This section, numbered 1.34E*, is about 20 feet thick, and consists principally of thinly laminated, fine-grained, friable, soft blue shale, with a few thin layers of fine-grained limestone and sandstone. The principal fossils are *Climacograptus typicalis* Hall, and *Bythocypris cylindrica* (Hall), both of which occur in great abundance. These species were not obtained

* The exact elevation of Section 1.34E is not known, but it is about 25 feet lower than as shown on the faunal charts.

from any higher horizon, and it seems quite probable that they are restricted to the Economy and Southgate.

We consider Section 1.34E as belonging to the Southgate member of the Eden. Nickles calls the middle Eden the *Batostoma jamesi* beds.* Not a single specimen, however, of this species was obtained from Section 1.34E, so that Nickles' faunal name would not apply to this part of the section. Neither the top nor the botton, however, of the Southgate is exposed at this locality. Higher up, in Cut 1, in the McMicken, *Batostoma jamesi* is abundant. Bassler says that at the type locality, Southgate, Kentucky, "througout the entire member, *Ctenobolbina ciliata, Aspidopora eccentrica,* and *Batostoma jamesi* are particularly abundant and characteristic."† None of these species were found in this member on Tanner's Creek. *Ctenobolbina ciliata* occurs in the McMicken. Six miles southeast of Guilford, at Section 5.9A, on the Kentucky bank of the Ohio river opposite Lawrenceburg, we found *Aspidopora eccentrica* and *Batosoma jamesi* in considerable numbers in the Southgate. This would seem to indicate that the typical Southgate fauna did not extend into Indiana.

McMicken.—These beds are exposed in Cuts 1, 2, 3, 4 and 5, and at Section 1.34C12a (on the creek just south of Cut 6). They consist mainly of soft, blue shale with occasional irregular layers of limestone from a few inches to a foot thick. The whole thickness of the upper Eden represented in these cuts is about 75 feet. Fossils are abundant throughout this division and the number of species is large. We have identified no fewer than 66 species from these beds, 47 of which are Bryozoa. The most abundant species are *Heterotrypa ulrichi, Coeloclema commune, Coeloclema alternatum, Batostoma jamesi, Batostoma implicatum, Hallopora onealli* and varieties, *Amplexopora septosa* and varieties, and *Dalmanella multisecta.* All of these occur in great profusion. The most fossiliferous horizon is from 545 to 565 feet above sea level, in the top of Cut 1, and bottom of Cuts 2 and 3.

The McMicken of Tanner's Creek agrees very well in thickness, lithological characters and fossil contents with the same strata elsewhere in Indiana and Kentucky and at Cincinnati. The base is not exposed in our section, but it cannot be much below the bottom of Cut 1.

There are three fairly well marked faunal divisions of the McMicken, the lower 25 feet, the middle 20 feet and the upper 25

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* Jour. Cin. Soc. Nat. Hist., XX, p. 72, 1902.
† Proc. U. S. Nat. Mus., XXX, pp. 9, 10.

feet. The lower 25 feet is not very fossiliferous, the species enumerated occuring sparingly at the bottom and in increasing abundance toward the top. At this point, and continuing for 20 feet, there is a marked increase in the number of species and the abundance of individual specimens. *Heterotrypa ulrichi,* as well as most of the other species listed above, occurs most abundantly at this horizon. In the upper 25 feet there is a marked decrease in the number of individuals and an equally well-marked increase in the number of species, *Batostoma jamesi, Coeloclema commune* and *Heterotrypa ulrichi* occur only sparingly, and *Hallopora onealli* not at all in this division. On the other hand, *Bythopora arctipora, Dekayia aspera, Hallopora dalei, Heterotrypa ulrichi lobata, Heterotrypa ulrichi robusta* and *Peronopora vera* become increasingly abundant.

The McMicken differs from the Economy and Southgate both in being more calcareous, and faunally; but there is no sharp dividing line between them. The top of the Eden is not marked by any sharp litholigical break, nor by a pronounced change in the fauna. The horizon we use as the top of the Eden is at an elevation of 590 feet in the top of Cut 3. This horizon is somewhat arbitrary, since any other horizon from 70 feet below to 50 feet above could be used with some justification, considering this section alone; but we believe that this horizon is substantially the same as that which former workers have considered as marking the top of the Eden, and there is at this level a fairly well-defined lithologic transition.

While at this horizon there is no very sharp change in the character of the sediments, there is a considerable change in the character of the fauna, particularly in the item of relative abundance. Many species which occur in abundance in the McMicken suddenly become rare or extinct at this level, while a number of other species first appear or become abundant. Among the species which make their last appearance at the top of the McMicken are *Trinucleus concentricus, Batostoma jamesi, Coeloclema alternatum, Coeloclema commune, Dekayia obscura, Hallopora onealli communis* and *Hallopora onealli sigillarioides. Constellaria constellata prominens* is characteristic of the base of the Maysville.

It is possible that the level 25 feet lower, which is indicated on the faunal charts by a heavy line, is the horizon which students of the Cincinnati section consider as the top of the Eden.

THE MAYSVILLE GROUP.

The rocks of the Maysville group, in this section, as well as elsewhere in Indiana, Ohio and Kentucky, consist largely of thin, slabby, irregular, often sandy, beds of limestone, intercalated with soft, usually yellowish shale. The Maysville is more calcareous than the Eden below and the Richmond above, and this constitutes its chief distinguishing feature lithologically. The most abundant fossils occurring throughout the Maysville are *Rafinesquina alternata* and its varieties, and *Hallopora ramosa* and *Heterotrypa frondosa.*

Mt. Hope-Fairmount (Fairview).—This division is 75 feet thick in this section, and is considerably more calcareous than the underlying McMicken beds. In this section the Mt. Hope cannot be distinguished from the Fairmount, either lithologically or faunally. Nickles* calls the Mt. Hope the *Amplexopora septosa* beds, and designates as a dividing line between them and the McMicken a thin layer of limestone made up mainly of *Dalmanella multisecta.* In the present section *Amplexopora septosa* is not confined to the lower Maysville, but occurs in almost equal abundance throughout the McMicken and 50 feet of the Maysville, a vertical range of at least 120 feet. Consequently the Mt. Hope cannot be identified by this species alone. The layer of *Dalmanella multisecta* cannot be identified in this section. This species occurs very abundantly in the middle and upper McMicken, and commonly in the Mt. Hope-Fairmount.

The Mt. Hope-Fairmount is very fossiliferous, a large number of species occurring and a great abundance of individuals. The species occurring most commonly are *Plectorthis plicatella, Platystrophia laticosta, Amplexopora septosa* and its varieties, *Batostoma implicatum, Bythopora arctipora, Dekayia aspera* (in the lower 20 feet), *Escharopora falciformis, Escharopora pavonia, Hallopora andrewsi, Hallopora dalei, Heterotrypa subfrondosa* and its allies, *Homotrypa curvata* and its allies, and *Peronopora vera. Constellaria constellata* and varieties, while not common, is very characteristic of the basal Maysville.

Bellevue.—The rocks of this division are similar to those of the division below, but the limestone layers are less sandy and more fissile, and weather more rapidly. There are fewer species of fossils is these beds, but these occur in great numbers. The most common species are *Hallopora ramosa, Heterotrypa frondosa, Hebertella*

* Jour. Cin. Soc. Nat. Hist., XX, p. 76.

sinuata, Platystrophia laticosta, Rafinesquina alternata and its varieties *R. fracta* and *R. ponderosa.* Many of the limestone layers are made up largely of the shells of *Rafinesquina. Monticulipora mammulata d'Orbigny* (= *Monticulipora molesta* Nicholson) is abundant in the Bellevue at Cincinnati and characteristic of the formation, but not a single specimen has been found in these beds on Tanner's Creek. A few specimens were found in the division immediately below.

*Corryville-Arnheim.**—This division, which is about 110 feet thick, consists of limestones and shales, similar to the rest of the Maysville. Limestones predominate at the base and are gradually replaced by shale toward the top, where the rocks consist largely of thin-bedded, sandy, yellow, nodular shale. Fossils occur in fair abundance, surpassing the lower Maysville in the number of species. Our collection from this division contains 85 species.

The lower 20 feet are apparently less fossiliferous than the rest, but part of this lack may be due to the difficulty of collecting. The most conspicuous fossils are *Hallopora ramosa* and *Rafinesquina alternata fracta,* neither of which is confined to these beds. The characteristic fossils are *Atactoporella ortoni, Coeloclema oweni, Homotrypa pulchra* and *Dinorthis retrorsa. Chiloporella flabellata* occurs in considerable numbers at an elevation of 710 feet in Cut 8, and sparingly for 35 feet below and 15 feet above this level. This species has been considered as being characteristic of the Corryville member of the Maysville. Its occurrence enables us to correlate these strata in a general way with the Corryville elsewhere, but we are unable to set any very definite limits to the Corryville in this section. The horizon of the Mt. Auburn is indicated by a thick layer of limestone containing the gerontic form of *Platystrophia lynx.* This horizon, which in this section is at an elevation of 725 feet, is considered by most geologists as marking the top of the Maysville, and Ulrich considers it as the top of the Ordovician.

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* If a single name is desired for this division we propose the name *Harmon,* from Harmon's Station, near which in Cuts 8 to 11 the entire formation is exposed. Owing to an error in drawing the faunal charts, several species that are restricted to the lower Arnheim, are shown as persisting throughout the division. The correct range is indicated in the lists on pp. 380-384.

We do not agree either that the Arnheim should be placed in the Richmond, or that the Richmond belongs in the Silurian. There is no lithologic or faunal break at this level, at least in the present section. Most of the Arnheim species range without interruption from within the Corryville to the middle Arnheim, and many of them throughout the Maysville. These facts are graphically shown on the faunal charts.

The Arnheim fauna, which has heretofore been little studied, is large and varied. It is interesting that *Homotrypa bassleri*, which characterizes the Arnheim in Ohio, should be entirely wanting in the present section. Our collections from the Arnheim are very extensive, yet we have searched in vain for a specimen of this species. Many species occur in large numbers, but only one, *Dinorthis retrorsa* (*D. carleyi* Hall) seems to be characteristic of these beds, and this is confined to a few feet of rock near the top of the Arnheim. All the other species either occur lower in the Maysville, or continue into the Waynesville.

The Richmond Group.

At the top of the Arnheim the rocks are irregularly bedded and nodular and almost barren of fossils. At this point limestones cease to predominate, and are replaced by soft, argillaceous shale and thin beds of limestone. Shale predominates throughout the Waynesville, which is 105 feet thick. There is also a marked faunal break at the top of the Arnheim. Not less than 30 species of Bryozoa fail at this point or abruptly become rare. Over 20 species make their first appearance at this horizon. The Waynesville fauna is quite distinct from the Arnheim and shows a change of life conditions. There are also numerous migrants from other regions, especially from the northwest, indicating a pronounced epeirogenic movement at this time. At no horizon throughout the Maysville is there any faunal or lithologic change comparable with the one at the top of the Arnheim. Hence, we maintain that the Arnheim should be classed with the Maysville sediments and that the Richmond should begin with the lower Waynesville. On the other hand, we believe that the Richmond is most intimately associated with the subjacent Ordovician, both lithologically and faunally, and that it should be retained in the Ordovician System.

Waynesville.—These beds consist of soft, blue shale, with occasional thin beds of limestone. Fossils are very abundant, and both the number of species and of individual specimens is great. Several species of *Heterotrypa* occur abundantly throughout the

Waynesville and are confined to these beds, especially *Heterotrypa prolifica*, which occurs in large numbers. The Waynesville species of *Heterotrypa* can, however, always be distinguished from the Maysville species of the genus by the presence of diaphragms in the axial region of the former.

The three divisions of the Waynesville proposed by Foerste, in ascending order, Fort Ancient, Clarksville and Blanchester,* cannot be very definitely delimited in this section and we prefer not to subdivide the formation. The upper 17 feet, corresponding in part to the Blanchester, is marked by the occurrence of *Hebertella insculpta, Leptaena rhomboidalis* and *Platystrophia laticosta* in great numbers.

The fauna of the Waynesville is the most prolific of any division of the Cincinnatian. Our collection from the Tanner's Creek Section contains 116 recogniazble species. Most of the fossils, except the Mollusca, are in an excellent state of preservation.

Dalmanella meeki occurs abundantly throughout this formation but is not restricted to the Waynesville. The lower and middle Waynesville are not characterized by any fauna markedly distinct from the upper part. The upper 17 feet are characterized by the abundant occurrence of *Protarea vetusta, Streptelasma divaricans, Hebertella insculpta, Leptaena rhomboidalis, Platystrophia laticosta* and *Calymene callicephala.* This upper portion is by some geologists placed in the Liberty formation.

The common forms which make their first appearance in the Waynesville, and probably represent an invasion from the northwest, are *Streptelasma rusticum, Protarea vetusta, Rhynchotrema capax, Rynchotrema dentata, Strophomena planumbona* and its allies, *Heterotrypa prolifica* and the associated species of the genus, *Homotrypella hospitalis, Batostoma prosseri* and *Rhombotrypa quadrata.*

Liberty.—The Liberty formation is 50 feet thick and consists almost entirely of limestone, the base being marked by layers of rock almost wholly made up of *Plectambonites sericeus.* A considerably smaller number of species occurs in the Liberty than in the Waynesville, but there is a large increase in the abundance of individuals of several of the holdovers from the Waynesville.

The most abundant and characteristic species of the Liberty are *Dinorthis subquadrata, Plectambonites sericeus, Rhynchotrema capax, Strophomena planumbona, Amplexopora granulosa* and *Homotrypa austini.*

* Bull. Sci. Labs. of Denison University, XIV, p. 291, 1909.

Saluda.—The Saluda in this section is about 10 feet thick, and made up of a basal member, the 'shale bed,' of exactly the same character as the same member at Versailles, Indiana; and an upper bed of massive limestone containing *Tetradium.* The fauna is very meager. The most abundant species is *Tetradium minus,* which occurs in large masses at the top of the division, representing the upper *Tetradium* reef of sections farther southwest.

*Whitewater.**—The lower 30 feet of the Whitewater is exposed in Cut 18, just north of the station at Weisburg, Indiana, and consists of a soft, very nodular, shaly limestone, exactly like the Whitewater of the type section at Richmond, Indiana.

Only a few species, outside of the Bryozoa, are restricted to the Whitewater, most of the fauna being the same as that of the Liberty. *Strophomena sulcata* occurs abundantly. The Bryozoa characteristic of the Whitewater are *Batostoma variabile, Bythopora delicatula, Homotrypa constellariformis, Homotrypa cylindrica, Homotrypa nicklesi, Homotrypa nitida, Homotrypa ramulosa* and *Homotrypa wortheni.* Those restricted to this division are *Batostoma variabile, Homotrypa constellariformis, H. nitida* and *H. nicklesi.*

The Elkhorn division is not present in this section.

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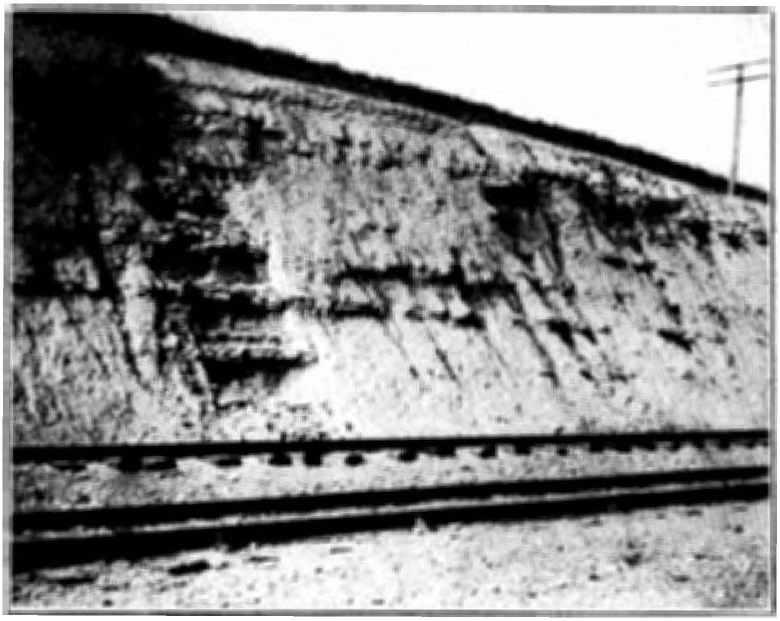
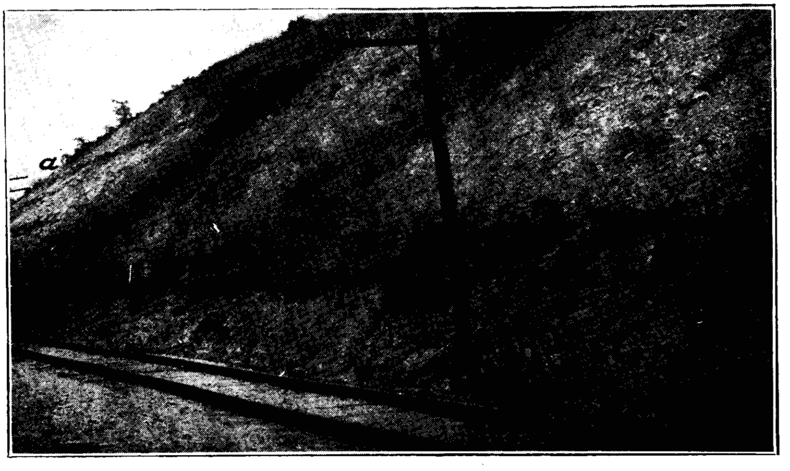
* Mr. Ulrich believes that the base of the Whitewater division should be taken at a horizon about 15 feet below the Saluda 'shale bed', where a number of species enter that are characteristic of the Whitewater. He believes, furthermore, that the 'Saluda' is merely a series of northwardly thinning wedges in the Whitewater.



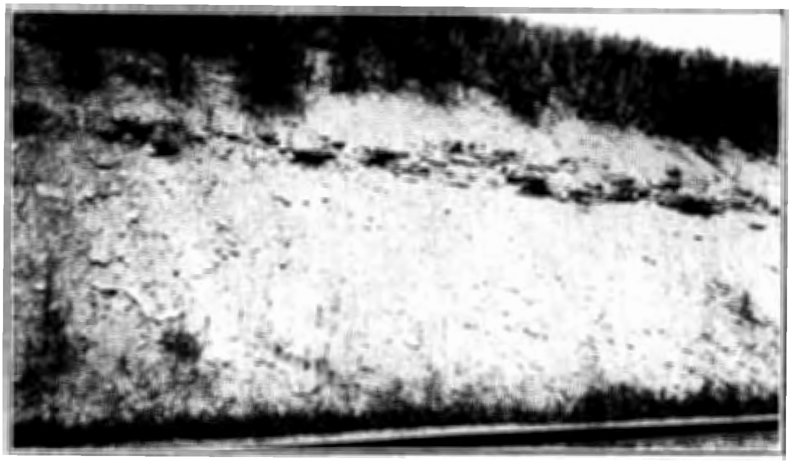
Cut 1.—Just east of Guilford. Lower McMicken.

Cut 2.—Just west of Guilford. Upper McMicken. Base of Maysville at *a*.

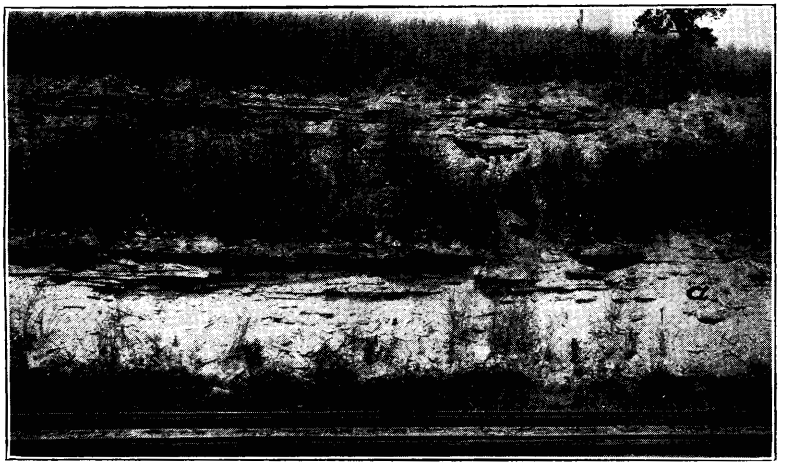
Cut 3.—South side. Upper McMicken.



Cut 4.—South side. Upper McMicken. Base of Maysville at *a*.



Cut 5.—North side. Zone of abundant *Dekayia aspera*.

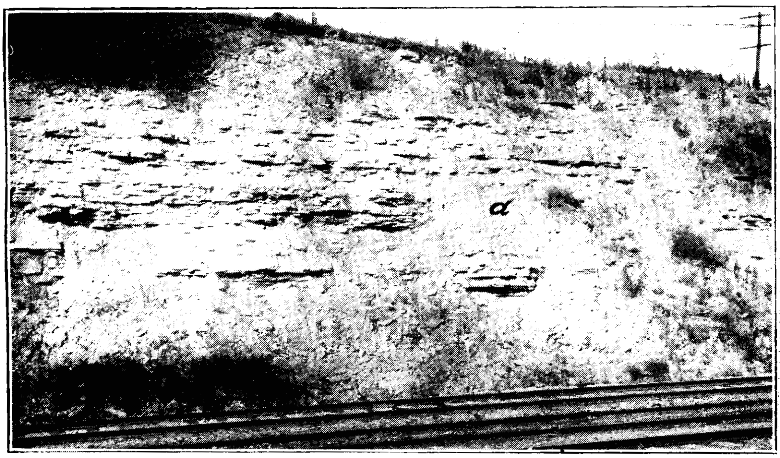


Cut 7.—North side. Lower Fairmount. *Strophomena planoconvexa* layer at *a*.

Cut 9.—Corryville. Bellvue at base.

Cut 5—South side. McMicken and Mt. Hope. Base of the Maysville at *a*.

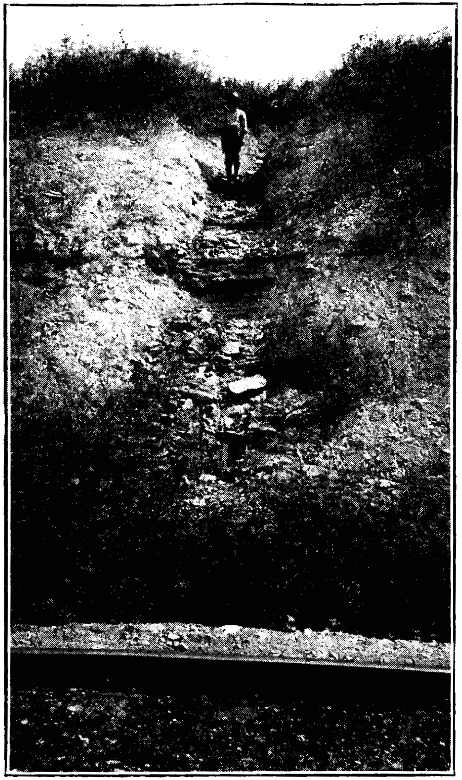
Cut 10.—Corryville-Arnheim. The *Platystrophia lynx* layer is at *a*.



Cut 16.—Top of the Waynesville and base of the Liberty. The *Plectambonites sericeus* layer is at *a*.

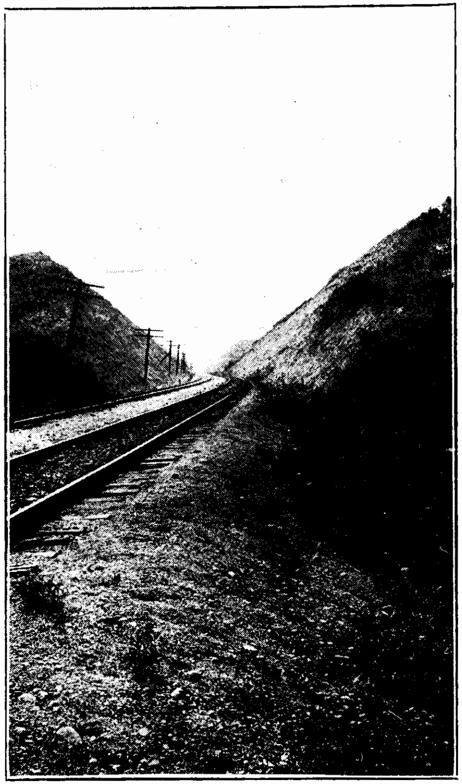
Cut 11. Arnheim.

Cut 15. Upper Waynesville and base of the Liberty.

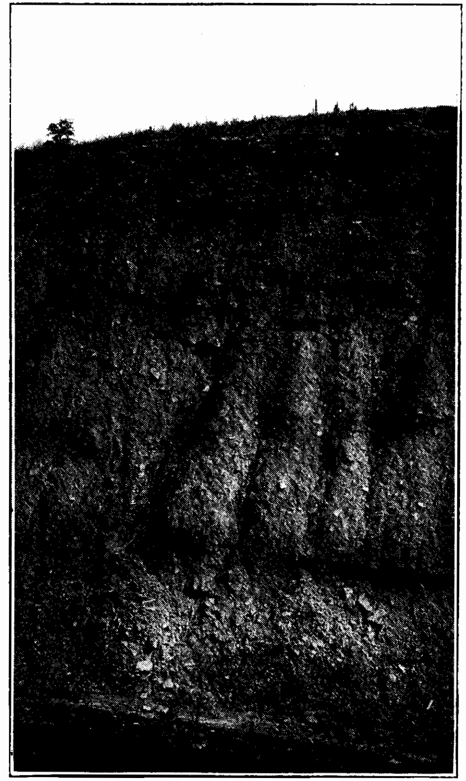


Cut 12.—Top of the Arnheim and base of the Waynesville. The man is standing at the base of the Waynesville.

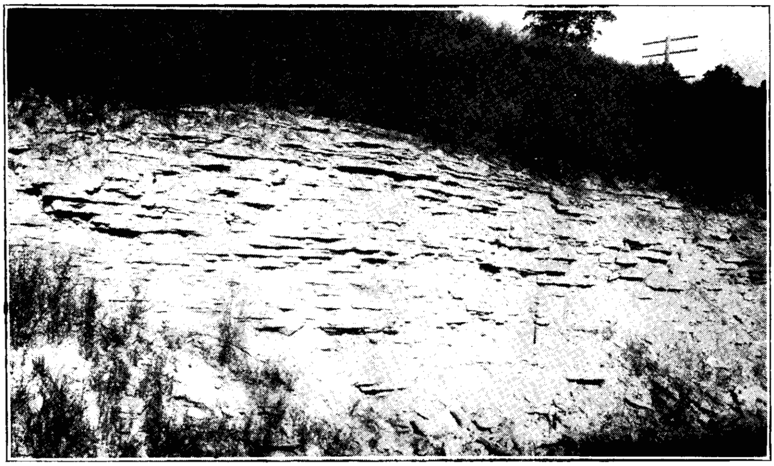
Cut 13.—Waynesville.



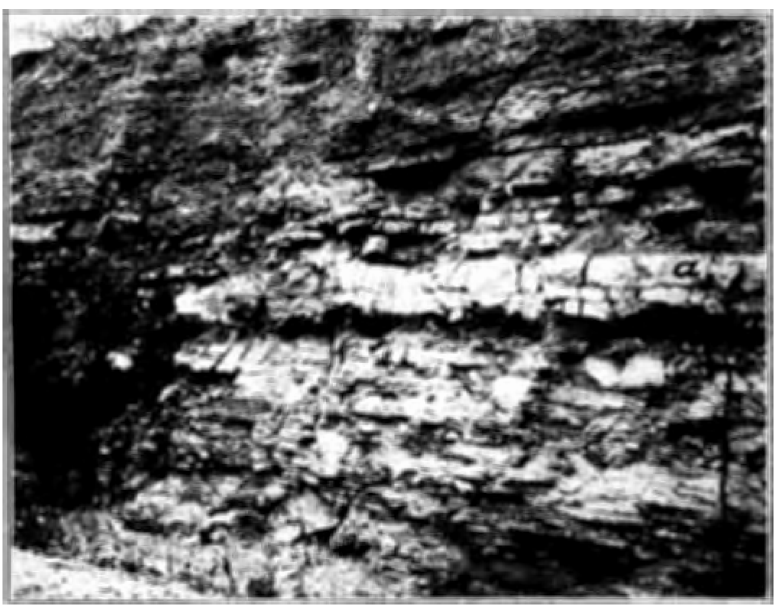
Cuts 13 and 14.



Cut 14.—Waynesville. *Hebertella insculpta* zone at the top.



Cut 17.—Middle and Upper Liberty.



Cut 18.—Just north of Weisburg. The hammer rests on the *Tetradium* layer *a*. Just below this layer is the black, carbonaceous shale bed *b* and below this the "shale bed" *c*.

PART II. DETAILED FAUNAL LISTS OF THE TANNER'S CREEK SECTION.

Fauna of Section 1.34E. Southgate.

Climacograptus typicalis (a)

Iocrinus subcrassus (r)

Cornulites flexuosus (c)

Amplexopora petasiformis (r)
Aspidopora areolata (r)
Bythopora parvula (r)
Hallopora onealli (c)
Stigmatella clavis (r)

Dalmanella multisecta (r)
Lingula modesta (c)
Leptobolis lepis (r)
Plectambonites sericeus (r)
Rafinesquina alternata (r)

Trematis millepunctata (r)
Zygospira modesta (r)

Bellerophon cf. gorbyi (r)

Orthoceras sp. (r)

Acidaspis sp. (r)
Calymene callicephala (c)
Isotelus maximus (c)
Proetus spurlocki (r)

Bythocypris cylindrica (a)
Leperditia caecigena (c)
Primitia centralis (c)

Lepidocoleus jamesi (r)

Fauna of Cut 1, Upper Part. Lower McMicken.

Cornulites sp. (a)

Amplexopora septosa (a)
    septosa minima (c)
    septosa maculosa (c)
    septosa multispinosa (a)
    petasiformis (r)
Arthropora shafferi (c)
Arthrostylus tenuis (r)
Batostoma implicatum (aa)
    jamesi (aa)
Bythopora arctipora (c)
Ceramoporella distincta (a)
    ohioensis (c)
    triloba (r)
    granulosa milfordensis (r)
Coeloclema alternatum (aaa)
    commune (aaa)
Dekayia maculata (r)
    obscura (c)
Hallopora dalei (c)
    onealli (aa)
Hallopora onealli communis (c)
    onealli sigillarioides (a)
    nodulosa (c)
    subplana (c)
Heterotrypa ulrichi (aaa)
Peronopora vera (a)
Proboscina frondosa (c)
Stigmatella clavis (c)
Stomatopora arachnoidea (a)

Dalmanella multisecta (a)
Rafinesquina alternata (r)
Zygospira cincinnatiensis (r)
    modesta (r)

Acidaspis sp. (c)
Isotelus maximus (r)

Ceratopsis chambersi (r)

Crinoid segments (c)

Fauna of Cut 2, 0-26 Feet Above Railroad. Middle McMicken.

Cornulites flexuosus (r)

Arthropora cleavelandi (c)
    shafferi (c)
Bythopora arctipora (c)
    parvula (rr)
Ceramoporella distincta (r)
Coeloclema alternatum (c)
    commune (r)
Dekayia maculata (r)
    obscura (r)
Hallopora dalei (a)
    nodulosa (c)
    onealli communis (c)
    onealli sigillarioides (c)
Heterotrypa ulrichi (a)
Homotrypa glabra (r)
Peronopora vera (a)
Petigopora asperula (r)
Stomatopora arachnoidea (c)

Dalmanella multisecta (c)
Rafinesquina alternata (c)
Zygospira modesta (c)

Pterinea demissa (r)

Acidaspis sp. (r)
Isotelus maximus (c)
Trinucleus concentricus (r)

Ctenobolbina ciliata (c)

Fauna of Cut 2, 26-62 Feet Above Railroad. Upper McMicken.

Cornulites flexuosus (r)

Amplexopora septosa (a)
    septosa maculosa (r)
Arthropora shafferi (c)
Batostoma implicatum (c)
Bythopora arctipora (a)
Escharopora pavonia (r)
Hallopora dalei (a)
    nodulosa (r)
Hallopora onealli sigillarioides (a)
Heterotrypa ulrichi (c)
    ulrichi robusta (r)
Peronopora vera (c)

Rafinesquina alternata (c)

Acidaspis sp. (c)
Isotelus maximus (r)

Fauna of Cut 2, Upper 40 Feet. Mt. Hope-Fairmount.

Amplexopora septosa (a)
    septosa minima (c)
Arthropora shafferi (c)
Batostoma implicatum (r)
Bythopora arctipora (a)
Ceramoporella distincta (c)
Constellaria constellata (r)
Dekayia aspera (c)
    cf. aspera (c)
Hallopora andrewsi (a)
    dalei (aa)
    nodulosa (a)
    ramosa (a)
Escharopora falciformis (c)
Heterotrypa frondosa (a)
    solitaria (r)
    subfrondosa (a)
    subpulchella (r)
    ulrichi (r)
    ulrichi lobata (a)
Homotrypa alta (a)
    cincinnatiensis (c)
    curvata praecipta (c)
    dumosa (r)
    spinea (c)
Peronopora vera (aa)
Petigopora asperula (r)
Proboscina frondosa (r)
Stigmatella clavis (r)
Stomatopora arachnoidea (c)

Dalmanella multisecta (r)
Platystrophia laticosta (c)

Plectorthis plicatella (r)
Rafinesquina alternata (a)
Strophomena planoconvexa (r)
Zygospira modesta (c)

Cyclonema bilix (c)

Isotelus maximus (r)

Fauna of Cut 2, Upper 10 Feet. Fairmount.

Amplexopora ampla (r)
    septosa (c)
Constellaria constellata (a)
Dekayia appressa (c)
    aspera (c)
Escharopora falciformis (r)
Hallopora dalei (a)
    nodulosa (r)
Heterotrypa frondosa (a)
    subpulchella (r)
    ulrichi (c)
    ulrichi lobata (c)
Homotrypa cincinnatiensis (c)
    dumosa (r)
    glabra (r)
    obliqua (c)

Petigopora asperula (r)
Stomatopora arachnoidea (r)

Cornulites flexuosus (c)

Dalmanella multisecta (r)
Hebertella sinuata (r)
Platystrophia costata (c)
Plectorthis plicatella (c)
Rafinesquina alternata (c)
Strophomena planoconvexa (r)
Zygospira cincinnatiensis (r)

sotelus maximus (r)

Fauna of Cut 2, Highest Ledge. Fairmount.

Amplexopora septosa (c)
    septosa multispinosa (c)
Dekayia multispinosa (r)
Escharopora falciformis (c)
    pavonia (r)

Hallopora andrewsi (r)
    dalei (a)
    ramosa (c)
Heterotrypa subpulchella (r)

Rafinesquina alternata (c)

Fauna of Cut 3, 0-15 Feet Above Railroad. Middle McMicken.

Amplexopora septosa (a)
    septosa maculosa (c)
    septosa minima (c)
    septosa multispinosa (a)
Arthropora cincinnatiensis (r)
    shafferi (r)
Atactoporella sp. (r)
Batostoma implicatum (c)
Ceramoporella distincta (r)
    ohioensis (c)
Coeloclema commune (c)
Dekayia aspera (r)

Dekayia maculata (c)
    obscura (c)
Hallopora dalei (c)
    nodulosa (c)
    onealli sigillarioides (c)
Heterotrypa subpulchella (r)
    ulrichi (aa)
Peronopora vera (c)
Stomatopora arachnoidea (c)

Dalmanella multisecta (a)
Platystrophia laticosta (r)

Fauna of Cut 3, 17-40 Feet Above Railroad. Upper McMicken.

Amplexopora septosa (a)
    septosa maculosa (r)
    septosa minima (c)
    septosa multispinosa (c)

Arthropora cleavelandi (r)
Atactopora intermedia (r)
Batostoma implicatum (c)
    jamesi (r)

Bythopora arctipora (r)
Ceramoporella distincta (c)
ohioensis (c)
tubulosa (c)
Constellaria constellata (c)
Dekayia aspera (c)
maculata (r)
Dicranopora meeki (c)
Hallopora dalei (a)
nodulosa (c)
onealli communis (a)
onealli sigillarioides (c)
Heterotrypa subpulchella (c)
ulrichi (c)
ulrichi lobata (c)
ulrichi robusta (c)
Peronopora vera (a)
Petigopora asperula (c)
petechialis (r)
Phylloporina variolata (r)
Stomatopora arachnoidea (c)

Dalmanella multisecta (c)
Platystrophia laticosta (c)
Rafinesquina alternata (c)
Zygospira cincinnatiensis (r)
modesta (r)

Orthoceras sp. (r)

Acidaspis sp. (r)
Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 3, Top 5 Feet. Top of McMicken. (Base of Maysville.)

Cornulites flexuosus (a)

Amplexopora septosa (c)
septosa maculosa (r)
septosa minima (c)
septosa multispinosa (r)
Arthropora cincinnatiensis (r)
Batostoma implicatum (c)
Ceramoporella distincta (r)
ohioensis (r)
Constellaria constellata (r)
Dekayia aspera (c)
Hallopora dalei (a)
subplana (aa)
Heterotrypa subpulchella (r)
ulrichi (r)
Peronopora vera (aa)
Stigmatella clavis (r)

Crania laelia (r)
scabiosa (r)
Dalmanella multisecta (r)
Platystrophia laticosta (r)
Plectorthis plicatella (r)
Zygospira cincinnatiensis (r)
modesta (c)

Ctenobolbina ciliata (r)

Fauna of Section 1.34C12a. Top of McMicken. (Base of Maysville.)

OEnonites cuneatus (r)
sp. (r)

Amplexopora septosa (a)
Arthropora cincinnatiensis (r)
shafferi (r)
Dekayia aspera (r)
Escharopora falciformis (c)
Hallopora dalei (a)
subplana (a)
Heterotrypa ulrichi lobata (r)
Homotrypa obliqua (r)
Peronopora vera (a)
Stomatopora arachnoidea (r)

Plectorthis plicatella (c)
Rafinesquina alternata (c)
Zygospira modesta (c)

Acidaspis sp. (r)
Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 4, Upper 25. Mt. Hope-Fairmount.

Cornulites flexuosus (r)

Amplexopora septosa (a)
septosa minima (c)
septosa multispinosa (c)
Arthropora cincinnatiensis (r)
shafferi (r)
Atactoporella typicalis (r)
Bythopora arctipora (r)
Ceramoporella distincta (r)
ohioensis (r)
Constellaria constellata (r)
Dekayia multispinosa (r)
Escharopora falciformis (c)
Hallopora dalei (aa)
subplana (r)
Heterotrypa frondosa (r)
Heterotrypa subfrondosa (r)
subpulchella (r)
ulrichi (r)
ulrichi lobata (c)
ulrichi robusta (r)
Homotrypa alta (r)
curvata praecipta (r)
spinea (r)
Peronopora vera (a)
Petigopora asperula (r)
Proboscina frondosa (r)
Stomatopora arachnoidea (a)

Crania scabiosa (r)
Platystrophia laticosta (a)
Zygospira modesta (c)

Cyclonema bilix (r)

Fauna of Cut 5, North Side. McMicken-Mt. Hope.

Amplexopora cf. robusta (r)
septosa (c)
septosa maculosa (r)
septosa multispinosa (a)
Arthropora shafferi (r)
Batostoma implicatum (c)
Ceramoporella distincta (r)
ohioensis (r)
Constellaria constellata (r)
Dekayia aspera (aa)
cf. aspera (c)
maculata (r)
Dicranopora emacerata (r)
Hallopora dalei (aa)
cf. subplana (aa)
Heterotrypa subfrondosa (r)
ulrichi (c)
Heterotrypa ulrichi lobata (r)
Peronopora vera (aa)
Petigopora asperula (r)
Stigmatella clavis (r)
Stomatopora arachnoidea (c)

Crinoid segments (c)

Platystrophia laticosta (r)
Plectorthis plicatella (r)
Zygospira modesta (c)

Cyclora minuta (c)

Orthoceras sp. (r)

Isotelus maximus (r)

Fauna of Cut 5, Upper 30 Feet. Mt. Hope-Fairmount.

Amplexopora septosa (c)
Arthropora cincinnatiensis (r)
shafferi (c)
Atactoporella sp. (r)
Corynotrypa inflata (r)
Dekayia aspera (r)
Escharopora falciformis (a)
Hallopora dalei (c)
subplana (r)
Heterotrypa subfrondosa (r)
subpulchella (r)
ulrichi lobata (r)
ulrichi robusta (r)
Homotrypa cincinnatiensis (r)
spinea (c)
Peronopora vera (r)
Petigopora asperula (r)
petechialis (c)

Stomatopora arachnoidea (r)

Crania scabiosa (r)
Dalmanella multisecta (r)
Platystrophia costata (c)
Plectorthis plicatella (c)
Rafinesquina alternata (c)

Zygospira modesta (c

Cyclora minuta (r)

Acidaspis sp. (r)
Isotelus maximus (c)

Fauna of Cut 5, Upper 15 Feet. Fairmount.

Amplexopora septosa (c)
    septosa multispinosa (c)
Arthropora cincinnatiensis (r)
Ceramoporella distincta (r)
    ohioensis (r)
Constellaria constellata (c)
Corynotrypa delicatula (r)
    inflata (r)
Dekayia aspera (r)
    cf. aspera (c)
Escharopora falciformis (a)
Hallopora dalei (a)
Heterotrypa inflecta (r)
    subfrondosa (c)
    subpulchella (r)
    ulrichi (r)
    ulrichi lobata (c)
Homotrypa curvata praecipta (r)
    spinea (r)
Petigopora asperula (c)
Stigmatella alcicornis (c)
Stomatopora arachnoidea (r)

Dalmanella cf. meeki (c)
Platystrophia costata (c)
Plectambonites sericeus (r)
Plectorthis plicatella (c)
Rafinesquina alternata (a)
Zygospira modesta (a)

Calymene callicephala (r)
Isotelus maximus (c)

Fauna of Cut 7, 10-30 Feet Above Railroad. Fairmount.

Atactoporella multigranosa (r)
Bythopora gracilis (r)
Ceramoporella ohioensis (c)
Constellaria constellata (r)
Dekayia appressa (c)
    aspera (r)
Escharopora pavonia (c)
Hallopora andrewsi (a)
    dalei (a)
Heterotrypa frondosa (c)
    pelliculata (r)
    solitaria (c)
    subfrondosa (r)
    subpulchella (c)
    ulrichi (r)
    ulrichi lobata (a)
    ulrichi robusta (c)
Homotrypa cincinnatiensis (r)
    curvata (r)
    dumosa (r)
Homotrypa flabellaris spinifera (c)
    obliqua (r)
    spinea (r)
Monticulipora mammulata (r)
Stigmatella sessilis (r)

Hebertella sinuata (r)
Platystrophia costata (r)
    laticosta (r)
    lynx (r)
Plectorthis plicatella (r)
Rafinesquina alternata (r)
    alternata fracta (r)
Strophomena planoconvexa
Zygospira cincinnatiensis (r)
    modesta (r)

Cyclora minuta (c)

Orthoceras sp. (r)

Fauna of Cut 7, Upper 20 Feet. Upper Fairmount.

Coral unidentified

Cornulites flexuosus (r)

Amplexopora septosa multispinosa (r)
Arthropora shafferi (c)
Ceramoporella ohioensis (r)
Constellaria constellata (r)
Crepipora solida (r)
Dekayia appressa (r)
 aspera (r)
 multispinosa (r)
Hallopora andrewsi (r)
 dalei (c)
 ramosa rugosa (r)
Heterotrypa frondosa (a)
 paupera (r)
 solitaria (r)
 ulrichi (r)
Homotrypa cincinnatiensis (r)
Homotrypa curvata (r)
 obliqua (r)
 spinea (r)
Petigopora asperula (r)
Stomatopora arachnoidea (r)

Platystrophia laticosta (r)
Plectorthis plicatella (r)
Rafinesquina alternata (r)
 alternata fracta (r)
Strophomena planoconvexa (r)
Zygospira cincinnatiensis (c)
 modesta (c)

Byssonychia radiata (r)
 sp. (r)

Cyclora minuta (c)
Cyrtolites ornatus (r)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 7, 50 Feet Above Railroad. Top of Fairmount.

Amplexopora septosa (r)
Bythopora gracilis (r)
Dekayia aspera (r)
 multispinosa (r)
Escharopora pavonia (r)
Hallopora andrewsi (aa)
 cf. subplana (a)
 dalei (c)
Heterotrypa cf. ulrichi lobata (r)
Hebertella sinuata (r)
Platystrophia laticosta (r)
Plectorthis plicatella (r)
Rafinesquina alternata (c)
 alternata fracta (r)
Zygospira modesta (r)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Section 1.34C13, Lower 5 Feet. Base of Mt. Hope.

Amplexopora septosa (a)
 septosa multispinosa (r)
Arthropora cincinnatiensis (r)
 shafferi (c)
Ceramoporella ohioensis (r)
Constellaria constellata prominens (r)
Dekayia aspera (r)
Dicranopora emacerata (c)
Escharopora falciformis (c)
Hallopora dalei (a)
Heterotrypa ulrichi lobata (r)
Homotrypa spinea (r)
Peronopora vera (a)
Petigopora asperula (r)

Dalmanella multisecta (c)
Platystrophia laticosta (c)
Rafinesquina alternata (a)
Zygospira modesta (c)

Acidaspis sp. (r)
Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Section 1.34C13, Upper Part. Mt. Hope-Fairmount.

Amplexopora septosa (r)
    septosa multispinosa (r)
Ceramoporella ohioensis (r)
Constellaria constellata (r)
Dekayia aspera (c)
    cf. aspera (r)
Escharopora pavonia (r)
Hallopora dalei (c)
Heterotrypa paupera (r)
    subfrondosa (c)
    subpulchella (r)
Heterotrypa ulrichi (c)
    ulrichi lobata (r)
    ulrichi robusta (r)
Homotrypa cincinnatiensis (r)
    glabra (r)
Stomatopora arachnoidea (r)

Dalmanella multisecta (r)
Platystrophia laticosta (r)
Rafinesquina alternata (r)
Zygospira modesta (r)

Faunt of Section 1.34C13. All. Mt. Hope-Fairmount.

Amplexopora septosa (r)
    septosa multispinosa (r)
Arthropora shafferi (c)
Ceramoporella distincta (r)
    ohioensis (r)
Dekayia aspera (r)
Dicranopora emacerata (c)
    sp. (c)
Escharopora falciformis (r)
    pavonia (r)
Hallopora dalei (a)
Heterotrypa subfrondosa (r)
Heterotrypa ulrichi lobata (r)
    ulrichi robusta (r)
Homotrypa cincinnatiensis (r)
    dumosa (r)
    spinea (r)
Peronopora vera (r)
Proboscina frondosa (r)

Rafinesquina alternata (c)
Zygospira modesta (r)

Fauna of Cut 8, 5-25 Feet Above Railroad. Bellevue.

Amplexopora filiosa (c)
    robusta (r)
Arthropora shafferi (c)
Atactoporella mundula (r)
Bythopora gracilis (a)
Dekayia appressa (c)
    multispinosa (r)
Hallopora andrewsi (r)
    ramosa (a)
    romosa rugosa (r)
Heterotrypa frondosa (a)
    cf. singularis (r)
    solitaria (r)
Peronopora pavonia (c)
Petigopora asperula (r)

Hebertella sinuata (c)
Platystrophia laticosta (c)
Rafinesquina alternata (c)
    alternata fracta (r)
Zygospira modesta (c)

Byssonychia radiata (r)
Pterinea demissa (r)

Cyclonema bilix (r)
Cyclora minuta (r)

Calymene callicephala (r)

Fauna of Cut 8, 36 Feet Above Railroad. Top of Bellevue.

Cornulites flexuosus (r)

Amplexopora robusta (r)
Bythopora gracilis (c)
Dekayia appressa (c)
    magna (r)
    multispinosa (c)
Hallopora ramosa (a)
    ramosa rugosa (r)
Heterotrypa frondosa (c)
Homotrypa obliqua (r)
Peronopora pavonia (a)
Petigopora petechialis (r)

Rafinesquina alternata (r)
Zygospira modesta (r)
Cyclonema bilix (r)
Cyclora minuta (r)

Fauna of Cut 8, 60 Feet Above Railroad. Corryville.

Amplexopora pustulosa (c)
Arthropora shafferi (c)
Bythopora gracilis (aaa)
Chiloporella flabellata (a)
Dekayia appressa (c)
cf. maculata (r)
Dicranopora emacerata (r)
Escharopora sp. (r)
Hallopora cf. andrewsi (c)
ramosa (a)
ramosa rugosa (c)
Heterotrypa frondosa (a)
paupera (r)
cf. singularis (c)
Homotrypa curvata (r)
obliqua (r)
Peronopora pavonia (aa)

Dalmanella meeki (r)
Platystrophia lynx (r)
Rafinesquina alternata (r)
Zygospira modesta (c)

Orthoceras sp. (r)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of the Borrow Cut. Bellevue.

Cornulites flexuosus (r)

Amplexopora filiosa (r)
Bythopora gracilis (a)
Chiloporella flabellata (r)
Dekayia magna (r)
Hallopora andrewsi (r)
ramosa (a)
ramosa rugosa (c)
sp. (c)
Heterotrypa frondosa (aa)
pelliculata (c)
cf. singularis (c)
Homotrypa curvata (r)
Peronopora pavonia (a)
Peronoporella dubia (c)
Petigopora asperula (r)
petechialis (r)
Stomatopora arachnoidea (r)

Hebertella sinuata (r)
Platystrophia laticosta (c)
Rafinesquina alternata (c)
alternata fracta (c)
alternata ponderosa (c)
Zygospira modesta (c)

Cyrtolites ornatus (r)

Isotelus maximus (r)

Fauna of Cut 10, 15 Feet Above Railroad. Mt. Auburn.

Cornulites flexuosus (c)

Amplexopora pustulosa (a)
robusta (r)
Atactoporella ortoni (c)
Bythopora delicatula (c)
Ceramoporella distincta (c)
ohioensis (r)
Chiloporella flabellata (r)
Coeloclema cf. alternatum (r)
oweni (c)
Dekayia appressa (a)
multispinosa (a)
Hallopora cf. onealli (r)
ramosa (c)
ramosa rugosa (r)
Heterotrypa frondosa (r)
Homotrypa pulchra (c)
Peronopora pavonia (aa)
Proboscina frondosa (r)

Dalmanella meeki (r)

Platystrophia lynx (r)
Rafinesquina alternata (c)
Zygospira modesta (r)

Modiolodon sp. (r)

Cyclora minuta (c)

Orthoceras sp. (r)

Calymene callicephala (r)
Isotelus maximus (r)

Primitia impressa (r)

Faunt of Cut 10, 10-20 Feet Above Railroad. Mt. Auburn-Arnheim.

Cornulites flexuosus (r)

Amplexopora ampla (r)
    pustulosa (a)
    robusta (a)
Arthropora shafferi (r)
Atactoporella multigranosa (c)
Bernicea primitiva (r)
Bythopora delicatula (r)
Ceramoporella ohioensis (r)
Corynotrypa delicatula (r)
    inflata (r)
Coeloclema cf. alternatum (c)
    oweni (c)
Dekayia cf. obscura (r)
Eridotrypa simulatrix (r)
Hallopora ramosa (a)
    ramosa rugosa (c)
Heterotrypa frondosa (c)
Homotrypa frondosa (c)
Peronopora pavonia (r)
Peronoporella dubia (r)
Stigmatella dychei (r)
Stomatopora arachnoidea (c)

Crania scabiosa (r)
Plectambonites sericeus (r)
Rafinesquina alternata (a)
    alternata fracta (c)
    alternata loxorhytis (r)
Zygospira modesta (c)

Cyclonema bilix (c)

Orthoceras sp. (c)
Acidaspis sp. (r)
Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 10, 25-55 Feet Above Railroad. Arnheim.

Amplexopora cingulata (r)
    pustulosa (a)
Arthropora shafferi (c)
Atactoporella mundula (c)
Batostoma varians (r)
Bernicea primitiva (r)
Ceramoporella ohioensis (c)
Coeloclema cf. alternatum (c)
Dekayia aspera (c)
    cf. maculata (c)
    magna (r)
    cf. obscura (c)
Hallopora cf. onealli (a)
    ramosa (aa)
    ramosa rugosa (c)
    cf. subplana (c)
    subnodosa (c)
Homotrypa frondosa (r)
    pulchra (c)
Mesotrypa orbiculata (c)
Peronopora pavonia (c)
Peronoporella dubia (c)
Petigopora asperula (c)
    petechialis (c)
Stigmatella catenulata (r)

Dalmanella meeki (r)
Dinorthis retrorsa (r)
Platystrophia laticosta (r)
Rafinesquina alternata (a)
    alternata fracta (c)

Conularia formosa (r)
Cyclonema bilix (a)
Cyclora minuta (c)

Calymene callicephala (c)

Fauna of Cut 10, Above P. lynx Layer. Mt. Auburn or Lower Arnheim.

Cornulites flexuosus (r)

Arthropora shafferi (c)
Bythopora delicatula (a)
Coeloclema cf. alternatum (r)
  oweni (r)
Hallopora cf. onealli (r)
Peronopora pavonia (r)
Petigopora asperula (r)
  petechialis (r)
Proboscina frondosa (r)

Crania scabiosa (c)
Dalmanella meeki (r)
Rafinesquina alternata (c)
  alternata loxorhytis (r)
Zygospira modesta (aa)

Byssonychia radiata (r)
Modiolodon sp. (r)
Pterinea demissa (r)

Conradella dyeri (r)
Cyclonema bilix (a)
Cyclora minuta (a)

Orthoceras sp. (c)

Acidaspis sp. (c)
Calymene callicephala (c)
Isotelus maximus (r)

Primitia impressa (c)

Crinoid segments (a)

Fauna of Cut 10, All. Corryville-Arnheim.

Cornulites flexuosus (a)

Amplexopora pustulosa (aa)
  robusta (a)
Arthropora shafferi (r)
Atactoporella ortoni (c)
Bernicea primitiva (r)
Bythopora striata (r)
  delicatula (r)
Ceramoporella ohioensis (c)
Coeloclema oweni (aa)
Corynotrypa inflata (r)
Dekayia appressa (aa)
  cf. maculata (c)
  multispinosa (c)
Eridotrypa simulatrix (r)
Hallopora ramosa (aa)
  ramosa rugosa (c)
Heterotrypa frondosa (c)
Homotrypa frondosa (r)
  pulchra (c)

Petigopora asperula (c)
  petechialis (c)
Stomatopora arachnoidea (c)

Crania scabiosa (c)
Dalmanella meeki (r)
Platystrophia lynx (r)
Rafinesquina alternata (a)
  alternata fracta (a)
  alternata loxorhytis (c)
Zygospira modesta (c)
Byssonychia sp. (r)
Modiolodon sp. (r)

Cyclonema bilix (c)

Orthoceras sp. (c)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 11, 5-30 Feet Above Railroad (South End of Cut). Lower Arnheim.

Crinoid segments (c)

Amplexopora cingulata (r)
  pustulosa (c)
  robusta (c)
Arthropora shafferi (c)

Atactoporella multigranosa (c)
Bernicea primitiva (r)
Ceramoporella distincta (r)
  ohioensis (c)
  whitei (r)
Co loclema cf. alternatum (c)

Corynotrypa inflata (r)
Dekayia appressa (c)
cf. aspera (r)
Eridotrypa simulatrix (c)
Hallopora cf. onealli (c)
ramosa (a)
ramosa rugosa (c)
subnodosa (a)
cf. subplana (c)
Helopora harrisi (r)
Heterotrypa ulrichi lobata (r)
Homotrypa flabellaris (r)
frondosa (r)
pulchra (r)
Peronopora pavonia (r)
Peronoporella dubia (c)
Petigopora asperula (r)
Proboscina auloporoides (r)

Crania scabiosa (r)

Dalmanella meeki (c)
Dinorthis retrorsa? (r)
Rafinesquina alternata (c)
alternata fracta (a)
alternata loxorhytis (c)
Zygospira modesta (a)

Byssonychia tenuistriata (c)
Modiolodon sp. (c)
Pterinea demissa (r)

Cyclonema bilix (a)
Cyclora minuta (a)

Orthoceras sp. (r)

Calymene callicephala (r)
Isotelus maximus (r)

Primitia impressa (c)

Fauna of Cut 11, Upper 20 Feet. Upper Arnheim.

Amplexopora pustulosa (r)
sp. (r)
Bythopora delicatula (r)
Ceramoporella distincta (r)
ohioensis (a)
Hallopora ramosa (r)
subnodosa (c)
cf. subplana (r)
Heterotrypa frondosa (r)
Homotrypa pulchra (r)
Peronopora pavonia (c)
Proboscina auloporoides (aa)
Rhopalonaria venosa (c)
Stomatopora arachnoidea (c)

Crania scabiosa (c)
Dinorthis retrorsa (c)

Lingula cincinnatiensis (r)
Rafinesquina alternata (a)
alternata fracta (c)
alternata loxorhytis (a)
Zygospira modesta (aa)

Byssonychia radiata (c)
sp. (c)

Cyclora minuta (c)
Orthoceras sp. (c)

Calymene callicephala (r)
Isotelus maximus (r)

Primitia impressa (r)

Fauna of Cut 11, All. Arnheim.

Cornulites richmondensis (r)
sp. (c)

Glyptocrinus sp. (c)

Amplexopora ampla (c)
cingulata (r)
pustulosa (a)
robusta (c)
sp. (c)
Atactoporella mundula (c)
ortoni (c)
Batostoma varians (r)
Berenicea primitiva (r)

Bythopora delicatula (c)
 gracilis (c)
Ceramoporella distincta (c)
 ohioensis (c)
 whitei (r)
Coeloclema cf. alternatum (a)
 oweni (r)
Corynotrypa inflata (c)
Dekayia appressa (c)
 aspera (c)
 cf. aspera (c)
 magna (r)
 multispinosa (r)
Hallopora cf. onealli (c)
 ramosa (aa)
 romosa rugosa (a)
Hallopora subnodosa (a)
 cf. subplana (c)
Heterotrypa solitaria (r)
 ulrichi lobata? (r)
Homotrypa frondosa (c)
 pulchra (a)
Nicholsonella peculiaris (r)

Peronopora pavonia (c)
Peronoporella dubia (a)
Petigopora asperula (a)
 petechialis (a)
Proboscina auloporoides (c)
Stigmatella catenulata (r)

Crania scabiosa (c)
Dalmanella meeki (c)
Leptaena rhomboidalis (r)
Platystrophia lynx (r)
Rafinesquina alternata (c)
 alternata fracta (aa)
 alternata loxorhytis (a)
Zygospira modesta (aa)

Cyclonema bilix (a)
Cyclora minuta (a)

Orthoceras sp. (c)

Calymene callicephala (c)
Isotelus maximus (r)

Fauna of Cut 12, 0-15 Feet Above Railroad. Top of Arnheim.

Amplexopora filiosa (r)
 pustulosa (r)
Ceramoporella ohioensis (r)
Eridotrypa simulatrix (r)
Peronopora pavonia (r)
Petigopora asperula (c)

Rafinesquina alternata (r)

Strophomena planumbona? (r)

Byssonychia grandis (r)

Cyclonema bilix (r)

Primitia impressa (r)

Fauna of Cut 12, 15-37 Feet Above Railroad. Lower Waynesville.

Cornulites richmondensis (a)

Amplexopora pustulosa (r)
Arthropora shafferi (a)
Bythopora delicatula (c)
 meeki (r)
 striata (r)
Hallopora cf. onealli (a)
 subnodosa (r)
Helopora harrisi (c)
Homotrypella hospitalis (r)
 rustica (r)
Peronopora pavonia (c)
Petigopora petechialis (c)
Proboscina auloporoides (r)

Stigmatella crenulata (c)
 interporosa (c)
 spinosa (c)

Dalmanella meeki (a)
Rafinesquina alternata (r)
Zygospira modesta (c)

Byssonychia grandis (r)
Pterinea demissa (c)

Conradella dyeri (r)
Cyclora minuta (a)

Acidaspis sp. (r)
Calymene callicephala (c)

Ceraurus pleurexanthemus (r)
Isotelus maximus (c)

Ctenobolbina ciliata (c)

Leperditia caecigena (c)
Primitia impressa (aa)

Lepidocoleus jamesi (r)

Fauna of Cut 13, Lower 40 Feet. Lower Waynesville.

Streptelasma rusticum (r)

Cornulites richmondensis (a)

Arthropora shafferi (a)
Batostoma varians (r)
Bythopora delicatula (r)
    meeki (a)
    striata (r)
Ceramoporella ohioensis (c)
    whitei (r)
Dicranopora emacerata (r)
Eridotrypa simulatrix (a)
Hallopora subnodosa (c)
Heterotrypa prolifica (c)
Homotrypa austini (c)
Homotrypella hospitalis (c)
Peronopora pavonia (r)
Petigopora asperula (r)
Proboscina auloporoides (r)
Stigmatella crenulata (c)
    spinosa (r)
Stomatopora arachnoidea (c)

Crania scabiosa (c)
Dalmanella meeki (aa)
Hebertella sinuata (r)
Leptaena rhomboidalis (r)
Platystrophia laticosta (r)
Plectambonites sericeus (c)
Rafinesquina alternata (c)
    alternata loxorhytis (c)
Strophomena planumbona (r)
Zygospira modesta (a)

Byssonychia sp. (c)
Pterinea demissa (r)

Cyclonema bilix (c)
Cyclora minuta (r)

Acidaspis sp. (r)
Calymene callicephala (c)
Isotelus maximus (r)

Primitia impressa (a)

Fauna of Cut 13, 40-60 Feet Above Railroad. Middle Waynesville.

Streptelasma rusticum (c)

Cornulites richmondensis (c)

Arthropora shafferi (c)
Atactoporella schucherti (r)
Batostoma prosseri (r)
    varians (a)
Bernicea primitiva (c)
Bythopora delicatula (c)
    meeki (a)
    striata (r)
Ceramoporella distincta (r)
    ohioensis (r)
Constellaria polystomella (r)
Dicranopora emacerata (r)
Eridotrypa simulatrix (a)

Hallopora cf. ramosa (c)
    ramosa rugosa (r)
    subnodosa (a)
Helopora sp. (r)
Heterotrypa affinis (r)
    prolifica (aa)
    singularis (c)
    subramosa (a)
Homotrypa austini (a)
    communis (a)
    flabellaris (a)
    cf. flabellaris spinifera (c)
Homotrypa nodulosa (c)
Homotrypella hospitalis (c)
Monticulipora parasitica (r)
Peronopora pavonia (a)
Proboscina auloporoides (r)

Rhombotrypa quadrata (a)
Stomatopora arachnoidea (a)

Crania laelia (r)
 scabiosa (r)
Dalmanella meeki (c)
Hebertella sinuata (r)
Platystrophia acutilirata (a)
 laticosta (c)
Rafinesquina alternata (a)
Strophomena planumbona (r)

Zygospira modesta (c)

Byssonychia sp. (r)
Pterinea demissa (r)

Cyclonema bilix (c)

Orthoceras sp. (r)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 13, Dump. Waynesville.

Protarea vetusta (r)
Streptelasma rusticum (c)

Cornulites richmondensis (a)
 sp. (coiled) (c)

Arthropora shafferi (c)
Atactoporella schucherti (r)
Batostoma varians (c)
Bernicea primitiva (c)
Bythopora delicatula (c)
 meeki (c)
Ceramoporella distincta (r)
 ohioensis (c)
Dicranopora emacerata (r)
Eridotrypa simulatrix (r)
Heterotrypa microstigma (r)
 prolifica (a)
 singularis (c)
 subramosa (c)
Hallopora ramosa rugosa (r)
 subnodosa (r)
Homotrypa austini (c)
 communis (a)
 flabellaris (c)
 frondosa (r)
Homotrypella hospitalis (a)

Peronopora pavonia (c)
Proboscina auloporoides (c)
 frondosa (r)
Rhombotrypa quadrata (a)
Stomatopora arachnoidea (c)

Crania scabiosa (r)
Dalmanella meeki (a)
Hebertella sinuata (r)
Leptaena rhomboidalis (r)
Platystrophia laticosta (a)
Rafinesquina alternata (c)
Strophomena subtenta (r)
Trematis millepunctata (r)

Byssonychia obesa (r)
Eridonychia crenata (c)
Modiolodon truncatus (r)
Modiolopsis versaillesensis (c)
Opisthoptera casei (c)
Pterinea demissa (c)

Gastropoda, unidentified (a)

Calymene callicephala (c)

Primitia impressa (c)

Fauna of Cut 14, 0-40 Feet Above Railroad. Middle Waynesville.

Cornulites richmondensis

Arthropora shafferi (c)
Batostoma varians (r)
Bernicea primitiva (r)
Bythopora delicatula (c)
 meeki (c)
 striata (c)

Eridotrypa simulatrix (r)
Heterotrypa prolifica (c)
 subramosa (c)
Homotrypa austini (r)
 communis (c)
Stomatopora arachnoidea (r)

Crania scabiosa (r)

Dalmanella meeki (a)
Platystrophia laticosta (r)
Plectambonites sericeus (r)
Zygospira modesta (r)

Byssonychia sp. (c)
Pterinea demissa (c)

Gastropoda, unidentified (r)

Orthoceras sp. (c)

Acidaspis cincinnatiensis (r)
Calymene callicephala (c)
Isotelus maximus (c)

Fauna of Cut 14, South Side, 40 Feet Above Railroad. Middle Waynesville.

Streptelasma rusticum (a)

Cornulites richmondensis (a)

Amplexopora pustulosa (r)
Arthropora shafferi (c)
Batostoma prosseri (r)
  varians (c)
Bythopora delicatula (c)
  meeki (a)
Ceramoporella distincta (r)
  ohioensis (c)
Eridotrypa simulatrix (c)
Hallopora subnodosa (c)
Heterotrypa prolifica (aa)
  singularis (r)
  subramosa (a)
Homotrypa austini (a)
  communis (a)
  flabellaris (a)
Homotrypella hospitalis (a)
Nicholsonella vaupeli (c)
Peronopora pavonia (c)
Rhombotrypa quadrata (c)
Spatiopora sp. (r)

Dalmanella meeki (aa)
Hebertella sinuata (c)
Leptaena rhomboidalis (c)
Platystrophia acutilirata (c)
  laticosta (a)
Plectambonites sericeus (r)
Rafinesquina alternata (a)
  alternata loxorhytis (c)
Strophomena planumbona (r)
Zygospira modesta (c)

Byssonychia sp. (c)
Modiolopsis versaillesensis (a)
Opisthoptera casei (r)
Pterinea demissa (c)

Cyclonema bilix (r)
Lophospira bowdeni (r)
  sp. (a)

Orthoceras sp. (c)

Calymene callicephala (r)

Fauna of Cut 14, 0-50 Feet Above Railroad. Middle Waynesville.

Streptelasma rusticum (c)

Glyptocrinus decadactylis (r)

Cornulites richmondensis (r)
  sp. (coiled) (c)

Amplexopora pustulosa (r)
Arthropora shafferi (r)
Atactoporella schucherti (r)
Batostoma varians (c)
Bernicea primitiva (r)
Bythopora meeki (c)
Ceramoporella ohioensis (c)

Dicranopora emacerata (c)
Eridotrypa simulatrix (c)
Hallopora subnodosa (r)
Heterotrypa prolifica (a)
  singularis (r)
Homotrypa austini (a)
  communis (a)
  flabellaris (a)
Homotrypella hospitalis (c)
Peronopora pavonia (c)
Rhombotrypa quadrata (a)

Crania scabiosa (c)
Dalmanella meeki (c)

Hebertella sinuata (c)
Leptaena rhomboidalis (r)
Platystrophia acutilirata (c)
  laticosta (c)
Rafinesquina alternata (a)
  alternata loxorhytis (c)
  alternata cf. ponderosa (c)
Rhynchotrema dentata (c)
Strophomena planumbona (r)

Zygospira modesta (c)

Byssonychia richmondensis (r)
Modiolopsis versaillesensis (r)

Cyclonema bilix (r)

Calymene callicephala (r)

Fauna of Cut 14, 25-50 Feet Above Railroad. Waynesville.

Streptelasma rusticum (a)

Cornulites richmondensis (a)

Arthropora shafferi (aa)
Batostoma prosseri (r)
  varians (c)
Bernicea primitiva (r)
Bythopora delicatula (c)
  meeki (c)
  striata (c)
Ceramoporella distincta (r)
  ohioensis (c)
Constellaria limitaris (r)
  polystomella (r)
Dicranopora emacerata (c)
  fragilis (c)
Eridotrypa simulatrix (c)
Fenestella granulosa (r)
Hallopora subnodosa (c)
Heterotrypa prolifica (a)
Homotrypa austini (a)
  cummunis (a)
  flabellaris (a)
  nodulosa (c)
Homotrypella hospitalis (a)
Monticulipora parasitica (r)
Peronopora pavonia (c)
Petigopora petechialis (a)
Proboscina frondosa (c)
Ptilodictya plumaria (r)

Rhombotrypa quadrata (a)
  subquadrata (r)
Crania scabiosa (c)
Dalmanella meeki (aa)
Hebertella sinuata (c)
Leptaena rhomboidalis (a)
Platystrophia acutilirata (r)
  laticosta (c)
Plectambonites sericeus (c)
Rafinesquina alternata (a)
  alternata loxorhytis (c)
Rhynchotrema capax (c)
  dentata (r)
Strophomena planumbona (c)
  subtenta (r)
Zygospira modesta (aa)

Byssonychia sp. (r)
Ischyrodonta ovalis (r)
Opisthoptera casei (r)
Pterinea demissa (c)

Conradella dyeri (r)
Cyclonema bilix (c)
Cyclora minuta (r)

Orthoceras sp. (r)

Acidaspis cincinnatiensis (r)
Calymene callicephala (c)
Ceraurus pleurexanthemus (r)
Isotelus maximus (c)

Fauna of Cut 14, 50-67 Feet Above Railroad. Upper Waynesville (or Lower Liberty).

Columnaria alveolata (r)
Protarea vetusta (a)

Streptelasma divaricans (a)
  rusticum (a)

Amplexopora pumila (a)
Arthropora shafferi (r)
Batostoma prosseri (c)
  varians (c)
Bythopora delicatula (a)
  meeki (c)
  striata (c)
Bernicea primitiva (r)
Ceramoporella ohioensis (c)
Constellaria limitaris (a)
  polystomella (c)
Dicranopora emacerata (r)
Eridotrypa simulatrix (aa)
Hallopora subnodosa (aa)
Heterotrypa prolifica (a)
Homotrypa communis (a)
  flabellaris (r)
Homotrypella hospitalis (a)
  rustica (r)
Monticulipora parasitica (r)
Nicholsonella vaupeli (c)
Peronopora pavonia (r)
Proboscina frondosa (r)
Rhombotrypa quadrata (a)
  subquadrata (c)
Spatiopora aspera (r)
Stomatopora arachnoidea (r)

Dinorthis subquadrata (c)
Hebertella insculpta (aa)
  sinuata (a)
Leptaena rhomboidalis (a)
Platystrophia laticosta (c)
Plectambonites sericeus (r)
Rafinesquina alternata (c)
Rhynchotrema capax (aa)
Strophomena planumbona (a)
Zygospira modesta (c)

Byssonychia sp. (r)

Cyclonema bilix (c)

Orthoceras sp. (c)

Callymene callicephala (a)
Isotelus maximus (c)

Fauna of Cut 14, All. Middle and Upper Waynesville.

Streptelasma rusticum (r)

Cornulites richmondensis (c)

Arthropora shafferi (r)
Batostoma varians (r)
  sp. (r)
Bythopora delicatula (c)
  meeki (c)
  striata (c)
Ceramoporella ohioensis (r)
Dicranopora emacerata (r)
Eridotrypa simulatrix (c)
Hallopora subnodosa (c)
Hetetrotrypa prolifica (c)
Homotrypa cummunis (c)
Homotrypella hospitalis (c)
Monticulipora parasitica (r)
Petigopora petechialis (a)

Dalmanella meeki (a)
Leptaena rhomboidalis (c)
Platystrophia laticosta (r)
Rafinesquina alternata (c)
Zygospira modesta (r)

Byssonychia sp. (c)
Pterinea demissa (c)

Calymene callicephala (c)
Isotelus maximus (c)

Fauna of Cut 15, 0-30 Feet Above Railroad. Middle Waynesville

Streptelasma rusticum (a)

Arthropora shafferi (r)
Batostoma prosseri (r)
  varians (c)
Bernicea primitiva (r)
Bythopora delicatula (c)
  meeki (c)
  striata (r)
Ceramoporella granulosa (r)
  ohioensis (r)
Constellaria polystomella (r)

Eridotrypa simulatrix (c)
Hallopora subnodosa (c)
Heterotrypa prolifica (a)
subramosa (c)
Homotrypa austini (a)
Homotrypa communis (r)
flabellaris (r)
cf. flabellaris spinifera (c)
Homotrypella hospitalis (c)
Peronopora pavonia (c)
Rhombotrypa quadrata (a)

Stomatopora arachnoidea (a)

Leptaena rhomboidalis (r)

Cyclonema bilix (r)
bilix fluctuatum (r)

Orthoceras sp. (r)

Calymene callicephala (r)

Fauna of Cut 15, 0-45 Feet Above Railroad. Middle and Upper Waynesville.

Streptelasma rusticum (a)

Cornulites richmondensis (c)
sp. (a)

Arthropora shafferi (a)
Batostoma varians (a)
Bernicea primitiva (c)
Bythopora delicatula (a)
meeki (a)
striata (r)
Ceramoporella granulosa (c)
ohioensis (r)
Constellaria polystomella (r)
Dicranopora emacerata (c)
Eridotrypa simulatrix (a)
Fenestella granulosa (r)
Hallopora subnodosa (c)
Heterotrypa prolifica (a)
subramosa (a)
Homotrypa austini (a)
communis (c)
dawsoni (c)
flabellaris (a)
cf. flabellaris spinifera (a)
Homotrypella hospitalis (a)
Nicholsonella vaupeli (c)
Peronopora pavonia (c)
Proboscina frondosa (r)
Rhombotrypa quadrata (a)
Stomatopora arachnoidea (c)

Crania laelia (r)
scabiosa (c)
Dalmanella meeki (a)
Hebertella insculpta (a)
occidentalis (r)
sinuata (c)
Leptaena rhomboidalis (a)
Platystrophia laticosta (c)
Rafinesquina alternata (a)
alternata loxorhytis (c)
Rhynchotrema capax (c)
Strophomena planumbona (c)

Byssonychia obesa (r)
radiata (r)
richmondensis (c)
sp. (c)
Modiolodon truncatus (r)
Opisthoptera casei (r)
Pterinea demissa (r)

Cyclonema bilix (c)
Cyclora minuta (r)

Orthoceras sp. (c)

Calymene callicephala (c)
Isotelus maximus (a)
Ostracoda, unidentified (c)

Lepidocoleus jamesi (r)

Fauna of Cut 15, 30-45 Feet Above Railroad. Top of Waynesville.

Streptelasma rusticum (r)

Arthropora shafferi (c)

Batostoma prosseri (r)
Bythopora delicatula (r)
meeki (r)

Constellaria limitaris (c)
Dicranopora emacerata (r)
Eridotrypa simulatrix (c)
Fenestella granulosa (r)
Hallopora subnodosa (c)
Heterotrypa prolifica (r)
  subramosa (r)
Homotrypa austini (r)
  richmondensis (r)
  wortheni (r)
Homotrypella hospitalis (c)
Nicholsonella vaupeli (c)
Rhombotrypa quadrata (r)
  subquadrata (r)

Dinorthis subquadrata (c)
Hebertella insculpta (a)
  occidentalis (c)
  sinuata (c)
Platystrophia laticosta (r)
Rafinesquina alternata (c)
Rhynchotrema capax (c)
Strophomena planumbona (c)
Zygospira modesta (r)

Cyclonema bilix (r)

Fauna of Cut 16, 5-15 Feet Above Railroad (South End of Cut). Top of Waynesville.

Streptelasma rusticum (c)

Arthropora shafferi (c)
Bythopora delicatula (a)
  meeki (r)
  striata (c)
Ceramoporella ohioensis (c)
Dicranopora emacerata (r)
Eridotrypa simulatrix (c)
Hallopora subnodosa (c)
Homotrypa nodulosa (r)
Homotrypella hospitalis (r)
Rhombotrypa quadrata (r)

Hebertella occidentalis (r)
  sinuata (c)
Leptaena rhomboidalis (aa)
Platystrophia acutilirata (r)
Platystrophia laticosta (r)
Rafinesquina alternata (c)
Rhynchotrema capax (c)
Strophomena planumbona (a)
Zygospira modesta (c)

Pterinea demissa (r)

Cyclonema bilix fluctuatum (r)

Orthoceras sp. (r)

Calymene callicephala (c)
Isotelus maximus (a)

Ceratopsis chambersi (r)
Leperditia caecigena (r)

Fauna of Cut 16, North End, 0-10 Feet Above Railroad. Base of Liberty.

Protarea vetusta (a)
Streptelasma rusticum (a)

Amplexopora pumila (c)
Bernicea primitiva (r)
Bythopora delicatula (r)
  meeki (c)
Constellaria polystomella (a)
Hallopora cf. ramosa (a)
  subnodosa (a)
Homotrypa austini (a)
  cylindrica (r)
  ramulosa (c)
  richmondensis (r)
  wortheni (r)
Homotrypella hospitalis (r)
Proboscina frondosa (r)
Rhombotrypa quadrata (a)
Stomatopora arachnoidea (c)

Dinorthis subquadrata (a)
Hebertella insculpta (c)
  occidentalis (r)
  sinuata (r)
Plectambonites sericeus (aa)
Rafinesquina alternata (c)
Rhynchotrema capax (aa)
Strophomena planumbona (aa)
Zygospira modesta (a)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 16, North End, 0-25 Feet Above Railroad. All Above PLECTAMBONITES *Layer. Lower Liberty.*

Protarea vetusta (c)
Streptelasma divaricans (r)
  rusticum (a)

Cornulites richmondensis (c)

Amplexopora granulosa (a)
Berenicea primitiva (r)
Bythopora meeki (a)
Hallopora cf. ramosa (c)
  subnodosa (a)
Homotrypa austini (aa)
  richmondensis (r)
Homotrypella hospitalis (r)
  rustica (r)
Proboscina auloporoides (r)
Rhombotrypa quadrata (a)
  subquadrata (r)
Stomatopora arachnoidea (r)
Crania laelia (r)
Dinorthis subquadrata (a)
Hebertella insculpta (c)
  occidentalis (a)
  sinuata (r)
Platystrophia laticosta (r)
Plectambonites sericeus (c)
Rafinesquina alternata (a)
Rhynchotrema capax (aaa)
Strophomena planumbona (aa)
  sulcata (r)
  vetusta (r)

Pterinea demissa (r)

Calymene callicephala (r)
Isotelus maximus (r)

Fauna of Cut 16, PLECTAMBONITES *Layer and Above. Liberty.*

Protarea vetusta (r)
Streptelasma rusticum (c)

Cornulites richmondensis (r)

Amplexopora granulosa (r)
  pumila (r)
Arthropora shafferi (aa)
Bythopora delicatula (a)
  meeki (aa)
  striata (r)
Ceramoporella ohioensis (r)
Constellaria polystomella (r)
Dicranopora emacerata (c)
Hallopora cf. ramosa (a)
  subnodosa (a)
Homotrypa austini (aa)
  nodulosa (r)
  ramulosa (r)
  richmondensis (r)
  wortheni (r)
  wortheni prominens (r)
Rhombotrypa quadrata (r)

Crania laelia (r)
Hebertella insculpta (c)
  occidentalis (r)
  sinuata (c)
Dinorthis subquadrata (c)
Platystrophia laticosta (r)
Plectambonites sericeus (aaa)
Rafinesquina alternata (c)
Rhynchotrema capax (aa)
Strophomena planumbona (aa)
  vetusta (r)

Byssonychia richmondensis (r)
  sp. (r)
Pterinea demissa (c)

Pelecypoda, unidentified (aa)

Conradella dyeri (r)
Cyclonema sp. (r)

Cyrtoceras amoenum (r)

Endoceras proteiforme (r)

Primitia cincinnatiensis (r)

Calymene callicephala (a)
Isotelus maximus (a)

Fauna of Cut 16, 15-45 Feet Above Railroad. Liberty.

Calapoecia cribriformis (r)
Columnaria alveolata (r)
Streptelasma rusticum (c)

Arthropora shafferi (aa)
Bythopora delicatula (c)
  striata (c)
Dicranopora emacerata (c)
Hallopora subnodosa (c)
Homotrypa austini (r)
Homotrypella hospitalis (r)
Mesotrypa patella (r)
Crania laelia (r)
Hebertella insculpta (r)

Hebertella occidentalis (c)
  sinuata (r)
Dinorthis subquadrata (c)
Plectambonites sericeus (aa)
Rafinesquina alternata (c)
Rhynchotrema capax (a)
Strophomena planumbona (a)
  vetusta (c)
Zygospira modesta (r)

Cyclora minuta (r)

Calymene callicephala (a)
Isotelus maximus (r)

Fauna of Cut 17, Ditch East of Railroad. Lower Liberty.

Protarea vetusta (c)

Streptelasma rusticum (c)
Amplexopora granulosa (r)
  pumila (r)
Arthropora shafferi (r)
Bythopora delicatula (r)
  meeki (c)
Dicranopora emacerata (r)
Hallopora cf. ramosa (c)
  subnodosa (c)
Homotrypa austini (a)
  cylindrica (r)
  wortheni (r)
Homotrypella rustica (c)

Rhombotrypa quadrata (c)

Dinorthis subquadrata (c)
Hebertella occidentalis (c)
Rafinesquina alternata (c)
Rhynchotrema capax (c)
Strophomena planumbona (a)
  planumbona subtenta (r)
  vetusta (r)
Zygospira modesta (r)

Pterinea demissa (r)

Isotelus maximus (r)

Fauna of Cut 17, South End, Lower 10 Feet. Middle Liberty.

Calapoecia cribriformis (r)
Protarea vetusta (c)
Tetradium minus (r)

Arthropora shafferi (c)
Bythopora delicatula (a)
  meeki (a)
  striata (r)

Hallopora cf. ramosa (r)
  subnodosa (c)
Homotrypa austini (c)
  communis (c)
  wortheni prominens (r)
Rhombotrypa quadrata (r)
Stigmatella incrustans (r)

Hebertella insculpta (r)
Rafinesquina alternata (c)
Rhynchotrema capax (c)
Strophomena planumbona (c)
Zygospira modesta (c)

Byssonychia richmondensis (r)

Orthoceras sp. (r)

Isotelus maximus (c)

Fauna of Cut 17, North End, 5-29 Feet Above Railroad. Upper Liberty.

Protarea vetusta (c)
Streptelasma rusticum (r)

Arthropora shafferi (c)
Bythopora delicatula (a)
  striata (r)
Dicranopora emacerata (c)
Hallopora cf. ramosa (c)
  subnodosa (a)
Homotrypa austini (c)
  richmondensis (r)
  wortheni (r)
Monticulipora epidermata (r)
Peronopora pavonia (r)
Rhombotrypa quadrata (r)

Hebertella occidentalis (r)
Platystrophia laticosta (r)
Plectambonites sericeus (r)
Rafinesquina alternata (c)
Rhynchotrema capax (a)
Strophomena planumbona (c)
  planumbona subtenta (r)
  sulcata (c)
  vetusta (c)
Zygospira modesta (a)

Opisthoptera casei (r)
Pterinea demissa (c)

Isotelus miximus (c)

Fauna of Cut 17, Upper 10 Feet, North End. Upper Liberty.

Protarea vetusta (c)
Streptelasma rusticum (c)

Bythopora delicatula (r)
  meeki (a)
Hallopora cf. ramosa (c)
  subnodosa (a)
Helopora sp. (r)
Homotrypa communis (c)
  cylindrica (r)
  wortheni (r)
  wortheni prominens (r)
Monticulipora epidermata (r)
Rhombotrypa quadrata (r)

Hebertella occidentalis (r)
Platystrophia laticosta (c)
Rafinesquina alternata (c)
Rhynchotrema capax (c)
Strophomena planumbona (a)
Zygospira modesta (r)

Byssonychia richmondensis (r)

Orthoceras bilineatum (r)

Isotelus maximus (c)

Primitia cincinnatiensis (r)

Fauna of Cut 18, Above TETRADIUM *Layer. Whitewater.*

Streptelasma rusticum (r)

Lichenocrinus tuberculatus (r)

Cornulites sp. (a)

Batostoma variabile (aa)
Bythopora delicatula (aa)
  meeki (aa)

Hallopora cf. ramosa (r)
Homotrypa constellariformis (c)
  cylindrica (a)
  nitida (r)
Homotrypa ramulosa (r)
  wortheni (a)

Monticulipora epidermata (r)
Hebertella occidentalis (c)

Platystrophia laticosta (c)
Strophomena sulcata (a)

Byssonychia sp. (r)

Pterinea demissa (c)

Orthoceras byrnesi (c)
mohri (r)

Fauna of Cut 18, Above Heavy Limestone. Whitewater.

Streptelasma divaricans (r)
Tetradium minus (r)

Arthropora shafferi (r)
Batostoma variabile (r)
Bernicea primitiva (r)
Bythopora delicatula (r)
Dicranopora emacerata (r)
Hallopora subnodosa (r)
Helopora sp. (r)
Homotrypa austini (r)
Homotrypella hospitalis (r)

Monticulipora epidermata (r)

Hebertella occidentalis (r)
Platystrophia laticosta (r)
Strophomena sulcata (r)

Pterinea demissa (r)

Endoceras proteiforme (r)

Primitia cincinnatiensis (c)

Fauna of Cut 18, Upper Part. Whitewater.

Streptelasma divaricans (r)
rusticum (r)

Batostoma variabile (a)
Bythopora delicatula (aaa)
meeki (c)
Homotrypa austini (a)
cylindrica (a)
wortheni (c)
Homotrypella hospitalis (r)
Monticulipora epidermata (r)

Hebertella occidentalis (c)
Platystrophia laticosta (c)
Rhynchotrema capax (r)
Strophomena sulcata (a)

Byssonychia richmondensis (c)
Ischyrodonta ovalis (r)

Orthoceras bilineatum (r)
byrnesi (r)

Fauna of Cut 18, Dump. Whitewater.

Protarea vetusta (r)
Streptelasma rusticum (c)
Tetradium minus (r)

Batostoma variabile (aa)
Bythopora delicatula (r)
meeki (r)
Homotrypa austini (r)
constellariformis (aa)
nicklesi (a)
nitida (a)
ramulosa (a)

Hebertella occidentalis (c)
Platystrophia laticosta (r)
Strophomena sulcata (r)

Byssonychia obesa (r)
richmondensis (c)
Ortonella hainesi (r)
Pterinea demissa (r)

Orthoceras byrnesi (c)

Ostracoda, unidentified (c)

Fauna of Cut 18. All. Whitewater.

Streptelasma rusticum (r)

Atactoporella schucherti (r)
Batostoma variabile (aa)
Bythopora delicatula (r)
Homotrypa cylindrica (c)
  nicklesi (r)
  richmondensis (r)
  wortheni (c)
Homotrypella hospitalis (r)

Monticulipora epidermata (r)

Hebertella occidentalis (c)
Platystrophia laticosta (c)
Rafinesquina alternata (r)
Strophomena sulcata (c)

Byssonychia richmondensis (c)
Pterinea demissa (r)

Leperditia caecigena (aa)

Detailed faunal lists of Section 5.9A, on the Kentucky bank of the Ohio River, opposite the mouth of the Miami River.*

Fauna of Section 5.9A, 50 Feet Above River. Lower Southgate.

Cornulites flexuosus (c)

Aspidopora newberryi (c)
Peronopora vera (r)
Stigmatella clavis (r)

Crania albersi (r)
Dalmanella multisecta (a)
Zygospira cincinnatiensis (c)

Zygospira modesta (c)

Calymene callicephala (r)
Isotelus maximus (c)
Trinucleus concentricus (a)

Ceratopsis chambersi (r)

Lepidocoleus jamesi (c)

Fauna of Section 5.9A, 50-55 Feet Above River. Lower Southgate.

Batostoma implicatum (c)
  jamesi (a)
Ceramoporella ohioensis (r)
Hallopora onealli (c)
  onealli communis (r)
  onealli sigillarioides (r)
Dalmanella multisecta (a)

Plectambonites sericeus (c)
Zygospira modesta (c)

Calymene callicephala (c)

Bythocypris cylindrica (c)

Fauna of Section 5.9A, 55-60 Feet Above River. Lower Southgate.

Climacograptus typicalis (a)

Bythopora arctipora (r)
Hallopora onealli (r)
Phylloporina variolata (r)
Stigmatella clavis (r)

Dalmanella multisecta (c)
Trematis millepunctata (r)

Zygospira modesta (r)
Byssonychia radiata (r)

Lophospira sp. (r)

Isotelus maximus (c)
Trinucleus concentricus (a)

Lepidocoleus jamesi (r)

* When the collections were made, upon which the following faunal lists are based, the stage of water of the Ohio was about 15 feet above low water stage at Lawrenceburg.

Fauna of Section 5.9A, 60-70 Feet Above River. Lower Southgate.

Climacograptus typicalis (a)

Cornulites flexuosus (c)

Aspidopora eccentrica (a)
Hallopora onealli (r)

Dalmanella multisecta (c)
Lingula covingtonensis (r)
Zygospira cincinnatiensis (r)
Zygospira modesta (r)

Acidaspis cf. crosotus (c)
Calymene callicephala (c)
Isotelus maximus (a)

Bythocypris cylindrica (a)
Ctenobolbina ciliata (r)

Lepidocoleus jamesi (c)

Fauna of Section 5.9A, 70-75 Feet Above River. Southgate.

Climacograptus typicalis (a)

Cornulites flexuosus (r)

Amplexopora petasiformis welchi (r)
Aspidopora eccentrica (r)
Batostoma jamesi (r)
Coeloclema alternatum (r)
  commune (r)
Hallopora onealli (r)
Peronopora vera (r)

Dalmanella multisecta (c)
Zygospira cincinnatiensis (c)
  modesta (c)

Byssonychia radiata (r)
Pterinea cf. mucronata (r)

Acidaspis sp. (c)
Calymene callicephala (r)
Dalmanites breviceps (c)
Isotelus maximus (c)
Proetus spurlocki (r)

Bollia pumila (r)
Bythocypris cylindrica (aa)
Ceratopsis chambersi (c)
Ctenobolbina ciliata (c)

Lepidocoleus jamesi (r)

Fauna of Section 5.9A, 75-80 Feet Above River. Southgate.

Climacograptus typicalis (a)

Cornulites flexuosus (r)

Amplexopora petasiformis welchi (r)
Arthropora cleavelandi (r)
  shafferi (c)
Arthrostylus tenuis (a)
Batostoma implicatum (c)
  jamesi (c)
Bernicea vesiculosa (r)
Bythopora arctipora (a)
Ceramoporella distincta (r)
  ohioensis (r)
Coeloclema alternatum (c)
  commune (c)
Dicranopora meeki (r)
Hallopora onealli (a)
  onealli communis (r)
  onealli sigillarioides (c)
Heterotrypa ulrichi (c)
Peronopora vera (r)
Phylloporina variolata (r)
Rhinidictya parallela (r)

Dalmanella emacerata (r)
  multisecta (c)
Lingula modesta (r)
Plectambonites sericeus (c)
Rafinesquina alternata (r)
Zygospira cincinnatiensis (c)
  modesta (c)

Byssonychia radiata (r)

Acidaspis sp. (c)
Calymene callicephala (r)
Isotelus maximus (c)

Bollia pumila (r)
Bythocypris cylindrica (aaa)

Ceratopsis chambersi (r)
Ctenobolbina ciliata (a)
Leperditia cf. caecigena (c)

Lepidocoleus jamesi (c)

Fauna of Section 5.9A, 70-85 Feet Above River. Southgate.

Cornulites flexuosus (r)

Amplexopora petasiformis welchi (r)
Arthropora shafferi (r)
Arthrostylus tenuis (c)
Aspidopora eccentrica (c)
Batostoma implicatum (c)
  jamesi (r)
Bythopora arctipora (a)
  parvula (r)
Ceramoporella distincta (r)
Coeloclema alternatum (r)
  commune (r)
Dicranopora meeki (r)
Escharopora acuminata (r)
Hallopora onealli (c)
  onealli communis (r)
  onealli sigillarioides (c)
Peronopora vera (r)
Proboscina confusa (r)
Rhinidictya parallela (c)

Stictoporella flexuosa (c)
Stigmatella clavis (r)
Stomatopora arachnoidea (r)

Crania albersi (r)
Dalmanella multisecta (a)
Plectambonites sericeus (a)
Rafinesquina alternata (r)
Zygospira modesta (r)

Acidaspis sp. (c)
Calymene callicephala (r)
Isotelus maximus (c)
Trinucleus concentricus (r)

Bollia persulcata (r)
  pumila (r)
Bythocypris cylindrica (c)
Ctenobolbina ciliata (r)
Leperditia caecigena (c)

Lepidocoleus jamesi (c)

Fauna of Section 5.9A, 110 Feet Above River. Southgate.

Batostoma jamesi (c)
Bythopora arctipora
Ceramoporella ohioensis (c)
Hallopora onealli (c)
Heterotrypa ulrichi (r)
Peronopora vera (r)

Dalmanella multisecta (r)
Zygospira cincinnatiensis (r)

Zygospira modesta (r)

Cladopherus sp. (r)
Hormotoma gracilis (r)

Trinucleus concentricus (c)

Bythocypris cylindrica (c)

Fauna of Section 5.9A, 125 Feet Above River. Base of McMicken.

Cornulites flexuosus (c)

Amplexopora septosa multispinosa (c)
Arthropora shafferi (c)
Aspidopora eccentrica (r)

Batostoma implicatum (c)
  jamesi (c)
Bythopora arctipora (c)
  parvula (r)
Ceramoporella distincta (r)
  ohioensis (r)

Coeloclema alternatum (a)
 commune (a)
Hallopora nodulosa (c)
 onealli (a)
 onealli communis (r)
 onealli sigillarioides (c)
Heterotrypa ulrichi (a)
Peronopora vera (c)
Rhinidictya parallela (r)
Stigmatella clavis (r)
Stomatopora arachnoidea (r)

Rafinesquina alternata (r)
Trematis millepunctata (r)
Zygospira cincinnatiensis (c)
 modesta (c)

Byssonychia radiata (r)

Acidaspis sp. (c)
Calymene callicephala (c)
Isotelus maximus (c)

PART III. COMPLETE REVISED LIST OF SPECIES REPORTED FROM THE CINCINNATI SERIES OF INDIANA, WITH THEIR HORIZONS, SO FAR AS KNOWN.*

SPONGIÆ AND COELENTERATA.

1. Beatricea nodulosa Billings. Saluda.
2. Beatricea undulata Billings. Saluda.
3. *Calapoecia cribriformis (Nicholson). Liberty.
4. *Climacograptus typicalis Hall. Southgate.
5. *Columnaria alveolata Goldfuss. Upper Waynesville, Liberty and Saluda.
6. Dystactospongia madisonensis Foerste. Saluda.
7. Labechia montifera Ulrich. Upper Richmond.
8. *Protarea vetusta (Hall). Waynesville, Liberty, Saluda and Whitewater.
9. Strephochetus richmondensis (Miller). Whitewater.
10. *Streptelasma divaricans (Nicholson). Upper Waynesville, Liberty and Whitewater.
11. *Streptelasma rusticum (Billings). Waynesville, Liberty, Saluda and Whitewater.
12. *Tetradium minus Safford. Saluda and Whitewater.

ECHINODERMATA.

13. Anomalocrinus incurvus Meek and Worthen. Richmond (?).
14. Dendrocrinus casei Meek. Richmond.
15. Dendrocrinus polydactylus (Shumard). Richmond.
16. Ectenocrinus simplex (Hall). Richmond.
17. *Glyptocrinus decadactylus Hall. Waynesville.
18. Heterocrinus juvenis Hall. Lower Richmond.
19. Heterocrinus heterodactylus Hall. Eden and Maysville.
20. *Iocrinus subcrassus Meek and Worthen. Southgate, Richmond (?).
21. Lepadocrinus moorei (Meek). Richmond.
22. Lepidodiscus faberi Miller. Richmond.
23. Lichenocrinus crateriformis Hall. Eden, Richmond (?).

* The species marked by an asterisk are found in the Tanner's Creek Section.

Coeloclema alternatum (a)
  commune (a)
Hallopora nodulosa (c)
  onealli (a)
  onealli communis (r)
  onealli sigillarioides (c)
Heterotrypa ulrichi (a)
Peronopora vera (c)
Rhinidictya parallela (r)
Stigmatella clavis (r)
Stomatopora arachnoidea (r)

Rafinesquina alternata (r)
Trematis millepunctata (r)
Zygospira cincinnatiensis (c)
  modesta (c)

Byssonychia radiata (r)

Acidaspis sp. (c)
Calymene callicephala (c)
Isotelus maximus (c)

PART III. COMPLETE REVISED LIST OF SPECIES REPORTED FROM THE CINCINNATI SERIES OF INDIANA, WITH THEIR HORIZONS, SO FAR AS KNOWN.*

SPONGIÆ AND COELENTERATA.

1. Beatricea nodulosa Billings. Saluda.
2. Beatricea undulata Billings. Saluda.
3. *Calapoecia cribriformis (Nicholson). Liberty.
4. *Climacograptus typicalis Hall. Southgate.
5. *Columnaria alveolata Goldfuss. Upper Waynesville, Liberty and Saluda.
6. Dystactospongia madisonensis Foerste. Saluda.
7. Labechia montifera Ulrich. Upper Richmond.
8. *Protarea vetusta (Hall). Waynesville, Liberty, Saluda and Whitewater.
9. Strephochetus richmondensis (Miller). Whitewater.
10. *Streptelasma divaricans (Nicholson). Upper Waynesville, Liberty and Whitewater.
11. *Streptelasma rusticum (Billings). Waynesville, Liberty, Saluda and Whitewater.
12. *Tetradium minus Safford. Saluda and Whitewater.

ECHINODERMATA.

13. Anomalocrinus incurvus Meek and Worthen. Richmond (?).
14. Dendrocrinus casei Meek. Richmond.
15. Dendrocrinus polydactylus (Shumard). Richmond.
16. Ectenocrinus simplex (Hall). Richmond.
17. *Glyptocrinus decadactylus Hall. Waynesville.
18. Heterocrinus juvenis Hall. Lower Richmond.
19. Heterocrinus heterodactylus Hall. Eden and Maysville.
20. *Iocrinus subcrassus Meek and Worthen. Southgate, Richmond (?).
21. Lepadocrinus moorei (Meek). Richmond.
22. Lepidodiscus faberi Miller. Richmond.
23. Lichenocrinus crateriformis Hall. Eden, Richmond (?).

* The species marked by an asterisk are found in the Tanner's Creek Section.

24. Lichenocrinus dyeri Hall. Richmond.
25. Lichenocrinus pattersoni Miller. Richmond.
26. *Lichenocrinus tuberculatus Miller. Whitewater.
27. Paleaster wycoffi Miller and Gurley. Richmond.
28. Paleasterina speciosa Miller and Gurley. Richmond.
29. Urasterella grandis (Meek). Richmond.
30. Xenocrinus baeri (Meek). Richmond.

ANNELIDA.

31. *Cornulites flexuosus (Hall). Eden and Maysville.
32. Cornulites minor (Nicholson). Lower Maysville.
33. *Cornulites richmondensis (Miller). Arnheim and Richmond.
34. *Nereidavus varians Grinnel. Southgate.
35. *Œnonites cuneatus Hinde. McMicken.

BRYOZOA.

36. *Amplexopora ampla Ulrich and Bassler. Maysville.
37. *Amplexopora cingulata Ulrich. Arnheim.
38. *Amplexopora filiosa (American authors). Middle and upper Maysville.
39. *Amplexopora granulosa n. sp. Lower Liberty.
40. Amplexopora persimilis Nickles. Southgate.
41. *Amplexopora petasiformis (Nicholson). McMicken.
42. Amplexopora petasiformis welchi (James). Southgate.
43. *Amplexopora pumila n. sp. Upper Waynesville and lower Liberty.
44. *Amplexopora pustulosa Ulrich. Upper Maysville and lower Richmond.
45. *Amplexopora robusta Ulrich. Maysville.
46. *Amplexopora septosa (Ulrich). McMicken, Mt. Hope and Fairmount.
47. *Amplexopora septosa maculosa n. var. McMicken and Mt. Hope.
48. *Amplexopora septosa minima n. var. McMicken, Mt. Hope and Fairmount.
49. *Amplexopora septosa multispinosa Cumings. McMicken, Mt. Hope and Fairmount.
50. *Arthropora cincinnatiensis (James). McMicken, Mt. Hope and Fairmount.
51. *Arthropora cleavelandi (James). Upper Eden.
52. *Arthropora shafferi (Meek). Throughout the Cincinnatian.
53. *Arthrostylus tenuis (James). McMicken.
54. *Aspidopora areolata Ulrich. Southgate.
55. *Aspidopora eccentrica (James). Southgate.
56. *Aspidopora newberryi (Nicholson). Southgate and McMicken.
57. *Atactopora hirsuta Ulrich. Southgate.
58. *Atactopora intermedia n. sp. McMicken.
59. *Atactoporella multigranosa (Ulrich). Fairmount, Mt. Auburn and Arnheim.
60. *Atactoporella mundula (Ulrich). Bellevue, Arnheim.
61. *Atactoporella newportensis (Ulrich). Lower Eden.

62. *Atactoporella ortoni (Nicholson). Bellevue, Corryville, Mt. Auburn and Arnheim.
63. *Atactoporella schucherti Ulrich. Richmond.
64. Atactoporella typicalis Ulrich. Lower Eden.
65. *Batostoma implicatum (Nicholson). Middle and upper Eden and lower Maysville.
66. *Batostoma jamesi (Nicholson). Middle and upper Eden. Lower Maysville (?).
67. *Batostoma prosseri Cumings and Galloway. Upper Waynesville.
68. *Batostoma variabile Ulrich. Whitewater.
69. *Batostoma varians (James). Arnheim, Waynesville and Liberty.
70. *Bernicea primitiva Ulrich. Upper Maysville and Richmond.
71. *Bernicea vesiculosa Ulrich. Southgate.
72. *Bythopora arctipora (Nicholson). Middle and upper Eden, Mt. Hope-Fairmount. (c)
73. *Bythopora delicatula (Nicholson). Corryville-Arnheim and Richmond. (c)
74. *Bythopora gracilis (Nicholson). Maysville. (c)
75. *Bythopora meeki (James). Waynesville, Liberty and Whitewater.
76. *Bythopora parvula (James). Southgate, McMicken, Mt. Hope-Fairmount. (r)
77. *Bythopora striata Ulrich. Bellevue, Corryville-Arnheim, Richmond. (r)
78. Calloporella circularis (James). Lower Richmond.
79. *Ceramoporella distincta Ulrich. Eden, Maysville and Waynesville. (c)
80. *Ceramoporella granulosa Ulrich. Upper Waynesville. (r)
81. *Ceramoporella granulosa milfordensis (James). McMicken. (r)
82. *Ceramoporella ohioensis (Nicholson). Throughout the Cincinnatian. (c)
83. *Ceramoporella triloba n. sp. McMicken. (r)
84. *Ceramoporella tubulosa n. sp. McMicken. (r)
85. *Ceramoporella whitei (James). Arnheim, Waynesville. (r)
86. *Chiloporella flabellata (Ulrich). Bellevue, Corryville. (c)
87. *Coeloclema alternatum (James). Southgate, McMicken. (a)
88. *Coeloclema cf. alternatum. Corryville-Arnheim. (c)
89. *Coeloclema commune Ulrich. Southgate and McMicken. (a)
90. *Coeloclema oweni (James). Mt. Auburn. (a)
91. *Constellaria constellata (Van Cleve) Dana. McMicken, Mt. Hope-Fairmount.
92. *Constellaria constellata prominens Ulrich. Base of Mt. Hope.
93. *Constellaria limitaris (Ulrich). Upper Waynesville. (c)
94. *Constellaria polystomella Nicholson. Waynesville and Liberty.
95. *Corynotrypa delicatula (James). Fairmount, Corryville-Arnheim.
96. *Corynotrypa inflata (Hall). Maysville.
97. Crepipora simulans Ulrich. Southgate.
98. *Crepipora solida Ulrich. Fairmount.
99. *Dekayia appressa Ulrich. Fairmount to middle of Arnheim. (c)
100. *Dekayia aspera Edwards and Haime. McMicken, Mt. Hope-Fairmount (a), Arnheim (?).

101. *Dekayia maculata James. McMicken, Mt. Hope.
102. *Dekayia magna Cumings. Bellevue, Arnheim.
103. *Dekayia multispinosa Ulrich. Maysville.
104. *Dekayia obscura (Ulrich). McMicken.
105. *Dicranopora emacerata (Nicholson). Maysville, Richmond.
106. *Dicranopora fragilis (Billings). Waynesville.
107. *Dicranopora meeki (James). Southgate, McMicken.
108. *Eridotrypa simulatrix (Ulrich). Corryville-Arnheim, Waynesville. (c)
109. *Escharopora acuminata (James). Southgate.
110. *Escharopora falciformis (Nicholson). McMicken, Mt. Hope-Fairmount.
111. *Escharopora pavonia (Edwards and Haime). McMicken, Mt. Hope-Fairmount.
112. *Fenestella granulosa Whitfield. Waynesville, Liberty and Whitewater.
113. *Graptodictya perelegans (Ulrich). Waynesville.
114. *Hallopora andrewsi (Nicholson). Maysville.
115. *Hallopora dalei (Edwards and Haime). McMicken, Mt. Hope-Fairmount. (a)
116. Hallopora frondosa (Cumings). Whitewater.
117. *Hallopora nodulosa (Nicholson). McMicken, Mt. Hope-Fairmount.
118. *Hallopora onealli (James). Southgate and McMicken.
119. *Hallopora onealli communis (James). Southgate, McMicken. (aa)
120. *Hallopora onealli sigillarioides (Nicholson). Southgate and McMicken. (c)
121. *Hallopora ramosa (d'Orbigny). Maysville. (aa)
122. *Hallopora cf. ramosa. Waynesville and Liberty. (c)
123. *Hallopora ramosa rugosa (Edwards and Haime). Middle and upper Maysville. (c)
124. *Hallopora subnodosa (Ulrich). Arnheim and Richmond. (c)
125. *Hallopora subplana (Ulrich). McMicken, Mt. Hope-Fairmount. (c)
126. *Helopora elegans Ulrich. Liberty.
127. *Helopora harrisi James. Arnheim and Waynesville.
128. *Heterotrypa affinis (Ulrich). Waynesville.
129. *Heterotrypa frondosa (d'Orbigny). Maysville, abundant in the Bellevue.
130. *Heterotrypa inflecta Ulrich. Fairmount.
131. *Heterotrypa microstigma n. sp. Waynesville.
132. *Heterotrypa paupera (Ulrich). Maysville.
133. *Heterotrypa pelliculata (Ulrich). Fairmount and Bellevue.
134. *Heterotrypa prolifica Ulrich. Waynesville, abundant and characteristic.
135. *Heterotrypa singularis Ulrich. Waynesville.
136. *Heterotrypa solitaria Ulrich. Fairmount and Bellevue.
137. *Heterotrypa subfrondosa (Cumings). Mt. Hope-Fairmount.
138. *Heterotrypa subpulchella (Nicholson). McMicken, Mt. Hope-Fairmount.
139. *Heterotrypa subramosa (Ulrich). Waynesville, Whitewater. (c)

140. *Heterotrypa ulrichi Nicholson. McMicken, (a). Mt. Hope-Fairmount. (r)
141. *Heterotrypa ulrichi lobata (Cumings). McMicken and lower Maysville.
142. *Heterotrypa ulrichi robusta (Foord). McMicken, Mt. Hope-Fairmount.
143. *Homotrypa alta n. sp. Mt. Hope-Fairmount.
144. *Homotrypa austini Bassler. Waynesville, Liberty and Whitewater.
145. *Homotrypa cincinnatiensis Bassler. Mt. Hope-Fairmount.
146. *Homotrypa communis Bassler. Waynesville, Liberty. (c)
147. *Homotrypa constellariformis Cumings. Whitewater.
148. *Homotrypa curvata Ulrich. Fairmount, Bellevue and Corryville.
149. *Homotrypa curvata praecipta Bassler. McMicken, Mt. Hope-Fairmount.
150. *Homotrypa cylindrica Bassler. Liberty and Whitewater.
151. *Homotrypa dawsoni (Nicholson). Waynesville, Whitewater.
152. *Homotrypa dumosa Bassler. Mt. Hope-Fairmount.
153. *Homotrypa flabellaris Ulrich. Arnheim, Waynesville, Liberty and Whitewater. (c)
154. *Homotrypa flabellaris spinifera Bassler. Fairmount, Waynesville and Whitewater (?).
155. *Homotrypa frondosa Bassler. Corryville-Arnheim, Waynesville.
156. *Homotrypa glabra n. sp. McMicken, Mt. Hope-Fairmount.
157. Homotrypa grandis Bassler. Upper Maysville.
158. *Homotrypa nicklesi Bassler. Whitewater.
159. *Homotrypa nitida Bassler. Whitewater.
160. *Homotrypa nodulosa Bassler. Waynesville and Liberty.
161. *Homotrypa obliqua Ulrich. McMicken (?) and Maysville.
162. *Homotrypa pulchra Bassler. Corryville-Arnheim.
163. *Homotrypa ramulosa Bassler. Liberty and Whitewater.
164. *Homotrypa richmondensis Bassler. Upper Waynesville, Liberty and Whitewater.
165. *Homotrypa spinea n. sp. Mt. Hope-Fairmount.
166. *Homotrypa wortheni (James). Richmond, Whitewater (aa).
167. *Homotrypa wortheni prominens Bassler. Liberty, (?) Elkhorn.
168. *Homotrypella hospitalis (Nicholson). Waynesville (c), Liberty and Whitewater.
169. *Homotrypella rustica Ulrich. Waynesville, Liberty and Whitewater.
170. *Leptotrypa calceola (Miller and Dyer). Lower Maysville.
171. *Leptotrypa clavacoidea (James). Upper Maysville.
172. *Leptotrypa discoidea (Nicholson). Maysville.
173. *Mesotrypa orbiculata n. sp. Arnheim.
174. *Mesotrypa patella (Ulrich). Liberty.
175. *Monticulipora epidermata Ulrich and Bassler. Liberty, Saluda and Whitewater. Characteristic of the Whitewater.
176. *Monticulipora mammulata d'Orbigny. Fairmount to Mt. Auburn.
177. *Monticulipora parasitica Ulrich. Waynesville, Liberty and Whitewater.
178. *Nicholsonella vaupeli (Ulrich). Maysville, Waynesville, Liberty and Whitewater.

179. *Nicholsonella peculiaris n. sp. Arnheim.
180. *Peronopora pavonia (d'Orbigny). Middle and upper Maysville and Richmond.
181. *Peronopora vera Nickles. Eden, Mt. Hope-Fairmount.
182. *Peronoporella dubia n. sp. Bellevue to middle of Arnheim.
183. *Petigopora asperula Ulrich. Upper McMicken to middle Waynesville.
184. *Petigopora gregaria Ulrich. Upper Maysville.
185. *Petigopora petechialis (Nicholson). McMicken, Maysville and Waynesville.
186. *Phylloporina variolata (Ulrich). Southgate and McMicken.
187. *Proboscina auloporoides (Nicholson). Maysville, Waynesville and Liberty.
188. *Proboscina confusa (Nicholson). Southgate.
189. *Proboscina frondosa (Nicholson). Eden, Maysville and Richmond.
190. *Ptilodictya plumaria James. Waynesville, Whitewater.
191. *Rhinidictya lata (Ulrich). Waynesville.
192. *Rhinidictya parallela (James). Southgate.
193. Rhombotrypa crassimuralis (Ulrich). Whitewater.
194. *Rhombotrypa quadrata (Rominger). Waynesville, Liberty and Whitewater. (c)
195. *Rhombotrypa subquadrata (Ulrich). Upper Waynesville and lower Liberty.
196. *Rhopalonaria venosa Ulrich. Arnheim, Waynesville and Liberty. (r)
197. *Spatiopora aspera Ulrich. Top of Waynesville.
198. Spatiopora maculosa Ulrich. Lower Maysville.
199. Spatiopora tuberculata (Edwards and Haime). Maysville and Richmond.
200. *Stictoporella flexuosa (James). Southgate.
201. *Stigmatella alcicornis n. sp. Fairmount.
202. *Stigmatella catenulata n. sp. Arnheim.
203. *Stigmatella clavis (Ulrich). Eden and lower Maysville.
204. *Stigmatella crenulata Ulrich and Bassler. Waynesville.
205. *Stigmatella dychei (James). Mt. Auburn.
206. Stigmatella irregularis (Ulrich). Lower Maysville.
207. *Stigmatella incrustans n. sp. Liberty.
208. *Stigmatella nicklesi Ulrich and Bassler. Southgate.
209. Stigmatella personata Ulrich and Bassler. Elkhorn.
210. *Stigmatella spinosa Ulrich and Bassler. Waynesville.
211. *Stigmatella sessilis n. sp. Fairmount.
212. *Stomatopora arachnoidea (Hall). Throughout the Cincinnatian.

BRACHIOPODA.

213. Catazyga headi (Billings). Waynesville.
214. *Crania albersi Miller. Southgate.
215. *Crania laelia Hall. Liberty.
216. *Crania scabiosa Hall. Maysville and Richmond.
217. *Dalmanella emacerata (Hall). Upper Eden.
218. *Dalmanella meeki (Miller). Corryville-Arnheim (nc) and Waynesville (a).
219. *Dalmanella multisecta (Meek). Eden (a), Mt. Hope-Fairmount (r).

220. *Dinorthis retrorsa (Salter). Top of the Arnheim. (c)
221. *Dinorthis subquadrata (Hall). Upper Waynesville, lower Liberty (c). Whitewater (r).
222. *Hebertella insculpta (Hall). Top of the Waynesville (aaa), lower Liberty (r).
223. *Hebertella occidentalis (Hall). Upper Waynesville, Liberty (a), Saluda and Whitewater (r).
224. *Hebertella sinuata (Hall). Fairmount, Bellevue (c), and Richmond.
225. *Leptaena rhomboidalis (Wilckens). Arnheim and Waynesville, very common at the top of the Waynesville.
226. *Leptobolus lepis Hall. Southgate and Corryville.
227. *Lingula cincinnatiensis (Hall and Whitfield). Arnheim.
228. *Lingula covingtonensis (Hall and Whitfield). Arnheim.
229. *Lingula modesta Ulrich. Southgate.
230. Orthis fissicosta Hall. Maysville.
231. *Platystrophia acutilirata (Conrad). Waynesville, Liberty and Whitewater.
232. Platystrophia acutilirata senex Cumings. Upper Whitewater.
233. *Platystrophia costata (Pander). Mt. Hope-Fairmount.
234. Platystrophia cypha James. Upper Maysville.
235. *Platystrophia laticosta Meek. McMicken, Maysville and Richmond.
236. *Platystrophia lynx (Eichwald). Maysville. Characteristic of the Bellevue and Mt. Auburn.
237. Platystrophia moritura Cumings. Characteristic of the Elkhorn.
238. *Plectambonites sericeus (Sowerby). Southgate (c), Mt. Hope-Fairmount, Mt. Auburn, Waynesville, and lower Liberty (aaa).
239. *Plectorthis ella (Hall). Maysville.
240. *Plectorthis plicatella (Hall). Top of the McMicken, Mt. Hope-Fairmount. Characteristic of the lower Maysville.
241. *Plectorthis triplicatella (Meek). Lower Maysville. (c)
242. *Rafinesquina alternata (Emmons). Throughout the Cincinnatian.
243. *Rafinesquina alternata fracta (Meek). Maysville. Characteristic of the Bellevue, Corryville and Arnheim.
244. *Rafinesquina alternata loxorhytis (Meek). Arnheim and Waynesville.
245. *Rafinesquina nasuta (Conrad). Middle Maysville.
246. *Rafinesquina alternata ponderosa Cumings. Bellevue (c), and Waynesville (?).
247. Retzia granulifera Meek. Upper Eden.
248. *Rhynchotrema capax (Conrad). Upper Waynesville, lower Liberty (aa), and Whitewater. (c)
249. *Rhynchotrema dentata (Hall). Upper Waynesville (rr), and Whitewater (a).
250. Schizocrania filosa (Hall). Trenton to Maysville.
251. Strophomena nutans Meek. Liberty.
252. *Strophomena planoconvexa (Hall). Fairmount.
253. *Strophomena planumbona (Hall). Waynesville, Liberty (a), and Whitewater.
254. *Strophomena sinuata Meek. Lower Maysville.
255. *Strophomena subtenta (Hall). Waynesville and Liberty.

256. *Strophomena sulcata (Verneuil). Liberty and Whitewater. (c)
257. *Strophomena vetusta James. Liberty and Whitewater.
258. *Trematis millepunctata Hall. Rare throughout the Cincinnatian.
259. Trematis reticularis (Miller). Maysville.
260. *Zygospira cincinnatiensis Meek. Southgate, McMicken, and Fairmount.
261. *Zygospira modesta (Hall). Throughout the Cincinnatian. (c)

PELECYPODA.

262. *Allonychia jamesi (Meek). Bellevue.
263. *Anomalodonta costata (Meek). Middle Maysville.
264. *Anomalodonta gigantea Miller. Waynesville, Whitewater.
265. *Byssonychia alveolata Ulrich Middle and upper Maysville and lower Richmond.
266. *Byssonychia grandis Ulrich. Arnheim, Waynesville, and Whitewater (?).
267. *Byssonychia obesa Ulrich. Waynesville (?), Whitewater.
268. Byssonychia praecursa Ulrich. Upper Maysville.
269. *Byssonchyia radiata (Hall). Eden, Maysville and Richmond.
270. *Byssonychia richmondensis Ulrich. Waynesville, Liberty and Whitewater.
271. *Byssonychia suberecta Ulrich. Lower and middle Richmond.
272. *Byssonychia tenuistriata Ulrich. Arnheim.
273. *Clidophorus fabula (Hall). Maysville.
274. Clionychia excavata Ulrich. Richmond.
275. Ctenodonta cingulata (Ulrich). Waynesville.
276. *Cymatonota typicalis Ulrich. Waynesville, Whitewater (?).
277. Cyrtodonta cuneata (Miller). Richmond.
278. *Eridonychia crenata Ulrich. Whitewater (?), lower Richmond.
279. Ischyrodonta decipiens Ulrich. Whitewater.
280. *Ischyrodonta elongata Ulrich. Middle Richmond.
281. Ischyrodonta miseneri Ulrich. Whitewater.
282. Ischyrodonta modioliformis Ulrich. Whitewater.
283. *Ischyrodonta ovalis Ulrich. Waynesville.
284. Ischyrodonta truncata Ulrich. Whitewater.
285. Ischyrodonta unionoides (Meek). Lower Maysville.
286. *Modiolodon declivis Ulrich. Arnheim (?), Waynesville.
287. Modiolopsis concentrica Hall and Whitfield. Waynesville.
288. *Modiolopsis versaillesensis Miller. Waynesville.
289. *Opisthoptera casei (Meek and Worthen). Richmond.
290. Opisthoptera obliqua Ulrich. Richmond.
291. Orthodesma canaliculatum Ulrich. Richmond.
292. Orthodesma rectum Hall and Whitfield. Lower Richmond.
293. Orthodesma subangulatum Ulrich. Richmond.
294. Orthodontiscus milleri (Meek). Lower Richmond.
295. *Ortonella hainesi (Miller). Whitewater.
296. Pterinea corrugata (James). Waynesville.
297. *Pterinea demissa (Conrad). McMicken, Maysville and Richmond
298. *Pterinea mucronata Ulrich. Southgate.
299. *Rhitimya byrnesi (Miller). Richmond.

300. Sedgwickia fragilis Meek. Lower Maysville. May not occur in Indiana.
301. Sphenolium richmondense Miller. Middle Richmond.
302. Tellinomya hilli Miller. Saluda.
303. Whiteavesia cincinnatiensis (Hall and Whitfield). Eden.
304. Whiteavesia pholadiformis (Hall). Richmond.
305. Whitella obliqua Ulrich. Lower Richmond
306. Whitella umbonata Ulrich. Lower Richmond.

GASTROPODA AND P.EROPODA.

307. *Bellerophon gorbyi Miller. Southgate, Maysville (?)
308. Bellerophon mohri Miller. Middle Richmond.
309. Bellerophon subangularis Ulrich. Middle Richmond.
310. Bucania crassa Ulrich. Whitewater.
311. Bucania simulatrix Ulrich. Whitewater.
312. Clathrospira subconica (Hall). Maysville and Richmond.
313. *Conradella dyeri (Hall). Richmond.
314. *Conularia formosa Miller and Dyer. Arnheim.
315. *Cyclonema bilix (Conrad). Arnheim and Waynesville.
316. *Cyclonema bilix fluctuatum James. Waynesville.
317. *Cyclonema bilix humerosum Ulrich. Upper Maysville and Richmond.
318. *Cyclonema bilix mediale Ulrich. Lower Maysville.
319. *Cyclora minuta Hall. Maysville and Richmond.
320. Cyclora parvula (Hall). Richmond.
321. Cyclora pulcella Miller. Liberty.
322. *Cyrtolites ornatus Conrad. Upper Fairmount and Bellevue.
323. Helicotoma marginata Ulrich. Elkhorn.
324. Holopea hubbardi Miller. Saluda.
325. *Hormotoma gracilis (Hall). Southgate.
326. Hyolithes (?) dubius Miller and Faber. Richmond.
327. Hyolithes versaillesensis Miller and Faber. Richmond.
328. Liospira vitruvia (Billings). Throughout the Cincinnatian.
329. Lophospira acuminata Ulrich. Middle Richmond.
330. Lophospira ampla Ulrich. Richmond.
331. Lophospira bicincta (Hall). Richmond.
332. *Lophospira bowdeni (Safford). Maysville.
333. Lophospira hammeli (Miller). Saluda.
334. Lophospira tropidophora (Meek). Whitewater.
335. *Microceras inornatus Hall. Maysville and Richmond.
336. Oxydiscus magnus (Miller). Richmond.
337. Protowarthia cancellata (Hall). Throughout the Cincinnatian.
338. Protowarthia subcompressa Ulrich. Lower Richmond.
339. Raphistoma richmondensis Ulrich. Middle Richmond.
340. Salpingostoma richmondensis Ulrich. Whitewater, upper part.
341. Schizolopha moorei Ulrich. Whitewater.
342. Trochonema madisonense Ulrich. Richmond.
343. Tryblidium indianense Miller. Richmond.
344. Tryblidium madisonense Miller. Richmond.

CEPHALOPODA.

345. *Cyrtoceras amoenum Miller. Richmond.
346. Cyrtoceras hitzi Foerste. Saluda.
347. Cyrtoceras tenuiseptum Faber. Richmond.
348. Cyrtoceras thompsoni Miller. Upper Richmond (?)
349. Cyrtocerina madisonensis Miller. Saluda.
350. *Endoceras proteiforme Hall. Throughout the Cincinnatian.
351. *Gomphoceras indianensis Miller and Faber. Richmond.
352. Gyroceras baeri (Meek and Worthen). Middle Richmond.
353. *Orthoceras bilineatum Hall. Richmond.
354. *Orthoceras byrnesi Miller. Upper Maysville.
355. Orthoceras carleyi Hall and Whitfield. Upper Maysville. (?)
356. *Orthoceras duseri Hall and Whitfield. Lower Richmond.
357. Orthoceras gorbyi Miller. Horizon unknown.
358. Orthoceras hammeli Foerste. Saluda.
359. Orthoceras hitzi Foerste. Saluda.
360. Orthoceras junceum Hall. Lower Eden. Probably does not occur in Indiana.
361. Orthoceras mohri Miller. Waynesville.

TRILOBITA.

362. Acidaspis ceralepta (Anthony). Eden.
363. *Acidaspis cincinnatiensis Meek. Throughout the Cincinnatian.
364. *Acidaspis crosotus (Locke). Southgate.
365. *Calymene callicephala Green. Common throughout the Cincinnatian, especially at the top of the Waynesville.
366. Ceraurus icarus (Billings). Whitewater.
367. *Ceraurus pleurexanthemus Green. Lower Maysville and Waynesville.
368. *Dalmanites breviceps Hall. Southgate (?), Waynesville.
369. Dalmanites callicephalus (Hall). Probably not found in the Cincinnatian.
370. *Isotelus maximus Locke. Rather common throughout the Cincinnatian.
371. *Proetus spurlocki Meek. Southgate and lower Maysville.
372. *Trinucleus concentricus (Eaton). Throughout the Eden.

OSTRACODA.

373. *Bollia persulcata Ulrich. Southgate.
374. *Bollia pumila Ulrich. Southgate (?), middle Richmond.
375. *Bythocypris cylindrica (Hall). Southgate (aa).
376. *Ceratopsis chambersi (Miller). Southgate, McMicken, Waynesville.
377. Ceratopsis chambersi robusta Ulrich. Lower Richmond.
378. *Ceratopsis oculifera (Hall). Economy, McMicken.
379. *Ctenobolbina ciliata (Emmons). Eden, Waynesville.
380. Ctenobolbina ciliata hammeli (Miller and Dyer). Arnheim.
381. Entomis madisonensis Ulrich. Saluda.
382. *Eurychilina striatomarginata (Miller). Saluda.
383. *Leperditia caecigena Miller. Eden (?), Richmond.

384. *Primitia centralis Ulrich. Southgate.
385. *Primitia cincinnatiensis (Miller). Richmond.
386. *Primitia impressa Ulrich. Arnheim and Waynesville.
387. Tetradella quadrilirata (Hall and Whitfield). Lower Richmond.
388. *Tetradella quadrilirata simplex Ulrich. Richmond.

CIRRIPEDIA.

389. *Lepidocoleus jamesi (Meek). Southgate, Waynesville.

PART IV. PALEONTOLOGY.

Under this heading we consider the points of special interest of the more important genera and species. The major part of our study has been devoted to the Bryozoa, on account of their abundance, their value as zone markers, and the fascinating interest they lend to paleobiology. The Bryozoa of the Cincinnatian exceed all other groups in number of species and individuals.

No attempt has been made in this paper to differentiate the smaller subdivisions of many old species, as has recently been done by Foerste, as it suits our present purpose better to retain the long-used names.

Corals.

Protarea vetusta (Hall). This coral makes its first appearance, in the Cincinnatian, in the middle of the Waynesville. In the upper 17 feet of this division and in the upper Liberty it occurs abundantly, and rarely in the Saluda and Whitewater. Foerste calls this species *Protarea richmondensis.*

Brachiopoda.

Dalmanella meeki (Miller) (=*Dalmanella jugosa* (James)), makes its first appearance in the Fairmount. This is the form recognized by Foerste as *Dalmanella fairmountensis. D meeki,* the typical form, comes in in the Corryville and increases in abundance to the base of the Waynesville. In this formation it is the dominant fossil. It disappears at the base of the Liberty.

Dalmanella multisecta (Meek). This form ranges throughout the Eden and up into the Fairmount. It is the characteristic brachiopod of the Eden.

Dinorthis retrorsa (Salter) (= *D carleyi* (Hall)), occurs apparently in a single layer near the top of the Arnheim at the top of Cut 11. The variety *D. carleyi insolens* Foerste, which occurs

384. *Primitia centralis Ulrich. Southgate.
385. *Primitia cincinnatiensis (Miller). Richmond.
386. *Primitia impressa Ulrich. Arnheim and Waynesville.
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CORALS.

Protarea vetusta (Hall). This coral makes its first appearance, in the Cincinnatian, in the middle of the Waynesville. In the upper 17 feet of this division and in the upper Liberty it occurs abundantly, and rarely in the Saluda and Whitewater. Foerste calls this species *Protarea richmondensis.*

BRACHIOPODA.

Dalmanella meeki (Miller) (=*Dalmanella jugosa* (James)), makes its first appearance in the Fairmount. This is the form recognized by Foerste as *Dalmanella fairmountensis. D meeki,* the typical form, comes in in the Corryville and increases in abundance to the base of the Waynesville. In this formation it is the dominant fossil. It disappears at the base of the Liberty.

Dalmanella multisecta (Meek). This form ranges throughout the Eden and up into the Fairmount. It is the characteristic brachiopod of the Eden.

Dinorthis retrorsa (Salter) (= *D carleyi* (Hall)), occurs apparently in a single layer near the top of the Arnheim at the top of Cut 11. The variety *D. carleyi insolens* Foerste, which occurs in some places at the top of the Waynesville, was not obtained from our section.

Hebertella sinuata (Hall) occurs rather commonly in the Bellevue and rarely in the Fairmount It also occurs in the Waynesville, increasing in abundance from bottom to top, and in the lower Liberty. The Richmond form is somewhat smaller than the typical Maysville species and does not have the dorsal fold so strongly developed.

Leptaena rhomboidalis (Wilckens). This species begins, in the present section, in the Arnheim, where it is very rare, and increases in abundance to the top of the Waynesville, where some of the thin limestone layers are largely made up of fragments of the shells of this species.

Platystrophia lynx (Eichwald). The gerontic form is common in a single thick layer at an elevation of 730 feet, in Cut 10, but it is not nearly so abundant as in Ohio, where it ranges through a considerable thickness of rock. This layer corresponds to the Mt. Auburn. We also found a few specimens of the typical form in the Fairmount, but none in the Bellevue. This is rather remarkable in view of the fact that at most localities the Bellevue is replete with specimens of this species.

Platystrophia acutilirata (Conrad) is fairly common in the middle and upper Waynesville. It occurs sparingly above and is absent below this horizon in the present section.

Platystrophia laticosta (Meek) first appears in the middle of the McMicken, and continues to the top of the section. It is most common at the top of the Waynesville, but is also a common and characteristic fossil of the Fairmount and Bellevue.

Plectambonites sericeus (Sowerby) is another long-lived species. It persists with little change throughout the Cincinatian, and reaches its culmination in the base of the Liberty, where several layers are made up almost entirely of this shell.

Plectorthis plicatella (Hall), which is characteristic of the Fairmount, first appears in the upper 15 feet of the McMicken. We include under this name all of the commonly recognized varieties of this species.

Raflnesquina alternata (Emmons) is one of the most conspicuous and omnipresent species of the Cincinnatian, second in this respect only to *Zygospira modesta*. It occurs throughout the section, in several places making up the bulk of the rock. From the base of the Maysville to the top of the Liberty it is very abundant. The variety *fracta* occurs in immense numbers in the Bellevue, Corryville and Arnheim. The variety *loxorhytis* is common from the Corryville to the top of the Waynesville. The variety *ponderosa* appears abundantly in the Bellevue, and a similar though probably distinct form in the middle Waynesville. It is possible to find all intermediate forms between the species and varieties, and one cannot be certain what variety he is dealing with unless the form is well marked.

Rhynchotrema capax (Conrad) is found first at about the middle of the Waynesville and extends up into the Whitewater. It occurs in large numbers in the lower Liberty.

Rhynchotrema dentatum (Hall) which is characteristic of the Whitewater at Richmond, appears to be lacking in this division on Tanner's Creek. It occurs rather commonly in the middle Waynesville.

Strophomena planoconvexa (Hall) is restricted to the Fairmount. Though occurring in small numbers it is characteristic of the Fairmount, and its first appearance marks the base of that division, as ordinarily defined.

Strophomena planumbona (Hall) first appears in the Waynes- and reaches its culmination in the Liberty, which it characterizes.

Zygospira modesta (Hall) occurs throughout the Cincinnatian. It is especially abundant in the Arnheim, Waynesville and Liberty. Our collections from the Saluda and Whitewater do not contain any specimens of this species, but it is found in these beds at Richmond.

BRYOZOA.

Amplexopora cingulata Ulrich. We found several specimens of this species, which appear to be perfectly typical, in the Arnheim, in Cut 11.

Amplexopora filiosa (American authors). This species occurs, in our section, in the Bellevue and at the top of the Arnheim, but it is rare and the zoaria are smaller than the typical form. It seems quite probable that this species is a lineal descendant of *Amplexopora petasiformis* (Nicholson) from the Eden, which it resembles very closely.

Amplexopora septosa Ulrich. This species is quite abundant throughout the McMicken and Mt. Hope-Fairmount. The inflections of the zooecial walls by the acanthopores scarcely ever show at the surface, so that sections are necessary to distinguish the species from the variety *multispinosa*. The variety *minima* is the simplest form, and the one from which the species and the other varieties were probably derived. In the variety *maculosa* the maculæ are quite different from the maculæ of *A. septosa,* as pointed out in the description.

Our study of maculæ and monticules has shown that they are of considerable importance in classification, and has thrown much light on their probable function. Our studies have also shown that curved diaphragms, which are quite common in species with numerous diaphragms, have little or no classificatory significance. These results, and other studies on morphology, will be brought out in detail in a succeeding paper.

There are three well-marked groups within the genus *Amplexopora.* The simplest type is the *filiosa* group, consisting of *A. filiosa, A. petasiformis, and A. Welchi.* A second group is the *pustulosa* type, consisting of *A. ampla, A. Columbiana, A. cylindracea, A. granulosa, A. pustulosa, A. pumila,* and *A. robusta.* A third group is the *cingulata* type, consisting of *A. cingulata, A. persimilis,* and *A. septosa* and its varieties. In this third group might appropriately be placed *Batostoma variabile, Batostoma minnesotense,* and *Batostoma winchelli.* It will probably be found advisable to redistribute most of these species among other genera and reserve *Amplexopora* for the *cingulata* type above.

Batostoma implicatum (Nicholson) and *Batostoma jamesi* (Nicholson) are characteristic of the Eden. *B. implicatum* extends up into the Fairmount also.

Batostoma varians (James) appears in the Arnheim and fails at the top of the Waynesville. It shows close relationship with *B. implicatum* of the Eden. The acanthopores and wall structure of the three species, *B. implicatum, B. jamesi* and *B. varians* (and probably *B. maysvillensis* Nickles, from the Mt. Hope at Maysville, Ky.), belong to a single type which is quite different from the acanthopores and wall structure of all the other species now referred to the genus *Batostoma.* We are of the opinion that it might be advisable to restrict the genus *Batostoma* to the *implicatum* type, and redistrbute the other species among *Amplexopora* and other genera. In this way we believe the natural relationships would be better shown.

Batostoma variabile Ulrich is restricted to the Whitewater. In Cut 18, near Weisburg, it is very abundant, but it is found only rarely at most other localities. At Ballstown, Ind., it is abundant in the Whitewater, and is beautifully preserved. This species was evidently not derived from any Cincinnatian *Batostoma*. It bears a remarkably close resemblance to *Amplexopora cingulata* and was either derived from that species, or more probably, migrated from the northwest and is the descendant of *Batostoma minnesotense* or some of its congeners in the Trenton.

Batostoma prosseri Cumings and Galloway, which occurs commonly in the upper Waynesville, has no near relative in the Cincinnatian rocks. The similarity between it and *Batostoma varium* Ulrich, from the Black River of Minnesota, would indicate that it may have been derived from that form and came into the Cincinnati area during the Waynesville invasion from the north. It is found also in the Richmond of northern Illinois.

The species of the genus *Bythopora,* which occur in the Cincinnatian strata, fall into two groups, the *B. arctipora* group, consisting of *B. arctipora, B. dendrina, B. parvula* and *B. striata,* characterized by their delicate zoaria, rather large zooecia, and scarcity of diaphragms and acanthopores; and the *B. gracilis* group, consisting of *B. delicatula, B. gracilis* and *B. mecki,* characterized by their much larger zoaria and conspicuous acanthopores. There is considerable variation in the latter group, especially in the size and number of acanthopores and number of diaphragms. Some of these variants may later be recognized as distinct varieties, but they will be of little value in stratigraphic determination.

Bythopora delicatula (Nicholson) ranges from the Corryville to the Whitewater. In the latter formation it occurs in immense numbers.

Bythopora gracilis (Nicholson) is restricted to the Maysville, occurring most abundantly from the Bellevue to the Arnheim.

Bythopora mecki (James) occurs throughout the Richmond in considerable numbers.

Chiloporella flabellata (Ulrich) occurs commonly in a layer in the Corryville at an elevation of 60 feet above the railroad in Cut 8, and sparingly above and below this horizon. It is of considerable value as a zone marker, being characteristic of the Corryville.

The genus *Dekayia,* as we conceive of it, consists of *Dekayia appressa* Ulrich, *Dekayia aspera* E. and H., *Dekayia maculata* James, *Dekayia magna* Cumings, *Dekàyia multispinosa* Ulrich, and *Dekayia obscura* (Ulrich). These species may be distinguished from all other species which have heretofore been placed in the genera *Dekayella* and *Heterotrypa* (which we refer to the single genus *Heterotrypa*) by fewer diaphragms, fewer mesopores, and by their peculiar type of wall structure, seen typically in *Dekayia aspera*. We have near completion a re-study of all the species of *Dekayia* and *Heterotrypa*, the results of which will be published in the near future. In that paper we shall show the evolution of these genera, and endeavor to demonstrate that they constitute two well-defined natural groups.

Dekayia aspera E. and H. occurs abundantly in Cut 5 at the base of the Maysville. A form scarcely distinguishable from it, probably a variety, occurs in the Arnheim. A form of *Dekayia* very similar to *D. obscura* occurs in the Corryville-Arnheim. The *Dekayias* appear in the McMicken and become extinct at the middle of the Arnheim. They are especially characteristic of the Maysville.

Eridotrypa simulatrix (Ulrich), the only species of this genus found in the Cincinnatian, ranges from the Corryville to the base of the Liberty. It is most abundant in the upper Waynesville.

The genus *Hallopora* (formerly *Callopora*) is represented in the Cincinnatian by ten species, all of which are abundant at their respective horizons.

Hallopora dalei (E. and H.) characterizes the Mt. Hope-Fairmount. It also occurs sparingly in the McMicken.

Hallopora onealli communis (James) is found sparingly in the Southgate and very abundantly in the McMicken, which formation it characterizes.

Hallopora ramosa (d'Orbigny) is very common throughout the Maysville, and is most abundant in the Bellevue and Corryville. A form scarcely distinguishable, perhaps the same species, occurs in the Waynesville and Liberty.

Hallopora subnodosa (Ulrich) extends from the Arnheim to the top of the Richmond.

Hallopora ramosa rugosa (E. and H.) is found throughout the middle and upper Maysville, and a form probably referable to this species occurs in the Waynesville. It reaches its maximum development in the Arnheim. The rugose phase is not confined to *H. ramosa*. It appears occasionally on all monticulose *Halloporas*.

Heterotrypa frondosa (d'Orbigny) occurs commonly throughout the Maysville. It reaches its culmination in the Bellevue. Occasionally specimens show inflected walls, as in *H. singularis*.

Heterotrypa prolifica Ulrich occurs only in the Waynesville, where it is very common. All the Waynesville species of *Hetero-*

TABLE I.

TABLE OF SPECIFIC CHARACTERS OF THE GENUS DEKAYIA.

SPECIES.	Zoarium.	Surface.			Zooecia in 2 mm.	Shape of Zooecia.	Tangential Section.				
		Mesopores.	Monticules.	Maculae.			Mesopores.	Acanthopores.		Thickness of Walls.	Cingulum.
								No. in 10 Zooecia.	Size.		
Dekayia appressa . . .	Ramose, flattened, 1-3 in. high; 7-10 mm. in diam.	Very few	None	Of large cells and meso-pores.	10	Polygonal . . . . (oval).	Few to none . .	4	2	Thin	Very thin or none.
Dekayia aspera	Ramose, 6-10 mm. thick; 3-6 cm. long.	None	None	Of large cells and meso-pores.	10	Polygonal	None	4	3, 4	Thin. Thicker than in *appressa*.	Very thin or none.
Dekayia maculata . . .	Ramose, 3-6 mm. thick; 3-6 cm. long.	Few, restricted to maculae.	None	Of mesopores . .	8	Oval	Few, except in maculae.	4-8	1, 2, 3	Thick	Very thin.
Dekayia magna	Massive, large, ra-mose; 2 or more cm. thick.	None	None	Of large zooe-cia.	8	Polygonal	None	1	1	Very thin	None.
Dekayia multispinosa.	Ramose, flattened; 8-15 mm. in di-ameter.	Few or none	None	Of large Zooe-cia and meso-pores.	10	Oval or poly-gonal.	Few, many in maculae.	4-10	2 (1, 3)	Medium	None.
Dekayia obscura	Ramose, slender, 4-6 mm. thick.	Moderate num-ber.	None	Of large zooe-cia and meso-pores.	9	Oval	Moderate num-ber, angular.	3-6	1, 2, 3	Thick	Thin.

TABLE 1—Continued.

TABLE OF SPECIFIC CHARACTERS OF THE GENUS DEKAYIA.—Continued.

Species.	Longitudinal Section.				Range.	Remarks.
	Diaphragms in Axial Region.	Diaphragms in Periphery.	Acanthopores.	Diaphragms in Mesopores.		
Dekayia appressa	None	5 to 10	Not conspicuous	Closer than in zooecia.	Upper Maysville	Surface sometimes covered with a pellicle.
Dekayia aspera	None	None (2 to 4)	From axial region to periphery.	None	McMicken to Fairmount.	Walls crinkled. Acanthopores large at surface. Communication pores sometimes present.
Dekayia maculata	None	2 to 4	From axial region to periphery.	None	McMicken (Maysville).	Walls crinkled, much thickened at surface. Acanthopores large at surface.
Dekayia magna	None	None	Rarely a large one in axial region.	None	Fairmount to Arnheim.	Walls crinkled, not thickened in periphery.
Dekayia multispinosa	None	None (1 or 2)	Common in axial region	None	Mt. Hope to Fairmount	Walls crinkled, not abruptly thickened in periphery. Sometimes covered with pellicle.
Dekayia obscura	None	2-4	Common from axis to periphery.	Closer than in zooecia	Upper Eden to lower Maysville.	Walls crinkled. Mature region shallow. Surface often with pellicle.

TABLE 2.

TABLE OF SPECIFIC CHARACTERS OF THE GENUS HETEROTRYPA.

Species.	Zoarium.	Surface.			Zooecia in 2 mm.	Shape of Zooecia.	Tangential Section.				
		Mesopores.	Monticules.	Maculae.			Mesopores.	Acanthopores. No. in 10 Zooecia.	Acanthopores. Size.	Thickness of Walls.	Cingulum.
Heterotrypa affinis	Irregularly ramose, 15 mm. thick.	Only in maculae	Very low	Of large zooecia and mesopores.	7-8	Polygonal	Few to none	20	1	Thin	None.
Heterotrypa frondosa	Frondescent, 5-10 mm. thick.	Numerous or few	Low, round	Of large zooecia and mesopores.	7-8	Oval or polygonal.	Numerous to few.	3-4	*1, 2	Medium	None.
Heterotrypa inflecta	Flabellate, 3-5 mm. thick.	Numerous	None	Of large zooecia and mesopores.	8	Round	Numerous	5-7	†1, 2	Thick	Thick, perfect.
Heterotrypa paupera	Ramose or subramose, 4-8 mm. in diameter.	Only in maculae	None	Of large zooecia and mesopores.	8	Polygonal	Very few	4-5	1	Very thin	None.
Heterotrypa pelliculata.	Large, subramose, 16-20 mm. thick.	Few to none	None	Of large zooecia and mesopores.	7-8	Polygonal	Few	4	1, 2	Very thin	None.
Heterotrypa solitaria	Frondescent, 2-4 mm. thick.	Very few or none	None or very low.	Of large zooecia and mesopores.	7-8	Polygonal	Very few	6-10	1	Thin	None.
Heterotrypa subfrondosa.	Frondescent, large, 8-10 mm. thick.	Few to numerous.	Low, round	Of large zooecia and mesopores.	7-8	Round	Few to numerous.	10	‡1, 2, 3, 4	Thin	None.
Heterotrypa subpulchella.	Large, subramosa, 10-15 mm. in diameter.	Few, except in the maculae.	Very low	Of mesopores, surrounded by zooecia.	7-8	Round	Numerous	6	1, 2, (3)	Medium	None.
Heterotrypa ulrichi	Ramose, 5-10 mm. in diameter.	Abundant	None (or low).	Of mesopores, surrounded by zooecia.	7-8	Round	Abundant	4-10	2, (3)	Medium to thick.	Thick, perfect.
Heterotrypa ulrichi lobata.	Subramose to frondescent, 3-5 mm. thick.	Abundant	None (or low).	Of large zooecia and mesopores.	7-8	Round	Numerous	4	1, 2, 3	Thin	None.
Heterotrypa ulrichi robusta.	Ramose, 10 mm. in diameter.	Numerous	Small, conical.	Of large zooecia and mesopores.	7-8	Polygonal (Round).	Numerous	6	1, 2, 3	Medium	None or thin.
Heterotrypa microstigma.	Ramose, 10 mm. or more in diameter.	None	None	Very small, of small mesopores.	9	Subcircular	None	20-25	1	Thick	Thick, perfect.
Heterotrypa prolifica	Frondescent, large, 8-15 mm. thick.	Few	Low, large, round.	Large, of large zooecia and mesopores.	8-9	Subcircular	Few	20	1	Thick	Thick, perfect.
Heterotrypa singularis.	Subramose, 7-10 mm. in diameter.	Abundant	Low, large, round.	Large, of large zooecia and mesopores.	8-9	Subcircular	Abundant	20	1	Thick	Thick, perfect.
Heterotrypa subramosa.	Ramose, 8-10 mm. in diameter.	Few or none (sometimes numerous).	None or low.	Large, of large zooecia and mesopores.	8-9	Subcircular	Few to numerous.	10-15	1, 2	Thick	Thick, perfect.

*Very regular. ‡Very variable. †Regular.

TABLE 2—Continued.

TABLE OF SPECIFIC CHARACTERS OF THE GENUS HETEROTRYPA—Continued.

Species.	Longitudinal Section.				Range.	Remarks.
	Diaphragms in axial Region.	Diaphragms in Periphery.	Acanthopores.	Diaphragms in Mesopores.		
Heterotrypa affinis	Numerous, 1-3 tube diameters apart.	$\frac{1}{2}$-1 tube diameters apart.	Small	Numerous, close-set (beaded).	Waynesville	Acanthopores slightly inflect the walls.
Heterotrypa frondosa	None	1 tube diameter apart.	Rarely a large one in axial region.	Numerous, close-set (beaded).	Mt. Hope to Arnheim	Very variable in all characters.
Heterotrypa inflecta	None	1 tube diameter apart.	Inconspicuous	Numerous, close-set (beaded).	Mt. Hope to Corryville.	Acanthopores inflect walls; conspicuous at surface.
Heterotrypa paupera	None	1-2 tube diameters apart.	Inconspicuous	Numerous, close-set (beaded).	Fairmount to Corryville	
Heterotrypa pelliculata	None	$\frac{1}{2}$-1 tube diameters apart.	No. 2 common	Numerous, close-set (beaded).	Fairmount and Bellevue	Surface sometimes covered with a pellicle.
Heterotrypa solitaria	None	$\frac{1}{2}$-1 tube diameters apart.	Inconspicuous	Numerous, close-set (beaded).	Fairmount to Arnheim.	
Heterotrypa subfrondosa	None	$\frac{1}{2}$-1 tube diameters apart.	Sometimes a large one in axial region.	Numerous, close-set (beaded).	Mt. Hope to Fairmount	
Heterotrypa subpulchella	None	1-2 tube diameters apart.	Sizes 2, 3 in submature region.	Numerous, close-set (beaded).	McMicken to Fairmount	
Heterotrypa ulrichi	None	$\frac{1}{2}$-2 tube diameters apart.	Sizes 2, 3 in submature region.	Numerous, close-set (beaded).	Southgate to Fairmount	Characteristic of the middle McMicken.
Heterotrypa ulrichi lobata.	None	$\frac{1}{2}$-2 tube diameters apart.	No. 3, rare	Numerous, close-set (beaded).	McMicken to Fairmount	
Heterotrypa ulrichi robusta.	None	$\frac{1}{2}$-2 tube diameters apart.	Nos. 2, 3 in submature region.	Numerous, close-set (beaded).	McMicken to Fairmount	
Heterotrypa microstigma	Numerous, 1-3 tube diameters apart.	1 tube diameter apart.	Small	Close-set	Waynesville	Zooecia sometimes inflected.
Heterotrypa prolifica	Numerous, 1-3 tube diameters apart.	$\frac{1}{2}$-1 tube diameters apart.	Small	Close-set	Waynesville	Zooecia sometimes inflected. Communication pores and infundibular diaphragms common.
Heterotrypa singularis	Numerous, 1-3 tube diameters apart.	$\frac{1}{2}$-1 tube diameters apart.	Small	Close-set	Waynesville	Zooecia much inflected.
Heterotrypa subramosa	Numerous, 1-3 tube diameters apart.	$\frac{1}{2}$-1 tube diameters apart.	Small	Close-set	Waynesville to Whitewater.	

trypa may be easily distinguished from the Maysville species of the genus by the presence of numerous diaphragms in the axial region of the Richmond forms. In the Maysville representatives of this genus diaphragms are almost always entirely lacking in the axial region. Communication pores and infundibular diaphragms are very beautifully developed in most species of *Heterotrypa,* especially in *H. prolifica* and its allies.

Heterotrypa ulrichi (Nicholson) ranges throughout the Eden and up into the Fairmount. It reaches its culmination in the middle of the McMicken.

The genus *Homotrypa* is represented in the Cincinnatian of Indiana by twenty-five species.

Homotrypa austini Bassler and *Homotrypa communis* Bassler, two closely related species, occur commonly in the Waynesville and Liberty, and occasionally in the Whitewater..

Homotrypa flabellaris Ulrich occurs rarely in the Arnheim and commonly in the Waynesville. The variety *H. flabellaris spinifera* Bassler occurs in the Fairmount and in the upper Waynesville. It it doubtful, however, if the Waynesville form is identical with the Fairmount form. Bassler does not say from which formation his type comes.

Homotrya frondosa Bassler occurs from within the Corryville to the top of the Waynesville. That this species is not a variety of *H. flabellaris* is shown by the absence of diaphragms in the axial region of *frondosa,* the large round monticules, and other minor differences.

In the Whitewater occurs a group of species, the *Homotrypa ramulosa* group, consisting of *Homotrypa constellariformis* Cumings, *Homotrypa nicklesi* Bassler, *Homotrypa nitida* Bassler and *Homotrypa ramulosa* Bassler, which are very closely related to each other, and distinguished from all other species of *Homotrypa* (except *H. gelasinosa* Ulrich, which probably belongs in the same group) by the peculiar, irregular maculæ.

Homotrypa pulchra Bassler is characteristic of the Corryville-Arnheim. The ease of identification of this species in the field makes it valuable for stratigraphic determination.

Homotrypa wortheni (James) occurs quite abundantly in the Whitewater, which it characterizes. It is not confined to this formation, however, but is found sparingly in the upper Waynesville and Liberty.

Homotrypella hospitalis (Nicholson) is characteristic of the Waynesville, increasing in abundance from the bottom to the top of this formation. It also occurs in the Liberty and rarely in the Whitewater.

Homotrypella rustica Ulrich occurs rarely in the Waynesville and Liberty. We have no specimens from the Whitewater of the Tanner's Creek section, although it occurs abundantly in that formation at Richmond, Laurel and Versailles.

Peronopora pavonia (d'Orbigny) is a common fossil, occurring from the top of the Fairmount to the middle of the Liberty. There is considerable variation in the characters of this species. The acanthopores vary considerably in size and number. There is also much variation in the size of the zoaria, number of mesopores, diaphragms and cystiphragms. Some of these variants may sometime be recognized as varieties or even distinct species. *P. pavonia* may always be distinguished from *Peronopora vera* by the much smaller zoœcia of the former.

Peronopora vera Nickles occurs in the Southgate and McMicken, and is particularly abundant in the Mt. Hope-Fairmount. There is also considerable variation in the characters of this species, variations which would at once be considered of sufficient importance to cause the erection of new species and varieties if they occurred in some other genera. However, it seems that no useful purpose would be served by recognizing these variants as new species or varieties at the present time.

The genus *Stigmatella* is represented by ten species in the Cincinnatian of Tanner's Creek. None of these species occur abundantly and they are consequently of little importance in stratigraphic work.

Scale of Sizes of Acanthopores.

We have found in our study of acanthopores that instead of there being two recognizable sizes, heretofore designated as "large" and "small," there are at least seven easily recognizable sizes, ranging from the extremely minute ones like those found in *Homotrypa grandis* Bassler to the extraordinarily large ones of *Lioclema spineum* Bassler.

We have taken as the unit of measurement 1/20 of a mm., so that when a tangential section is magnified 20 diameters, No. 1 acanthopores will be 1 mm. in diameter, No. 2, 2 mm. in diameter, etc. This scale makes it possible, and frequently desirable, to recognize half sizes.

The following species exhibit typically the various sizes of acanthopores:

No. 0. *Homotrypa grandis* Bassler and *Homotrypa alta* n. sp. In this size there is no central lumen and the acanthopore presents an indistinct, "fuzzy" appearance.

No. 1. *Heterotrypa prolifica* Ulrich, and *Homotrypa communis* Bassler.

No. 2. *Heterotrypa affinis* (Ulrich), and *Homotrypella hospitalis* (Nicholson).

No. 3. *Homotrypa nodulosa* Bassler, and *Dekayia aspera* Edwards and Haime.

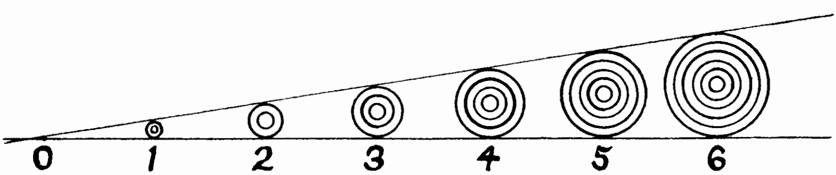
No. 4. *Homotrypa flabellaris spinifera* Bassler, and *Dekayia aspera* Edwards and Haime.

No. 5. This size is not typically developed in any species so far described, but acanthopores of this size are sometimes found in several species of *Dekayia*.

No. 6. *Lioclema spineum* Bassler. We have a specimen of *Dekayia,* probably a new species, which has all seven sizes, and all intermediate sizes.

Most species provided with acanthopores have two or three sizes. The size of most common occurrence is No. 1.

Scale of Acanthopores, x45



PART V. DESCRIPTION OF NEW SPECIES.

AMPLEXOPORA GRANULOSA n. sp.

Plate I, Figs. 1-1c.

Zoarium ramose or subramose, 8 to 10 mm. in diameter, the branches short and irregular, sometimes anastomosing. Surface nearly smooth, with medium-sized maculæ consisting of smaller etc. This scale makes it possible, and frequently desirable, to recognize half sizes.

The following species exhibit typically the various sizes of acanthopores:

No. 0. *Homotrypa grandis* Bassler and *Homotrypa alta* n. sp. In this size there is no central lumen and the acanthopore presents an indistinct, "fuzzy" appearance.

No. 1. *Heterotrypa prolifica* Ulrich, and *Homotrypa communis* Bassler.

No. 2. *Heterotrypa affinis* (Ulrich), and *Homotrypella hospitalis* (Nicholson).

No. 3. *Homotrypa nodulosa* Bassler, and *Dekayia aspera* Edwards and Haime.

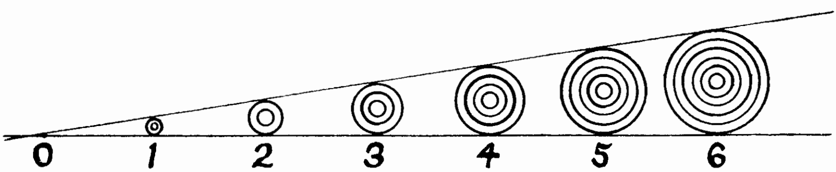
No. 4. *Homotrypa flabellaris spinifera* Bassler, and *Dekayia aspera* Edwards and Haime.

No. 5. This size is not typically developed in any species so far described, but acanthopores of this size are sometimes found in several species of *Dekayia*.

No. 6. *Liocloma spineum* Bassler. We have a specimen of *Dekayia*, probably a new species, which has all seven sizes, and all intermediate sizes.

Most species provided with acanthopores have two or three sizes. The size of most common occurrence is No. 1.

Scale of Acanthopores, x45



PART V. DESCRIPTION OF NEW SPECIES.

Amplexopora Granulosa n. sp.

Plate I, Figs. 1-1c.

Zoarium ramose or subramose, 8 to 10 mm. in diameter, the branches short and irregular, sometimes anastomosing. Surface nearly smooth, with medium-sized maculæ consisting of smaller zoœcia and mesopores surrounded by zoœcia larger than the average; maculæ very little elevated above the general surface, about 9 in one sq. cm.

Tangential sections show the zoœcia to be subpolygonal to oval, moderately thick walled, each aperture surrounded by a thin, light-colored cingulum; about 8 zoœcia in 2 mm. The zoœcial walls are made up of a light-colored material in which are embedded numerous dark, fuzzy granules. These granules are commonly arranged in transverse rows. Under high magnification each granule shows a light-colored nucleus. In longitudinal sections the granules are seen to be in parallel, vertical rows. Acanthopores are apparently absent, none of our slides showing any. There are occasionally, however, indefinite structures which may be acanthopores. Mesopores are restricted to the Maculæ. The mesopores have the same wall structure as the zoœcia, and may be only young zoœcia.

Longitudinal sections show that the zoœcia in the axial region have thin, crinkled walls, and are crossed by diaphragms from one to two tube diameters apart. In the mature region the zoœcial walls are considerably thickened, and exhibit the usual median, black line. Diaphragms are close-set in the mature region, many of them being curved and infundibuliform.

This species does not sufficiently resemble any described species to require comparison. The only associated species of the genus is *Amplexopora pumila* n. sp., from which it differs in having no acanthopores. It was probably derived from *Amplexopora robusta*, which occurs over 100 feet lower in the section.

Occurrence: Rather abundant in the lower 25 feet of the Liberty, in Cuts 16 and 17, on the Big Four Railroad, near Weisburg, Ind.

Amplexopora Pumila n. sp.

Plate II, Figs. 1-1e.

Zoarium irregularly ramose, consisting of short, knotted branches from 3 to 8 mm. thick, and 3 or 4 cm. long. Surface nearly smooth, with slightly raised maculæ composed of large zoœcia and a few mesopores; about 8 maculæ in 1 sq. cm. Zoœcia polygonal, thin-walled at the surface; mesopores few, scattered among the ordinary zoœcia as well as in the maculæ.

In tangential sections the zoœcia are seen to be subpolygonal in form, with medium thick walls, 7 or 8 in 2 mm. The double zoœcial wall consists of two very light-colored rings of tissue separated by a dark, granular line. These rings are not cingula, but parts of the true zoœcial walls. The granules in the median line vary in number and size and are not arranged in transverse rows, as in *Amplexopora granulosa*. Mesopores are few in number and have the same wall structure as the zoœcia; they are probably only young zoœcia.

The acanthopores vary much in size and number, there being ordinarily about 3 in 10 zoœcia. In size they range from No. 0 to 2, averaging about size 1. They are indefinite in outline and shape, fading out into the median line. The lumen is not clear and well-defined, but only somewhat lighter in color than the surrounding tissue.

The zoœcia in the axial region have the usual thin, flexuous walls, and are crossed by diaphragms about their own diameter apart. As the mature region is reached the walls become considerably thickened, and the diaphragms about three times as numerous, many of them being curved.

The large, indistinct acanthopores are occasionally seen in longitudinal sections, but are never conspicuous. The dark line between adjacent zoœcia is quite distinct, not straight and uniform, but irregularly crinkled and varied in thickness, and of a granular structure.

This species bears some resemblance to *Amplexopora pustulosa*, but may be distinguished by the small, irregular, smooth zoarium, the granulose intermural line, and larger and fewer acanthopores. The only associated species is *A. granulosa*, which differs from *A. pumila* in the absence of acanthopores, the presence of a cingulum, the wide intermural line with granules in transverse rows, and the absence of mesopores.

Ocurrence: Rather abundant in the upper 15 feet of the Waynesville and lower 25 feet of the Liberty, in Cuts 14, 16 and 17, on the Big Four Railroad, near Weisburg, Indiana.

Amplexopora Septosa Maculosa n. var.

Plate III, Figs. 1-1c.

Zoarium robust, ramose, about 10 mm. in diameter and 4 or 5 cm. long, branching every 2 or 3 cm. Surface with elevated, subsolid, flat-topped maculæ about 1 mm. in diameter, composed of mesopores or very small zoœcia surrounded by zoœcia considerably larger than the average; 12 maculæ in 1 sq. cm. These maculæ constitute the main distinguishing characteristic between this variety and *A. septosa* and its other varieties, all of which have maculæ on a level with the general surface of the zoarium, and composed of larger zoœcia and a few open mesopores.

Tangential sections show that the zoœcia are thick-walled, although at the surface the walls are usually thin and the zoœcia polygonal, and separated by a definite dark median line; 8 zoœcia in 2 mm. There is usually no cingulum present in the zoœcia, as is ordinarily the case with the variety *A. septosa multispinosa.* The acanthopores are numerous, 5 or 6 surrounding a zoœcium about 2/3 the size of No. 1, that is 1/30 mm. in diameter, sometimes inflecting the zoœcial walls. The outlines of the acanthopores are indistinct; the lumen is extremely small and seldom showing, but sometimes appearing clear and well-defined. The maculæ are seen to be composed of mesopores either completely filled with secondary tissue or possessing a thick cingulum. Communication pores are sometimes present in large numbers.

The zoœcia in the axial region have thin, irregularly crinkled walls and are usually without diaphragms, although an occasional very thin one is present. In the curve from the immature to the mature region the zoœcial walls are considerably thickened and there begins a close-set series of diaphragms which become more and more crowded till a point about half way from the submature region to the surface is reached, at which point the diaphragms suddenly stop and only an occasional one is inserted from there on to the surface. In the type specimen there appears to have been a rejuvenation after maturity was reached and several diaphragms are again inserted. The median dark line is quite distinct, and nearly straight, as ordinarily seen. In good slides under a high power of the microscope (320 diameters) this median line is seen to be composed of curved, transverse rows of granules, and is not a double, or even single, plate separating adjacent zoœcia and along which the walls tend to split. This variety agrees in all respects with *A. septosa multispinosa,* except the presence of the prominent, subsolid, elevated maculæ.

Occurrence: Common in the upper 70 feet of the Eden and lower 50 feet of the Maysville, in Cuts 1, 2, 3, 4 and 5, on the Big Four Railroad, near Guilford, Indiana.

AMPLEXOPORA SEPTOSA MINIMA n. var.

Plate IV, Figs. 1-1d.

Zoarium small, ramose, 2-5 mm. in diameter and 3 or 4 cm. long, branching frequently. Surface smooth, with small, inconspicuous maculæ composed of large zoœcia and a few mesopores, not raised above the general level of the surface.

In tangential sections the zoœcia are seen to be thin-walled, with no cingulum, the dark median line showing quite plainly; 8 or 9 zoœcia in 2 mm. Acanthopores are numerous, 5 or 6 surrounding a zoœcium, about 1/3 the size of No. 1, that is, 1/60 mm. in diameter, with a clear, well-defined lumen. Mesopores few, scarcely more numerous in the maculæ than elsewhere.

Diaphragms numerous in the submature region, absent in the mature, and absent or few in the axial region; walls crenulated. Walls somewhat thickened in the mature region.

This variety differs from *A. septosa* in having smaller zoaria, thinner walls and smaller acanthopores which do not inflect the zoœcial walls.

Occurrence: Common in the upper 70 feet of the Eden and lower 50 feet of the Maysville, in Cuts 1, 2, 3, 4 and 5, on the Big Four Railroad, near Guilford, Ind.

ATACTOPORA INTERMEDIA n. sp.

Plate IV, Figs. 2, 2a; Plate V, Figs. 1-1d.

Zoarium parasitically attached to *Orthoceras,* no basal epitheca, about 20 sq. cm. in area and 1 mm. thick, and made up of superimposed layers. The surface presents prominently raised subsolid monticules, which are slightly elongated in the direction of the longitudinal axis of the *Orthoceras* and in rows in the same direction, about 15 occupying the space of 1 sq cm. Zoœcia floriform, thin-walled at the surface, indented by the small but conspicuous acanthopores.

Tangential sections show the zoœcia to be very irregular in shape, indented by the numerous conspicuous acanthopores, about 9 zoœcia in 2 mm. Each zoœcium is surrounded by a very thin dark line, the interzoœcial tissue consisting of irregular granular material, slightly lighter in color than the zoœcial wall. Acanthopores very abundant, 4 or 5 surrounding each zoœcium, No. 1 in size. The maculæ are made up of irregularly concentric tissue, enclosing a few acanthopores. Mesopores are practically absent.

In the longitudinal section the zoœcia are thick-walled, the acanthopores very conspicuous with a clear canal, which is somewhat irregular in size but not increasing in size as the surface is approached. Diaphragms numerous in the lower half of each zoœcium, usually absent in the outer half. Cystoid diaphragms are present in some of the tubes. The zoœcia are at first prone, but soon turn at right angles, and then proceed direct to the surface. The maculæ are composed of aborted zoœcia and acanthopores, as described by Ulrich.*

This species presents several very interesting features. It is very similar to *Atactopora hirsuta,* except in possessing numerous diaphragms in the lower portion of the tubes. It resembles *Atactoporella* in possessing cystiphragms in some of the zoœcia. We do not, however, attach even specific importance to the sporadic development of cystiphragms, inasmuch as we have found them in at least nine genera, exclusive of the Monticuliporidæ. In a subsequent paper, now in preparation, we shall suggest an explanation of these structures.

This species also resembles very closely several species of *Spatiopora,* but the total absence of a lunarium would indicate that it is not a Ceramoporoid.

Occurrence: Rare in the McMicken division of the Eden, in Cut 3, on the Big Four Railroad, near Guilford, Ind.

CERAMOPORELLA TRILOBA n. sp.

Plate VI, Figs. 1-1c.

Zoarium growing parasitically upon other bryozoans (*Heterotrypa ulrichi*), with no epitheca, forming large masses by superimposition of layers. Each layer is less than 1 mm. in thickness. The type specimen is 5 cm. long and about 2 cm. in diameter.

Surface nearly smooth, with maculæ slightly raised or depressed. Maculæ composed of smaller, distorted zoœcia and mesopores. Zoœcia irregularly trilobed, with a strongly arching lunarium. On unweathered surfaces minute acanthopores are discernable. Mesopores are numerous.

In tangential sections the zoœcia are seen to be roughly trilobed, with moderately thin walls; 7 zoœcia in 2 mm. Mesopores rather abundant, oval or irregular in shape. Structures exactly like the acanthopores in some Trepostomata, and which we consider to be true acanthopores, are common, though irregularly distributed among the zoœcia. They are about half the size of No. 1, that is 1/40 mm. in diameter. Lunaria prominent, horseshoe shaped, occupying one-third of the zoœcial circumference, the ends projecting slightly into the zoœcial cavity. Opposite the lunarium is another very small crescent-shaped, light-colored structure very sim-

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*Jour. Cin. Soc. Nat. Hist., VI, p. 246.

ilar to the lunarium but much smaller. These structures occur also in several other Ceramoporoids.

In longitudinal sections the walls are seen to be irregular in structure, rather thin, with no mural pores or large granules. Diaphragms thin, one or two in each tube. Acanthopores not conspicuous, but typically developed, with comparatively wide canals and thin walls.

This species is closely related to *Ceramoporella distincta,* but has fewer mesopores, differently shaped zoœcia and more prominent lunaria. It resembles *Crepipora* in the distinct lunaria with projecting ends, but the mesopores are not collected into maculæ, and the lunarium overarches more than in that genus. It is distinguished from *Ceramoporella ohioensis* by the prominent, horseshoe-shaped lunarium.

Occurrence: Rare in the McMicken member of the Eden, in Cut 3, on the Big Four Railroad, near Guilford, Ind.

CERAMPORELLA TUBULOSA n. sp.

Plate VI, Figs. 2, 2a; Plate VII, Figs. 1-1c.

Zoarium parasitically attached to foreign bodies, in the type specimen to a species of *Orthoceras,* covering over 30 sq. cm. and having a thickness of about 1 mm. There is no epitheca.

Surface smooth, with maculæ composed largely of irregular mesopores, neither elevated nor depressed and scarcely distinguishable. Zoœcia oval, surrounded completely by irregular mesopores. Lunarium not elevated. Numerous minute acanthopores may be seen on unweathered surfaces.

Tangential sections present a bizarre appearance. The zoœcia are regularly oval in shape, all orientated the same way, 1/4 mm. long and 1/6 mm. wide, about 6 in 2 mm., including mesopores. Walls of medium thickness. Lunarium pronounced, occupying a little less than one-half the zoœcial circumference, the ends not projecting into the zoœcial cavity. Mesopores abundant, very irregular in shape, separating the zoœcia the distance of their shorter diameter and in the same direction; usually also separating the zoœcia in the direction of their longer diameter. The most noticeable thing in tangential sections is the numerous acanthopores. They occupy for the most part the angles between the mesopores. They are sometimes much more abundant than in the section figured (Plate VII, Fig. 1), there being as many as ten or more to a zoœcium. They are about half the size of No. 1, or 1/40 mm. in diameter, though they vary somewhat in size.

Longitudinal sections show very few diaphragms, these structures averaging less than one to a tube. The acanthopores are perfectly typical, with wide canal and thin, laminated walls. Diaphragms occasionally cross the tube of the acanthopore.

This species most closely resembles *Ceramporella granulosa*, but has fewer diaphragms, more mesopores, and absolutely lacks the large granules which are such a conspicuous feature of longitudinal sections of that species. The two species also occupy different horizons. We do not agree with Ulrich that the "small dark spots, precisely like acanthopores in tangential sections,"* are simply the cross-sections of granules, but hold that they are cross-sections of true acanthopores. Our specimens of *Ceramoporella granulosa* show these granules as well as acanthopores, from which they are easily distinguished by differences in structure.

Ceramoporella tubulosa resembles *Ceramoporella distincta* externally, but tangential sections of the two are quite different.

Occurrence: Rare in the upper 25 feet of the Eden in Cut 3, on the Big Four Railroad, near Guilford, Ind.

HETEROTRYPA MICROSTIGMA n. sp.

Plate VIII, Figs. 1-1c.

Zoarium ramose or subramose, about 10 mm. thick and 6 cm. long. Surface nearly smooth, with very small, subsolid maculæ composed only of mesopores, surrounded by zoœcia slightly larger than the average; 15 maculæ in 1 sq. cm. Maculæ averaging about 1 mm. in diameter, sometimes slightly elongated transversely to the zoarium. Zoœcia medium thick walled, subpolygonal. No mesopores show at the surface except in the maculæ. Acanthopores not showing at the surface.

Tangential sections show the zoœcia to be subcircular, very thick walled, 9 zoœcia in 2 mm. Mesopores absent, except in the maculæ, where they are usually nearly closed by a secondary deposit of tissue. The zoœcial aperture is surrounded by a thick ring of light-colored tissue. To this structure which is found in many species of Trepostomata, we apply the name "cingulum." The cingulum is typically developed in *Amplexopora cingulata* Ulrich. Immediately surrounding the cingulum is a thin dark line, the true zoœcial

* Geol. Surv. Ill., VIII, p. 466.

wall. The intermural tissue is light-colored, and finely granular. Acanthopores small, No. 1 in size, and abundant, from 20 to 25 in 10 zoœcia; sometimes slightly inflecting the zoœcial walls. The zoœcia and acanthopores are quite regular in size and arrangement.

In longitudinal sections the zoœcia in the axial region are seen to be crossed by diaphragms averaging 3 tube diameters apart. In the mature region the zoœcia are very thick walled and provided with diaphragms less than one tube diameter apart. Mesopores are rarely seen in these sections.

The character which distinguishes this species from associated species of *Heterotrypa* is the minute, subsolid maculæ. Other differences are indicated on the chart, pages 417, 418.

Occurrence: Rather rare in the Waynesville, in Cut 13, on the Big Four Railroad, near Weisburg, Ind.

HOMOTRYPA ALTA n. sp.

Plate IX. Figs. 1-1e; Plate X. Figs. 1-1e.

Zoarium robust, ramose, or slightly compressed, 6 to 10 mm. in diameter and 4 or 5 cm. long, branching about every 2 cm. Surface perfectly smooth, with numerous subsolid, stellate maculæ, which are neither raised nor depressed, composed of small mesopores surrounded by zoœcia somewhat larger than the average. The maculæ have a tendency to be drawn out in the direction of the longitudinal axis of the zoarium; 10 maculæ in 1 sq. cm. At the surface the zoœcia are polygonal to oval with medium thick walls, and the acanthopores rarely show.

As seen in tangential sections the zoœcia are polygonal, medium thick walled, with oval apertures; 10 zoœcia in 2 mm. The aperture is surrounded by a ring of dark tissue, succeeded by a lighter ring, and this is in turn surrounded by a second dark ring of granular tissue. Ordinarily there is a median line of light-colored tissue, but occasionally this is absent, in which case the median line is made up of the second, granular zoœcial wall. Mesopores are practically absent, except in the maculæ, but there are occasional small zoœcia which might be mistaken for mesopores, but differ from mesopores in having walls exactly like the large zoœcia. The maculæ are composed of mesopores which have almost always been filled by a deposit of light-colored schlerenchyma. Acanthopores common, 4 in 10 zoœcia, very minute, number 0 in size, with no central lumen. Communication pores are sometimes present.

In longitudinal sections the zoœcia have wavy walls and no diaphragms in the axial region. The zoœcia turn sharply outward in the submature region and proceed direct to the surface. Mature region deep, 1.5 to 2 mm. from the submature region to the surface. A series of 5 or 6 cystiphragms is developed in the bend of the submature region. A close-set series of diaphragms extends from the immature region to the surface. Cystiphragms are frequently interpolated near the surface, where the diaphragms are variously curved. Rarely in the submature region an acanthopore about number 1 in size appears, but never reaches the surface.

This species is most closely related to *Homotrypa grandis* Bassler, from the Lorraine of Tennessee, but differs in having only about a tenth as many acanthopores, and in wall structure. The specimen figured on Plate IX, Fig. 1c seems to be intermediate between these two species; the tangential section, however, is different (Plate X, 1c).

Occurrence: Common in the Mt. Hope-Fairmount in Cuts 2 and 4 on the Big Four Railroad, near Guilford, Ind.

Homotrypa Glabra n. sp.

Plate XI, Figs. 1-1d.

Zoarium small, ramose, 2 to 5 mm. in diameter and 2 or 3 cm. long. Surface smooth, with solid, stellate maculæ composed of mespores which have been completely filled with schlerenchyma. Zoœcia thick walled, their apertures oval.

In tangential sections the zoœcia are seen to be thick walled, the zoœcial apertures oval and largely filled with a secondary deposit of schlerenchyma, most of the thickening being on the upper side of the zoœcium. Zoœcial walls granular, much as in *Homotrypa cylindrica,* with a light streak of intermural tissue. Acanthopores rare, minute, number 0 in size, and indistinct. Mesopores absent. About 9 zoœcia in 2 mm.

Longitudinal sections show the zoœcia in the axial region to have thin, crinkled walls, and no diaphragms. Four or five cystiphragms appear in the submature region but there are none in the mature region. Occasionally a diaphragm or two is present in the mature region. Some of the zoœcia are without cystiphragms. The zoœcial walls are greatly thickened in the mature region, most of the thickening being on the upper side. The zoœcia emerge obliquely to the surface. Acanthopores are almost wanting in longitudinal sections, but occasionally one of about $\frac{1}{3}$ the size of number 1 is present in the submature region. These acanthopores do not appear to reach the surface.

This species is not sufficiently similar to any described species of *Homotrypa* to require comparison. The most nearly related form seems to be *Homotrypa exilis* Ulrich, from the lower third of the Trenton shales at Minneapolis, Minn.

Occurrence: Rare in the McMicken in Cut 2 on the Big Four Railroad, near Guilford, Ind.

HOMOTRYPA SPINEA n. sp.

Plate XII, Figs. 1-1c; Plate XIII, Figs. 1-1d.

Zoarium subramose to subfrondescent, about 5 mm. thick, 10 mm. wide and 4 to 6 cm. long. Surface ordinarily smooth, with stellate maculæ of mesopores surrounded by zoœcia larger than the average. Well-preserved surfaces show the projecting ends of the numerous large acanthopores; but in most of our specimens these are broken off. Zoœcia polygonal, medium thick walled. Mesopores are usually absent except in the maculæ.

In tangential sections the zoœcia are subpoygonal to oval, with thick walls; 9 zoœcia in 2 mm. Each zoœcial aperture is surrounded by a dark ring of tissue, then a lighter ring and finally by a second dark ring. The median line between adjacent zoœcia is dark in some places, but ordinarily there is a line of light-colored tissue between the second set of dark rings. Mesopores are practically absent except in the maculæ. Deep sections, or sections from immature zoaria, show a considerable number of small mesopores. The acanthopores are rather large, from number 1 to 2 in size, 4 in 10 zoœcia.

The zoœcia in the axial region are without diaphragms, their walls thin and crinkled. A considerable number of large acanthopores appear in the axial region and proceed to the surface, bending with the zoœcia, though sometimes they cut across the zoœcia and maintain a straight course. The zoœcia turn with an increasing curvature after they reach the immature region, and emerge at the surface almost at right angles. The walls become considerably thickened in the mature region. A close-set series of cystiphragms and diaphragms is developed from the immature region to the surface.

The internal characters of this species are quite constant. No associated species resembles it very closely in internal characters.

Homotrypa flabellaris spinifera Bassler resembles it zoarially, but *H. spinea* is readily distinguished by the thicker walls, smaller acanthopores and the absence of diaphragms in the axial region.

Occurrence: Rather common in the Mt. Hope-Fairmount in Cuts. 2, 4, 5 and 7, on the Big Four Railroad, near Guilford, Ind.

MESOTRYPA ORBICULTATA n. sp.

Plate XIV, Figs. 1-1b.

Zoarium discoidal or hemispherical, 10 to 15 mm. in diameter and 2 to 5 mm. thick, with a concave base, growing parasitically upon brachiopod shells; there is no basal epitheca. The zoarium is made up of two or three superimposed layers or successive rejuvenations with thickening of the walls and maximum development of acanthopores, exactly as found in the genus *Stigmatella*. We do not attach even varietal significance to this feature, which is merely due to rejuvenation and is common to all genera of Trepostomata.

The surface is smooth, with the ordinary maculæ of large zoœcia and mesopores. The zoœcia are subcircular, 7 in 2 mm. and separated from each other by angular mesopores. Conspicuous acanthopores occur between adjacent zoœcia. They are regularly of size number 1, 20 in 10 zoœcia. Several diaphragms are developed in the young part of each zoœcium, some of them being curved, but are practically absent in the mature part of the zoœcium. The mesopores are provided with a close-set series of diaphragms throughout their length.

This species most nearly resembles *Mesotrypa patella* (Ulrich), which is also found in the Richmond. It may, however, be disdinguished by the larger acanthopores of *M. orbiculata*. *Mesotrypa* (?) *spinosa* Ulrich, from the Black River of Minnesota, is also a closely related form, but has many more cystiphragms and diaphragms, and no mesopores at the surface.

Occurrence: Common in the middle of the Arnheim, in Cut 10 on the Big Four Railroad, near Harmon's station, Ind.

NICHOLSONELLA PECULIARIS n. sp.

Plate XIII, Fig. 2; Plate XIV, Fig. 2, 2a.

Zoarium irregularly frondescent, 3 mm. thick, about 2 cm. wide and 4 cm. long. Surface smooth, having maculæ which are slightly depressed, composed of 6 or 8 large zoœcia separated from each other by large, irregular mesopores. Maculæ 2 or 3 mm. in diameter, about 10 in 1 sq. cm. The zoœcia are circular, medium thick-walled, the angles between them occupied by mesopores.

Tangential sections present a pretty appearance. The zoœcial apertures are nearly circular and surrounded by a cingulum of light-colored tissue; 8 or 9 zoœcia in 2 mm. The true zoœcial wall is an irregular, dark line, enclosing numerous, very minute acanthopores. These acanthopores are number 0 in size and rarely show the central canal; 8 or 10 surround a zoœcium. Communication pores are occasionally present.

Irregular mesopores occupy the angles between the ordinary zoœcia. The zoœcia of the maculæ have no cingula, consequently their apertures are larger than the average. They are more or less completely separated by large, extremely irregular mesopores. The mesopores are not hazy or indefinite, but clear-cut, as if they were merely spaces between the zoœcia. The mesopores, rather than the zoœcia, are strongly inflected by the acanthopores. The structure of the walls, as well as the arrangement of zoœcia, mesopores and acanthopores, is the most irregular of any species we have seen.

The zoœcia in the axial region are without diaphragms, their walls thin and wavy. They curve gradually till they reach the submature region, whence they proceed direct to the surface. One or two diaphragms are developed in the mature region. The mesopores have a chain-like appearance, very similar to those of *Stigmatella catenulata* n. sp.

This species, which has all the generic characters of *Nicholsonella,* bears a close resemblance to *Stigmatella,* and raises the question whether *Nicholsonella* should not be replaced in the family Heterotrypidae.

The irregular structure and arrangement of parts makes this species easy to recognize and to distinguish from other species of *Nicholsonella.*

Occurrence: Rare in the Arnheim, in Cut 11 on the Big Four Railroad, near Harmon's station, Ind.

PERONOPORELLA new genus.

Compressed, flabellate Monticuliporidæ, having a much abbreviated axial region but no median lamina. Zoœcia oval or petaloid, commonly indented by the abundant, rather large acanthopores, which give to the surface a hirsute appearance. Mesopores numerous, crossed by numerous diaphragms, sometimes closed at the surface. No monticules, but inconspicuous maculæ of larger zoœcia and mesopores are present.

This genus is distinguished from *Homotrypa* by its abundant mesopores, from *Peronopora* by the absence of a median limina, and from *Atactoporella* by its frondescent form. *Peronoporella* is distinguished from *Homotrypella,* to which it is evidently most closely related, by the narrow axial region and the presence of cystiphragms all the way from the axial region to the surface. The longitudinal section is very similar to that of *Peronopora,* except that there is no median lamina, and there is a longer immature region in *Peronoporella.* The zoarium is also like that of *Peronopora,* with which it has probably been confused, but it can unually be distinguished by the less regular arrangement of zoœcia and mesopores and the conspicuous acanthopores of *Peronoporella.*

Genotype: Peronoporella dubia n. sp.

PERONOPORELLA DUBIA n. sp.

Plates XV, XVI and XVII.

Zoarium compressed, frondescent or laminar, 6 or 8 cm. long, 5 or 6 cm. broad and about 2 mm. thick. Surface smooth, no monticules, but about 9 inconspicuous maculæ in 1 sq. cm. Maculæ only slightly elevated above the general surface, composed of 5 or 6 zoœcia slightly larger than the average and separated by large, irregular mesopores. The maculæ are about 2 mm. in diameter and 3 mm. apart.

The zoœcia at the surface are oval or irregularly petaloid, inflected by the numerous acanthopores, and usually separated more or less completely from each other by irregular mesopores. The conspicuous acanthopores give to the surface a granulose appearance. Sometimes the mesopores are closed at the surface, but in ordinary specimens and in weathered specimens they more or less completely surround the zoœcia. The zoœcial walls are thick at the surface.

Tangential sections near the surface show that the zoœcia are oval or irregularly petaloid in shape, thick-walled, about 8 in 2 mm. Mesopores are few on account of their being closed by the thickening of the zoœcial walls and the enlargement of the acanthopores. The zoœcial walls are amalgamated, having no distinct boundary; and the intermural deposit is light-colored, corresponding in position to the mesopores deeper down (Plate XV, Fig. 1 b.)

In the typical tangential section (Plate XV, Figs. 1, 1c) the zoœcia are oval, indented by the acanthopores, and separated from each other at the angles by numerous oval mesopores. The crescentic edges of one or more cystiphragms occupy each zoœcial aperture. The walls are of medium thickness, and consist of a dark ring next to the aperture, surrounded by lighter tissue. Occasionally there is a second, indistinct, interrupted dark line separating two zoœcia, but not comparable to the dark median line of the Integrata. Three or four acanthopores having a diameter of about one-fourth the zoœcial aperture, or a little larger than number 1, surround a zoœcium. In deeper sections they are slightly smaller and in shallower sections slightly larger than in ordinary sections. They have a central lucid canal surrounded by a very dark ring, which is in turn surrounded by successively lighter concentric rings. The outer limits of the acanthopores are not clearly defined, where they fade into the mural tissue. Deeper sections show thinner walls, more numerous and larger mesopores and somewhat smaller acanthopores (Plate XV, Fig. 1a). Communication pores, similar to those found in *Homotrypa* and many other genera, are occasionally present in tangential sections.

In longitudinal sections the immature region is seen to be about one-fifth as broad as the whole zoarium. The zoœcia are at first almost parallel to the surface, thin-walled and crossed by a few remote diaphragms. They gradually bend toward the surface till the submature region is reached, where they bend more abruptly outward and proceed in a straight line to the surface and emerge at right angles to the latter.

Numerous cystiphragms are developed in the immature region, on the upper or distal side of the zoœcia, and extend almost to the surface in an increasingly crowded series. They also become smaller as they approach the surface. There are a few diaphragms in the immature region of the zoœcia, but usually none in the mature region. The mesopores are provided with a close-set series of diaphragms from the immature region to the surface.

Acanthopores are numerous in the longitudinal section, of rather large size and with a clear central canal. They are ordinarily straight, beginning in the immature region and increasing slightly in size till they reach the surface. Sometimes, where they have been protected by an overgrowth, the acanthopores extend some distance (one or two zoœcial diameters) above the general level of the surface. In this case they consist only of the central canal and the thin dark tube immediately surrounding it. We have observed this same feature in many other species, and it throws much light on the structure and function of acanthopores. Ordinarily this tenuous tube is broken off near the surface, and we do not see the complete acanthopore.

A remarkable feature of the acanthopores of *Peronoporella* is their occasional irregularity as seen in longitudinal sections. Very frequently, instead of proceeding in a straight line, they are bent in the shape of a hook, or in other unusual forms (Plate XVI, Fig. 1a). Then they appear to be rejuvenated and proceed toward the surface, sometimes showing several successive dislocations. Almost every longitudinal section shows these hooked acanthopores. They indicate that as the zoarium grew these tubes, which extended above the surface, were sometimes accidentally broken off or bent and were immediately rejuvenated. So far these peculiarly shaped acanthopores have not been detected in any genus except *Peronoporella*. We do not, however, at present, consider this feature as constituting a generic or even a specific character.

This species resembles species of *Peronopora* very closely, both in zoanial habit and in longitudinal sections, but the absence of any median lamina in over 50 longitudinal and cross-sections examined convinces us that it is not a *Peronopora*. Figures of *Peronopora vera* for comparison are given on Plate XVII, Figs. 2, 2a.

Occurrence: Common in the Bellevue in the Borrow Cut and abundant in the Arnheim in Cuts 10 and 11, on the Big Four Railroad near Harmon's station, Ind.

Stigmatella Alcicornis n. sp.

Plate XVIII, Figs. 1-1e.

Zoarium compressed, frondescent or subramose, about 2 mm. thick, 2 or 3 cm. high and about the same distance in width. Around the margin there are short, subramose branches, giving to the zoarium the appearance of the antlers of the moose. The surface is nearly smooth, having about 10 slightly raised maculæ in 1 sq. cm. The maculæ are composed of larger cells and a few mesopores. The zoœcia at the surface are thin-walled and polygonal.

The zoœcia, in tangential sections, are thin-walled, polygonal and separated in some places by an interrupted dark line; 7 or 8 zoœcia in 2 mm. Acanthopores are very small, between number 0 and 1 in size, about 10 occurring in 10 zoœcia. Mesopores are usually absent.

Longitudinal sections show that the zoœcia have thin walls throughout, with very little thickening in the mature region. The zoœcial walls are more or less crinkled. Diaphragms are absent, except a single one occasionally in the young part of the zoœcium. The acanthopores are not conspicuous, but have a clear, sinuous canal; they are numerous in the periphery and rare in the axial region.

The only associated bryozoan with which this species might be confused is the very thin form of *Heterotrypa frondosa*, but the larger zoœcia, thinner walls and absence of mesopores will distinguish *S. alcicornis*.

Occurrence: Rather common in the Fairmount, in the upper 15 feet of Cut 5 on the Big Four Railroad, near Guilford, Ind.

STIGMATELLA CATENULATA n. sp.

Plate XIX, Figs. 1-1c.

Zoarium robust, subramose, 1.5 to 2 cm. in diameter and 5 or 6 cm. long. Surface nearly smooth, with low, round monticules or large maculæ, composed of mesopores and large zoœcia. Zoœcia subcircular, with medium thin walls. Mesopores are usually restricted to the clusters, but sometimes, on immature branches, there may be a small area in which mesopores are numerous.

Tangential sections show the zoœcia to be subpolygonal and thin walled, with a light-colored intermural line; 9 zoœcia in 2 mm. Where there are mesopores the zoœcia are smaller, but there is the same number in 2 mm., including mesopores. The acanthopores are small but conspicuous, about half the size of number 1, that is, 1/40 mm. in diameter, about 10 in 10 zoœcia. They are situated at the angles of junction of the zoœcia and never inflect the zoœcial wall. Mesopores are usually few or absent in sections near the surface, but occasionally a section will show a region of numerous mesopores, especially if the section is deep or taken from an immature branch.

Diaphragms are absent in the axial region and there are only one or two in the mature region. The zoœcial walls are only slightly thickened in the mature region, which is 2 or 3 mm. in depth. The chain-like mespores are the noticeable feature of longitudinal sections. They begin in the submature region and ordinarily do not reach the surface. Where the diaphragms cross the mesopores there is a constriction, giving to the mesopores the appearance of chains or strings of beads. The zoœcial walls are nearly straight or only slightly flexuous.

This species is evidently most closely related to *Stigmatella interporosa* Ulrich and Bassler, which it resembles, but it may be distinguished from that species by its more rebust habit of growth, thicker mature region and less numerous mesopores and greater development of chain-like mesopores.

Occurrence: Rather common in the Arnheim, in Cuts 10 and 11, on the Big Four Railroad near Harmon's station, Ind.

STIGMATELLA INCRUSTANS n. sp.

Plate XIX, Fig. 2; Plate XX, Figs. 1, 1a.

Zoarium incrusting foreign bodies, in the type specimen attached by an epitheca to a cast of *Orthoceras;* irregular in growth, 4 or 5 cm. long and 2 to 3 cm. wide, and from 1 to 5 mm. in thickness, and composed of several superimposed layers. The surface is strongly monticulated, 10 monticules in 1 sq. cm.

In tangential sections the zoœcia are very thin-walled, polygonal, 8 in 2 mm. Mesopores are practically absent. Acanthopores are conspicuous, situated at the angles or in the walls between adjacent zoœcia, sometimes strongly inflecting the zoœcial walls; 10 acanthopores in 10 zoœcia and in size ranging from number 0 to 1.

The zoœcia are at first prone, but quickly assume an erect position and proceed in undulating curves to the surface. Diaphragms are almost absent, except in the successive mature regions, which makes the whole section appear to have numerous diaphragms.

This species differs from *Stigmatella nicklesi* Ulrich and Bassler, to which it seems to be most closely related, in zoarial habit, in possessing prominent conical monticules, and in having fewer acanthopores which vary considerably in size. It differs from *Stigmatella clavis* (Ulrich) in the same respects. This form also resembles *Cyphotrypa wilmingtonensis* Ulrich and Bassler, but there is no doubt of its being a *Stigmatella* as the latter genus is at present defined.

Occurrence: Rare in the lower Liberty, in Cut 17 on the Big Four Railroad, near Weisburg, Ind.

Stigmatella Sessilis n. sp.

Plate XIX, Fig. 3; Plate XX, Figs. 2-2b.

Zoarium discoidal, about 15 mm. in diameter and 3mm. thick in the center, growing parasitically upon foreign objects. There is no basal epitheca.

The zoœcia, as shown by tangential sections, are polygonal, their apertures oval or circular, 10 zoœcia in 2 mm. Surrounding the aperture is a ring of very light-colored schlerenchyma, which is in turn surrounded by a very thin dark ring. The median line is usually light in color, but is absent in some places, in which case the two dark rings constitute the median line. Mesopores are practically absent. Acanthopores are numerous, 10 in 10 zoœcia, quite constant in size, about 2/3 the size of number 1, that is 1/30 mm. in diameter. The lumen is clear.

The zoœcia at first are crossed by thin diaphragms, their own diameter or less apart. In this region there is also a considerable number of chain-like mesopores. In the remaining portion of the zoœcia the diaphragms are twice their diameter apart. At several successive levels, 4 in the type specimen, the acanthopores and walls show the characters of maturity. At these levels there is one diaphragm, occasionally 2, in each tube, at the same height in adjacent zoœcia. That these levels represent successive stages of maturity is proven by the specimen, for the growth is interrupted completely in one part of the zoarium at these four levels. This characteristic of rejuvenation and overgrowth is not confined to the genus *Stigmatella*. It is a common feature of a good many species of Trepostomata, and we consider it as an inadequate basis upon which to found a genus. We consider *Stigmatella* as a valid genus; but we rely chiefly upon the thin walls, small acanthopores, few diaphragms and the presence of mesopores for its recognition.

Stigmatella sessilis differs from *S. nicklesi* Ulrich and Bassler, which it closely resembles, in internal characters, in zoarial habit, and in having thicker walls and smaller acanthopores.

Occurrence: Rare in the Fairmount, in Cut 7, on the Big Four Railroad, near Manchester Station, Ind.

EXPLANATION OF PLATES.

PLATE I.

Amplexopora granulosa n. sp. .... p. 421

1. Portion of the surface of the original of Fig. 1c, x 8, showing the usual appearance of the surface, except that the walls are not ordinarily quite so thick.

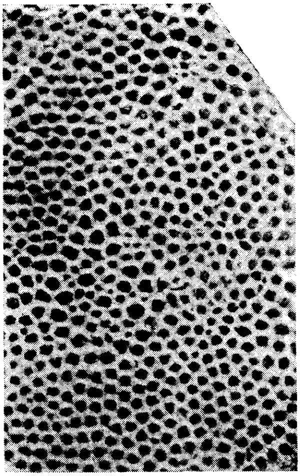
1a. Tangential section x 45, showing the granulose walls, the cingula, and absence of acanthopores. (109-14)

1b. Longitudinal section, x 20, showing abundant ordinary diaphragms and curved diaphragms. (110-23)

1c. A nearly complete zoarium, natural size, showing anastomosing branches.

Lower Liberty, in Cut 16, Weisburg, Ind.

PLATE I.



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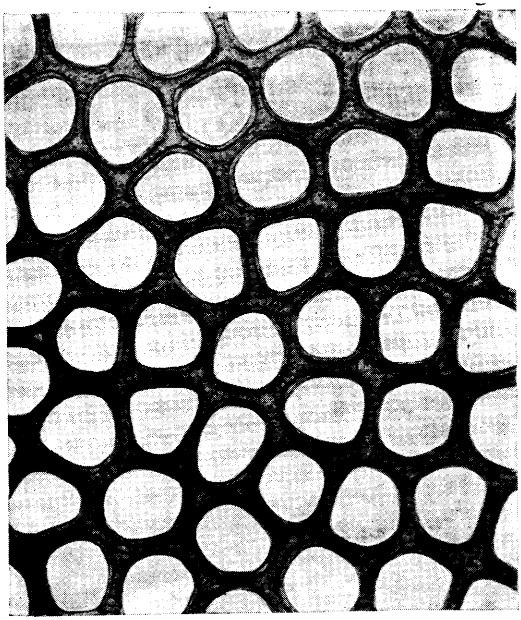

1a

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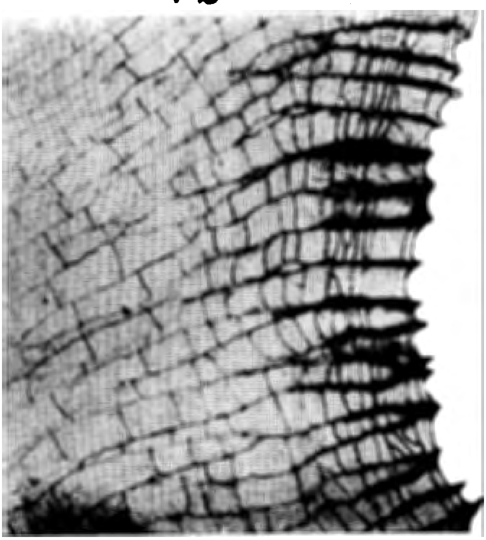

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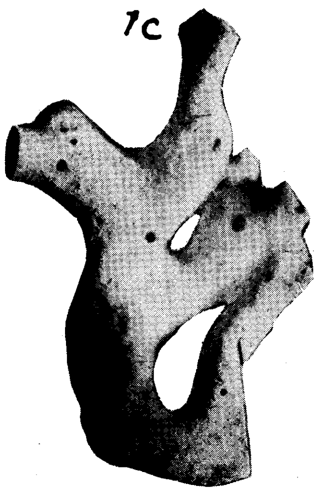


PLATE II.

Amplexopora pumila n. sp....................................p. 422

1. A portion of the surface of the original of Fig. 1d, x 8, showing the thin walls and few mesopores.

1a. Typical tangential section, x 45, showing the granulose median line and large acanthopores; from the upper 10 feet of Cut 16, lower Liberty, Weisburg, Ind. (110-1)

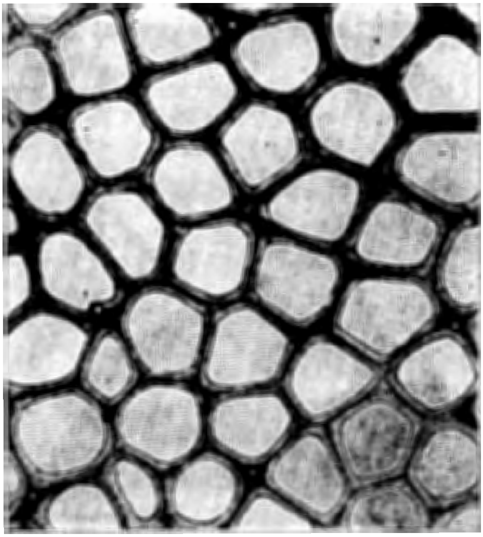
1b. Longitudinal section of the original of Fig. 1e, x 20, showing numerous diaphragms, curved diaphragms and a few large acanthopores; from the ditch east of the railroad in Cut 17, Weisburg, Ind. Lower Liberty. (107-23)

1c and 1d. Two zoaria, natural size, showing the irregular method of branching. Upper 15 feet of the Waynesville, Cut 14, Weisburg, Ind.

1e. A specimen from the Liberty; same as 1b.

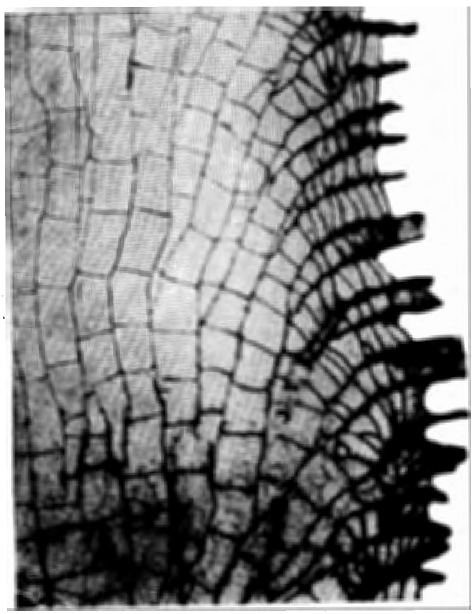
PLATE II.

1



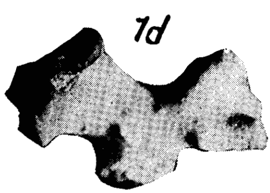
1a.

1b



1c

1d



1e

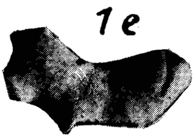


PLATE III.

Amplexopora septosa maculosa n. var. .... p. 423

1. Surface of the original of Fig. 1c, x 8, showing thin walls and elevated, subsolid maculæ.

1a. Tangential section, x 45, showing thick walls, imperfect cingula, indistinct acanthopores, and a macula of mesopores. (149-1)

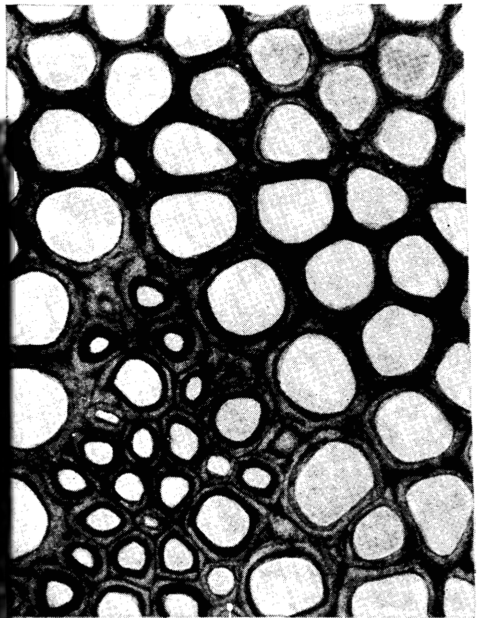
1b. Longitudinal section from the same specimen as 1a, x 20, showing close-set diaphragms in the submature region.

1c. Natural-size view of a nearly complete specimen.

Mt. Hope, Cut 5, Guilford, Ind.

PLATE III.

1



1a

1b

1c

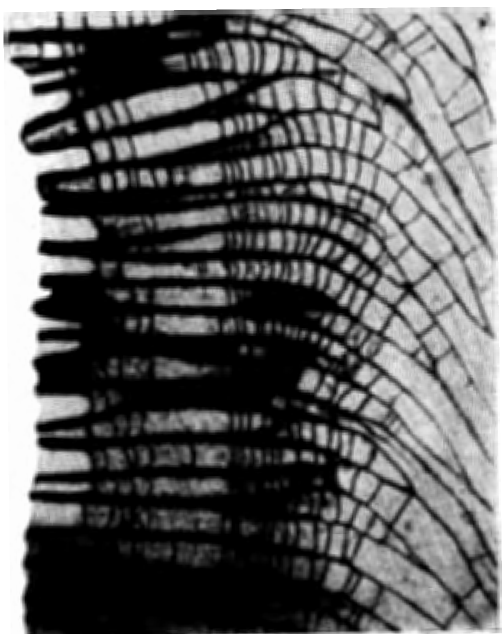


PLATE IV.

Amplexopora septosa minima n. var. .... p. 424

1 and 1a. Two zoaria, natural size.

1b. Tangential section of the original of Fig. 1, x 45, showing thin walls and conspicuous acanthopores which do not inflect the zoœcial walls. Upper 25 feet of Cut 4, Fairmount, Guilford, Ind. (156-17)

1c. Longitudinal section of the end of a mature branch, x 20. Diaphragms are not ordinarily present in the axial region. Upper 40 feet of Cut 2, Fairmount, Guilford, Ind. (162-2)

1d. Surface of the original of Fig. 1a, x 8. Upper 40 feet of Cut 2.

Atactopora intermedia n. sp. .... p. 425

(See also Plate V.)

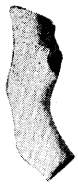
2. Surface of the original of Fig. 1c, Plate V, x 8.

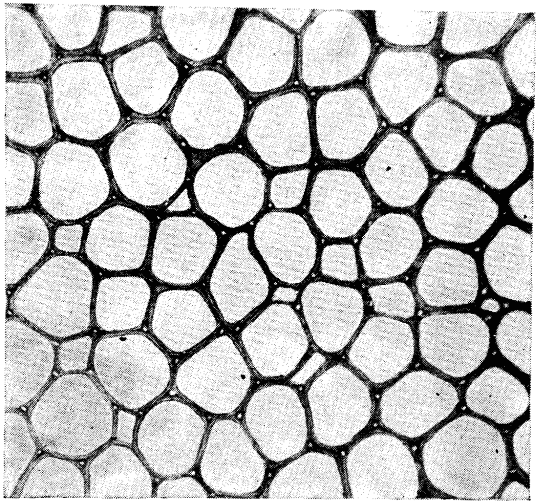
2a. Longitudinal section, x 20, showing a macula, diaphragms in the lower part of the zoœcia and cystiphragms in the outer part. (157-23)

PLATE IV.

1

1 a

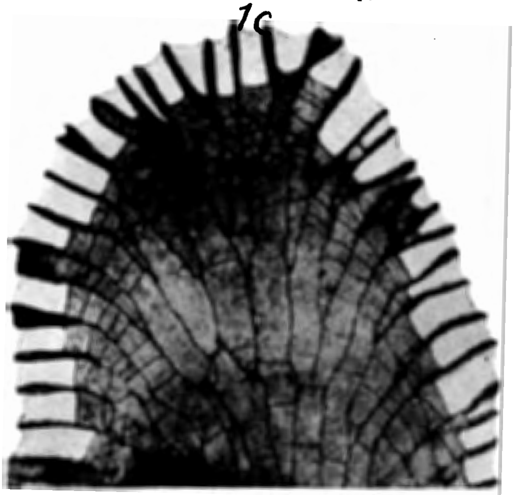




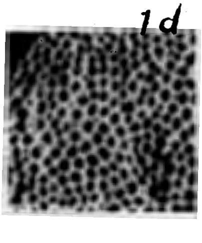
1b

2

1c



1d



2 a

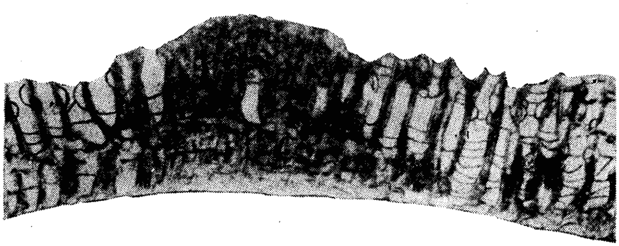


PLATE V.

Atactopora intermedia n. sp. .... p. 425

(See also Plate IV, Figs. 2, 2a.)

1. Typical tangential section, x 45, showing thick walls and abundant acanthopores inflecting the zoœcial walls. (157-23.)

1a. Tangential section, x 45, showing the structure of a macula. (157-23)

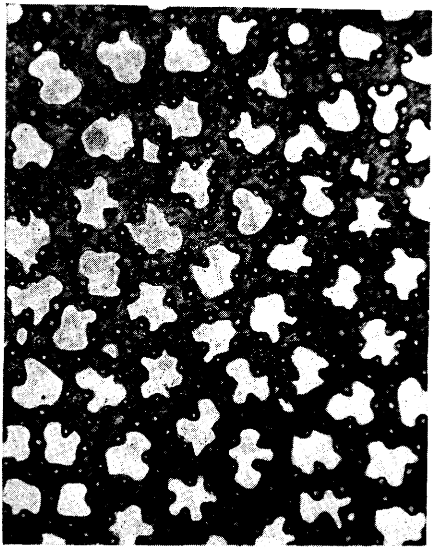
1b. Longitudinal section, x 45, showing the structure of a macula. (171-25)

1c. Natural-size view of the type specimen, showing the elevated, subsolid maculæ.

1d. Typical longitudinal section, x 20, showing two layers, and irregularly disposed diaphragms and cystiphragms. (171-25)

Upper 25 feet of the Eden, Cut 3, Guilford, Ind.

PLATE V.



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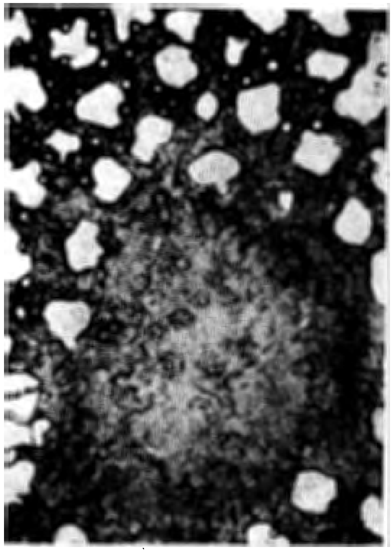
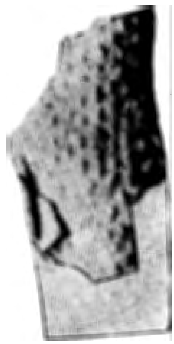


1a

1b

1c



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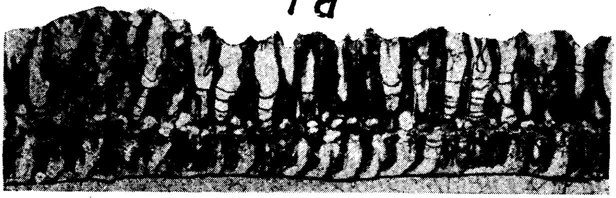


PLATE VI.

Ceramoporella triloba n. sp. .... p. 426

1. Typical tangential section, x 45, showing the strong lunarium and three-lobed zoœcia. (167-18)

1a. View of the type specimen, x 5/4.

1b. Longitudinal section, x 20, showing three superimposed layers. (167-18)

1c. Portion of the surface of the type specimen, x 8, showing the prominent, overarching lunaria.

Upper Eden, Cut 1, Guilford, Ind.

Ceramoporella tubulosa n. sp. .... p. 427

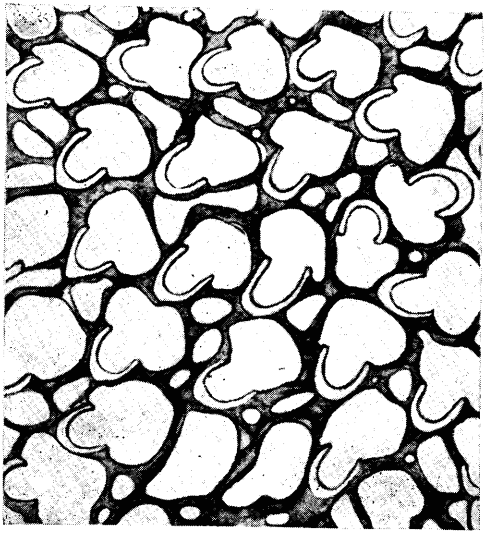
(See also Plate VII.)

2. Surface, x 8, showing the oval zoœcia and numerous mesopores.

2a. Longitudinal section of the same specimen, x 20. (158-2)

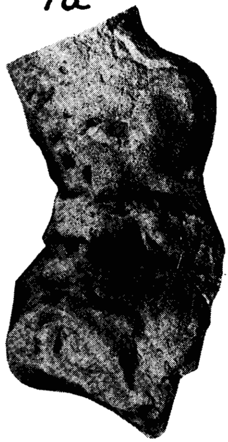
Upper Eden, Cut 3, Guilford, Ind.

PLATE VI.



1

1a



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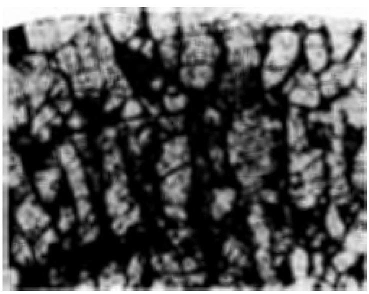

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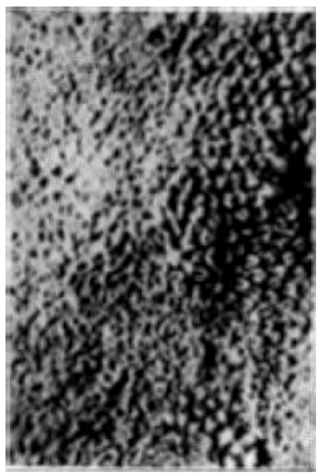
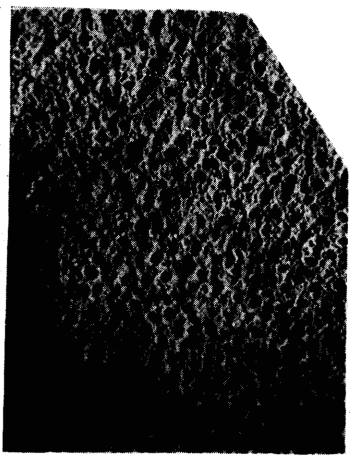


2



2a

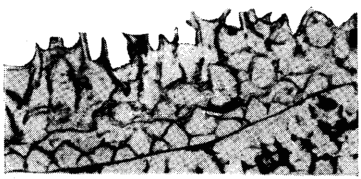


PLATE VII.

Ceramoporella tubulosa n. sp....................................p. 427

(See also Plate VI, Figs. 2, 2a.)

1. Tangential section, x 45, showing the oval zoœcia, prominent lunaria, numerous mesopores and acanthopores. (158-3)

1a. Natural-size view of the type specimen.

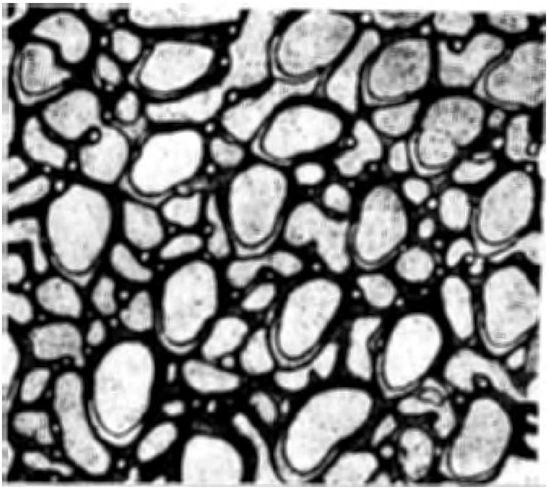
1b. Longitudinal section, x 45, showing the acanthopores, one of them crossed by diaphragms. (158-2)

1c. Longitudinal section, x 20, showing few diaphragms, and irregular structure. (158-2)

Upper 25 feet of the Eden, Cut 3, Guilford, Ind.

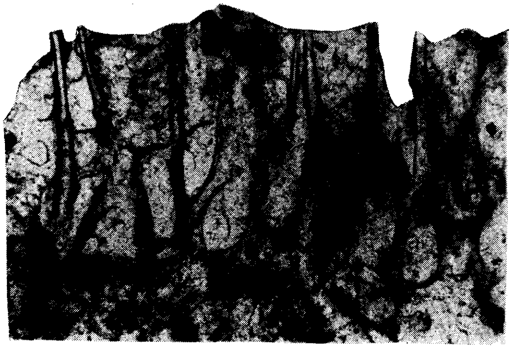
PLATE VII.

7



7a

7b



7c

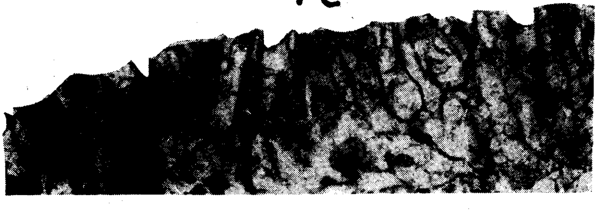


PLATE VIII.

Heterotrypa microstigma n. sp. . . . . p. 428

1. Tangential section, x 45, showing the thick walls, absence of mesopores, perfect cingula, and numerous acanthopores inflecting the zoœcial walls. (123-23)

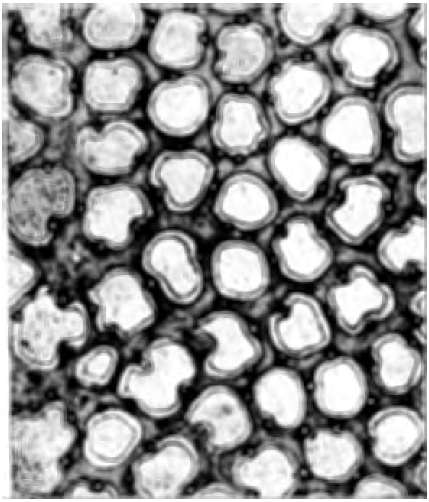
1a. A portion of the surface of the original of Fig. 1c, x 8, showing the small maculæ.

1b. Longitudinal section, x 20, showing diaphragms in the axial region, and thick walls, abundant diaphragms and absence of mesopores in the mature region. (123-23)

1c. View of a typical specimen, natural size.

Waynesville, Cut 13, dump, Weisburg, Ind.

PLATE VIII.



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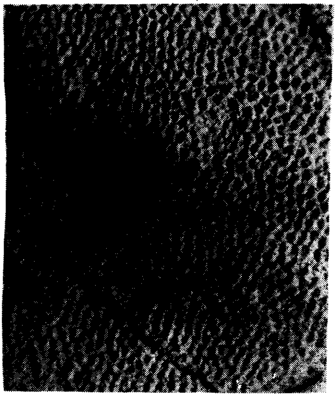
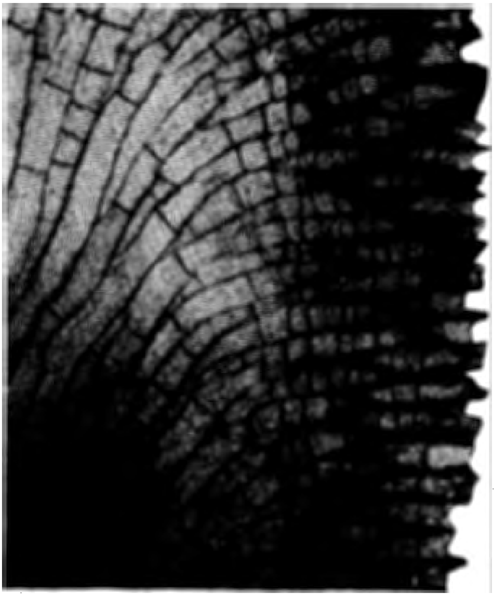


1a

1d



1c

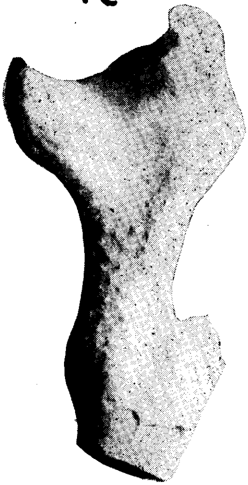


PLATE IX.

Homotrypa alta n. sp...p. 429

(See also Plate X.)

1. View of a nearly perfect specimen, natural size.

1a. Longitudinal section, x 45, showing details of wall structure. (163-23)

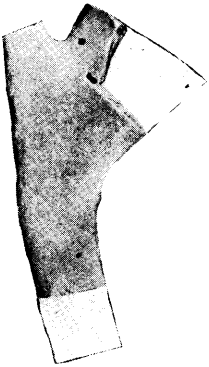
1b. Longitudinal section, x 20, showing crinkled walls, absence of diaphragms in the axial region, and cystiphragms in the bend. (163-23)

1c. Longitudinal section, x 20, showing deep mature region, and diaphragms and cystiphragms in the bend. (163-21)

Fairmount, upper 40 feet of Cut 2, Guilford, Ind.

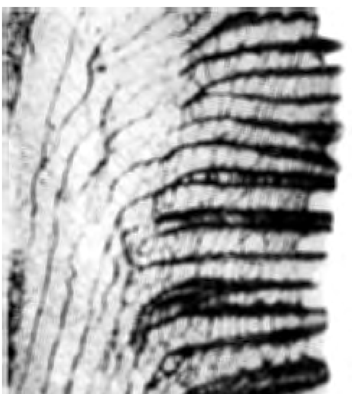
PLATE IX.

1



1a

1b



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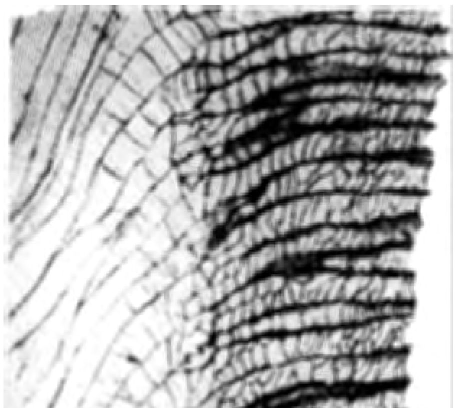


PLATE X.

Homotrypa alta n. sp. .... p. 429

(See also Plate IX.)

1. Portion of an unweathered surface, x 8, showing the elongated, subsolid, stellate maculæ.

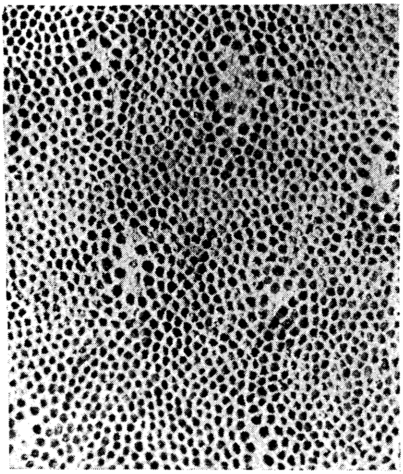
1a. Typical tangential section, x 45, showing few mesopores and the minute acanthopores. (163-23)

1b. Longitudinal section of the mature region, x 45, showing the dark median line and other details of structure. (163-21)

1c. Tangential section, x 45, showing communication pores. (163-21)

Fairmount, upper 40 feet of Cut 2, Guilford, Ind.

PLATE X.



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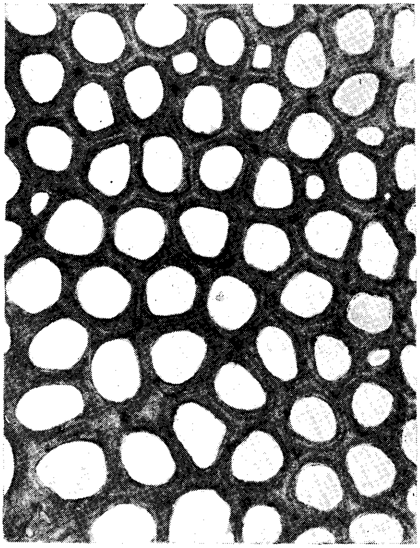


1a

1b

1c

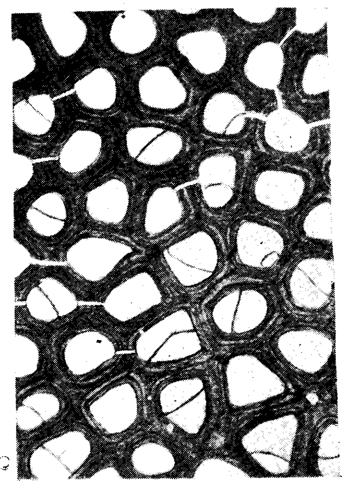


PLATE XI.

Homotrypa glabra n. sp. . . . . .p. 430

1. Tangential section, x 45, showing thick walls, thick cingula, absence of open mesopores, and an occasional small acanthopore. (165-6)

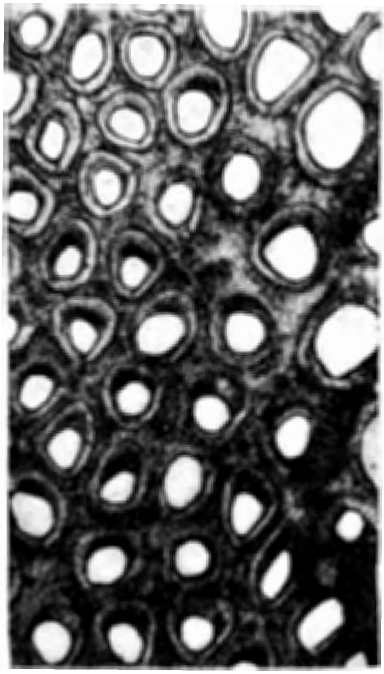
1a. Longitudinal section, x 20, showing zoœcia with crinkled walls and no diaphragms in the axial region, oblique, thick-walled zoœcia in the mature region, and a series of cystiphragms in the submature region. (165-6)

1b. Longitudinal section, x 45, showing wall structure; same as Fig. 1a.

1c. A fragment of a specimen, natural size, from which the sections illustrated on this plate were prepared.

1d. Portion of the surface, x 8.

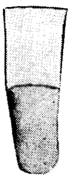
McMicken, lower part of Cut 2, Guilford, Ind.



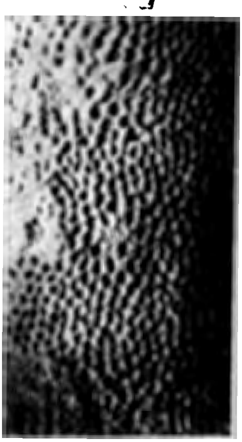
1

1a

1c



1d



1b

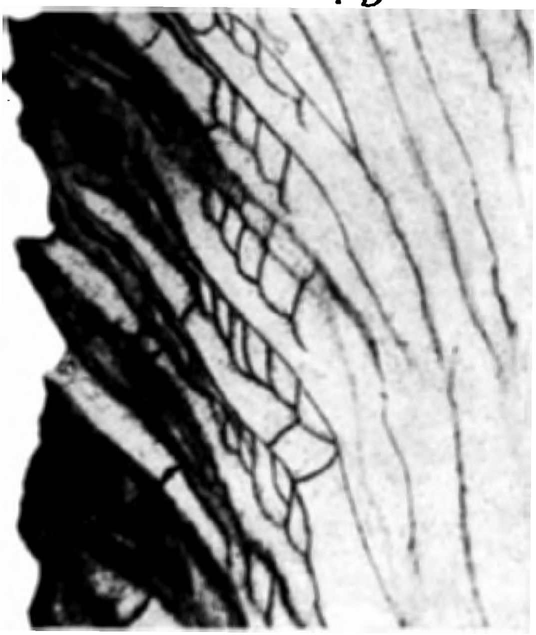


PLATE XII.

Homotrypa spinea n. sp. .... p. 431

(See also Plate XIII.)

1. Surface, x 8, of a well preserved specimen, showing conspicuous acanthopores.

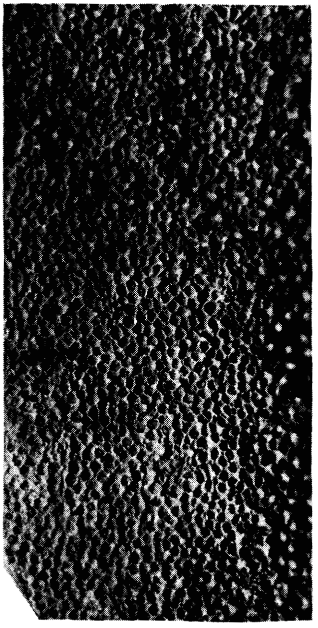
1a. Deep tangential section, x 45, from the same specimen as Fig. 1, showing a macula and more mesopores than in ordinary sections. (165-1)

1b. Typical longitudinal section, x 20, of the same specimen. Fairmount, upper 40 feet of Cut 2.

1c. Typical tangential section, x 45, showing thick walls, large acanthopores and few mesopores. (156-1)

Fairmount, upper 15 feet of Cut 5, Guilford, Ind.

PLATE XII.



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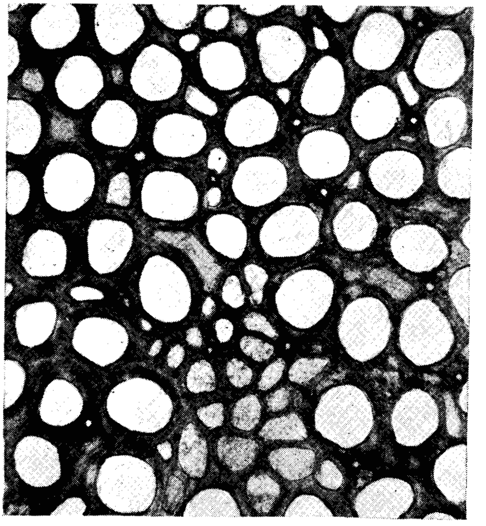


1a

1b

1c

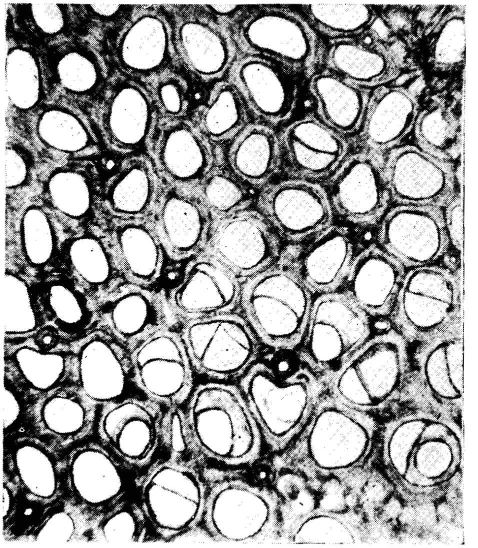


PLATE XIII.

Homotrypa spinea n. sp. .... p. 431

(See also Plate XII.)

1. Longitudinal section, x 45, showing details of structure. Same as Fig. 1b, Plate XII. (165-1)

1a. Typical tangential section, x 45. (157-2)

Upper 25 feet of Cut 4, Mt. Hope-Fairmount, Guilford, Ind.

1b. A large, subfrondescent specimen, natural size. Section 1.34C13, Mt. Hope. (152-15)

1c and 1d. Two zoaria, natural size, from the upper 40 feet of Cut 2, Mt. Hope-Fairmount.

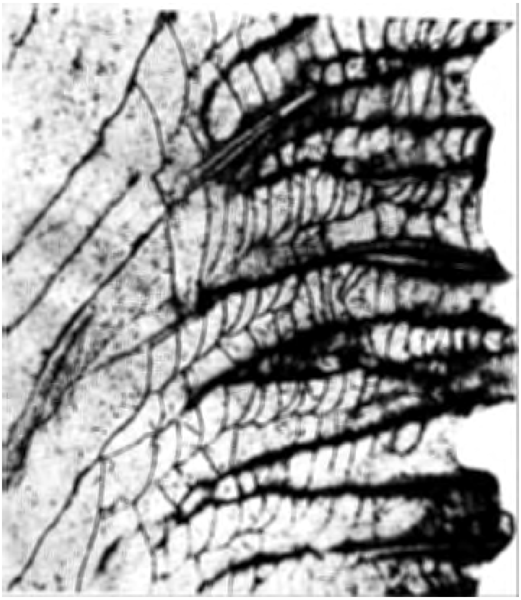
Nicholsonella peculiaris n. sp. .... p. 432

(See also Plate XIV, Fig. 2, 2a.)

2. Natural-size view of a nearly complete zoarium.

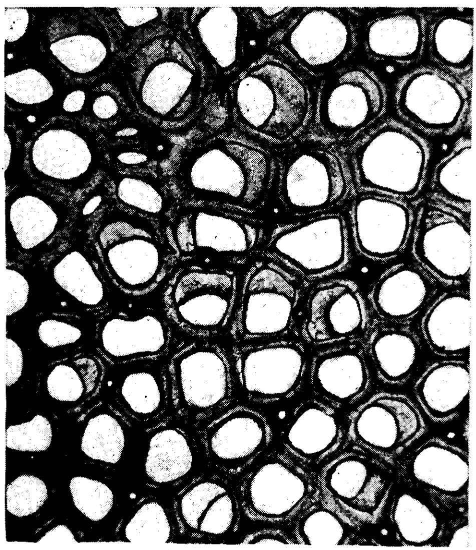
Arnheim, Cut 11, Harmon's station, Ind.

PLATE XIII.

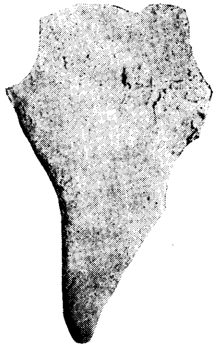


1

1 a



1b



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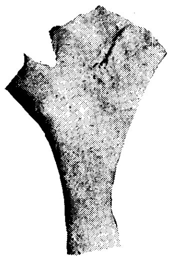
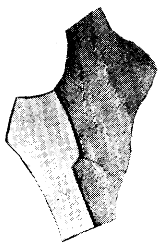
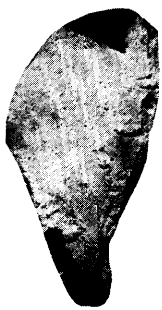


1d



2



30—33700

PLATE XIV.

Mesotrypa orbiculata n. sp. .... p. 432

1. Longitudinal section, x 20, showing three regions of maturity and two rejuvenations. (134-9)

1a. A typical tangential section, x 45. (134-9)

1b. Natural-size view of a nearly perfect specimen.

Middle Arnheim, upper 30 feet of Cut 10.

Nicholsonella peculiaris n. sp. .... p. 432

(See also Plate XIII, Fig. 2.)

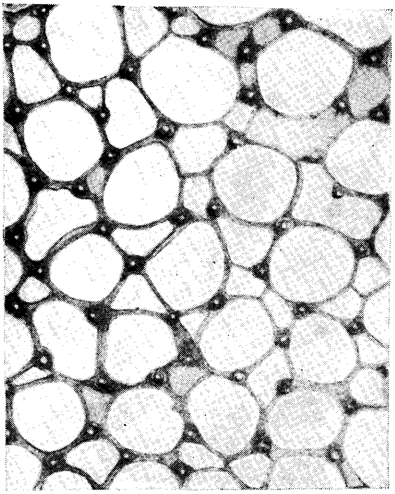
2. Longitudinal section, x 20, showing the crenulated walls and beaded mesopores. (133-4)

2a. Tangential section, x 45, showing the peculiar mesopores, small acanthopores and communication pores. (133-4)

Arnheim, Cut 11, Harmon's station, Ind.

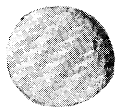
PLATE XIV.

1



1a

1b



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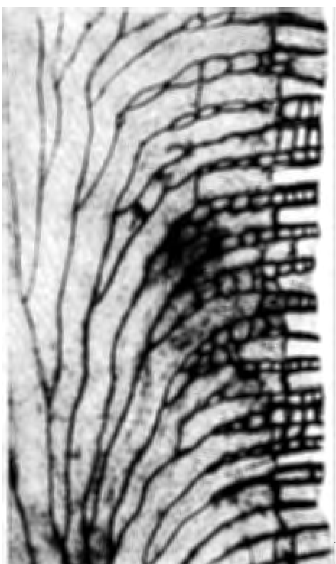


2 a

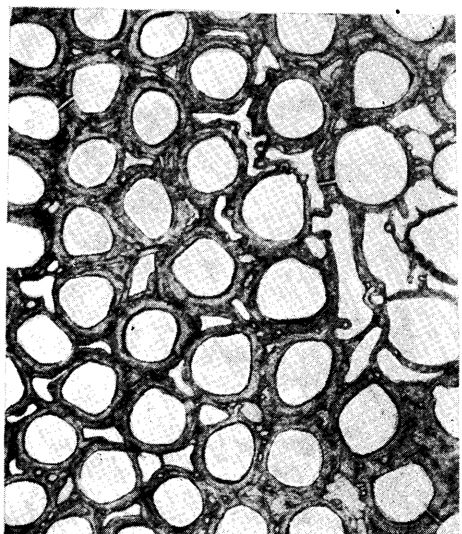


PLATE XV.

Peronoporella dubia n. sp. . . . . p. 434

(See also Plates XVI and XVII.)

1 and 1c. Typical tangential sections, x 45, showing the thick walls, conspicuous acanthopores and ill defined mesopores. (128-3; 129-4)

1a. Deep tangential section, x 45, showing thinner walls, more numerous mesopores and slightly smaller acanthopores than the typical sections. (130-5)

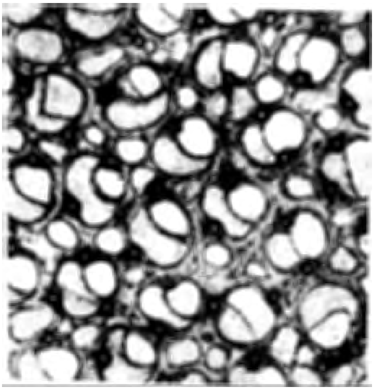
1b. Tangential section near the surface, x 45, showing very thick walls and few mesopores. (131-20)

1d and 1e. Portions of the surfaces of two well-preserved specimens, x 8, showing the usual appearance of the surface. (131-18, 20)

1f. A nearly complete specimen, natural size.

Arnheim, Cut 11, Harmon's, Ind.

PLATE XV.



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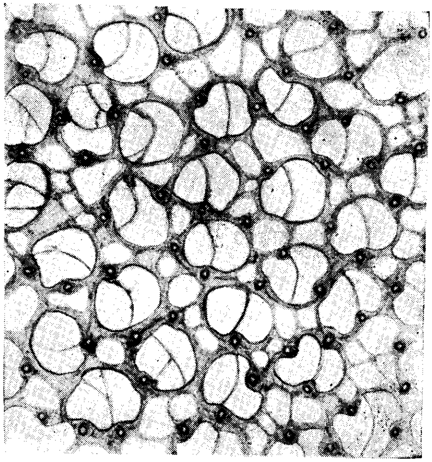
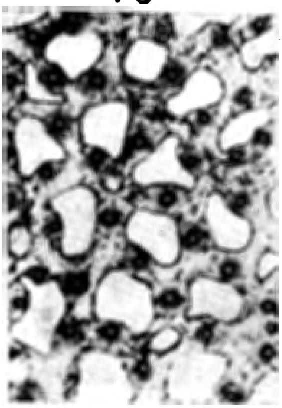
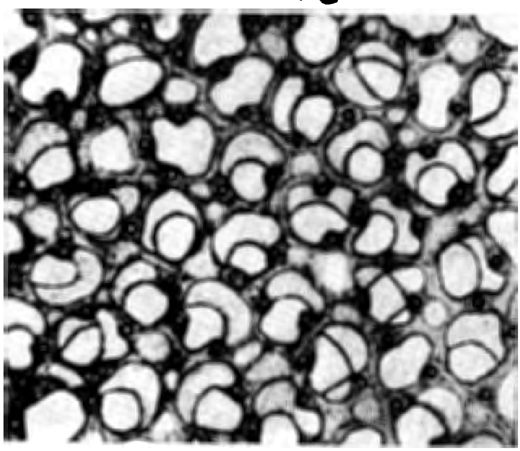


1a

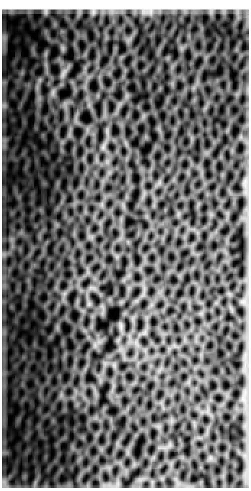
1b



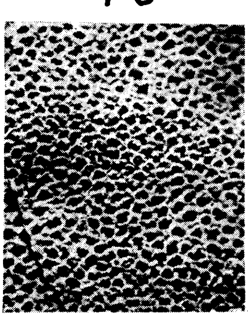
1c



1d



1e



1f

PLATE XVI.

Peronoporella dubia n. sp. . . . . p. 434

(See also Plates XV and XVII.)

1. Typical longitudinal section, x 20. (129-24)

1a. Portion of 1c, x 45, showing distorted acanthopores and details of wall structure. (128-5)

Arnheim, Cut 11.

1b. Longitudinal section of a very thin specimen, x 20. (133-18) Arnheim, Cut 10.

1c. Transverse section of an average specimen, x 20, showing the median region, and an overgrowth of the same species. (128-5) Arnheim, Cut 11.

1d. Median region of a longitudinal section, x 45, showing the absence of a median lamina, and the beginning of several zoœcia. (140-1)

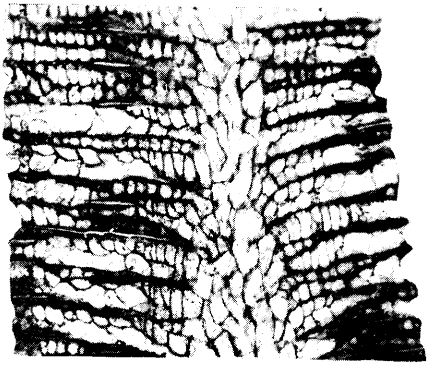
Bellevue, Borrow Cut.

1e. Typical longitudinal section, x 20. (140-1)

Bellevue, Borrow Cut.

Near Harmon's, Ind.

PLATE XVI.



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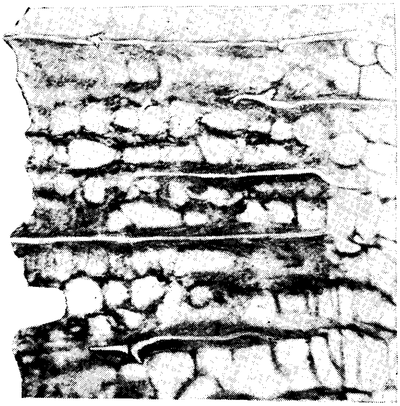
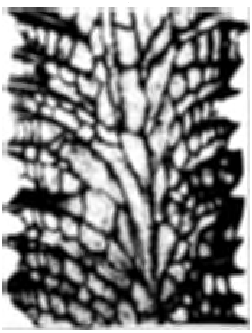


1a

1b



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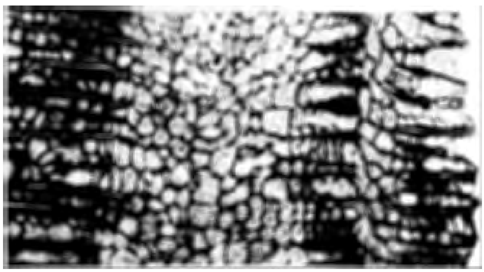


1d

1e

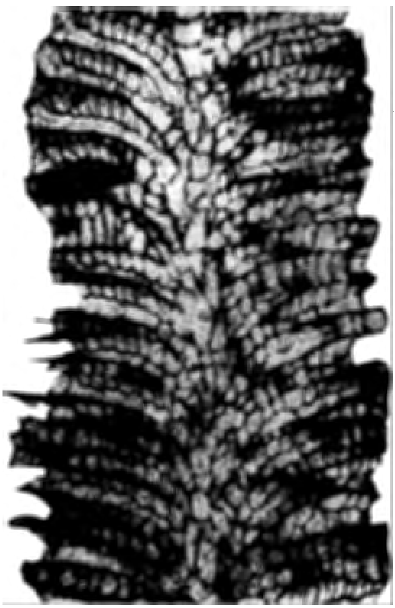


PLATE XVII.

Peronoporella dubia n. sp. . . . . p. 434

(See also Plates XV and XVI.)

1. Portion of 1b, x 45, showing structure of acanthopores and details of wall structure. (133-24) Arnheim, Cut 10.

1a. Longitudinal section of a thin zoarium, x 20. Arnheim, Cut 11. (128-12)

1b. Longitudinal section showing zoœcia in the axial region, and rejuvenated mature region, x 20. Arnheim, Cut 10. (133-24)

1c. Portion of Fig. 1, Plate XVI, x 45, showing a distorted acanthopore and wall structure. Arnheim, Cut 11. (129-24)

Near Harmon's, Ind.

Peronopora vera Nickles

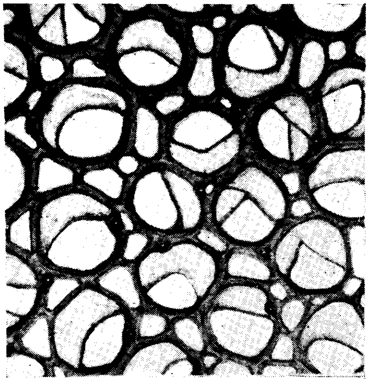
2. Tangential section, x 45. (147-14)

2a. Longitudinal section, x 20, showing median lamina and short immature region. Mt. Hope, Cut 5. (147-16)

These figures are placed here for comparison with those of *Peronoporella.*

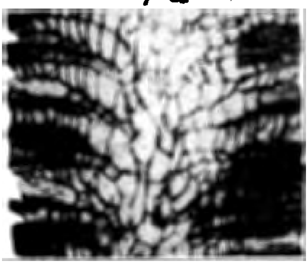
PLATE XVII.

1

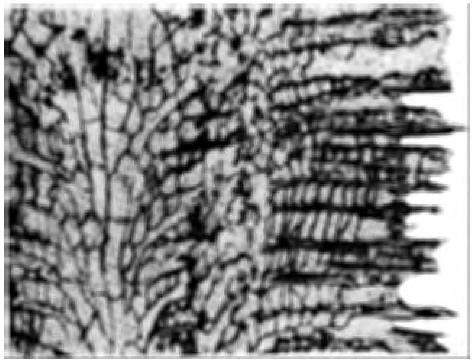


2

1a



1b



2a

1c

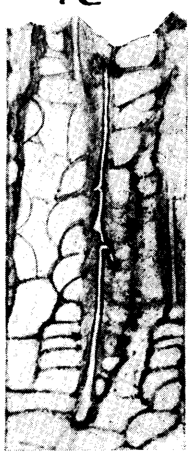


PLATE XVIII.

Stigmatella alcicornis n. sp. . . . . p. 436

1, 1a and 1b. Three nearly perfect zoaria, natural size.

1c. Portion of the surface of the specimen illustrated in Fig. 1, x 8, showing the thin walls and the maculæ.

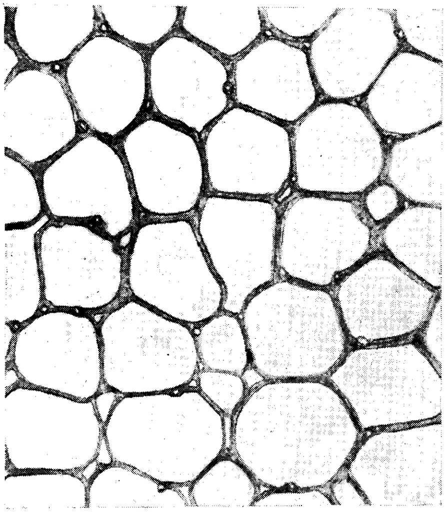
1d. Tangential section, x 45, showing thin walls, small acanthopores and few mesopores. (155-17)

1e. Longitudinal section, x 20. (155-18)

Fairmount, upper 15 feet of Cut 5, Guilford, Ind.

PLATE XVIII.

1

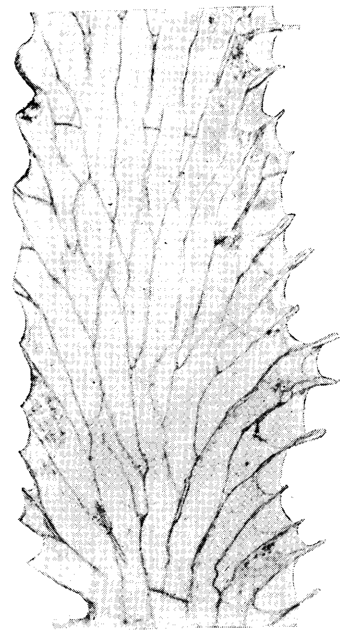


1d

1a

1d

1e



1c

PLATE XIX.

Stigmatella catenulata n. sp......................................p. 437

1. Tangential section, x 45, showing a portion in which there are no mesopores, and a deeper part with numerous mesopores. (131-15)

1a and 1b. Two typical longitudinal sections, x 20, exhibiting the characteristic chain-like mesopores. (133-20; 131-15)

1c. Fragment of a specimen, natural size.

Arnheim, Cuts 10 and 11, Harmon's, Ind.

Stigmatella incrustans n. sp......................................p. 438

(See also Plate XX, Figs. 1, 1a.)

2. View of a specimen, natural size.

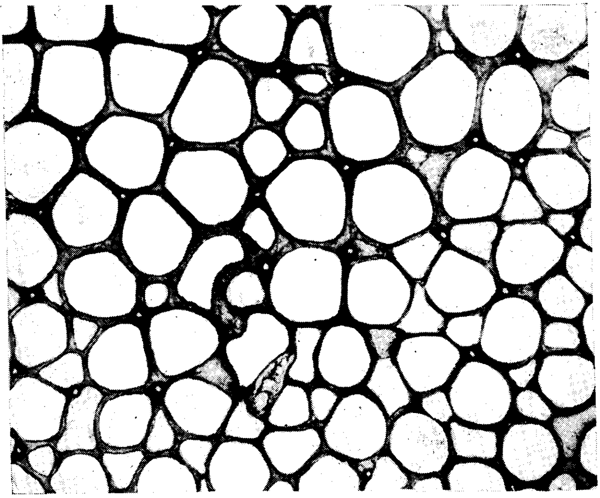
Lower Liberty, Cut 17, Weisburg, Ind.

Stigmatella sessilis n. sp......................................p. 439

(See also Plate XX, Figs. 2-2b.)

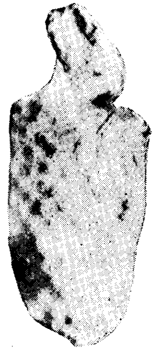
3. Surface, x 8, of the specimen shown in Fig. 2, Plate XX.

PLATE XIX.

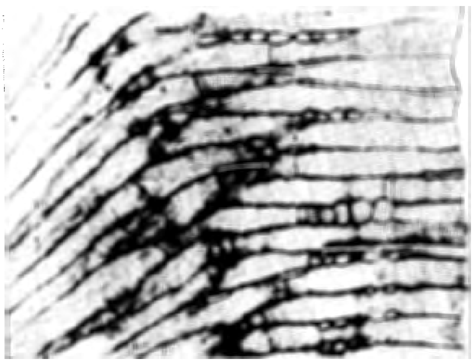


1

2



1a



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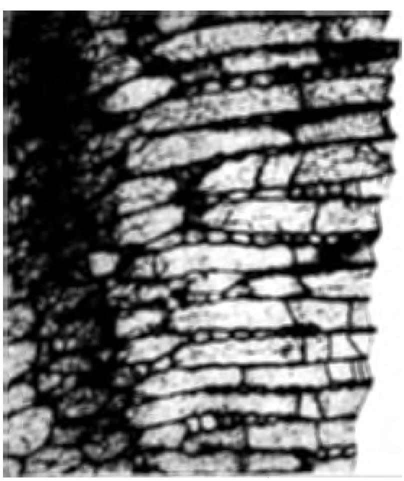
1b



3

PLATE XX.

Stigmatella incrustans n. sp....................................p. 438

(See also Plate XIX, Fig. 2.)

1. Longitudinal section, x 20, showing three mature regions. (107-17)

1a. Tangential section, x 45, exhibiting several sizes of acanthopores. (107-17)

Lower Liberty, lower 10 feet of Cut 17. Weisburg, Ind.

Stigmatella sessilis n. sp.......................................p. 439

(See also Plate XIX, Fig. 3.)

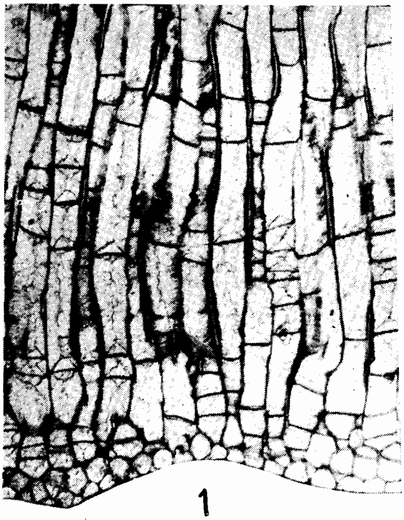
2. Natural-sized view of the specimen from which the sections were prepared for Figs. 2a and 2b.

2a. Longitudinal section, x 20, showing two mature regions. (146-8)

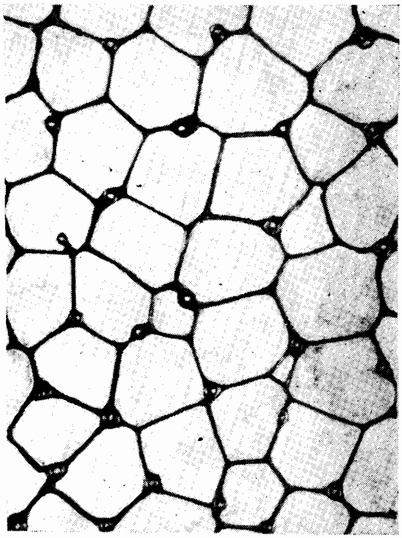
2b. Tangential section, x 45. (146-8)

Fairmount, Cut 7, Manchester, Ind.

PLATE XX.

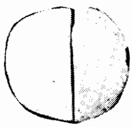


1

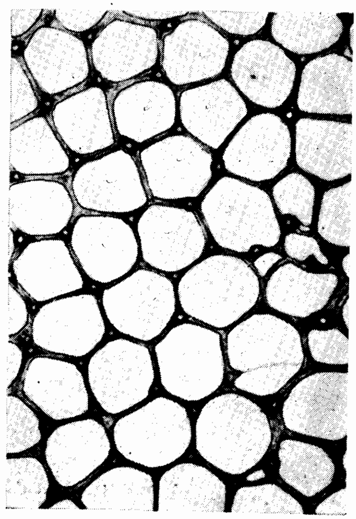


1a

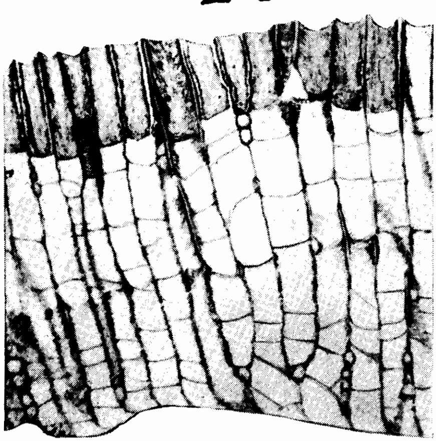
2



2b



2a



GENERAL INDEX.

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