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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.

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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 $39^{\circ} 28'$. 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 $17\frac{1}{2}$ 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 fluvial 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 $3\frac{1}{2}$ 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 $1\frac{1}{2}$ 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 Limesdale.

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 illly 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 fifth 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 addi-

tion 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 unslacked 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 deserye 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 im-

portant 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.

	<i>Acres.</i>	<i>Bushels.</i>
Corn	61,898	2,175,110
Oats	15,772	377,280
Wheat	18,559	228,310
		<i>Tons.</i>
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:

<i>Station.</i>	<i>First in Autumn.</i>	<i>Last in Spring.</i>
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 ¹¹/₁₁ temperature and average precipitation at (1) Rockville:

<i>Month.</i>	<i>Mean Temperature, Degrees F.</i>	<i>Average Precipitation, Inches.</i>
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:

<i>Month.</i>	<i>Mean Temperature, Degrees F.</i>	<i>Average Precipitation, Inches.</i>
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 ⁽¹³⁾	77.6	3.12

<i>Month.</i>	<i>Mean Temperature, Degrees F.</i>	<i>Average Precipitation, Inches.</i>
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 con-

stituents 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 Limesdale, 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 briars.

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	{	<i>Merom sandstone.</i>
		Pennsylvanian		<i>Coal measures, shale, limestone.</i>
				<i>Mansfield sandstone.</i>
		Mississippian	{	<i>Huron limestone and sandstone.</i>
				<i>Mitchell limestone.</i>
<i>Salem (Indiana Oölitic) limestone.</i>				
<i>Harrodsburg limestone.</i>				
<i>Knobstone, sandstone, shale.</i>				
		{	<i>Rockford Goniatite limestone.</i>	
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 laminae.

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 reploting. 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 aeration. 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 shrubby-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. Inceas-

ing 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... Center of East ½ Sec. 26, T. 14 N., R. 4 W.....	(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
	(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 available 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 quantities 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, allaying 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 percent 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 origin 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. $\frac{1}{4}$ 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 hilly, 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 Cent.	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 after 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 $\frac{1}{2}$ ton to $1\frac{1}{2}$ 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. $\frac{1}{4}$ Sec. 16, T. 14 N., R. 4.	/Soil.....	1.1	8.2	9.4	45.3	6.3	17.4	12.3
W.....	\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 constituent 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 1½ 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 deepening 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 containing 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 rain-

fall 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, Fincaastle, 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.