

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH PURDUE UNIVERSITY AGRICULTURAL
EXPERIMENT STATION

SOIL SURVEY OF LAWRENCE COUNTY INDIANA

BY

W. E. THARP, U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND
T. M. BUSHNELL AND J. E. ADAMS, PURDUE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

PART 2. THE MANAGEMENT OF LAWRENCE COUNTY SOILS

BY

A. T. WIANCKO AND S. D. CONNER, DEPARTMENT OF AGRONOMY
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

[Advance Sheets—Field Operations of the Bureau of Soils, 1922]



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[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

Preface

This report consists of two parts. Part 1 is designed to be descriptive and in a measure technical in the discussion of the soils. Part 2 is intended to furnish information about the treatment and management of the soils to county agents, farmers, and others interested in the use of the soils. The soil map serves both parts of the report.

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MAP

Soil map, Lawrence County, Indiana

SOIL SURVEY OF LAWRENCE COUNTY, INDIANA

By W. E. THARP, U. S. Department of Agriculture, in Charge, and T. M. BUSHNELL and J. E. ADAMS, Purdue University Agricultural Experiment Station

COUNTY SURVEYED

Lawrence County is in the south-central part of Indiana, and comprises 444 square miles, or 284,160 acres. Bedford, the county seat, is about 60 miles northwest of Louisville, Ky., and approximately 80 miles northeast of Evansville, Ind.

The county is within that part of Indiana which has a rather sharp and varied relief. Where sandstones and shales form the bedrock, narrow steep-sided ridges and deeply entrenched streams are characteristic, whereas in the limestone region, broad divides with smooth contours prevail. However, where the softer rocks are thinly covered by limestone, undercutting by streams has resulted in the development of bluffs along the streams and rougher surfaces in general. This is particularly evident southeast of Bedford and north of East Fork White River, where the main interstream divides rise sharply from the valleys. To the north and northeast of Bedford the broad uplands include many undulating or gently rolling areas with occasional small tracts that are nearly level.

All the region south of East Fork White River and east of Bryantsville and Mitchell is underlain by limestone. In the eastern part of this region several small tributary streams have cut rather deep valleys, and there has consequently developed a sharp relief, particularly along the river, though elsewhere the local surface inequalities are due chiefly to many limestone "sinks," which range from mere sags a few yards in diameter to depressions from 50 to 100 feet deep and a quarter of a mile wide. The smaller sinks are more or less bowl-shaped, but the larger ones have very irregular outlines and may resemble small surface drainage systems, except that no outlet for the waters they receive is visible.

The southwestern part of the county is hilly or broken, with differences in elevation as great as 200 or 300 feet. High narrow divides with occasional domelike eminences rise in the eastern part of this section of the county. These crests afford strips and patches of arable land, but few fields are more than a quarter of a mile wide.



FIG. 57.—Sketch map showing location of Lawrence County, Indiana

The slopes are steep, with many exposures of the sandstones and shales which underlie all this section.

The sandstone-shale country north of East Fork White River extends 4 or 5 miles east from the western boundary of the county. Here the ridge tops are wider than those farther south, and the underlying limestone crops out at a higher level, so that the lower slopes include varying areas of limestone soils, patches of which are tillable. Most of the ridge crests are under cultivation, and less of the country is wooded than that to the south of East Fork White River.

The northeastern part of the county also is underlain by sandstones and shales, and the streams have cut deeply into these soft rocks. The country drained by the upper branches of Back Creek and that north of Little Salt Creek consists of a series of narrow divides separated by ravines and deep valleys. A thin limestone capping remains on many of the wider and flatter divides, but where this has disappeared the ridges are usually narrow. The wider divides afford broad open fields and pastures, whereas much of the cultivated land is in the creek valleys. Elevations above sea level range from 470 feet in the East Fork White River valley to about 900 feet on the highest uplands.

East Fork White River crosses the county from east to west, and its sinuous course as seen on the map suggests wide meanders in a great flood plain. The inner side of these great bends, however, are high ridges or extensions of the uplands and are usually bordered on the east by bluffs from 150 to 200 feet high, whereas less precipitous slopes prevail on the western side. The flood plain seldom exceeds one-half mile in width. In some places along the river tillable slopes extend from the uplands to the flood plain, and below Bedford there are a few well-drained terraces; but the flood plains are generally bordered by rocky bluffs and steep, eroded hills.

East Fork White River receives comparatively little drainage from the south, and west of Dixie Highway there are no tributaries of even local importance. Mill Creek is the lower course of a subterranean stream which emerges from a cave in a deep glen 2 miles east of Mitchell. Water power is developed here for use in the town, and a dam on East Fork White River at Williams furnishes power for a hydroelectric plant supplying electricity for the stone mills and the city of Bedford.

The largest tributary to East Fork White River from the north is Salt Creek, which rises in Brown County. Its lower valley is wider in most places than that of East Fork White River and is further marked by terraces extending several miles up from the river. The narrow winding valley of Indian Creek has some small well-defined benches, remnants of a former flood plain much wider than the present one. In the eastern part of the county the small creeks flow in deep narrow valleys, with high wooded hills on each side. The erratic course of Guthrie Creek brings it, at the Devil's Backbone, within one-half mile of East Fork White River, but turning northwest, it enters a valley comparable with that of the major stream which it joins 7 miles below the Backbone.

All these small streams have rocky bottoms, but the banks are usually brown silty alluvium.

The smoother portions of the limestone region are improved farm lands with rather numerous remnants of the original forest occurring as small wood lots and shady pastures. Much of the rougher land, where sinks are numerous, is in open pastures, but near the towns and quarries such lands are used as sites for small homesteads.

Lawrence County was organized January 7, 1818, by settlers from the Eastern States. Bono was settled in 1816, and Leesville about two years later, and though there were scattered clearings prior to these dates, the first land entries were made in Marion Township in 1816.

The population of the county according to the 1920 census is 28,228, of which 12,101 is classed as urban. Bedford, the county seat, and its near-by villages include about 10,000 persons. Until the recent expansion of the stone industries near Bedford, few foreign-born people had moved into this region.

The Chicago, Indianapolis & Louisville Railway (Monon Route) affords shipping facilities north and south, and similar service is furnished by the Baltimore & Ohio Railroad to points east and west. The Chicago, Terre Haute & Southeastern branch of the Chicago, Milwaukee & St. Paul Railway also crosses the county, and a branch line of the Chicago, Indianapolis & Louisville Railway extends from Bedford to Bloomfield in Greene County.

Most of the county roads are surfaced with gravel or crushed stone. Rural mail delivery and telephone service reach nearly all farm homes.

CLIMATE

The average annual rainfall as recorded at Bedford, considered as typical for this section of Indiana, is about 40 inches. The variation in amount between the driest and wettest years is about 18 inches, but this is exceptional and of less importance to agricultural interests than the amount and distribution during the growing season. The normal precipitation for the three summer months—June, July, and August—is 9.5 inches, not too much for corn on any soil. When rainfall is scanty during July and August a marked effect upon pasture and meadows is noticed. Corn especially is affected, the July-August rainfall being a highly important factor in its growth. Great variations in the oat crop on account of seasonal conditions occur, and although this is true of wheat also the latter crop seems less sensitive to weather conditions than oats.

Snowfall averages about 10 inches a year.

The mean annual temperature at Bedford is 55.1° F. There is a range of 43.4° between the summer mean and winter mean, and the highest temperature recorded at this station is 111°, and the lowest 18°.

The average date of the last killing frost in spring is April 19, and that of the first in the fall, October 13, giving an average frost-free season of 176 days. Bedford, located on comparatively smooth uplands, has experienced a killing frost as late as May 25, and as early in the fall as September 27.

The normal monthly, seasonal, and annual temperature and precipitation at Bedford are given in the following table compiled from the Weather Bureau records:

Normal monthly, seasonal, and annual temperature and precipitation at Bedford

[Elevation, 681 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1924)	Total amount for the wettest year (1921)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	34.8	75	-9	3.63	4.10	5.86	3.1
January.....	31.8	74	-14	2.62	3.21	3.09	3.4
February.....	31.3	72	-18	2.20	2.32	3.07	2.5
Winter.....	32.6	75	-18	8.45	9.63	12.02	9.0
March.....	44.6	86	5	4.51	3.08	5.59	.5
April.....	53.6	88	22	3.48	5.09	4.38	Trace.
May.....	64.7	103	31	3.82	4.88	2.34	.0
Spring.....	54.3	103	5	11.81	13.05	12.31	.5
June.....	74.2	102	37	3.72	4.61	3.58	.0
July.....	77.6	111	45	2.36	1.23	1.58	.0
August.....	76.2	102	43	3.42	3.08	7.97	.0
Summer.....	76.0	111	37	9.50	8.92	13.13	.0
September.....	68.6	105	28	2.94	4.21	8.62	.0
October.....	58.2	96	23	3.25	.23	1.66	Trace.
November.....	45.7	87	8	3.28	1.80	7.87	.4
Fall.....	57.5	105	8	9.47	6.24	18.15	.4
Year.....	55.1	111	-18	39.23	37.84	55.61	9.9

AGRICULTURE

Lawrence County is just south of the Corn Belt, and is well within the limits of the more southerly belt where winter wheat and corn are both staple crops. The climatic conditions and the diversity of soils in this particular area allow a wide range in crop production. With the exception of several kinds of specialized products which have been developed largely in recent years, the agricultural conditions are similar to those prevailing throughout southern Indiana. No very large bodies of individual soils occur so that the difference in the proportion of land devoted to the principal crops is local rather than regional. In general, similar methods of farming prevail throughout the county, and no very marked changes in agricultural production have taken place since the earliest development. On practically all farms, much land has been cleared for tillage that might more profitably have been left as forest land. Much of the rougher lands as well as some smooth areas of low productivity have been abandoned for pasture.

In the following table compiled from the census returns, the comparatively slight changes in the relative acreage of the three leading cereal crops and rye since 1879 are indicated:

Acreage and production of leading cereal crops in Lawrence County, 1879 to 1919, inclusive, as reported by the Federal census

Year	Corn		Oats		Wheat		Rye	
	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Bushels
1879	37, 112	912, 215	14, 406	251, 876	15, 036	138, 051	1, 453	21, 489
1889	24, 870	731, 211	12, 425	202, 257	12, 600	158, 039	102	1, 089
1899	29, 420	789, 030	9, 891	212, 480	17, 573	194, 550	190	1, 730
1909	35, 027	1, 078, 641	6, 894	136, 230	10, 070	129, 647	451	4, 865
1919	35, 557	940, 664	8, 483	150, 350	15, 788	204, 619	1, 559	16, 716

In recent years there has been considerable decrease in the acreage and yield of oats. Wheat is extensively grown, many times at a loss, but it is almost indispensable as a nurse crop for clover and timothy. It is usually sold, and only enough kept for farm use for seed. Corn is the most important crop, and is grown for home use only. The amount of corn produced determines the number of head of livestock which can be profitably kept, and there are so many farms on which the acreage of pasture land greatly exceeds that suitable for corn, that the local demand for this grain is great. Rye has never been grown to any considerable extent, although it yields well on some soils.

Clover, alfalfa, timothy, redtop, orchard grass, millet, sorgho (sweet sorghum), and Sudan grass are all more or less common hay and forage crops, clover and timothy being the most important. According to the reports for 1921, clover alone was grown on 6,641 acres, timothy 8,190 acres, and mixed clover and timothy 9,604 acres. The total acreage of these crops is about one-half the average annual acreage planted to corn. The yields vary considerably from year to year, owing chiefly to seasonal influences which affect the stands. Redtop and orchard grass are common roadside grasses, particularly in the limestone areas, and the former forms a considerable proportion of the hay crop on land inclined to be wet. Bluegrass is well distributed throughout the area, and would probably become the dominant growth on the brown alluvial soils were these not so generally in cultivation. This valuable pasture grass seems less abundant than formerly and its weak growth or entire absence in many pastures is noticeable. This may be due to overgrazing, lack of humus in many old fields, and in some measure to soil acidity. White clover is not so common as in the central and northern parts of the State. In most old fields on sandstone ridges short thin grasses of rather inferior quality are abundant, and in such locations sedge grass is more or less prevalent but rarely attains its usual size and vigor. During the dry season of 1922, scanty growths of *Lespedeza* were observed in the western part of the county. Although its distribution seems restricted at present, it is spreading rapidly over all southern Indiana.

Goldenrod, ragweed and whitetop are usually abundant on the hill-land pastures, and sassafras, sumac, trumpet vine, and small trees tend to overrun such lands if abandoned.

Sorgho, millet, and Sudan grass are grown particularly on alluvial lands, where a mixture of millet and cowpeas is commonly sown and yields of 3 or 4 tons of hay to the acre obtained. The practice of planting soy beans with corn is gaining in favor, and to a limited extent this legume is also planted for seed.

The 1920 census reports 1,448 acres of alfalfa in 1919, yielding 2,739 tons, but it is estimated that there are now (1922) about 2,000 acres in alfalfa. Much of this is grown on Fox loamy sand and Princeton fine sandy loam, but its culture is extending to other soils with considerable success.

Lawrence County is famed for its production of fine apples and peaches, and contains a number of commercial apple orchards with 40 acres or more of bearing trees. The census returns for 1919 report 77,334 apple trees of bearing age, with a total production of 15,300 bushels, and 32,524 trees of nonbearing age, though recent plantings have increased this number. The more common summer varieties of apples are Benoni, Yellow Transparent, Oldenburg (Duchess), and Wealthy. The more valuable winter varieties include Grimes Golden, Rome Beauty, Winesap, and Ben Davis. Many other varieties of less commercial value are produced in smaller quantities. The commercial peach orchards have, according to the 1920 census, 38,830 trees of bearing age and 30,761 trees of nonbearing age. Elberta and Hale Early (Early Hale) are the leading varieties. In most commercial orchards a sod is maintained, clover and bluegrass forming the principal growth. However, cultivation is necessary in young orchards during the spring and summer, and a cover crop of soy beans or cowpeas is usually planted in the fall. Very little commercial fertilizer is used in apple orchards, but it is used to some extent in peach orchards.

Cherries are grown successfully, but local horticulturists consider this region a little too far south for the best quality of this fruit. Small pear orchards are numerous, and plums, grapes, and the more common small fruits are grown rather extensively for home use. Watermelons and cantaloupes are the principal truck crops, and some sweet potatoes and minor garden crops are grown near Bedford and Mitchell. The total acreage in truck crops in 1921 was 126 acres.

Dairying has been developed to a considerable extent near Bedford and Mitchell. The census returns for 1919 gave the value of dairy products, exclusive of those for home use, as \$267,525. There were 6,424 dairy cattle in the county in 1920, of which 4,059 were cows and heifers over 2 years old. Beef cattle numbered 8,757.

Many small flocks of sheep are raised, but sheep raising has not developed to such an extent as natural conditions would seem to warrant. The 1920 census reported 4,713 sheep in the county. The sale of swine is an important cash item where the corn produced is sufficient for feed. According to the 1920 census there were 23,325 swine in the county, valued at \$325,457. The production of poultry is steadily increasing and a number of farms are devoted exclusively to this business. The 1920 census reported the total value of poultry and eggs in 1919 as \$404,965.

The adaptability of soils to certain crops is very generally recognized by farmers, but this relationship can not govern the distribution of crops in all cases, even on well-managed farms. On most farms excellent cultural methods are practiced, particularly in the preparation of ground for wheat and corn, and the subsequent cultivation of the latter.

The census returns for 1879 reported an expenditure of \$10,518 for commercial fertilizer; for 1909, \$35,482; and in 1919, the year of

high prices, 1,375 farmers paid out \$107,971 for fertilizers. In 1919, 59 per cent of all farms in the county reported the use of commercial fertilizer, and in 1921, 6,093 tons of commercial fertilizer were reported purchased.

Superphosphate (acid phosphate) is the principal commercial fertilizer. The majority of farmers purchase very little nitrogen, but use a mixture of phosphate and potash.

Commercial fertilizer is used chiefly on wheat land and is applied at the time of seeding in quantities of 100 or 200 pounds an acre. Where cornland has not recently been used as pasture or meadow, many farmers apply commercial fertilizer. Many farmers use clover sod and manure in growing corn, and many use no other fertilizer on average soils for ordinary farm crops. The quantity of barnyard manure on practically all farms is insufficient for the corn acreage. Since almost all the soils of the county are naturally low in organic matter, it is necessary to use fertilizers for good results.

As a rule stable manure is carefully conserved and scattered on stubble ground in late summer; but on a few farms it is spread on the fields as fast as it accumulates at the barns. The use of pulverized limestone for soil improvement is increasing, and in 1921, 164 tons, exclusive of dust and "planer chips" from the stone mills, were applied to the land.¹

Farm buildings are in good condition, and modern farm equipment is in common use. On the majority of farms labor is rarely hired, but on the larger farms and especially those on which there is a large acreage of hay or fruit, considerable hired help is required at certain seasons. In recent years the comparatively high wages paid by the stone industries have made farm labor scarce and expensive. In 1919 there was an average expenditure of \$287.74 per farm on 25.5 per cent of the farms in the county; in 1909 an average of \$126.91 per farm covered this outlay on 35.4 per cent of the farms.

According to census returns, the average size of farms has decreased from 157 acres in 1880 to 108 acres in 1920. During the same period the number of farms increased from 1,764 to 2,332.²

According to the 1920 census 79.2 per cent of the farms are operated by owners, 1 per cent by managers, and 19.8 per cent by tenants. The present prevailing rental is one-half the grain in the crib or bins and cash payment for hay and pasture land.

SOILS³

The mature or fully developed soils of Lawrence County are light in color, conforming in this respect to the mature soils developed in other places under conditions similar to those prevailing in Lawrence County.

There are two outstanding features of this environment: (1) A rainfall heavy enough to wet the soil to an indefinite depth, so that a

¹ Wiancko, A. T., Conner, S. D., and Jones, S. C. 1918. The Value of Lime on Indiana Soils. Purdue Univ. Agr. Expt. Sta. Bul. 213. 16 pp. (In Indiana Agr. Expt. Sta. Bulletin.)

Wiancko, A. T., and Jones, S. C. 1918. The Value of Manure on Indiana Soils. Purdue Univ. Agr. Expt. Sta. Bul. 222. (In Indiana Agr. Expt. Sta. Bulletin.)

² The tax assessor's figures show only 1,630 farms in 1921, but the difference in the census figures is due largely to many small acreages or farms without buildings not considered as farms by the assessors.

³ This chapter was prepared by C. F. Marbut,

moist condition, except in very short periods, is maintained throughout the soil and well into the parent rock; and (2) a forest cover under which the soils have developed. Much of the time, the soil is not only moist but through it percolates large quantities of rain water.

The heavy rainfall of the region is responsible for a soil characteristic that is common to all the mature soils, not only in Lawrence County, but in the region of which the county is a part, namely, the absence of lime carbonate or of any easily soluble salt in any part of the soil, no matter how much carbonate or other salts may have been present in the materials from which the soils have developed.

The statement that the mature soils of the county are light in color does not apply to a very thin top layer of dark leaf mold, but to the true surface layer of the soil. In the virgin or uncultivated areas still covered by forests there is always present a layer from 1 to 3 inches thick, of dark-colored mineral material blanketed by a thin cover of leaves and leaf mold. Notwithstanding the presence of this layer, the expression "soil color" is applied either to that part of the soil which is affected by farming operations or to that portion which is known in soil science as topsoil, or horizon A. In the first case the soil referred to constitutes a layer about 7 or 8 inches thick. When the material of this layer in cultivated fields has been mixed by plowing, the influence of the light-colored material is so much greater than that of the thin surface layer of dark material above that the whole layer becomes light in color. This holds true to a greater degree when we regard "soil" as meaning the topsoil, or horizon A, which in the mature soils of the region of which Lawrence County is a part, consists of material that is lighter in texture than that composing the subsoil.

All the well-drained soils of Lawrence County, even though some may be young or imperfectly developed, may be classed as light colored. Throughout the region in which the county lies, dark soils have developed under two conditions—(1) excessive water or very poor drainage, and (2) from a highly calcareous, unconsolidated material. Where a soil has developed from highly calcareous material, the dark color prevails only during the early stages of development, and in the later stages the soil is light in color.

The soil map of Lawrence County shows a belted distribution of the soils. Extending across the county are parts or all of four clearly defined belts running in a northwest-southeast direction. Beginning in the northeastern corner of the county, there is a belt in which Muskingum stony silt loam is the dominant type of soil and Bedford silt loam the principal subordinate type, the latter occurring most extensively in the southeastern part of the belt.

In a second belt Hagerstown silt loam is the dominant type of soil. In this belt, which averages about 5 miles in width, there are important areas of Bedford silt loam and other soils.

A third belt comprises Frederick silt loam as the dominant soil, though there are also rather large areas of Bedford silt loam. The boundary line between this third belt and the belt of Hagerstown silt loam begins very near the northwestern corner of the county and extends to very near the southeastern corner, dividing the county diagonally into nearly equal halves.

In the southwestern part of the county is part of a fourth soil belt which evidently extends into adjoining counties. In this belt occurs Muskingum stony silt loam and Tilsit silt loam about equally distributed. This belt is somewhat irregular in its distribution; instead of extending in a northwest-southeast direction as do the other belts, it runs northward along the western boundary of the county so that it includes not only the southwestern corner of the county, but also a narrow strip along the western side.

It will be noted that the Bedford soils are found in three of the belts mentioned. They have developed only on rather flat areas and their character has been determined to a greater extent by this than by the character of the parent material, although the latter has been one of the important factors in the differentiation of the predominant soils in the several belts.

THE MUSKINGUM-BEDFORD BELT

The Muskingum-Bedford belt is thoroughly dissected, so that the only areas of smooth upland in it are extremely narrow ridges or "hogbacks" between the streams. Even the small streams have cut moderately deep valleys, and on the slopes along the sides of the valleys Muskingum stony silt loam occurs. Generally it consists of disintegrated shale, and the soil, being in an early stage of development, has not a distinct profile or series of distinct layers differing in texture, color, or other characteristics. The surface layer of this soil represents thoroughly disintegrated material, some of the finer particles of which have been carried downward, resulting in the development of soils varying in texture from silt loam to loam. This layer ranges in thickness from a very few inches to about a foot. Beneath the surface layer the material consists of clay and sand, with shale fragments.

On the narrow ridges between the streams throughout most of the belt are narrow areas or stringers mainly of Bedford silt loam. A few areas have been mapped as Muskingum silt loam, and in other places as Tilsit silt loam. Along the southeastern part, larger areas of the Bedford soils extend into the Hagerstown belt to the southwest. In these larger areas Bedford silt loam has developed a more characteristic profile than in the smaller strips along the ridge tops.

The following description of typical Bedford silt loam from the surface downward is based on an exposed cross section of the soil within the city of Bedford.

(1) Horizon A, or topsoil, is composed of two layers, an upper 6-inch layer of gray or light grayish-brown silty material having an imperfectly developed granular structure, and a thicker subsurface layer. The subsurface layer is 15 inches thick and consists of material similar to the surface layer in texture. There are, however, a great many gray streaks and pockets or spots many of which are worm or insect borings, into which the gray material from above, presumably has been washed. The topsoil contains numerous pockets, evidently worm casts, which are filled with round soil granules. The granular character of the material composing the topsoil is due in part to the great number of these casts and in part to the fact that the soil material itself is finely granular, especially in

the surface layer. Some of these granules, except for being flattened, are similar to the structural particles of horizon B. It is apparent that the material of the subsurface layer was originally like that composing horizon B, but owing to the downward development of the layers resulting from the soil-forming forces, the material now comprising the subsurface layer of horizon A has acquired characteristics differing from that of horizon B. It will be noted that the dark thin surface cover which is always present in the uncultivated soil is absent in this soil, since it has long been cultivated.

(2) Horizon B, or the true subsoil, consists of two layers. The upper layer is of heavier-textured material, and is predominantly yellowish in color but with a faintly reddish shade. The material resembles that which comprises horizon B of all the normally well-developed soils of this region in that it breaks into angular chunks or particles which range in size from one-eighth to more than one-fourth inch in diameter. They are smaller in the upper portion of the layer than lower down. These structure particles are darker on the outside than on the inside; that is, either brownish or reddish brown on the outside and reddish or brownish yellow on the inside. Because of the comparatively early stage of development of this horizon, the material has not such definite lines of cleavage as that found in the corresponding horizon of the Hagerstown soils, so that the material breaks partly around these lumps or structure particles and partly through them. The color on the outside of the structure particles increases in intensity for a short distance downward, but within 12 inches from the top of this horizon faint gray spots appear along joints and cracks. These gray spots and streaks increase in number and thickness for about 6 inches downward, and the material then becomes predominantly bluish gray, as against the light gray of the material in horizon A. An examination shows that the gray color is present mainly on the outside of the particles even where all the material appears gray. Beneath this gray material is a layer of moderately heavy clay breaking vertically into imperfect columns. The upper ends are covered with gray silty material from the overlying layer which has been washed down into the cracks between the columns. The material inside the columns, however, is mottled with yellow, brown, and other dark colors, apparently the effect of iron or manganese oxide. This layer continues to a depth of about 24 inches.

Beneath this the material is looser than that in the layer above it. It is predominantly gray, but contains a number of yellowish-brown spots which increase with depth in size and number. There are occasional dark splotches and coatings on some of the particles. This layer continues to a depth of about 36 inches.

(3) Horizon C, or substratum, consists of red and gray mottled clay, immediately underlain by the limestone of which it is apparently the disintegrated product.

The Bedford soil described above has developed on a gently undulating area where the land is nearly flat. The upper part of horizon B, consisting of heavier-textured material, is somewhat paler in color and thinner, and the grayish color in the lower part is more prominent. The layer of imperfectly developed columnar material lying immediately below the grayish material seems to be somewhat better developed in proportion to the flatness of the land surface. A layer

of gray or grayish material underlying the layer of brownish or reddish material, designated here as horizon B, and itself underlain by a rather heavy clay with columnar breakage, is a characteristic feature of the soils lying on the smooth uplands in a large area of country in southwestern Indiana. These can not be properly described as the normally developed or mature soils of the region but rather as the product of a somewhat unusual development, the reason for which can not be discussed here. This includes especially the Tilsit and Gibson soils. The Bedford soils originally, without much doubt, belonged in the same stage of development, but have developed into a stage approximating somewhat more closely that which would be considered normal to the region. Where the Tilsit soils have been rather well drained during the later period of their development they resemble the Bedford soils. It is apparent, therefore, that the profiles of the Tilsit soils in the small areas along the narrow ridges in the northeastern part of the county where the belts are so narrow that they are well drained, approach those of the better-developed Bedford soils. They have been differentiated as Tilsit in these areas largely because the B horizon is brown rather than reddish, as in the Bedford soils, and because of development from sandstones and shales, the Bedford soils having developed from limestone material. This limestone, however, was somewhat less rich in carbonate than the limestone from which the Hagerstown soils have developed.

It is not only apparent that the Tilsit soils mapped along the narrow ridge tops in the northeastern part of the county have profiles less well developed than in the Tilsit soils in the southwestern part, but the same modification has taken place in the profile of the Bedford soils in the narrow strip which occurs in a similar position. Attention is here called to this relationship in order to point out the fact that the same type of soil may vary in its characteristics within a narrow range.

THE HAGERSTOWN BELT

Southwest of the belt in which Muskingum stony silt loam predominates is the Hagerstown silt loam belt, which is a rolling area. Even the ridge tops in many cases are undulating. Although the dissecting streams in this area are less numerous than in the northeastern part of the county, the flat tops of these ridges are little wider than those in the Muskingum-Bedford belt. This rolling and undulating surface is partly the result of the sinking of the earth's surface, following the dissolution of the underlying limestone. Limestone underlies other parts of the county also. Because of the prevailing undulating surface, the porosity of the underlying limestone, and other conditions under which the soils of this belt have developed, this belt is characterized by good surface and underground drainage. The soils, therefore, have developed profiles that are characteristic of the mature soils of the region of which the county is a part. The predominant features as evident in the soil layers from the surface downward are:

(1) Horizon A, or topsoil, is about 1 foot deep and consists of a surface layer of light-brown material, the lower portion of which is more yellowish. In forested areas this topsoil has a thin covering of leaves and leaf mold, underlain by a thin layer of dark material.

This dark layer is usually granular, although the material beneath it is single-grained or silty and has a more or less well defined lamination. The lamination, however, is not usually so well defined as in the corresponding layer of the Tilsit and Bedford silt loams, probably because of their having developed under conditions of less perfect drainage. Observations show that lamination of the soil is developed in inverse proportion to the development of the drainage. This topsoil is lighter in texture than the material of the subsoil.

(2) Horizon B, the true subsoil, varies in color from slightly yellowish brown to reddish brown, and is heavier in texture than the topsoil. This subsoil material breaks readily into well-defined angular chunks or particles which range in size from one-eighth to one-half inch in diameter, the material near the top of the horizon breaking into the smaller pieces. There is usually a marked difference in color between the outside and the inside of these lumps or particles, the outside being a pronounced reddish brown and the inside yellowish. These structural particles are better developed than those in the corresponding layers of the Bedford soils, so that here the soil material, in conditions of optimum moisture, is more likely to break around the chunks than through them. This layer in some places may range in thickness to more than 2½ feet; and the gray, faintly columnar layer, which is so marked a feature of the lower part of horizon B of the Bedford soils, is entirely lacking in the Hagerstown soil.

The subsoil material of the Hagerstown soil grades downward into moderately heavy, though somewhat loose, clay which nevertheless is sticky and plastic, and which is underlain by the limestone of which it seems to be the disintegration product.

It will be noted by an inspection of the map that there are narrow belts of Bedford soils along the ridge tops in parts of the Hagerstown belt. On the steeper slopes along the sides of the valleys a shallow phase of Hagerstown stony silt loam has been mapped, and lower down on the slopes, especially in the southeastern part of the area, strips of considerable width of Muskingum stony silt loam. Both of these soils differ from the Hagerstown soils in that they lack a true subsoil, owing to the fact that the materials have accumulated on these slopes so recently that not sufficient time has elapsed for the development of a true subsoil, or horizon B. These soils are in the process of development, so that profiles are incomplete or imperfect. The shallow phase of Hagerstown stony silt loam will eventually develop into Hagerstown silt loam, and Muskingum stony silt loam will presumably develop into a soil whose profile will be normal but different from that of the Hagerstown silt loam in having a more nearly yellow subsoil, or horizon B, and a less red substratum of disintegrated material.

THE FREDERICK BELT

Southwest of the belt of Hagerstown soils is the Frederick silt loam belt. Along the northern part of this belt there are numerous areas of Bedford soils which occur on the flat tops of ridges. The Frederick soils are in certain respects intermediate in character between the Hagerstown and the Bedford soils.

Frederick silt loam, as found in an area about 2 miles southeast of the city of Bedford, may be described as follows, according to the layers from the surface downward:

(1) A surface layer of grayish-brown or light-brown material about 4 inches thick, with the usual thin covering of dark material under the forest litter.

(2) A 5-inch layer of yellowish silt loam.

(3) A layer of reddish-yellow material grading downward into yellowish red. The color of a cut surface is yellow, whereas a broken surface is reddish. In the first case the color is determined by the yellow interior of the structural particles, and in the latter case by their red exterior. The material is heavier than that composing the topsoil, but no heavier than the corresponding material in Hagerstown silt loam. This constitutes the horizon B, or true subsoil, which characterizes the mature soils of this region. In the lower part a very few faint grayish spots indicate a relationship to Bedford silt loam. The quantity of gray material increases with depth but is nowhere so marked as in the corresponding horizon of the Bedford, or of any other soil developed in the smooth areas of the region.

(4) A layer of dull reddish-brown, rather heavy clay or silty clay having a faintly columnar structure suggesting conditions which obtain to a much greater extent where the Bedford soils were developed.

Normally developed or mature Frederick soils do not have a columnar layer nor the gray layer above it. The soil is practically the same in texture and in the number of layers with the Hagerstown soils. It differs from them in its pale color throughout and in its somewhat heavier substratum material. The soil materials have originated from limestone, but the limestone is less pure, or contains a lower percentage of carbonate and a correspondingly higher percentage of argillaceous material than does the limestone from which the Hagerstown soils have developed.

THE MUSKINGUM-TILSIT BELT

The fourth and last belt of soils in the county is in the southwestern corner and includes a strip 4 or 5 miles in width parallel to the western border. It includes two soils about equal in extent, Muskingum stony silt loam and Tilsit silt loam, though in part of the belt there is considerable Frederick silt loam.

The Muskingum stony silt loam corresponds in general character and position of occurrence with this type of soil occurring in other parts of the county. It is found on comparatively steep slopes, and is derived from disintegrated sandstone and shale material.

The Tilsit soils also have developed from material accumulated by the disintegration of sandstone and shale, mainly shale. Instead of occurring on rather steep slopes on the sides of the valleys, however, they occur on the smooth ridge tops. This is the usual position of Tilsit soils.

The map, however, shows areas of Tilsit soils which evidently are not along the ridge tops. These have been designated as an eroded

phase of Tilsit silt loam which differs from the typical soil mainly in having developed from sandstone and shale material washed from the valleys in the areas of Muskingum stony silt loam, and spread out as sloping fans at the foot of slopes. Because of occurring on slopes rather than on flat ridge tops, the surface soil has been rather severely eroded in many places. The designation "eroded phase" does not tell the whole story, for the differentiation is also based on its development from material that has been deposited by water. It is possible that in the future this soil will be grouped in some other series, but for the present it is classed Tilsit soil, because of its profile and because of the mineralogical character of the parent material.

The profile of the Tilsit soil on the ridge top about 3 miles northwest of Mitchell, Ind., may be described as follows:

(1) A layer about 10 inches thick of single-grained material varying in color from grayish brown to pale yellow and having a well-defined lamination. In forested areas there is the usual thin covering of more granular, dark material.

(2) A layer of material which, within a depth of a very few inches, shows the well-defined granular structure characteristic of this horizon in the normally developed soils throughout this region, and which becomes gradually heavier and less definitely laminated with increasing depth. The granules have a slightly deeper yellow color on the outside than on the inside. They are soft and somewhat imperfectly developed, so that in condition of optimum moisture the material breaks through the lumps as well as around them. This layer continues to a depth of 24 inches.

(3) A layer of yellow material with no apparent lamination and less well-developed granulation than that in layer 2. Gray spots, which first appear in the upper portion, increase in number downward until within a few inches it is a decided gray material without lamination or granulation.

(4) A layer of heavier material, which in the upper portion breaks into moderately well-defined columns. The tops of the columns are rounded, and gray material from the layer immediately overlying it has been washed into the cracks between the columns. This layer is about 6 inches thick.

(5) A layer of comparatively loose material mottled yellowish brown and gray and containing some dark splotches presumably of iron or manganese oxide.

This soil differs from the soils derived from limestone, such as the Frederick and Hagerstown, in that there is practically no suggestion of red anywhere in the soil. In places where the drainage is most nearly perfect, a faint reddish color may develop, but the normal color of the comparatively heavy subsoil material in the Tilsit soils is yellow. The gray layer in the lower part of the heavy horizon of the Bedford and Tilsit soils, as well as the columnar layer beneath it, are unusual, or may be designated as "abnormal" features.

OTHER SOILS

In the vicinity of the town of Mitchell, and in other practically level areas scattered rather widely over the county, is a soil which has been mapped as Guthrie silt loam. This soil consists of a very

light-brown surface layer underlain at a depth of about 6 inches by a layer of gray material mottled with brown and yellow and having about the same texture as that of the first layer, the two constituting what is usually called horizon A. The subsoil, or horizon B, consists of gray or bluish-gray heavy clay having a great many brown and yellowish-brown spots and a considerable number of dark spots, presumably of iron oxide. In the third horizon the material is mottled gray and brown and is somewhat lighter in texture and more friable in consistence than that of the subsoil.

Another soil similar in profile, but which has developed on level terraces along the streams, is McGary silt loam. It differs from Guthrie silt loam largely in position of occurrence and in the material from which it has been developed. The material does not necessarily differ in composition, but it has accumulated by deposition from water, whereas the material from which the Guthrie soils have developed was accumulated apparently by disintegration of limestone rock. Both soils occur in very flat areas.

Lickdale silt loam is mapped in a few small areas in the northern part of the county in association with eroded phase of Tilsit silt loam. Its profile and parent material do not differ essentially from those of the Tilsit soils, and in this general description of soils and their relationships it may be considered as a member of the Tilsit group.

Another soil similar to the McGary and Guthrie soils and developed on terraces, is the Calhoun silt loam. This soil is unimportant, as its occurrence is very limited. A rather detailed description will be found under the proper heading on a subsequent page.

A comparatively important soil occurring along White River in considerable areas is Princeton fine sandy loam, in which the profile is as fully developed as in Hagerstown silt loam. Hagerstown silt loam and Princeton fine sandy loam are the two representative soils of the region, which have developed under well-drained conditions and have reached a mature stage of development. Briefly, Princeton fine sandy loam consists of a light-colored topsoil of fine sandy loam and a heavier brown or faintly reddish brown subsoil with a well-defined structure identical with that in the corresponding horizon of Hagerstown silt loam and having the same distribution of color in the structural particles. This horizon, which continues to a depth of about 3 feet, is underlain by loose material mainly fine sand, which at a depth of 10 feet or more contains a sufficient quantity of lime carbonate to effervesce with hydrochloric acid. This is wind-deposited material, called loess. The soil is productive.

Two other soils in the county, Elk fine sandy loam and Fox loamy sand, have attained a stage of development almost like that of Princeton fine sandy loam. The profile of Fox loamy sand is less well developed than that of Elk fine sandy loam. These soils are unimportant, occurring only in patches on smooth terraces along streams. Because there is no definite relationship between these and the other soils in this region, it is not necessary to describe in detail their profiles.

Four series of soils are represented by the recently laid alluvium along the streams of the county. These were differentiated on the basis of texture and drainage conditions into seven types. They are all imperfect in their development, since the material has been

recently deposited, and but slightly, if at all, modified by soil-forming processes. Their characteristics need not be described here, since their general features may be ascertained by reference to the descriptions on a subsequent page.

TYPES OF SOIL

In subsequent pages of this report the different types of soil occurring in Lawrence County are described, and their agricultural importance discussed. In the following table are given the names, acreage, and proportionate extent of the soils mapped in the county.

Acreage and proportionate extent of the soils in Lawrence County

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Hagerstown silt loam.....	24,320	10.1	Elk fine sandy loam.....	768	.3
Shallow phase.....	4,352		Elk silt loam.....	576	.2
Hagerstown stony silt loam, shallow phase.....	15,232	5.4	Calhoun silt loam.....	192	.1
Frederick silt loam.....	27,328	25.4	Huntington silt loam.....	6,976	2.4
Eroded phase.....	33,280		Huntington very fine sandy loam.....	6,080	2.1
Rough phase.....	9,408		Huntington fine sandy loam.....	2,688	1.4
Shallow phase.....	2,368		Colluvial phase.....	1,472	
Bedford silt loam.....	40,064	14.1	Genesee silt loam.....	4,224	1.5
Lawrence silt loam.....	2,752	1.0	Genesee silty clay loam.....	1,856	.8
Muskingum stony silt loam.....	40,440	14.2	Poorly drained phase.....	320	
Muskingum silt loam.....	1,600	.6	Genesee fine sandy loam.....	1,792	.6
Tiltsit silt loam.....	19,328	11.7	Holly silt loam.....	5,184	1.8
Eroded phase.....	12,096		Waverly silt loam.....	1,280	.5
Flat phase.....	1,664		Waverly silty clay loam.....	192	.2
Princeton fine sandy loam.....	4,864	1.7	Dark-colored phase.....	256	
Guthrie silt loam.....	4,416	1.5	Rough stony land.....	2,496	.9
Lickdale silt loam.....	384	.1	Quarries.....	320	.1
Fox loamy sand.....	1,664	.6			
McGary silt loam.....	1,920	.7	Total.....	284,160	-----

HAGERSTOWN SILT LOAM

The surface soil of Hagerstown silt loam is rather dark brown smooth silt loam, 6 or 8 inches deep. The subsoil, to a depth of 18 or 20 inches, is brown, friable or crumbly silty clay loam material which is more compact at greater depth. At a depth of about 36 inches a heavy, reddish-brown silty clay appears and continues down to the underlying limestone. In a few places the lower subsoil is too compact to permit the free movement of ground water or deep aeration. This soil is associated with the Bedford limestone, and in places on steeper slopes outcrops of this rock occur.

The soil occurs on undulating or gently rolling uplands somewhat below the general level of Frederick and Bedford soils. The largest areas are east and northeast of Bedford, and smaller areas occur between De Witt Creek and the eastern county boundary.

All Hagerstown silt loam is under cultivation, with the exception of a wood lot here and there, where the preponderance of large sugar maple, walnut, oak, ash, and some tulip poplar probably indicates the character of the original forest. All farm crops commonly grown in this area are successfully raised on this soil. Because of its friable consistence, it responds exceptionally well to good management, and withstands either droughts or excessive moisture. The organic matter is naturally low and has been further reduced by

almost continuous cropping. Both its topsoil and subsoil are acid, and in common with other limestone soils of the county, it requires phosphate. Corn yields from 30 to 40 bushels an acre, with returns of 50 to 60 bushels under favorable conditions. The range in wheat yields is variable, but crops of 20 bushels to the acre are not uncommon. Clover generally makes a good stand the first season, but seldom does well the second. Small fields of alfalfa on this soil indicate a fair adaptation to this crop but liming is necessary for a permanent and profitable stand. Bluegrass, timothy, and orchard grass are common along roadsides and constitute much of the pasturage in wood lots. Apple, pear, and peach trees in farm orchards produce well. This is a very desirable soil for general farming.

Values of highly improved farms range from \$75 to \$100 an acre, but much land is sold for \$50 an acre.

Hagerstown silt loam, shallow phase.—The surface soil of Hagerstown silt loam, shallow phase, is dark-brown, smooth, friable silt loam, underlain by crummy silty loam material to depths of 18 or 20 inches, beneath which is a heavier and slightly more compact reddish-brown, granular, silty clay, resting upon the bedrock at depths of 4 or 5 feet.

This soil is associated with typical Hagerstown silt loam and occurs on lower gentle slopes of hillsides where the typical soil is found on the crests of the ridges. Slopes are smooth, but moderately steep, and in places have rock outcrops and bluffs.

The larger areas of Hagerstown silt loam, shallow phase, are mapped north and northeast of Bedford, and elsewhere in the northern part of the county in association with the typical soil. Smaller developments which include some hilly land occur near Leesville and Tunnelton.

Most of this land is now used for pasture and hay meadows. Some alfalfa is grown though this is a more favorable soil for clover and bluegrass than the lighter-colored limestone soils. It is not highly acid.

Most of the soil of this phase is on farms consisting largely of other upland soils so that an estimate of a sale price for it is not possible.

HAGERSTOWN STONY SILT LOAM, SHALLOW PHASE

Hagerstown stony silt loam, shallow phase, is smooth, dark-brown silt loam underlain by dark reddish-brown silt loam or friable silty clay loam material which prevails to bedrock.

It is found on the steeper slopes and somewhat broken margins of the uplands where Bedford limestone crops out, and also may occur on bluff slopes bordering small stream valleys, such as along Leatherwood Creek near Bedford. In the eastern part of the county it usually occurs at the heads of drainage ways, whereas in the western section it occurs along the main waterways. Degree of slope, depth of material, and rock outcrops are important factors in determining variations.

As a rule, areas of this soil are somewhat smoother than those of the eroded phase of Frederick silt loam. The rock is more uniformly covered with soil, there being few prominent or extensive outcrops.

Much of the land is included in partially wooded pastures. Bluegrass, timothy, and orchard grass do especially well on the moist, partly sheltered northern slopes.

FREDERICK SILT LOAM

The surface soil of Frederick silt loam is very friable, light-brown or slightly yellowish brown silt loam, which crumbles and becomes very fine when tilled. The subsoil, at a depth of 6 or 8 inches, is slightly heavier and more compact than the topsoil, and grades, at a depth of 15 or 20 inches into brown or slightly reddish brown crummy silty clay loam material. At a depth of about 30 inches, the lower subsoil is red, waxy or tough plastic clay containing some chert fragments. At depths varying from 4 to 5 feet, heavy sticky red clay is encountered, and just below this is limestone. Both topsoil and subsoil are acid.

This description applies to the smoother areas, but some variations are included on the map. On some flats and on many gentle slopes, Bedford silt loam or a phase of that soil is found. In such places, the surface soil is lighter colored, and more or less compacted grayish material occurs at variable depths. On slopes the slight depth to red clay is revealed in many places by the reddish-brown coloration of the surface soil. In the latter locations fragments of chert are usually abundant and ledges of limestone may be partially exposed. As mapped, the soil includes areas in which there are comparatively few sinks (Pl. LVI, fig. 1), chert-covered ridges, or clay spots.

Nearly all this soil is included in cultivated fields, and many large apple and peach orchards are located on it. It is a desirable soil and is similar to Hagerstown silt loam in crop adaptation. Several of the oldest commercial orchards, south of Mitchell, are located on this soil in conjunction with some phases of Bedford silt loam. These soils are well adapted to apples and other tree fruits and the trees thrive well, though the rate of growth is less uniform where the surface soil has been washed off, exposing the red clay. The 20-acre apple orchard, 3 miles southeast of Mitchell, under the management of Purdue University Agricultural Experiment Station, is located on a smooth deep variation of this soil.

Considerable alfalfa is grown on this land. Some small fields have been established for 10 or 12 years, but most seedings are much more recent. Three cuttings are usually obtained, but in a dry season the last cutting is light. The total yield usually ranges from 2½ to 3 tons an acre. The heaviest crops of red clover are obtained on land that has been limed, but timothy, redtop, orchard grass, and bluegrass persist in unlimed meadows and pastures.

Improved farm land sells from \$75 to \$100 an acre.

Frederick silt loam, eroded phase.—Frederick silt loam, eroded phase, occurs in the hilly or broken areas associated with Mitchell and other limestones. Although the depth to the limestone is extremely variable, it is usually less than 30 inches, and in places there is only a brown silty rock residue above the limestone. Chert fragments and outcrops of limestone are abundant.

Less than 1 per cent of this soil is tilled, and this is confined to the gentler slopes. A somewhat greater proportion consists of old fields

so badly gullied that further tillage is impracticable, and a much larger part is in partially wooded pastures. The roughest portions, usually at the heads of tributary drainage ways, and on bluffs or very steep short slopes along streams, are thickly wooded with rapidly growing young trees.

The pasture value of this soil is enhanced by numerous springs. In general, the land may be more profitably utilized for forests and pasturage than for cultivated crops.

Frederick silt loam, rough phase.—Frederick silt loam, rough phase, includes areas of the typical soil in which sinks are very numerous. East and northeast of Mitchell these sinks are so numerous that the surface is chiefly bowl-shaped depressions separated by rims or rather narrow flat-top divides. The floors of the sinks may be from 25 to 50 feet below the level of the rims, and in the larger areas west of Dixie Highway and those north of East Fork White River the depressions are from 100 to 150 feet deep.

Much of this soil has been cultivated, but is now covered with brushy pastures, in which sassafras, scrubby oaks, small hickories, and young tulip poplars are taking possession of the gullied slopes, and blackberries, dewberries, cinquefoil, goldenrod, and other weeds cover the ground more recently abandoned. Overgrazing and occasional exposure of the rather highly acid subsoil account for the sparse growth of bluegrass. Seeded clover and timothy pastures and hay meadows give fair returns.

Many of the sinks hold water throughout the year and serve as local watering places for livestock. Others are bare mud flats during the summer. Frederick silt loam, rough phase, is better suited for pasture than for cultivation, and many old fields on which brush and weeds are now the principal vegetation could be made good permanent pasture or be planted to tame grasses and legumes.

This land includes many suitable sites for rural homes where a small acreage for pasture, orchard, and garden is desired.

Frederick silt loam, shallow phase.—The surface layer of Frederick silt loam, shallow phase, consists of floury, light-colored, very fine textured silt loam which becomes yellowish gray or very pale yellow with increasing depth, and grades into a crummy red silty clay at a depth of 4 or 6 inches. This is underlain by a sticky brick-red clay which continues down to the underlying limestone. Below the surface where the material is less thoroughly oxidized, dull grayish-brown and reddish-brown colorations are apparent where the soil cracks. On slopes the silty surface layer is thin or may be entirely lacking, leaving exposed a silty clay, rather friable when dry, but very sticky when wet.

Frederick silt loam, shallow phase, occurs only in the southeastern part of the county, and mapped areas include patches of Lawrence and Bedford soils. Small circular sinks and irregular depressions vary the surface of areas of this soil, and some of them retain water throughout the year.

The original forest cover included much white oak, post oak, and red oak, and some walnut, elm, ash, and hickory. Land formerly in cultivation is now covered by a growth of hazel, sumac, sassafras, and other small bushes. About 15 per cent of this land, confined to fields on the smoother surfaces, is in cultivation, and the grayish

silty soil over the red clay as seen in freshly plowed fields has considerable range in color and tilth. This soil is better adapted to the production of grass and forage crops than to the production of corn or wheat. Clover does very well in most places, and alfalfa could be grown in the more loamy depressions.

BEDFORD SILT LOAM

Bedford silt loam is smooth, friable, light-brown silt loam to a depth of 6 or 7 inches. The upper subsoil may be heavy silt loam grading into somewhat more compact yellowish-brown silt loam material, or silt loam slightly less friable than the surface soil, and it is underlain by yellowish-brown silty clay loam material, which, below depths of 20 or 30 inches is compact and mottled gray, yellow, and rust brown. Below this is tenacious red clay, at a depth of about 40 inches, and limestone is found at 5 or 6 feet. In places the mottled gray layer of the subsoil is only a few inches thick, but in general it is sufficiently developed to obstruct the downward movement of water. In small flat areas this soil resembles Lawrence silt loam or Guthrie silt loam. On gentle slopes and in locations where underdrainage is accelerated by sinks, Bedford silt loam grades into Frederick and Hagerstown silt loams.

This soil occurs on high gently rolling uplands, but near Fayetteville it is in a valleylike depression surrounded by higher lands. The original forest growth on Bedford silt loam included sugar maple, walnut, tulip poplar, and beech. Most of the land is now in cultivation, and corn, wheat, oats, clover, and timothy are the principal crops grown. Some alfalfa is raised, and with both alfalfa and clover the best results are obtained by liming. In many old fields timothy, redbud, and orchard grass thrive better than clover.

Land of this kind has not been so generally used for fruit growing as Frederick silt loam, but the great variety of fruit and ornamental trees grown in yards and farm orchards indicates its adaptability to such uses. Although more susceptible to drought than Hagerstown and Frederick soils, this difficulty is largely overcome on those farms where good tillage is regularly practiced and some organic matter incorporated in the soil by applying barnyard manure or plowing under crop residues and weeds.

The Moses Fell annex, a 600-acre farm near Bedford, under the direct management of the State experiment station, is chiefly Bedford silt loam, with Frederick silt loam as the prevailing soil on the rougher land. The experiment field is located on a rather heavy variation of this soil in which the grayish subsoil horizon is slightly more than 20 inches below the surface. The experimental plots include some Lawrence silt loam, and all have had tile drains installed for several years. The results of improved drainage and thorough tillage are evident in the somewhat better physical condition of the surface soil here than in fields elsewhere which have not been so well managed. The results of the experimental work at Moses Fell annex is of great interest and value in the fertilization and general management of all limestone soils, but is of special importance with respect to Bedford silt loam.⁴

⁴ See Indiana Agricultural Experiment Station, Lafayette, Ind. Publications pertaining to Bedford experiment field, Moses Fell annex.

The prices for improved land vary from about \$40 to \$75 an acre, but may be as low as \$10 or \$15 an acre for land which has many sinks or chert-covered spots where the soil has been washed off.

The following table gives the results of mechanical analyses of samples of the topsoil and subsoil of Bedford silt loam:

Mechanical analysis of Bedford silt loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
2829103	Topsoil, 0 to 7 inches.....	1.9	1.6	0.5	1.0	9.9	68.7	16.4
2829104	Subsoil, 7 to 14 inches.....	1.4	1.2	.5	.8	11.2	67.7	17.2
2829105	Subsoil, 14 to 24 inches.....	1.0	1.2	.4	1.2	6.4	69.8	20.0
2829106	Subsoil, 30 to 40 inches.....	.8	.8	.2	.8	8.5	63.7	25.1
2829107	Subsoil, 48 to 50 inches.....	1.4	1.2	.4	1.8	10.8	54.1	30.5

LAWRENCE SILT LOAM

The surface soil of Lawrence silt loam is light grayish-brown very friable silt loam, 6 or 8 inches deep, and is underlain by a light, mottled subsoil containing some very small iron concretions. The lower subsoil is light-brown compact silt loam or silty clay loam material with mottlings of yellow and brownish yellow, and continues to depths ranging from 24 to 30 inches, where it grades into friable, compact, mottled gray and brown silty clay immediately above a red clay substratum.

Because of the poor drainage resulting from the occurrence of this soil on flat or in slightly depressed areas of the upland limestone soils and from the subsoil consistence the crops are damaged during periods of heavy rainfall; but in normal seasons or even in seasons of light rainfall the crops are fairly good.

All the common farm crops are grown, but timothy, redtop, millet, and sorgo are more certain crops than clover or grain. Profitable crop yields depend to a considerable extent on tillage and previous soil treatment. Tile drainage and the liberal use of lime and phosphate fertilizers are necessary for best results.

The following table gives the results of mechanical analyses of samples of the topsoil and subsoil of Lawrence silt loam:

Mechanical analysis of Lawrence silt loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very sand	Silt	Clay
		<i>Per cent</i>						
282945	Topsoil, 0 to 6 inches.....	0.4	0.5	0.2	1.6	9.2	66.8	21.4
282946	Subsoil, 6 to 24 inches.....	.2	.2	.0	.6	8.4	65.3	25.3
282947	Subsoil, 24 to 36 inches.....	.2	.4	.2	2.4	9.2	61.5	26.2
282948	Subsoil, 40 to 50 inches.....	1.4	.6	.3	3.0	8.4	45.0	41.3
282949	Subsoil, 5 to 7 feet.....	.6	.2	.2	1.4	5.2	39.0	53.4

MUSKINGUM STONY SILT LOAM

Muskingum stony silt loam has brown, shallow, more or less stony silt loam topsoil with a lighter-brown or yellowish-brown subsoil, usually containing many rock fragments, and lying on bedrock at

depths of 2 or 3 feet. Throughout the northeastern part of the county where this soil occurs on the steep slopes of narrow divides, the soil is brown silty loam or fine sandy loam, underlain by partially decomposed and disintegrating sandstone or shale. The areas in the western part of the county have more rock fragments on the surface than those in the eastern part.

The surface of this land is steep and broken. On narrow ridge tops and on the less steeply sloping portions of hillsides, the deeper soils may have yellowish-brown compact subsoils. Some of these areas have been cleared, but usually are abandoned after a few seasons. The forest growth on this soil in the eastern part of the county consists of chestnut and other trees, which supply firewood, posts, and saw logs. Nearly all Muskingum stony silt loam is either forested or is used for pasture, but seems best adapted to timber growth, since bluegrass, timothy, redbud, and orchard grass do not flourish.

MUSKINGUM SILT LOAM

Muskingum silt loam consists of a brown or yellowish-brown, friable, silty topsoil, underlain by a heavier, friable silt loam or silty clay loam subsoil. In places the lower subsoil is reddish or dull chocolate brown and contains rock fragments, and where the underlying rock is bluish-gray shale the soil and subsoil may be heavier, with some tendency to seepage and otherwise variable moisture conditions. As a rule, the rolling surface prevents the accumulation of excessive moisture even in the heavier areas.

The larger areas of this soil near Back Creek and north of Tunnelton occur on sandstone and shale divides with less rugged slopes than those of Muskingum stony silt loam. In the extreme western part of the county this soil occurs on many of the narrow hogbacks of the sandstone ridges, and in the northern part small areas are found on narrow ridges with steep slopes.

About half the Muskingum silt loam is in open pasture or small fields around farmhouses. Fruit trees and garden crops do well, but pasturage is poor. The forest growth includes much red oak, sassafras, persimmon, and a few chestnut trees.

The results of mechanical analyses of samples of the topsoil and subsoil of Muskingum silt loam are given in the following table:

Mechanical analysis of Muskingum silt loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
282969	Topsoil, 0 to 8 inches.....	0.0	0.0	0.5	0.6	9.6	77.4	12.1
282970	Subsoil, 8 to 24 inches.....	.0	.0	.0	.2	9.2	65.4	25.3
282971	Subsoil, 24 to 30 inches.....	.0	.0	.1	.2	4.0	65.9	29.7
282972	Subsoil, 30 to 40 inches.....	.0	.0	.2	.2	5.6	58.9	35.2

TILSIT SILT LOAM

Tilsit silt loam is very friable, light-brown slit loam low in organic matter, grading at a depth of 6 or 8 inches into light yellowish-brown or brownish-yellow silty clay loam which is underlain,

at depths ranging from 20 to 30 inches, by a gray, more compact silty clay loam material with yellow and brown mottlings. This material continues downward to the disintegrated and decomposed sandstone or shale. Both topsoil and subsoil are distinctly acid.

On steep slopes and narrow ridges the surface soil is brown and the subsoil material is not compact. A poorly drained phase of this soil occurs on some level spots.

Tilsit silt loam occurs most extensively in the hilly or broken region of the southwestern part of the county, where it is found on top of the highest divides. The soil surface is undulating or gently rolling.

Most of this land has been cleared and perhaps 50 per cent is in small farms. The remainder is used for pasture, and much of it supports a tree growth of sassafras, small oak, hickory, and persimmon. (Pl. LVI, fig. 2.) Walnut, elm, ash, hard maple, and tulip poplar are less common. Sedge grass, whitetop, and wild carrot grow in the pastures, and poverty grass (*Aristida tuberculosa*) grows on flat, poorly drained spots and on slopes where much of the surface soil has been removed. Redtop commonly grows in meadows that were originally seeded to clover and timothy.

On this soil wheat yields from 12 to 20 bushels an acre and corn about 23 bushels. In recent years, commercial apple and peach orchards have been planted on this soil, the trees thriving and yielding well. The orchards require crops to prevent washing.

The value of this land is considerably below that of the limestone lands. As a rule the improvements are not so good, and many farms are less conveniently located with respect to public roads.

Tilsit silt loam, eroded phase.—Tilsit silt loam, eroded phase, is friable, brown silt loam underlain by a heavier yellowish-brown silt loam or silty clay, containing more or less disintegrated rock in the lower subsoil. It occurs at the heads of drainage lines. Most of it supports a growth of scrubby trees, but a small acreage is under cultivation though the land is of little agricultural value except for pasture. (Pl. LVII.)

Tilsit silt loam, flat phase.—The flat phase of Tilsit silt loam differs from the typical soil in that it occurs as level or flat areas and consequently has poor surface and internal drainage, and in that the soil is shallow, bedrock usually being within a few feet of the surface.

Areas of this soil occur from 75 to 100 feet below the general upland, on the sloping benchlike uplands north of Little Salt Creek. Along upper Back Creek the areas lie at lower levels, though there are a few patches of this soil on the high ridge in the western part of the county.

This land is used chiefly for pasture. Poverty grass is growing in old abandoned fields, and on one farm, where lime is used in the form of "planer chips," or fine refuse from the stone mills alsike clover does well. Rome Beauty, Maiden Blush, and Winesap apples are grown near Bartlettsville.

PRINCETON FINE SANDY LOAM

Princeton fine sandy loam is loose, dull-brown or grayish-brown fine sandy loam, sand or coarse sand. The coarser-textured material

continues to a depth of 2 feet with little change, but the fine sandy loam is underlain, at depths ranging from 10 to 20 inches, by stiff brown loam or sandy loam material which, with increasing depth, grades into gritty, reddish-brown sandy clay. In most places the topsoil and subsoil are acid.

This soil occurs along East Fork White River, closely associated with Fox loamy sand. It is found on slopes above the latter soil and usually extends to the adjacent hilltops. The surface of the areas may be level, sloping, or hilly, and there is much evidence of drift by wind. The drainage is good, in some places excessive. This soil is low in organic matter and leaches rapidly.

This land, with heavy fertilization, is used to some extent for corn and wheat. Clover does well and alfalfa is successfully grown, these legumes thriving better on the darker-colored and lower sandy areas. Melons, cantaloupes, and tomatoes are grown with less danger of injury by frost than on lower-lying soils.

The results of mechanical analyses of samples of the topsoil and subsoil of Princeton fine sandy loam are given in the following table:

Mechanical analysis of Princeton fine sandy loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
282926	Topsoil, 0 to 8 inches-----	0.2	4.7	17.3	51.2	8.6	14.2	3.7
282927	Subsoil, 8 to 24 inches-----	.0	5.8	19.8	51.2	8.2	11.1	3.9
282928	Subsoil, 24 to 36 inches-----	.0	5.4	17.4	47.4	8.5	13.3	8.1
282929	Subsoil, 8 to 10 feet-----	.0	7.6	21.6	56.3	5.2	5.1	4.1

GUTHRIE SILT LOAM

Guthrie silt loam in cultivated fields is gray or light brownish-gray silt loam, about 6 inches deep, over an upper subsoil of mottled light-gray, friable silt loam. This is underlain by a compact mottled silty clay loam material. Both topsoil and subsoil give an acid reaction, and in many places yellowish and brownish stains and small brownish ferruginous concretions are very numerous in the lower part of the surface soil, and even more numerous in the subsoil. The soil contains very little organic matter.

The soil is associated with Bedford silt loam, occurring on flat or nearly level areas where excess water runs off slowly, and downward percolation is prevented by the compact lower subsoil. Where associated with Lawrence silt loam, it lies in more poorly drained situations.

Beech, red, white, and post oaks are the predominant trees with here and there a sweet gum, birch, or soft maple tree. With adequate drainage, crop adaptations on this soil are similar to those on Lawrence silt loam.

LICKDALE SILT LOAM

The surface soil of Lickdale silt loam is light-gray silt loam containing small brown concretions. The subsoil to a depth of about 20 inches consists of gray silt or silty clay loam material very much

mottled with rust-brown and yellow. Below this the material is compact and offers much resistance to the movement of ground water. Under normal moisture conditions the surface soil is rather friable, but when wet it becomes "clammy" and tends to pack on drying.

This kind of soil is on the terracelike slopes of the uplands which border Little Salt Creek Valley in the northeastern corner of the county. A few small areas on stream terraces also occur near Guthrie and Back Creeks. Other patches occur on high divides where sandstone and shale form the bedrock. Both surface and internal drainage are poor, causing a tendency to oversaturation during rainy periods and excessive dryness during droughts.

Fair yields of corn are obtained, but most of this land is used for pasture. Timothy and redtop do well if poverty grass and small weeds do not invade the pasture.

FOX LOAMY SAND

Fox loamy sand is dark-brown or very slightly reddish-brown medium or coarse sand, which contains sufficient fine material to impart some coherence when moist. This may continue downward with no change, except a lightening in color, until at depths varying from 5 to 8 feet, a highly calcareous, loose, gray sand is encountered. In places a heavier, reddish-brown subsoil occurs above the calcareous sand.

This soil occurs on terraces along East Fork White River and in places extends up the valley slopes. The low rounded ridges and mounds over the surface are indicative of æolian work.

The texture and consistence of the soil are highly favorable to deep and easy penetration of plant roots as well as to good drainage and deep aeration. Land of this kind is suitable for growing water-melons, cantaloupes, and sweet potatoes, and a considerable acreage is devoted to these crops. Alfalfa does well, and several hundred acres are seeded in this each year. A stand of alfalfa is easily obtained by seeding in the spring or late summer, with neither a nurse crop nor lime. Three cuttings a year are made and the yields under favorable conditions are 2 or 3 tons an acre.

The value of land conveniently located for truck gardening or seeded to alfalfa is around \$100 an acre.

M'GARY SILT LOAM

McGary silt loam is a floury, light-gray silt loam, which becomes ash gray and sticky when wet, and is underlain to a depth of 12 inches by a layer of pale yellowish-gray heavy silt loam with brown and yellowish mottlings and small soft dark-brown concretions. Below this, tight silty clay loam material, brown or yellowish brown, prevails to depths varying from 40 to 50 inches, where it rests upon a lighter colored, friable, highly calcareous silt or silty clay loam material. In areas along lower Crooked Creek, near Williams, this soil grades into Holly silt loam and includes patches of McGary fine sandy loam. Many swales, drainage ways, and lower slopes occur where the surface soil is darker and contains a higher percentage of

organic matter than is usual. These are inclusions of Montgomery soil.

This soil occurs on the terraces along the lower courses of Guthrie, Leatherwood, and Salt Creeks, and other streams tributary to East Fork White River. The poor drainage and high acidity of this soil make it unsuitable for the growing of corn, small grains, and clover. These crops are grown to some extent, but most of the soil is used for meadow and pasture, as timothy, redtop, and various native grasses do well.

The following table gives results of mechanical analyses of samples of the topsoil and subsoil of McGary silt loam:

Mechanical analysis of McGary silt loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
282933	Topsoil, 0 to 6 inches.....	0.2	0.5	0.4	2.0	7.5	69.4	19.9
282934	Subsoil, 6 to 12 inches.....	.0	.2	.2	1.1	7.4	62.1	29.0
282935	Subsoil, 12 to 32 inches.....	.0	.0	.1	.5	5.8	55.9	37.7
282936	Subsoil, 32 to 45 inches.....	.0	.2	.2	.7	5.4	48.2	45.5
282937	Subsoil, 45 to 50 inches.....	.2	.1	.0	.4	1.6	58.8	38.8

ELK FINE SANDY LOAM

Elk fine sandy loam to a depth of 5 or 6 inches consists of dull-brown or dark grayish-brown fine sandy loam or silt loam. This is underlain by a moderately compact yellowish-brown or reddish-brown silty clay loam, which in the lower subsoil grades into more sandy material.

Small areas of this soil occur throughout the East Fork White River Valley, but only the larger areas are shown on the map. The surface is level or gently undulating and the drainage good.

Corn is the principal crop on land of this kind, but some clover and alfalfa are grown, and yields are about the same as those on Genesee silt loam.

The following table gives results of mechanical analyses of samples of the topsoil and subsoil of Elk fine sandy loam:

Mechanical analysis of Elk fine sandy loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
282914	Topsoil, 0 to 6 inches.....	0.1	3.1	9.2	43.5	14.7	21.7	7.8
282915	Subsoil, 6 to 18 inches.....	.0	3.6	9.2	37.2	14.7	23.3	12.0
282916	Subsoil, 18 to 30 inches.....	.0	7.8	11.3	39.6	14.8	17.4	9.2
282917	Subsoil, 30 to 36 inches.....	.7	26.2	27.2	27.0	4.2	8.5	6.3

ELK SILT LOAM

Elk silt loam consists of yellowish-brown silt loam or fine sandy loam over a somewhat compact, yellowish-brown silt or silty clay loam subsoil, which rests upon a sandy substratum. The surface soil is acid. Mapped with this soil are several small areas along

Indian Creek that are not subject to normal overflow, and a few patches or strips along Guthrie Creek, where the surface soil is brown silty loam. Some brown, well-drained soils on small terraces are also included with Elk silt loam. In general, the surface is undulating and the drainage good.

The largest area of this soil is located on East Fork White River just below the mouth of Salt Creek. The soil has been in cultivation for many years and produces good crops of corn, wheat, and clover, but is in need of organic matter and liming.

CALHOUN SILT LOAM

The topsoil of Calhoun silt loam consists of a surface layer of light-gray, friable silt loam about 6 inches deep, and a subsurface layer of light-gray, friable silt loam or silty clay loam mottled with yellow and brown. The subsoil, to depths ranging from 14 to 24 inches, is compact plastic clay mottled with light gray, yellowish brown, and brown. At a depth of about 30 inches this grades into compact silty clay loam material which continues to a depth of more than 40 inches.

Calhoun silt loam occurs on the terraces of lower Indian and Salt Creeks.

HUNTINGTON SILT LOAM

Huntington silt loam is light-brown or grayish-brown, mellow silt loam, 20 or 30 inches deep, which becomes brown or almost reddish-brown when wet. In places the subsoil is a fine sandy loam, and it may be slightly acid.

This soil occurs on flood plains along streams. The surface is level or gently sloping and drainage is good.

Huntington silt loam is devoted chiefly to growing corn, with occasional changes to other crops. Without fertilization corn yields from 40 to 60 bushels an acre. Clover and timothy do well, and ordinary overflows do not injure these crops. Very few farms consist entirely of this soil, but it forms the most productive part of a large number. The value of this kind of land is estimated at \$100 an acre.

HUNTINGTON VERY FINE SANDY LOAM

Huntington very fine sandy loam is mellow, brown very fine sandy loam, which continues downward for several feet with little change. On low mounds and near stream channels, the texture is coarser than usual, and along Guthrie Creek small areas of Holly and Waverly soils are included with this soil. Huntington very fine sandy loam lies on flood plains along streams and is well drained. It is easy to manage and has good moisture-holding power, so that crops rarely suffer seriously either from lack or excess of water. It is all in cultivation and is preferred for growing corn and clover. Wheat and oats would do well but the danger of injury by flood waters is so great that these crops are seldom planted. Yields of corn range from 40 to 50 bushels an acre.

Because Huntington very fine sandy loam is usually sold in conjunction with other soils, no definite value can be given for it.

HUNTINGTON FINE SANDY LOAM

Huntington fine sandy loam is brown sandy loam or fine sandy loam which becomes somewhat lighter in color with increasing depth, but otherwise does not change to depths of several feet. In a few low or flat spots this soil resembles soils of the Holly or Waverly series; and some deep sandy loam spots, which are somewhat droughty, are included with it. It occurs chiefly along small streams in the western part of the county, and is flooded only during exceptionally high water.

Corn is the chief crop, yields comparing favorably with those on Huntington silt loam. Clover and timothy thrive, and alfalfa is grown where overflows are infrequent. On a few sandy benches 5 or 10 feet above the creek banks, melons and other truck crops are grown.

Huntington fine sandy loam, colluvial phase.—Huntington fine sandy loam, colluvial phase, ranges in texture from silt loam to stony loam, but is predominantly fine sandy loam. It occurs on the sides of larger valleys on alluvial fans, and on the floors and sides of smaller valleys. In crop production, land of this kind is similar to typical Huntington fine sandy loam.

GENESEE SILT LOAM

Genesee silt loam is friable, brown heavy silt loam, slightly acid, and containing little organic matter. It continues to depths of 4 or 5 feet with little change, though the color may become somewhat lighter and the material slightly more compact. It may be underlain by beds of loose stratified sand.

This is the dominant soil in the East Fork White River valley. The areas are level and the drainage good, the soil is easily tilled and productive, and crops rarely suffer seriously from lack or excess of moisture. Practically all of it is in cultivation. Corn, the leading crop, yields as much as 50 or 60 bushels an acre. At rare intervals a crop is lost or seriously damaged by late overflows. Crabgrass, fox-tail, and cocklebur are more troublesome than on upland soils; and giant ragweed, wild hemp, and various tall weeds belonging to the Compositae family of plants which abound in uncultivated areas along the channel, encroach upon fields temporarily abandoned. Clover, timothy, redtop, and all forage crops do well, but their total acreage is very small compared with that of corn. Millet, sorgho, and cowpeas are used as catch crops, and a few small fields of alfalfa have been yielding well for many years, but frequent inundations prevent the more extended use of the land for this crop.

GENESEE SILTY CLAY LOAM

Genesee silty clay loam consists of brown or dark-brown heavy silt loam or silty clay loam, 5 or 6 inches deep, underlain by stiff silty clay loam which continues to depths varying from 20 to 30 inches, where a layer of lighter material is generally encountered. This soil and Genesee silt loam are so closely associated that in places the boundary lines between them were arbitrarily drawn. In general Genesee silty clay loam is friable under ordinary moisture conditions,

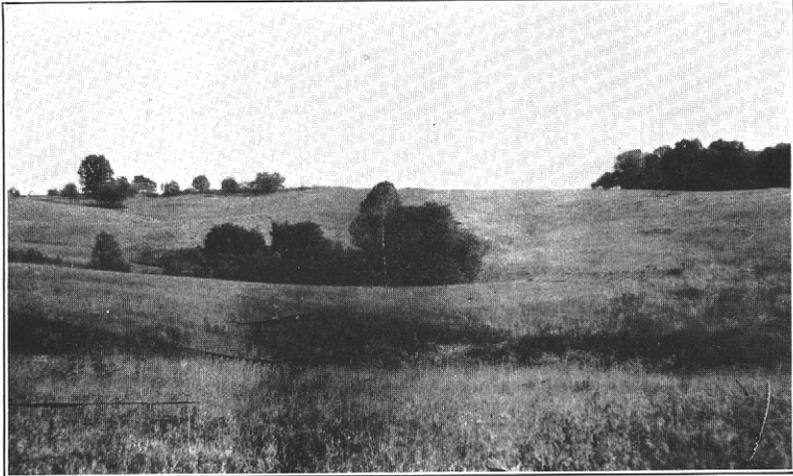


FIG. 1.—AN AREA OF FREDERICK SILT LOAM, SHOWING A SINK HOLE



FIG. 2.—TILSIT SILT LOAM USED FOR PASTURE



TILSIT SILT LOAM, ERODED PHASE

but when wet it is decidedly sticky and may be readily recognized by its heavy texture and slow rate of drying.

This soil occurs in the flood plains along East Fork White River, and the largest area is south of Fort Ritner. All of the land is subject to frequent overflow.

Genesee silty clay loam, poorly drained phase.—Genesee silty clay loam, poorly drained phase, is dark, heavy silty clay loam, slightly acid, and usually mottled below depths of 24 or 30 inches. This soil occurs in broad sags and long sinuous depressions within areas of Genesee silt loam and Genesee silty clay loam. A small acreage is cultivated, and agricultural practices are similar to those on Genesee silt loam. Some of this land supports a growth of willow, button-bush, cottonwood, and sycamore. This soil is similar to Eel silty clay loam of later surveys.

GENESEE FINE SANDY LOAM

Genesee fine sandy loam consists of brown sandy loam or fine sandy loam with a high content of silt, underlain by a lighter-colored sandy material, which becomes lighter in texture with increasing depth. This soil lies in the flood plains of East Fork White River.

Almost all Genesee fine sandy loam is tilled. Alfalfa thrives on the higher areas which ordinarily remain under water only a few days at a time. Clover and timothy are also grown, but may be damaged by floods or by sediment. Corn is a reasonably certain crop and much of the land is regularly planted to it.

HOLLY SILT LOAM

Holly silt loam is brown or light-brown silt loam, underlain, below a depth of 10 or 15 inches, by lighter-colored material with brownish and yellowish mottlings, and ferruginous concretions.

The largest areas of Holly silt loam occur on the flood plains along Salt Creek and smaller areas are along Guthrie and Back Creeks and other streams. All the land is subject to overflow. The surface is level or gently sloping, and where this soil is associated with Huntington or Waverly soils it usually lies at a slightly lower level than the Huntington soils and is not so uniformly flat as the Waverly soils. Surface drainage is good, but internal drainage poor, because of a high ground-water level.

This soil is planted to corn with occasional changes to other crops. Yields are lower than those on Huntington silt loam, and the soil is better suited to clover and grasses, particularly timothy.

WAVERLY SILT LOAM

Waverly silt loam consists of a thin layer of partially decayed organic matter with specks of bog iron and yellowish stains, underlain by light-gray or light yellowish-gray silt loam, which at a depth of 4 or 5 inches grades into heavier, somewhat compact silt loam material 8 or 10 inches deep, and mottled with yellowish and brownish iron stains. Below this is a layer of light-gray silty clay loam material mottled with yellow and containing some soft, ferruginous,

dark-brown concretions. At a depth of 20 or 30 inches this layer rests upon ferruginous, silty clay which is streaked with yellow and brown. The surface soil is acid.

Soil of this type occurs as flat or in small, slightly depressed areas within areas of Huntington soils along the larger creeks. They are poorly drained and subject to rather frequent overflow, but the summer inundations are usually of short duration.

Practically all this land is devoted to cultivated crops and tame grasses, though the yields are lower than on the adjoining darker soils. Oats, wheat, and rye give poor returns, but timothy, redtop, alsike clover, and sorgo do well. On the somewhat darker-colored areas of this soil cowpeas and soy beans do fairly well, but often fail on the light-colored soils.

The general lowering of the ground-water level has greatly benefited most of this land, but further improvement by means of open ditches or tile drains is necessary for profitable cultivation. In most places the adjacent creek channels are sufficiently deep to afford good outlets for ditches and tile.

WAVERLY SILTY CLAY LOAM

Waverly silty clay loam is light grayish-yellow heavy silt loam or silty clay loam with a low content of organic matter. Underlying this at a depth of 4 or 5 inches is a light-gray silty clay loam or silty clay subsoil with many yellowish and rust-brown stains. With increasing depth this subsoil becomes more compact. In places, however, there is little or no change in the character of the material from the level of the upper subsoil to a depth of 40 or 50 inches.

Waverly silty clay loam is inextensive, occurring in the flood plain along Salt Creek. The poor drainage and deficiency of organic matter render these small areas unsuitable for tilled crops.

Waverly silty clay loam, dark-colored phase.—Waverly silty clay loam, dark-colored phase, is dark-brown crumbly silty clay, containing much organic matter which at about 20 inches grades into dark-drab or bluish-drab clay. Soil of this phase occurs in small poorly drained areas in the flood plains along Salt Creek. It is a fertile soil and corn and grasses grow well on it.

The following table gives results of mechanical analyses of samples of the topsoil and subsoil of Waverly silty clay loam, dark-colored phase:

Mechanical analysis of Waverly silty clay loam, dark-colored phase

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
282991	Topsoil, 0 to 6 inches.....	0.0	0.2	0.1	0.4	6.4	74.0	19.0
282992	Subsoil, 6 to 20 inches.....	.0	.2	.1	.7	8.2	71.2	19.7
282993	Subsoil, 20 to 36 inches.....	.0	.0	.2	2.1	7.0	64.3	26.3
282994	Subsoil, 36 to 45 inches.....	.0	.2	.2	2.2	8.3	63.3	25.9

ROUGH STONY LAND

Rough stony land embraces steep hillsides in the limestone areas of the county, on which much rock is exposed. Many of the narrow

strips of this soil mapped along streams are bluffs, or in some places rocky gorges. The large area, 3 miles east of Mitchell, includes the deep gorge of upper Mill Creek. Some of the small areas in other parts of the county are outcrops of rock on the eroded phase of Frederick silt loam. All these areas have some forest growth, which is usually of inferior size and low value.

SUMMARY

Lawrence County is in the south-central part of Indiana, and has an area of 444 square miles, or 284,160 acres.

The southeastern and central sections are underlain by limestone, and sandstone and shale form the bedrock in the southwestern, western, and northeastern parts. The surface of the limestone region ranges from rolling to hilly, with some broken land along the drainage ways. The surface relief in the sandstone and shale areas is more broken by deep valleys, ravines, and prominent ridges. The prevailing narrow stream valleys are bordered by bluffs and wooded hills.

All the smoother uplands and practically all the bottom lands are under cultivation. Corn, wheat, clover, and timothy are the principal crops, and cattle and hogs the most important livestock. Commercial orchards are important in the southern part of the county.

The soils of the sandstone areas are not so favorable for cultivation as the silt loam soils of the limestone belt.

Some of the important soils of the county are mapped as Hagerstown, Frederick, Bedford, Lawrence, Muskingum, Tilsit, and Guthrie soils.

The Hagerstown series includes moderately dark-brown soils having reddish-brown crumbly subsoils, which are important agriculturally.

Soils of the Frederick series are somewhat lighter colored than the Hagerstown soils, but only slightly inferior in agricultural value. The soils in this series include some areas so rough as to be untillable.

Bedford soils are characterized by a somewhat lighter color than the Frederick soils and the presence of a grayish mottled layer in the subsoil. They, also, are important agriculturally.

The other silty soils of the limestone belt are the Lawrence and Guthrie silt loams, which are tillable but very likely to have excess moisture.

The Muskingum series includes light-brown well-oxidized soils derived from sandstone and shale.

Soils of the Tilsit series are light brown with grayish compacted subsoils. Two unimportant phases of Tilsit silt loam occur in Lawrence County.

The Genesee series includes well-drained alluvial soils of the East Fork White River bottoms. They are brown, friable sandy silt loams or silty clay loams, and are the principal corn-producing soils of the county. Soils of the Huntington series are similar to Genesee soils, but are derived chiefly from sediments transported by wash and by streams from the limestone uplands.

PART 2. THE MANAGEMENT OF LAWRENCE COUNTY SOILS

By A. T. WIANCKO and S. D. CONNER, Department of Agronomy, Purdue University Agricultural Experiment Station

INTRODUCTION

The farmer should know his soil and have a sound basis for every step in its treatment. Building up the productivity of a soil to a high level, in a profitable way, and then keeping it up is an achievement for which every farmer should strive. The business of farming should be conducted as intelligently and as carefully as any manufacturing business, in which every process must be understood and regulated, from the raw material to the finished product, in order to be uniformly successful. The farmer's factory is his farm, and a knowledge of the soil is highly important. Different soils present different problems as to treatment, which must be studied and understood in order that crops may be produced in the most satisfactory and profitable way.

It is the purpose of the following discussion to call attention to the deficiencies of the several soils of the county and to outline in a general way the treatments most needed and most likely to yield satisfactory results. No system of soil management can be satisfactory that does not in the long run produce profitable returns. Some soil treatments and methods of management may be profitable for a time but ruinous in the end. One-sided or unbalanced soil treatments have been altogether too common in the history of farming in this country. A properly balanced system of treatment will make almost any soil profitably productive.

CHEMICAL COMPOSITION OF LAWRENCE COUNTY SOILS

The following table gives the results of chemical analyses of the different types of soil of Lawrence County, expressed in pounds of elements in 2,000,000 pounds of plowed surface soil of an acre.

Three groups of analyses are given—total plant-food elements, elements soluble in strong (specific gravity 1.115) hydrochloric acid, and elements soluble in weak (fifth-normal) nitric acid.

The total plant-food content is more valuable in indicating the origin of a soil than its fertility. This is particularly true of potassium. The quantity of total potassium in a soil is seldom an indication of its need of potash. Some Indiana soils, which have more than 30,000 pounds of total potassium per acre in the 6-inch surface layer, fail to grow corn without potash fertilization, because so little of the potassium they contain is available.

1988 FIELD OPERATIONS OF THE BUREAU OF SOILS, 1922

Chemical composition of Laurence County soils

[Elements, in 2,000,000 pounds of surface soil per acre]

Element	No. 8, Hagers-town silt loam	No. 35, Hagers-town silt loam, shallow phase	No. 40, Hagers-town stony silt loam, shallow phase	No. 35X, Fred-erick silt loam, shallow phase	No. 30, Fred-erick silt loam	No. 30R, Fred-erick silt loam, rough phase	No. 30, Musk-ingum silt loam	No. 50, Musk-ingum stony silt loam	No. 2, Bed-ford silt loam	No. 11, Law-rence silt loam
Phosphorus ¹	1,660	1,223	1,049	786	1,660	1,223	1,223	1,398	1,573	1,922
Potassium ¹	2,354	2,858	4,035	2,017	3,027	1,681	2,690	3,027	2,018	2,018
Calcium ¹	4,000	3,143	7,860	4,670	8,860	3,140	3,000	2,430	3,570	4,290
Magnesium ¹	3,260	5,670	7,480	4,340	2,774	5,670	3,380	3,980	2,530	2,770
Manganese ¹	1,729	1,870	2,740	1,870	1,010	430	580	430	720	1,150
Iron ¹	31,820	33,940	41,360	23,330	33,800	33,900	31,800	15,900	39,400	34,470
Aluminum ¹	42,500	43,600	57,700	39,200	40,600	46,300	33,000	37,300	46,000	53,700
Sulphur ¹	640	480	400	560	800	240	560	160	800	1,040
Phosphorus ²	22	26	17	17	28	17	14	30	13	17
Potassium ²	218	168	168	84	218	151	218	168	151	185
Nitrogen ³	2,600	3,600	3,400	1,400	2,200	1,200	1,300	1,400	2,000	2,800
Potassium ³	19,337	24,213	22,195	17,655	25,390	26,231	20,510	22,360	24,720	23,200

Element	No. T., Elk silt loam	No. 18, Tilsit silt loam, eroded phase	No. 27, Tilsit silt loam, flat phase	No. 21, Tilsit silt loam	No. 54, Cal-houn silt loam	No. 57, Guthrie silt loam	No. 20, Lick-dale silt loam	No. 9, Mc-Gary silt loam	No. 17X, Fox loamy sand	No. 14, Prince-ton fine sandy loam
Phosphorus ¹	961	786	1,485	1,398	524	1,311	1,311	1,311	874	786
Potassium ¹	3,531	2,354	2,354	2,522	840	2,354	2,018	5,380	1,177	1,008
Calcium ¹	3,290	3,860	2,860	4,140	2,860	3,710	2,140	5,430	4,570	4,860
Magnesium ¹	3,500	4,820	3,620	4,825	5,190	2,410	1,930	7,320	3,500	2,650
Manganese ¹	3,025	430	430	430	1,300	580	580	3,460	2,740	2,310
Iron ¹	25,650	28,500	39,900	35,600	44,200	57,100	37,400	55,600	19,900	24,200
Aluminum ¹	28,300	40,600	34,400	43,400	31,400	37,100	41,360	53,600	16,900	14,500
Sulphur ¹	400	320	400	720	320	560	560	160	320	560
Phosphorus ²	17	9	22	22	17	10	26	17	61	87
Potassium ²	100	319	118	185	67	118	84	135	118	100
Nitrogen ³	2,000	2,000	1,800	1,800	1,800	1,700	2,200	2,400	1,200	1,200
Potassium ³	25,730	25,390	20,180	17,990	16,980	14,970	15,130	30,940	15,130	14,290

Element	No. 43, Wa-verly silty clay loam, dark phase	No. 10, Holly silt loam	No. 6, Wa-verly silt loam	No. 31, Wa-verly silty clay loam	No. 15, Hunt-ington silt loam	No. 39, Hunt-ington very fine sandy loam	No. 23, Gen-eesee silty clay loam	No. 12, Gen-eesee silt loam	No. 47, Gen-eesee fine sandy loam	No. 47T., Elk fine sandy loam
Phosphorus ¹	1,485	1,573	1,485	1,485	1,398	1,136	1,922	1,748	1,223	1,177
Potassium ¹	8,071	5,380	5,550	8,407	2,858	2,018	6,390	5,550	3,363	1,008
Calcium ¹	19,400	6,290	7,714	6,140	10,860	3,570	19,700	21,140	9,710	5,430
Magnesium ¹	9,170	7,320	9,170	10,010	6,150	6,150	13,510	10,980	5,670	5,670
Manganese ¹	2,020	2,450	1,730	580	1,010	580	2,305	1,900	2,880	1,150
Iron ¹	48,450	48,450	42,750	45,600	42,750	31,350	48,450	62,700	28,500	35,600
Aluminum ¹	80,400	54,200	58,000	80,200	42,400	38,000	64,600	60,000	21,700	27,600
Sulphur ¹	400	400	240	160	400	320	400	560	240	240
Phosphorus ²	79	22	96	52	52	26	79	61	61	114
Potassium ²	286	151	252	286	100	135	185	118	151	100
Nitrogen ³	3,600	2,200	3,600	2,600	2,000	2,000	2,800	3,200	1,400	1,400
Potassium ³	31,270	24,550	33,630	31,950	24,550	15,980	27,680	21,860	16,140	24,380

¹ Soluble in strong hydrochloric acid (specific gravity, 1.115).

² Soluble in weak nitric acid (fifth normal).

³ Total.

The total content of nitrogen is generally indicative of the need for nitrogen, although some soils with a low total may have a supply of available nitrogen sufficient to grow a few large crops without the addition of nitrogen. Soils having low total nitrogen soon wear out,

so far as that element is concerned, unless the supply is replenished by the growing and returning of legumes or by the use of nitrogenous fertilizer.

The quantity of total phosphorus in ordinary soils is usually about the same as that shown by a determination with strong acid. For this reason a separate determination of total phosphorus has been omitted. The supply of total phosphorus usually indicates the general need of a soil for phosphate fertilizers.

The quantity of phosphorus soluble in weak acid is considered by many authorities as a still better indication of the phosphorus needs of a soil. The depth of a soil may modify its need for phosphates. Everything else being equal, the more soluble phosphorus a soil contains, the less it is apt to need phosphate fertilizers. Whenever the soluble phosphorus runs less than 100 pounds to the acre, phosphates are usually needed.

The quantity of potassium soluble in strong or weak acid is to some extent significant. This determination, however, is not so reliable an indicator as is the determination of phosphorus, particularly with soils of high lime content. Sandy soils and muck soils are more often in need of potash than clay and loam soils.

The use of strong or weak acid in the analysis of a soil has sometimes been criticized as having little or no value, yet such analyses can more often be correlated with crop production than can analyses of the total elements of the soil. For this reason acid solutions have been employed in these analyses.

It must be admitted, however, that no one method of soil analysis will definitely indicate the deficiencies of a soil. For this reason these chemical data are not intended to be the sole guide in determining the soil needs. The depth of the soil, the physical character of the subsoil and the surface soil, and the previous treatment and management of the soil are all factors of the greatest importance and should be taken into consideration. The better types of soil and those containing large amounts of plant-food elements will endure exhaustive cropping much longer than the less fertile soils.

The nitrogen, phosphorus, and potassium contents of a soil are by no means the only chemical indications of high or low fertility. One of the most important factors in soil fertility is the degree of acidity. Soils which are very acid will not produce well even though there be no lack of plant-food elements. Although nitrogen, phosphorus, and potassium are of some value on acid soils, they will not produce their full effect where lime is deficient. The following table shows the percentages of volatile matter and nitrogen, and the acidity of the various soils in the county. The acidity is expressed in terms of pounds of pulverized limestone needed per acre. Samples were taken from the surface soil (0 to 6 inches), from the subsurface (6 to 18 inches), and from the subsoil (18 to 36 inches). It is important to know the reaction not only of the surface soil but of the lower layers of the soil as well. Given two soils of the same acidity, the one with the greater acidity in the subsurface layer is in greater need of lime than the other. Furthermore, the more organic or volatile matter and nitrogen a soil contains and the greater the depth to which they extend, the less will be its need for lime.

1990 FIELD OPERATIONS OF THE BUREAU OF SOILS, 1922

Volatile matter, nitrogen, and acidity of Lawrence County soils

No.	Soil type	Depth	Volatile matter		Nitrogen	Acidity, limestone requirement ¹
			Inches	Per cent		
8	Hagerstown silt loam.....	0 to 6	4.55	0.13	200	
		6 to 18	3.72	.10	180	
		18 to 36	3.25	.05	1,800	
35	Hagerstown silt loam, shallow phase.....	0 to 6	5.60	.18	120	
		6 to 18	4.17	.08	2,860	
		18 to 36	5.07	.05	3,660	
40	Hagerstown stony silt loam, shallow phase.....	0 to 6	5.53	.17	220	
		6 to 18	5.50	.10	160	
		18 to 36	5.27	.04	440	
35X	Frederick silt loam, shallow phase.....	0 to 6	3.22	.07	140	
		6 to 18	4.52	.05	6,360	
		18 to 36	7.20	.04	7,600	
30	Frederick silt loam.....	0 to 6	4.25	.11	80	
		6 to 18	3.85	.06	440	
		18 to 36	4.22	.05	1,500	
30R	Frederick silt loam, rough phase.....	0 to 6	3.09	.06	1,100	
		6 to 18	3.85	.04	4,300	
		18 to 36	5.00	.01	3,700	
32	Muskingum silt loam.....	0 to 6	3.70	.07	1,860	
		6 to 18	3.75	.03	6,600	
		18 to 36	4.17	.02	9,600	
51	Muskingum stony silt loam.....	0 to 6	3.28	.07	1,800	
		6 to 18	3.45	.01	4,800	
		18 to 36	2.90	.01	5,200	
2	Bedford silt loam.....	0 to 6	4.34	.10	340	
		6 to 18	3.80	.05	4,200	
		18 to 36	3.60	.03	8,600	
11	Lawrence silt loam.....	0 to 6	4.80	.14	200	
		6 to 18	3.80	.06	360	
		18 to 36	3.92	.02	8,000	
T	Elk silt loam.....	0 to 6	3.04	.10	200	
		6 to 18	3.00	.06	500	
		18 to 36	3.50	.02	4,600	
18	Tilsit silt loam, eroded phase.....	0 to 6	3.68	.10	240	
		6 to 18	3.90	.07	1,200	
		18 to 36	3.85	.04	2,880	
27	Tilsit silt loam, flat phase.....	0 to 6	3.52	.09	1,040	
		6 to 18	3.00	.05	2,500	
		18 to 36	3.35	.02	9,900	
21	Tilsit silt loam.....	0 to 6	3.45	.09	360	
		6 to 18	3.42	.04	3,300	
		18 to 36	2.92	.01	5,800	
54	Calhoun silt loam.....	0 to 6	3.48	.09	1,800	
		6 to 18	3.35	.06	5,000	
		18 to 36	3.70	.04	9,600	
57	Guthrie silt loam.....	0 to 6	3.61	.09	260	
		6 to 18	2.80	.03	2,500	
		18 to 36	3.00	.02	4,100	
20	Lickdale silt loam.....	0 to 6	3.85	.11	840	
		6 to 18	3.17	.04	4,200	
		18 to 36	4.00	.02	8,400	
9	McGary silt loam.....	0 to 6	4.71	.12	560	
		6 to 18	4.87	.05	4,300	
		18 to 36	6.72	.03	700	
17X	Fox loamy sand.....	0 to 6	1.88	.06	100	
		6 to 18	1.07	.02	60	
		18 to 36	1.10	.01	80	
14	Princeton fine sandy loam.....	0 to 6	1.76	.06	80	
		6 to 18	2.32	.03	60	
		18 to 36	3.05	.01	860	
43	Waverly silty clay loam, dark phase.....	0 to 6	6.67	.18	120	
		6 to 18	7.30	.19	100	
		18 to 36	8.50	.19	140	
10	Holly silt loam.....	0 to 6	4.53	.11	140	
		6 to 18	4.37	.05	2,800	
		18 to 36	4.10	.03	8,300	
6	Waverly silt loam.....	0 to 6	6.03	.18	200	
		6 to 18	4.57	.09	1,460	
		18 to 36	4.07	.04	1,700	
31	Waverly silty clay loam.....	0 to 6	5.36	.13	180	
		6 to 18	5.82	.09	500	
		18 to 36	4.70	.04	1,460	
15	Huntington silt loam.....	0 to 6	3.84	.10	100	
		6 to 18	4.50	.05	100	
		18 to 36	4.45	.05	60	

¹ Limestone requirement determined by Hopkins method.

Volatile matter, nitrogen, and acidity of Lawrence County soils—Continued

No.	Soil type	Depth	Volatile matter	Nitrogen	Acidity, limestone requirement
		<i>Inches</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Pounds per acre</i>
39	Huntington very fine sandy loam.....	0 to 6	3.35	0.10	240
		6 to 18	3.15	.04	200
		18 to 36	2.95	.03	940
23	Genesee silty clay loam.....	0 to 6	5.50	.14	140
		6 to 18	5.87	.10	100
		18 to 36	5.00	.05	80
12	Genesee silt loam.....	0 to 6	6.26	.16	140
		6 to 18	6.15	.11	100
		18 to 36	4.57	.06	80
47	Genesee fine sandy loam.....	0 to 6	2.45	.07	80
		6 to 18	2.02	.06	80
		18 to 36	1.32	.02	100
47T	Elk fine sandy loam.....	0 to 6	2.40	.07	160
		6 to 18	3.40	.05	300
		18 to 36	2.45	.01	600

In interpreting the soil-survey map and analyses, it should be borne in mind that a well-farmed, well-fertilized or manured soil, which is naturally low in fertility, will produce larger crops than a poorly farmed soil that is naturally high in fertility.

SOIL MANAGEMENT

For convenience in discussing the management of the several soils of the county, they have been arranged into groups according to certain important characteristics which indicate that in many respects similar treatment is required. For example, several of the upland silt loams which have practically the same requirements for their improvement may be conveniently discussed as a group, and thus avoid the repetition that would be necessary if each were discussed separately. Where different treatments are required they are specifically pointed out. *The reader should study the group including the soils in which he is particularly interested.*

SILT LOAM UPLAND AND TERRACE SOILS

The silt loam upland and terrace soils include the silt loam soils of the Bedford, Lawrence, Hagerstown, Frederick, Tilsit, Elk, Calhoun, Lickdale, Guthrie, Muskingum, and McGary series. The practical problems in the management of these soils are very similar, regardless of their topographic positions. Important differences in natural productivity do exist and are fully recognized, but they are differences in degree and do not require separate groupings for the purpose of this discussion. In the discussion which follows these differences will be indicated.

As a general proposition it may be stated that all these soils are naturally deficient in phosphorus. With the exception of some of the Hagerstown and McGary types they are also decidedly low in nitrogen and organic matter. In some cases there is also need of more available potassium, especially in the Calhoun, Lickdale, and the shallow phase of Frederick silt loam. With few exceptions they are also more or less in need of lime.

The steep and rough phases of the soils included in this group are not adapted to grain crops and should be utilized as pasture or forest lands.

Drainage.—The Elk, Muskingum, some of the Frederick, and most of the Hagerstown soils in this group have fair to good natural drainage and are not in need of tiling. The more nearly level areas of the Frederick soil need to be tiled before the best results can be secured from other good treatments. Some of the Hagerstown would also be benefited by tile drainage. The Tilsit and Bedford soils, for the most part, have good surface drainage, but their subsoils are heavy, and tile drainage is needed to lessen surface run-off and soil erosion and to improve their physical condition. The soil conditions should be made as favorable as possible for the absorption of rain water. The surplus water should pass down through the soil and run away in underdrains rather than over the surface. Surface drainage is wasteful of the plant-food elements. Tile drainage will also tend to lessen soil erosion. Enormous losses occur every year through soil erosion on hillsides. The best of the topsoil is washed away, carrying with it the available plant-food elements that should go into the production of crops. These losses should be guarded against by every possible means. Steep slopes in cultivated fields should be protected against erosion by terracing, or by keeping them covered with vegetation to hold the soil in place.

The rest of the soils of this group are all more or less seriously in need of tile drainage. Their generally flat surface and tight subsoils make natural drainage very slow and difficult. A mottled subsoil is a further indication of insufficient natural drainage. Without tile drainage these soils can not be satisfactorily managed, and no other beneficial soil treatment can produce its full effect. Results on experiment fields on other soils of similar texture and topography indicate that tile lines laid 30 inches deep and not more than 3 rods apart will give good results. Where the land is very flat, great care must be exercised in tiling in order to obtain an even grade and uniform fall. Grade lines should never be established by guess or any "rule-of-thumb" method. Nothing less accurate than a surveyor's instrument should be used, and the lines should be accurately staked and graded before the ditches are dug, to make sure that all the water will flow to the outlet, with no interruption or slackening of the current. The rate of fall may be increased toward the outlet, but it should never be lessened. Checking the current may cause the tile to become choked with silt. It is an excellent plan, before filling the ditches, to cover the tile to a depth of a few inches with straw or weeds, or grass cut from the fields. This prevents silt from washing into the tile at the joints while the ground is settling, thus insuring perfect operation of the drains from the beginning.

Liming.—All the soils of this group, except some of the Elk, Hagerstown, and Frederick soils, are more or less acid and in need of lime. Application of lime in some form should be one of the first steps in their improvement. A very acid soil will not respond properly to other needed treatments until after it has been limed. The failure of clover to develop satisfactorily on any of these soils indicates the need of lime, although clover failures may also be due to lack of available phosphorus. Wherever there is doubt, the soil

should be tested for acidity and some form of lime applied where the need is indicated.

On the Francisco experiment field, located on Tilsit silt loam, 3 tons of ground limestone to the acre, applied in 1915, has since produced crop increases averaging 10.4 bushels of corn, 3 bushels of wheat, and 819 pounds of mixed clover and timothy hay per acre. On manured land a similar application of ground limestone has produced crop increases averaging 3.8 bushels of corn, 4.4 bushels of wheat, and 710 pounds of hay per acre. (Pl. LVIII, fig. 1, and table, p. 1990.) In the 10 years since the limestone was applied the values, at present crop prices, of the total crop increases produced by the liming have amounted to from \$40 to \$50 an acre at a cost of \$10.50 for the limestone applied.

On the Bedford experiment field, located on Bedford silt loam, 3 tons of ground limestone applied in 1917 has since produced crop increases averaging 4.6 bushels of corn, 2 bushels of soy beans, 1.7 bushels of wheat, and 555 pounds of hay to the acre. The value of these crop increases to the end of 1925, at present crop prices, has amounted to more than \$25 an acre.

Liming these acid soils is one of the most profitable investments that can be made. As a rule, the first application of ground limestone should be 2 tons to the acre. After that a ton to the acre every second round of the crop rotation will keep the soil reasonably "sweet." Where alfalfa or sweet clover is to be grown on an acid soil, heavier applications of lime may be needed.

Organic matter and nitrogen.—All of the soils of this group are naturally low in organic matter and nitrogen. Constant cropping without adequate returns to the land has made matters worse, so that in many cases conditions are now such that satisfactory crops can not be raised until the supplies of organic matter and nitrogen have been considerably increased. There is only one practical way to do this, and that is to plow under more organic matter than is used up and to utilize legumes in sufficient quantities to supply the needed nitrogen. To do this satisfactorily, the land must first be put in condition to grow clover and other legumes. This means liming wherever the soil is acid and also applying available phosphates, because acid soils are deficient in available phosphorus. After liming, at least 200 or 300 pounds of acid phosphate should be applied per acre. Wet lands must also be drained before legumes will do well on them. In a practical program for building up the organic matter and nitrogen content of the soil clover or other legumes should appear in the crop rotation every two or three years; as much manure as possible should be made and applied to the land, and all produce not fed, such as cornstalks, straw, and cover crops, should be plowed under directly. It must be remembered that legumes are the only crops that can add appreciable quantities of nitrogen to the soil, and then only to the extent to which top growth is plowed under, either directly or in the form of manure. The beneficial effect of a legume in the rotation is strikingly shown on the Francisco experiment field on Tilsit silt loam in Gibson County. This experiment has been in progress 10 years, and although only the second-growth clover has been plowed under, the average grain yields have been increased by 10.5 bushels of corn and 2.8 bushels of wheat to the acre. Aside from these

increases in the grain crops, the clover has produced an average of 725 pounds more hay per acre than the timothy on the adjoining plot. Wherever clover-seed crops are harvested, the haulm should be returned to the land and plowed under. Cover crops should be grown wherever possible to supply additional material for plowing under. Planting soy beans or cowpeas between the corn rows at the time of the last cultivation, or seeding rye as a cover crop early in the fall on corn land that is to be plowed the following spring, are good practices to increase both nitrogen and organic matter. It is important to have some kind of a growing crop on these soils over winter to take up the soluble nitrogen which would otherwise be lost through leaching. Without living crop roots to take up the nitrates from the soil water, large losses will occur between crop seasons through drainage. In this latitude the ground is not frozen much of the time during the winter, so that frequent heavy rains cause much leaching, especially of nitrates. The winter rains also cause much soil erosion where the ground is not well covered with vegetation. Both of these losses may be considerably lessened by a good cover of winter rye on all lands that would otherwise be bare over winter.

Crop rotation.—With proper fertilization, and liming and tile drainage where needed, these soils will satisfactorily produce all the ordinary crops adapted to the locality. On account of the prevailing shortage of organic matter and nitrogen, every system of cropping should include clover or some other legume to be returned to the land in one form or another. Corn, soy beans, wheat, and clover constitute an excellent rotation on these soils. Oats are not adapted to the climatic conditions and, as a rule, should be omitted. The soy bean is not only worth more as a crop but it also adds some nitrogen and improves the ground for the wheat which follows. If more corn is wanted, the rotation may be lengthened to five years on the better areas by growing two corn crops in succession. Cover crops of rye should be seeded in the corn in September for plowing under the following spring. If two corn crops are grown in succession, the second one should be more liberally fertilized. Timothy is not a good crop for these soils; but, if wanted, it may be seeded with the clover and the rotation lengthened another year. Alfalfa and sweet clover may be grown on the better-drained and more friable soils of this group if they are properly inoculated and sufficiently limed to neutralize harmful acidity. Special literature on the soil and on the cultural requirements of these crops can be obtained from the Purdue University Agricultural Experiment Station.

Pastures.—There is much land in Lawrence County that is too hilly and subject to erosion to be satisfactorily used for corn and small-grain crops. Such areas include the eroded and rough phases of Frederick silt loam, the Muskingum stony silt loam, the eroded phase of Tilsit silt loam, and the Hagerstown stony silt loam. Although much of this land, especially the stony phases, should be used for the production of timber, that which is cleared should be "laid down" to permanent pasture. For new seedings, a mixture of 5 pounds of Kentucky bluegrass, 5 pounds of redtop, 1 pound of white clover, and 6 pounds of Lespedeza an acre is recommended. On the Hagerstown and Frederick soils, bluegrass and white clover will be most important, whereas on the other rough areas, whose soils are

generally too acid for clover and bluegrass, dependence will have to be placed on red top and Lespedeza to provide the bulk of the pasturage. When preparing the seed bed a dressing of from 200 to 400 pounds per acre of acid phosphate should be disked in. Liming the acid areas would be highly beneficial to Kentucky bluegrass and white clover, but it may not be practical in many cases.

Old "thin" pastures can be greatly improved by sowing a few pounds per acre of Lespedeza. This plant makes excellent pasturage and thrives on both acid and "sweet" soils, and it will reseed itself and spread everywhere. The bare spots should also receive some grass seed. All the old pastures should receive a top dressing of 300 or 400 pounds of acid phosphate every few years. Liming the acid areas will also be helpful. Old pastures so treated will produce good pasturage for many more head of livestock and make profitably productive much land that is now practically waste. A few pounds per acre of Lespedeza seed alone will do wonders, and at least that much should be undertaken as a beginning in the improvement of all "run-down" pastures.

Fertilization.—All the soils of this group are naturally low in phosphorus, and the available supplies of this element are so extremely low that the phosphorus required by crops should be wholly supplied in applications of manure and commercial fertilizer. The nitrogen supplies are also too low for the production of satisfactory crops of corn, wheat, and other cereals, especially on the Muskingum, Tilsit, Guthrie, and some of the Frederick soils. The total quantities of potassium in these soils are large, but the quantities available to crops are comparatively low, and in many cases the addition of some potash fertilizer would be profitable, especially where little manure is used.

The problem of supplying nitrogen has been discussed in connection with provisions for supplying organic matter. Legumes and manure are the logical and only really practical means of supplying the bulk of the nitrogen needed by crops, and should be largely relied upon for this purpose. A livestock system of farming, with plenty of legumes in the crop rotation is, therefore, best for these soils. However, it will pay, in most cases, to have some nitrogen in the fertilizer for wheat, regardless of its place in the rotation. Even though wheat follows soy beans or cowpeas it should receive some fertilizer nitrogen at seeding time, because the nitrogen in the residues of these legumes does not become available quickly enough to be of much help to the wheat in the fall. The material must first decay, and that does not take place to any considerable extent until the following spring.

Phosphorus is the mineral plant-food element in which all of these soils are most deficient. The only practical way to increase the supply is through the use of purchased phosphatic fertilizers. It will pay well to supply the entire phosphorus needs of crops in this way. In rotations of ordinary crops, producing reasonable yields, it may be counted that 20 pounds of available phosphoric acid (P_2O_5) per acre is required each year. It will pay well to use larger quantities at first so as to create a little reserve. Enough for the entire rotation may be applied at one time, or the application may be divided according to convenience. Where manure is used,

it may be counted that each ton supplies 5 pounds of phosphoric acid (P_2O_5), so that a correspondingly smaller quantity will be required in commercial fertilizer.

On the experiment field located on Bedford silt loam on the Moses Fell Annex Farm belonging to Purdue University, highly profitable returns have been obtained wherever phosphate fertilizers have been used. During the 10 years since this experiment was begun, applications of 225 pounds per acre of 16 per cent acid phosphate on each corn and wheat crop in a four-year rotation of corn, soy beans, wheat, and mixed clover and timothy on limed land have produced additional crop increases averaging 16 bushels of corn, 5.5 bushels of soy beans, 7 bushels of wheat, and 1,159 pounds of hay to the acre, worth \$35.60 an acre for each rotation, at a cost of \$5.40 for the phosphate. On land receiving 6 tons of manure for corn, a similar use of acid phosphate increased the crop yields over manure alone by 1,096 pounds of hay an acre (Pl. LVIII, fig. 2), 6.1 bushels of soy beans, 8 bushels of wheat, and 8.2 bushels of corn (Pl. LIX). Where the land was not limed, rock phosphate has been just as profitable as acid phosphate, whereas on limed land the acid phosphate has given much better results. These experiments demonstrate the importance of using liberal applications of phosphate on this type of soil both with and without manure. Most of the upland soils of this county will respond similarly to phosphate. The use of high-grade complete commercial fertilizers has also increased the profits, averaging about 300 per cent.

The amount of potash that should be supplied as fertilizer depends on the general condition of the soil and the quantity of manure used. In building up a "run-down" soil, some fertilizer potash should be used at least until such time as considerable quantities of manure can be applied or until the general condition of the soil has materially improved. The flat areas of the gray soils are likely to be most in need of potash fertilizer. There is plenty of potassium in these soils for all time if it only could be made available, which can be achieved in large measure by good farming, including proper tillage, tile drainage, the growing of deep-rooted legumes, and the incorporation into the soil of liberal amounts of organic matter. The better these practices are carried out and the greater the quantity of manure applied, the less potash will have to be purchased as fertilizer.

As a general rule, from 200 to 300 pounds per acre of a high-analysis complete fertilizer should be applied for wheat. The manure should usually be plowed under for corn, but a portion, say 2 tons per acre, may be applied profitably on wheat as a top-dressing during the winter. This practice is also helpful in obtaining a stand of clover. Corn should also receive acid phosphate or some other available phosphate, applied with the drill when preparing the seed bed, so that, together with the phosphorus in the fertilizer applied for wheat and that in the manure, there would be enough phosphorus for all the crops in the rotation. A part of the phosphate or a phosphate-potash mixture, say 100 pounds per acre, may be drilled into the row when planting the corn. Where legumes and manure are used, it will seldom pay to use nitrogen in the fertilizer for corn.

SANDY UPLAND AND TERRACE SOILS

Sandy upland and terrace soils include Elk fine sandy loam, Fox loamy fine sand, and Princeton fine sandy loam. These soils are naturally very deficient in organic matter and all three of the major nutrient elements—nitrogen, phosphorus, and potassium. Lime is not usually needed, except on some of the Elk and Princeton fine sandy loams for such crops as alfalfa and sweet clover. On some of these areas clover may also need some lime. Wherever clover fails to do well, the soil should be tested and then limed if the test shows acidity.

The drainage of these soils varies from good to excessive, so that crops often suffer from drought. The only remedy is to increase the content of organic matter so that the soil may have a greater water-holding capacity.

Organic matter and nitrogen.—The chemical analyses of these sandy soils show them to be low in both organic matter and nitrogen. Some special provision, therefore, must be made for increasing both of these constituents before their productiveness can be materially increased. As much manure as possible should be plowed under, along with all unused crop materials. Special green manure and cover crops should be planted wherever possible, for plowing under, including such crops as soy beans, cowpeas, rye, and winter vetch. What has been said concerning this subject in connection with the upland silt loam soils applies equally well here, and the practices recommended for those soils should be followed on these sandy soils also. In fact, the very sandy soils need larger supplies of both organic matter and nitrogen than the heavier soils, because they use these constituents at a faster rate.

Crop rotation.—Of the extensively grown farm crops, these sandy soils are best adapted to the small grains and legumes, especially alfalfa. Corn, as a rule, does well only on the lower areas and where the sandy surface soil is shallow and is underlain by heavier material, as in most of the Elk fine sandy loam.

The higher and drier sandy soils, including the Fox and Princeton soils, are better adapted to such crops as melons, sweet potatoes, early potatoes, and early tomatoes. They are also good for cowpeas, alfalfa, and sweet clover, although for the last two crops, liming is needed wherever there is any considerable degree of acidity. Clover will not stand as much drought as alfalfa and sweet clover and should perhaps be replaced by these crops. Alfalfa, moreover, can be grown as satisfactorily as clover in short rotations after the land is once inoculated for alfalfa, and it will not suffer so much from drought.

Fertilization.—The sandy upland and terrace soils are naturally deficient in all of the principal plant-food constituents. The chemical analyses show that they contain fair amounts of available phosphorus, but the total supplies of this element are so low that they should not be further drawn upon. Stable manure should be applied as liberally as possible both for its fertilizer constituents and for the organic matter it supplies. Manure, however, is seldom available in sufficient amounts, and commercial fertilizers which are high in phosphorus should be resorted to. Early potatoes and tomatoes will

respond profitably to heavy applications of high-analysis complete fertilizers. For these and other truck crops, 500 pounds or more per acre of a 2-12-6 fertilizer should be applied. For wheat, 300 pounds to the acre of such fertilizer is advisable. Where manure is not used, the fertilizer for truck crops on the more sandy soils should contain more potash.

Where alfalfa or sweet clover is to be grown, 500 pounds per acre of an 0-12-6 or 0-12-12 fertilizer, or the equivalent in some other fertilizer, should be applied at seeding time. A continuous stand of alfalfa should receive a top-dressing of several hundred pounds to the acre of such a fertilizer every two years.

LIGHT-COLORED BOTTOM-LAND SOILS

Light-colored bottom-land soils include the Holly silt loam and Waverly silt loam and silty clay loam. The Waverly soils are naturally wet and heavy and very generally acid. The Holly soil is more friable and drains more readily where the water table is not too high, but it is also generally acid and in need of lime. The chemical analysis shows Holly silt loam to be especially low in available plant-food constituents. The Waverly silt loam in this county seems to be naturally more fertile than in other parts of the State.

Drainage.—All these soils should be tile-drained wherever suitable outlets can be provided, so that the surplus water in the soil can drain away more readily when not interfered with by floods or high water in the streams. Tile lines should be laid about 30 inches deep and from 2½ to 3 rods apart. The precautions suggested in the discussion of the drainage of the heavy upland soils should be carefully observed in tiling this land in order to get satisfactory results.

Liming.—The light-colored bottom-land soils are very generally acid and in need of liming. Therefore, as a rule, the first steps in their improvement should be the application of 2 or 3 tons per acre of ground limestone or its equivalent in some other form of lime. After that 1 or 2 tons per acre every five or six years will keep the land in good condition.

Organic matter and nitrogen.—What has been said about supplying organic matter and nitrogen to the light-colored upland and terrace soils applies equally well to the light-colored bottom-land soils, especially the Holly silt loam and the Waverly silty clay loam. The Waverly silt loam seems to be somewhat better supplied with organic matter and nitrogen than the other soils in this group. On the lighter-colored and poorer areas of these soils, especially, considerable quantities of organic matter should be plowed under, either directly or in the form of manure, and legumes should be grown frequently in the rotation and largely returned to the land in one form or another to increase the nitrogen content.

Where the land is periodically flooded, clover and other deep-rooted legumes, especially biennials and perennials, can not be depended upon, but certain shallow-rooted legumes such as soy beans, cowpeas, and sometimes alsike clover and Lespedeza can be satisfactorily grown. These crops should be used largely for gathering nitrogen from the air, which they will do in large measure when the



FIG. 1.—COMPARATIVE YIELDS OF CLOVER HAY ON TILSIT SILT LOAM, FRANCISCO EXPERIMENT FIELD, 1921

From left to right: Treatment, first, manure only; second, manure and lime; and third, manure, lime, and acid phosphate

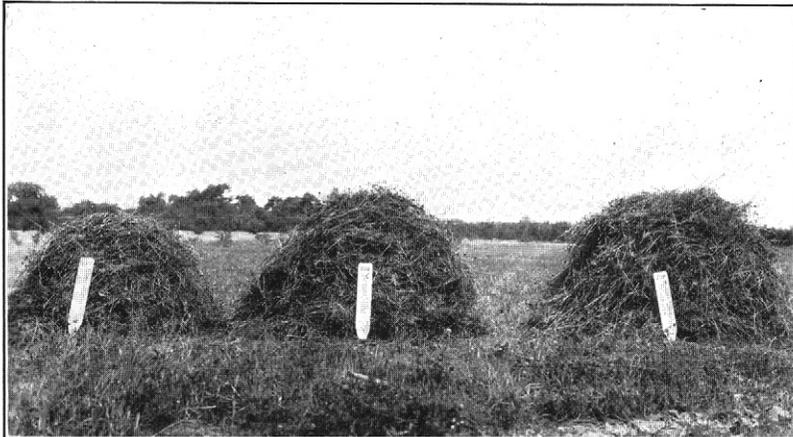


FIG. 2.—COMPARATIVE YIELDS OF CLOVER HAY ON BEDFORD SILT LOAM, BEDFORD EXPERIMENT FIELD, 1921

From left to right: Treatment, first, lime only; second, lime and manure; and third, lime, manure, and acid phosphate



COMPARATIVE YIELDS OF CORN ON BEDFORD SILT LOAM, BEDFORD EXPERIMENT FIELD, 1922

Left to right: Treatment, first, lime only; second, lime and manure; and third, lime, manure, and acid phosphate

soil is properly inoculated. Here again it must be remembered that only the top growth plowed under, either directly or in the form of manure, will really increase the nitrogen content of the soil on which grain crops must depend. Cover crops, such as cowpeas, soy beans, and rye in cornfields, should be used to the fullest possible extent. Cornstalks should not be burned but should be completely plowed under whenever this is practicable.

Crop rotation.—Where overflowing can not be prevented, the crop rotation must consist largely of annual spring-seeded crops and such grass-and-clover mixtures as will not be seriously injured by ordinary floods. For the most part, corn, soy beans, cowpeas, and in some cases oats or wheat with a mixture of timothy and alsike clover following for a year or two, are the only crops that can be satisfactorily grown. With proper fertilization, two crops of corn may often be grown in succession, or the second crop of corn may follow soy beans or cowpeas. Timothy and alsike, mixed, will do well on this land after it has been limed and may be allowed to stand for two or three years. Where the land is too acid for alsike, Lespedeza may be used. For late seeding in emergencies, early varieties of soy beans and Sudan grass for either hay or seed will be found useful.

Fertilization.—After the land has been limed, most of the nitrogen required can be provided through the growth of legumes. Cowpeas and soy beans grow fairly well on acid soils, but liming will aid the development of the nitrogen-gathering bacteria. The frequent growth of legumes on this land is very important, because it is naturally very poor in nitrogen. Fertilizer nitrogen can not be profitably employed to any considerable extent on corn and the other cereal crops, as it is too expensive for these low-priced crops. Legumes should, therefore, be grown frequently enough to supply the nitrogen required by the other crops. Manure, of course, should be used whenever it is available.

There is also more or less deficiency in available supplies of phosphorus and to some extent also in available potassium. The Holly silt loam is poorest in both elements.

As a general rule, if wheat or oats are grown, these crops should receive 200 pounds per acre of a 2-12-4 or 2-12-6 fertilizer. Corn should receive from 200 to 300 pounds per acre of 16 per cent acid phosphate, or its equivalent, broadcast and harrowed in before planting, and 100 pounds of an 0-12-6 or 2-12-6 fertilizer drilled in the row when planting. Where manure is used, the fertilizer for corn can be correspondingly reduced. Soy beans and cowpeas may also need some phosphate and potash fertilizer. Timothy meadow may be materially improved, particularly on the lighter-colored soils, by broadcasting 100 pounds of nitrate of soda to the acre, or its equivalent in the form of some other good carrier of nitrogen, after growth is well under way in April.

DARKER-COLORED BOTTOM-LAND SOILS

The darker-colored bottom-land soils include the soils of the Genesee and Huntington series and the inextensive dark Waverly soils. The greatest difficulty in the management of these soils is pro-

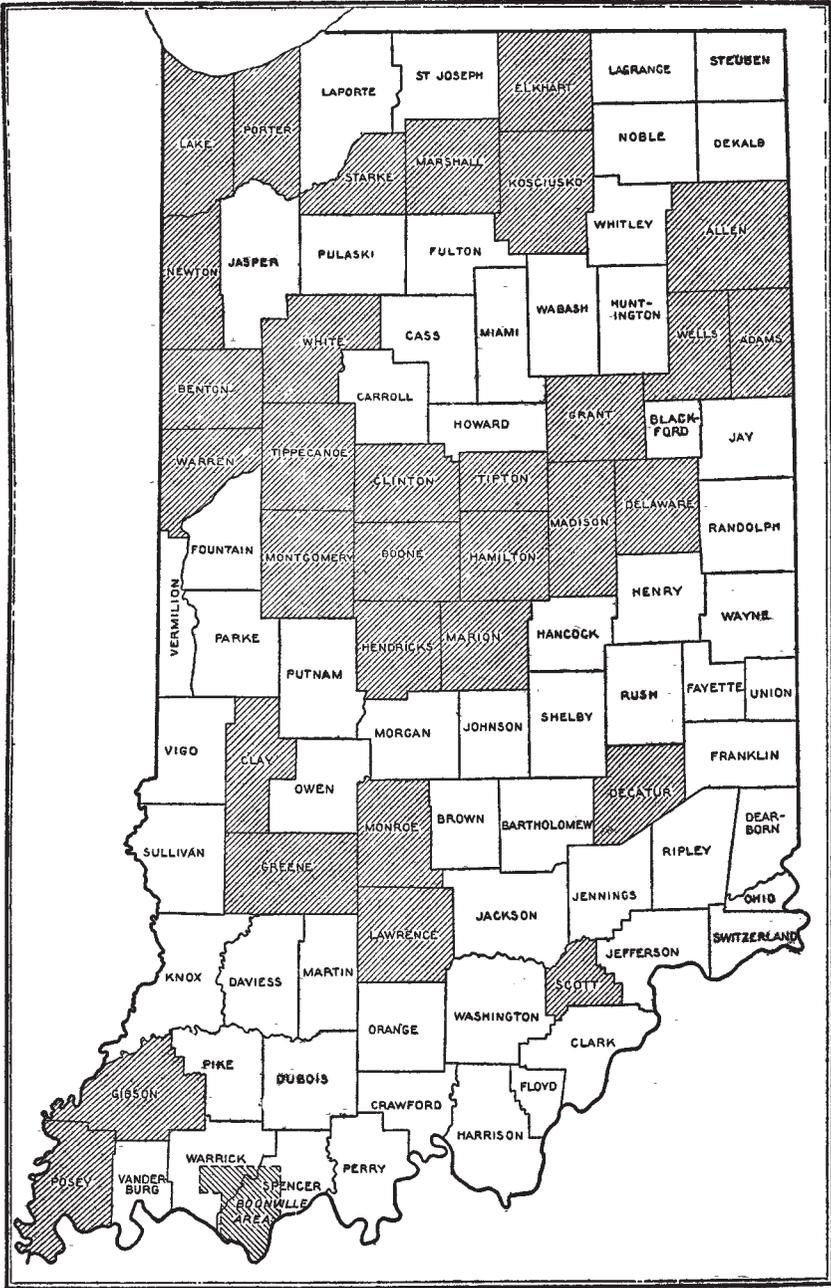
viding adequate drainage and preventing damage from flooding. Tile underdrainage should be provided in the heavier soils wherever suitable outlets may be provided. For the most part, these soils are well enough supplied with lime for all ordinary crops.

All this land is well adapted to corn, but where the drainage is satisfactory and flooding does not prohibit, some wheat and clover should be included in the rotation. Soy beans or cowpeas and Sudan grass can often be used to advantage where small grains can not be satisfactorily grown, as they provide some variations from constant cropping with corn.

Most of these soils are fairly well supplied with organic matter; and with reasonable care in their management, the nitrogen supply can be satisfactorily maintained, except perhaps in the case of the Genesee fine sandy loam, on which the rotation should include legumes. Cover crops for plowing under should be seeded in the corn, and all crop residues should be conserved and worked into the soil.

Much of this land receives fertile sediments from the periodic overflows, and for this reason less fertilizer is required than on the other soils of the county. On poorer areas, however, the soils will respond to applications of soluble phosphates and in some cases the use of potash will also prove profitable.





Areas surveyed in Indiana, shown by shading

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