SOIL SURVEY

St. Joseph County Indiana

Series 1938, No. 27 Issued June 1950

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

SOIL SURVEYS provide a foundation for all land use programs. This report and the accompanying map present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part. Ordinarily he will be able to obtain the information he needs without reading the whole. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers of three general groups: (1) Farmers and others interested in specific parts of the area; (2) those interested in the area as a whole; and (3) students and teachers of soil science and related agricultural subjects. Attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested chiefly in specific areas—as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm loan agencies. These readers should (1) locate on the map the tract with which concerned; (2) identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them; and (3) locate in the table of contents in the section on Soils the page where each type is described in detail and information given as to its suitability for use and its relations to crops and agriculture. They will also find useful specific information relating to the soils in the sections on Estimated Yields and Productivity Ratings and on Management of the Soils.

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users: (1) General Nature of the Area, in which location, extent, physiography, relief, drainage, climate, water supply, vegetation, organization, population, industries, transportation, markets, and cultural development and improvement are discussed; (2) Agriculture, in which a brief history and the present status of the agriculture are described; (3) Estimated Yields and Productivity Ratings, in which the productivity of the soils is given and a grouping of soils is presented according to their relative physical suitability for agricultural use; and (4) Management of the Soils, in which the present use of the soils is described, their management requirements are discussed, and suggestions made for improvement.

Students and teachers of soil science and allied subjects—including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology—will find their special interest in section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils, in which are presented the general scheme of classification of the soils of the area and a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on General Nature of the Area, Agriculture, Estimated Yields and Productivity Ratings, and the first part of the section on Soils of particular value in determining the relations between their special subjects and the soils of the area.

This publication on the soil survey of St. Joseph County, Ind., is a cooperative contribution from the—

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Series 1938, No. 27 Issued June 1950

SOIL SURVEY OF ST. JOSEPH COUNTY, IND.

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[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

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ORIGINALLY most of St. Joseph County was covered with a heavy growth of deciduous forest, and the rest with prairie vegetation. After this former home of the Miami and Potawatami Indians was opened to settlement about 1829, the population increased steadily. To the early production of corn, wheat, oats, and livestock have been added soybeans, hay crops, and special truck crops. Dairying has become a specialized occupation in some parts. In addition, the county now supports a variety of manufacturing industries. To make possible the best agricultural uses of the land a cooperative soil survey was begun in 1938 by the United States Department of Agriculture and the Purdue University Agricultural Experiment Station. The essential features may be summarized as follows.

SUMMARY OF THE SURVEY

Geologic evidence indicates that St. Joseph County, Ind., was entirely covered more than once by thick sheets of glacial ice. It lies within the Northern Moraine and Lake physiographic region, which is divided into (1) the Valparaiso moraine section, (2) the Steuben morainal-lake section, and (3) the Kankakee lacustrine section. The Valparaiso moraine section, including only about 6 square miles in the extreme northwestern part of the county, consists of undulating to rolling topography, with numerous kettle holes and lakes both intermittent and permanent. The Steuben morainal-lake section includes the south-central and southeastern parts and is characterized in general by low ridges and swales. The Kankakee lacustrine section includes the rest of the county and is essentially sandy lacustrine plains, outwash plains, and valley plains.

The soils vary widely in slope, texture, color, drainage, susceptibility to erosion, fertility, and acidity. They are grouped in the following five main divisions: (1) Soils of the uplands, (2) soils of the glaciofluvial outwash plains and terraces, (3) soils of the glacial outwash and lake deposits, (4) mineral soils of the flood plains, and (5) organic soils.

The soils of the uplands, covering 37.4 percent of the total county area, are all developed on glacial drift of Late Wisconsin age and are grouped on the basis of parent material as follows: Soils developed on (1) light to moderately heavy textured highly calcareous glacial drift; (2) moderately heavy to heavy textured calcareous glacial till containing a high proportion of shale; and (3) light-textured calcareous and noncalcareous siliceous glacial drift.

Soils developed on light to moderately heavy textured highly calcareous glacial drift are of the Miami, Crosby, Conover, Brookston, Clyde, Bellefontaine, and Washtenaw series. All are developed on highly calcareous glacial drift composed of unassorted silt, clay, sand, and rock fragments, except the Bellefontaine soils, which are developed on loose calcareous gravel and sand. Lime carbonates are leached to a depth of about 36 inches.

Soils developed on moderately heavy to heavy textured calcareous glacial till containing a high proportion of shale—the Galena, Otis, and Brookston—occur chiefly in the central, south-central, and extreme northwestern parts of the county. Lime carbonates and other bases in

the parent material originally were low and have been leached to a depth of 48 to 60 inches or more.

Soils developed on light-textured calcareous and noncalcareous siliceous glacial drift include the Hillsdale series, developed on calcareous drift containing a high proportion of siliceous sand, and the Coloma series, developed on noncalcareous drift. The Hillsdale soils occupy principally undulating to rolling relief, the more extensive areas occurring north and southwest of South Bend. Coloma soils occur on slightly elevated positions, occasionally occupying kames, knolls, or dunes. The parent material of loose noncalcareous sand extends to depths of several feet.

Soils of the glaciofluvial outwash plains and terraces, occupying 39.7 percent of the county, are grouped as soils developed (1) on highly calcareous stratified gravel and sand; (2) on noncalcareous to slightly calcareous sand and gravel containing a high proportion of Devonian shale fragments; and (3) on thin deposits (4 to 6 feet) of glaciofluvial outwash material over glacial till.

The soils developed on highly calcareous stratified gravel and sand—the Fox and Warsaw—occur generally on nearly level to undulating relief, principally in the eastern part of the county. The Fox soils are developed under a timber vegetation and the Warsaw under a prairie vegetation.

Soils developed on noncalcareous to slightly calcareous sand and gravel containing a high proportion of Devonian shale fragments include those of the Tracy, Hanna, Willvale, and Quinn series, developed under a timber vegetation, the Door and Pinola series, under a prairie vegetation, and the Lydick and Alida series, under a prairie-border vegetation. These soils occupy extensive areas in the northeastern, northern, central, and western parts of the county. The parent material was originally low in lime, and it has been leached to a depth of 60 to 90 inches or more. The content of siliceous sand is high in the lighter textured soils of this group.

The soils developed on thin deposits (4 to 6 feet) of glaciofluvial outwash material over glacial till—the Argos, Walkerton, and Lapaz—occur principally in the south-central part of the county.

Soils of the glacial outwash and lake deposits—the Granby, Maumee, and Newton—occur on nearly level to slightly depressed relief, principally in the west-central, eastern, and northern parts of the county. Granby and Maumee soils are developed on loose calcareous sands, and Newton soils on loose strongly acid sands. They occupy 11.2 percent of the total area.

The mineral soils of the flood plains are represented by only one type—Griffin loam. It occurs in relatively narrow areas adjacent to the larger drainageways, except the Kankakee River, and covers only 1.3 percent of the county.

Organic soils include Carlisle, Edwards, Houghton, and Kerston mucks, Peat, and Wallkill silt loam. They occur in the central and western parts of the county, principally in the valley of the Kankakee River and adjacent to lakes.

Estimated average acre yields of each soil for the principal crops of the county and some use limitations are given.

St. Joseph County lies within the region of Gray-Brown Podzolic soils of the east-central part of the United States. A large part of the soils developed under a heavy forest cover of deciduous trees, with sufficient rainfall to maintain a moist condition throughout the soil, except for short periods. Rather extensive areas, however, were developed under a prairie-grass vegetation.

All the soils of the county are developed on glacial drift of Late Wisconsin age, and on the basis of profile characteristics are classified as zonal, intrazonal, and azonal.

Under recommended soil-management practices the deficiencies of many of the soils can be corrected and satisfactory results produced.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

St. Joseph County, covering an area of 464 square miles, or 296,960 acres, is the central county of the northern tier of counties in Indiana, bordering Michigan on the north (fig. 1). It is roughly rectangular in shape. South Bend, the county seat, is 60 miles east of Gary; 135 miles north of Indianapolis, the State capital; 70 miles northwest of Fort Wayne; and 165 miles northeast of Terre Haute.

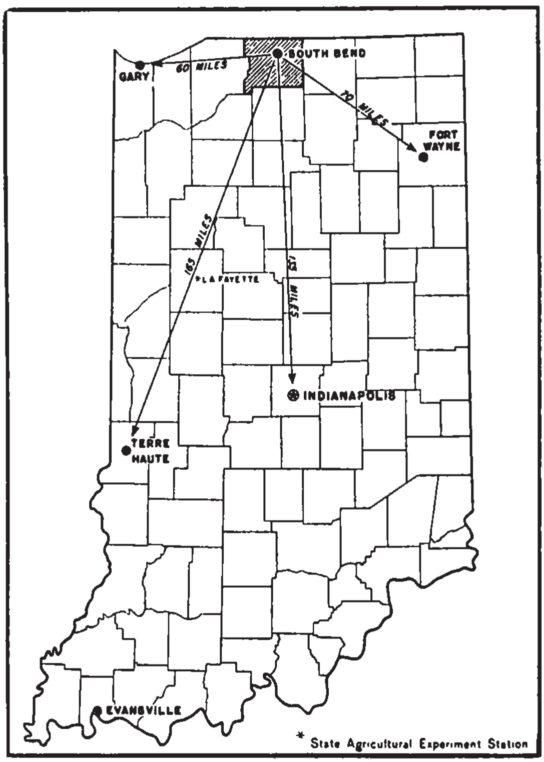

FIGURE 1.—Location of St. Joseph County in Indiana.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

St. Joseph County lies within the Northern Moraine and Lake physiographic region of Indiana.[2] From abundant geologic evidence it seems certain that all of the county, as well as a large part of the rest of Indiana and other Northern States, was covered more than once by thick sheets of glacial ice. The last ice sheet, called the Late Wisconsin glacier, melted some thousands of years ago, leaving deposits of unconsolidated silt, sand, clay, gravel, boulders, and rock fragments. These materials are composed largely of the local underlying bedrock formations over which the glacier advanced. A large proportion of limestone is included in the drift in the eastern and southeastern parts and a large proportion of shale in the other areas. Part of the drift, however, consists of quartz, granite, schist, gneiss, and other igneous and metamorphic rocks. These do not outcrop in Indiana but were transported by the glacier from farther north in the United States and Canada. The mineralogical and chemical composition of the drift varies, depending upon the proportion of each constituent; thus the soils developed on this heterogeneous mixture vary with the proportions of the various sizes and kinds of material.

As the glacier moved forward it ground up the bedrock formations over which it moved, mixed the material, and either pushed it along in front or carried it within or on top of the ice. The ice sheet rounded off the hills and filled in the valleys, but where it remained rather stationary—when the rate of melting at the ice front equaled the rate of forward movement—the material was deposited as moraines or kames. These deposits assumed the form of a single ridge or a series of ridges extending for a considerable distance, with kettle holes or depressions between the knolls or ridges. When the retreat of the ice sheet was rather uniform, the material was deposited as ground moraines, or gently undulating plains.

Gravel and sand, which was assorted and usually shows cross bedding, was deposited by the intraglacial streams and in crevices on the sides of the glacier. Rather wide streams flowing from the melting glacier carried gravel, sand, silt, and clay and rolled large boulders along where the current was torrential. The coarser gravel was deposited nearer the ice front, and the finer materials, as silt and clay, were carried progressively farther downstream. In some instances large boulders were floated down in icebergs.

As the ice sheet retreated the distance or length of the glacial streams became longer, and sand, silt, and clay were deposited on the gravel and coarser material. This stratified, or assorted, material, deposited by the streams flowing from the glacier front, comprises the glaciofluvial outwash plains and terraces.

Three subdivisions of the Northern Moraine and Lake physiographic region occur in this county—(1) Valparaiso moraine section, (2) Steuben morainal-lake section, and (3) Kankakee lacustrine section. These subdivisions, as well as the drainage system, are shown in figure 2.

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[2] LOGAN, W. N., CUMINGS, E. R., MALOTT, C. A., VISHER, S. S., TUCKER, W. M., and REEVES, J. R. HANDBOOK OF INDIANA GEOLOGY. Ind. Dept. Conserv. Pub. 21, 1120 pp., illus. 1922.

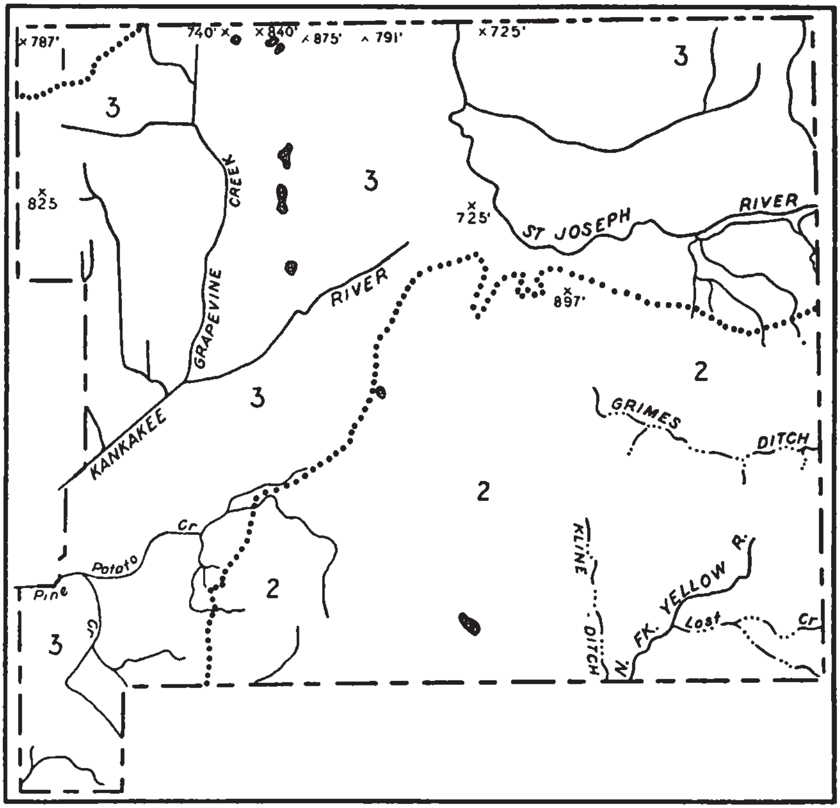

FIGURE 2.—Physiographic regions, elevations, and drainage system of St. Joseph County, Ind.: 1, Valparaiso moraine section; 2, Steuben morainal-lake section; and 3, Kankakee lacustrine section.

The Valparaiso moraine section includes only about 6 square miles in the extreme northwestern part of the county, but the region is extensive in southern Michigan and extends southwestward in Indiana. This area is a broad undulating ridge with numerous depressions, or kettle holes. The crest of the ridge rises to an average elevation of about 775 feet above sea level. A few knolls reach 800 feet. Local relief ranges from 20 to 40 feet. Practically no streams have developed, but small ponds, both permanent and intermittent, occur throughout the area. On the southern border of the moraine the melting glacial ice formed an outwash apron.

The Steuben morainal-lake section occurs in the south-central and southeastern parts of the county, including all of Union, Madison, and Center Townships; the eastern parts of Liberty and Greene Townships; the extreme southeastern part of Portage Township; and the southern part of Penn Township. Most of this area is part of the Maxinkuckee moraine, although several low ridges southeast of South Bend may be parts of the New Paris and Bremen moraines. This physiographic section is an extensive region of morainic topography, characterized in other parts of Indiana by strongly rolling relief with numerous glacial lakes. In this county the relief is undulating to rolling, characterized in general by low ridges and swales.

The average altitude is slightly above 800 feet, but local areas reach nearly 900 feet. The area south and west of South Bend has numerous basins with rather steep walls, and is generally irregular in topography. Local relief ranges from 30 to 70 feet, but in other places in this section it is generally less than 20 feet.

The Kankakee lacustrine section includes the rest of the county and is part of an extensive area of sandy lacustrine plains, outwash plains, and valley plains that extend from southern Michigan southwestward through northwestern Indiana and northeastern Illinois. In general there are two levels of the Kankakee plains. The main one at an average elevation of 750 feet borders the St. Joseph River and includes the extensive former marshlands, which comprise the headwaters area of the Kankakee River. Local relief rarely exceeds 20 feet. In the vicinity of New Carlisle and northwest of Lydick remnants of outwash plains lie 50 to 75 feet higher than the main plain. These areas are highly pitted. The depressions are usually small and well drained, although small lakes and intermittent ponds do occur. Relief of 50 feet or more is not uncommon.

The maximum elevation, 891 feet above sea level, is about 3 miles southeast of South Bend; and the minimum, 654 feet, is where the St. Joseph River enters Michigan. The maximum difference in elevation, therefore, is 237 feet, although the maximum local relief is 100 feet. Other elevations are Lakeville, 837 feet; Warren, 832; Osceola, 739; Notre Dame, 712; and Walkerton, 712.

The St. Joseph and Kankakee Rivers and their small tributaries and the tributaries of the Yellow River drain the county. The St. Joseph River, draining the northeastern part, is a large stream, but has very few tributaries. It flows in a trench generally less than 20 feet below the level of the outwash plain. According to geologists, this river formerly followed the course of the glacial Kankakee River, but during the recession of the late Wisconsin glacier it abandoned the glacial Kankakee Valley and turned abruptly northward into the glacial valley of Dowagiac River.[3] The Kankakee River is a broadly meandering sluggish stream rising in the marshlands of the former glacial stream about a mile west of South Bend and flowing southwest to La Porte County. It lies less than 10 feet below the adjoining marsh and 10 to 30 feet below the nearby outwash plains. Pine, Grapevine, and Potato Creeks form the tributaries of Kankakee River draining the western half of the county. The few natural streams developed since glaciation are short, have a small drainage area, and rise either in the marshlands or along the steeper borders of the moraine. Several small tributaries of the Yellow River drain the southeastern part of the county through Marshall County. The drainage of the county is shown in figure 2.

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[3] LEVERETT, F., and TAYLOR, F. B. THE PLEISTOCENE OF INDIANA AND MICHIGAN AND THE HISTORY OF THE GREAT LAKES. U. S. Geol. Survey Monog. 53, 529 pp., illus. 1915.

CLIMATE

The humid, temperate, and continental climate of this county is characterized by warm to hot summers and moderately cold winters, tempered somewhat by Lake Michigan. Shifting winds and frequent storms crossing northern Indiana prevent most of the prolonged hot, humid periods that occur farther south of the lake. Wide variations in temperature occur throughout the year, however, from an average of 25.2° F. in January to an average of 73.6° in July.

The mean winter temperature is 26.4°, with wide variations from a maximum of 67° to a minimum of —21°. These variations, occasionally rather sudden, are accompanied by alternate freezing and thawing, which at times cause considerable damage to fall-sown small grains, clover, and alfalfa, especially when severe cold occurs without a protective cover. If protected by a snow cover, these crops, especially wheat and other fall-sown small grains, withstand extremely low temperatures except when the soil is saturated or when a coating of ice forms over the plants. Frequency of this damage, however, is not such as to discourage growing these crops.

The mean summer temperature is 71.1°, ranging from a maximum of 103° to a minimum of 37°. This wide variation does not often seriously injure the general farm crops, except when high temperatures occur during prolonged periods of drought.

The average frost-free season is 176 days—from April 27 to October 20—although killing frost has occurred at Notre Dame as late as May 25 and as early as September 11. Late spring frosts occasionally severely injure corn, small fruits, and vegetable crops, especially on low-lying areas. Early frosts in fall sometimes injure corn, tomatoes, and soybeans, but the frequency of such injury is not such as to discourage growing these and other crops common to this county.

The mean annual precipitation is 33.62 inches, about half of which falls during the growing season—May to September, inclusive. The average snowfall for the year is 39.5 inches. Rainfall is rather uniformly distributed throughout the year, although the greatest is in May and June and the least in winter. During winter and early spring the rains are usually gentle, but thunderstorms and flash rains are more common in summer. Excessive rainfall in spring delays seeding operations, and severe soil erosion results on the more sloping areas, especially when the land is being prepared for crops. Hailstorms are rare, but they occasionally cause some damage to crops. The frequency of damage from adverse weather conditions, as prolonged droughts, excessive moisture, and unfavorable temperatures, is rarely such as to cause complete crop failures.

Variations in elevations and positions of the various soils within the county cause differences in climatic conditions. Frost often occurs on the lower lying areas of dark-colored soils, including areas of muck, when there is no frost on the surrounding uplands. The rolling upland areas have more favorable air drainage and provide a safe location for orchards. The nearness of Lake Michigan aids in reducing wide fluctuations in temperature and retards tree growth in spring.

The normal monthly, seasonal, and annual temperature and precipitation at Notre Dame, which may be considered fairly representative of climatic conditions of the county, are given in table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Notre Dame, St. Joseph County, Ind.*[1]

[Elevation, 733 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	28.4	60	−17	2.49	1.03	2.72	9.4
January	25.2	60	−21	2.25	3.72	4.68	11.3
February	25.7	67	−12	1.85	1.09	.82	6.3
Winter	26.4	67	−21	6.59	5.84	8.22	27.0
March	36.3	79	−3	2.83	2.30	4.39	6.1
April	47.6	88	13	2.78	2.57	7.20	1.3
May	59.0	92	27	3.65	2.66	3.84	.4
Spring	47.6	92	−3	9.26	7.53	15.43	7.8
June	68.4	100	37	3.34	1.95	3.28	.0
July	73.6	103	43	3.09	2.12	1.51	.0
August	71.2	102	41	2.94	.97	2.64	.0
Summer	71.1	103	37	9.37	5.04	7.43	.0
September	64.6	98	33	3.05	1.84	2.65	.0
October	53.4	88	20	2.93	1.22	5.23	.5
November	40.6	74	−2	2.42	3.26	2.70	4.2
Fall	52.9	98	−2	8.40	6.32	10.58	4.7
Year	49.5	[2] 103	[3] −21	33.62	[4] 24.73	[5] 41.66	39.5

[1] From U. S. Weather Bureau records.
[2] In July 1930.
[3] In January 1918.
[4] In 1930.
[5] In 1929.

WATER SUPPLY

Usually potable and abundant water supplies for both people and livestock are obtained largely from wells driven into the unconsolidated glacial drift. Water from the bedrock formations is likely to be mineralized. Several artesian wells supply water in the vicinity of South Bend, and springs occur in various parts of the county. Water for livestock is obtained from rivers, lakes, and streams.

VEGETATION

Before settlement of the county by white people most of the upland areas was covered with a heavy growth of deciduous forest. The varieties of trees on the well-drained upland areas included maple (*Acer* sp.), beech (*Fagus grandifolia*), American elm (*Ulmus americana*), and white ash (*Fraxinus americana*). The imperfectly and poorly drained associated areas had a predominance of beech, maple, ash, and elm, and the light-colored well-drained sandy areas, white oak (*Quercus alba*) and black oak (*Q. velutina*). Lower-lying areas and bottom lands sustained a growth of ash, linn or white basswood (*Tilia heterophylla*), sycamore, and European white willow (*Salix alba*). The well-drained prairie regions were covered with a growth of tall prairie grasses, including Indian grass, bluejoint, big bluestem (*Andropogon furcatus*), and little bluestem (*Andropogon scoparius*), with numerous patches of wild flowers. Groves of bur oak (*Q. macrocarpa*) were common in transitional belts where the prairie grades into the forested areas. The marshland of the Kankakee Valley was covered with sedges, rushes, sloughgrass, goldenrod, aster, and wild sunflower, and the better drained areas of muck had stands of tamarack, aspen, ash, and elm.

Practically no stands of virgin timber now exist, and trees on the forested areas are for the most part reproductions of the original species. The principal timbered areas at present occur as scattered woodland on the more sloping areas adjacent to the Kankakee River and on the bluffs adjacent to the St. Joseph River.

ORGANIZATION AND POPULATION

The area now occupied by this county was originally the home of the Miami and Potawatami Indians, although the Shawnee, Delaware, and Kickapoo Indians also were permitted to live here before moving farther west. As the Indians were friendly, settlement of the area was rapid. Some of the earliest explorations in the vicinity were made by Catholic priests and explorers. The early settlers were fur traders, the first of whom were Alexes Coquillard, who settled here in 1823, and Lanthrop M. Taylor, in 1827. Land offices opened in 1829 and land sales followed immediately. Large numbers of immigrants—chiefly from Ohio, New York, Pennsylvania, and other Eastern States—arrived about 1830. The county then included four townships, or an area 30 miles square. South Bend was chosen as the county seat in May 1831, although St. Joseph, a town in name only, was first selected. On July 4, 1850, the present boundaries were established.

The population of the county increased rapidly, and by 1880 it was 33,178, of which approximately 52 percent was rural. In 1940 the total population was 161,823, of which 129,566 were urban and 32,257 rural, the total density being 346.5 per square mile. The native-born white population was 88.1 percent, the foreign-born white 9.6 percent, and the Negro 2.3 percent. The highest proportion of people of foreign extraction reside in and adjacent to the large cities, whereas the rural population is predominantly native-born white.

Since 1880 the rural population has changed little. It is well distributed over the county, except in the vicinity of the large cities, where farms are smaller. The urban population, however, has increased rapidly since 1880 but decreased slightly between 1930 and 1940. South Bend and Mishawaka are industrial cities that have grown rapidly since early settlement. In 1940 South Bend, the fourth largest city in the State, had a population of 101,268, and Mishawaka, the second largest, 28,298. Other towns and villages serving as local trading centers and their populations are Walkerton, 1,178; North Liberty, 978; Roseland, 782; New Carlisle, 747; Lakeville, 567; and Osceola, 498. The rapidly growing cities and the widely scattered towns provide an expanding market for agricultural products.

INDUSTRIES

A large proportion of the population is employed in the manufacturing industries, most of which are centered in the industrial cities of South Bend and Mishawaka. The numbers and kinds of products have been expanding greatly in recent decades—automobiles, batteries, brakes, automobile accessories, aeronautic products, farm equipment including wagons, plows, and feed grinders, electrical products including motors and radios, machine tools and other metal products, hospital and medical supplies and equipment, clothing, food products, and numerous articles used in general industry are manufactured. Most of the products are nonagricultural, although food processing for local consumption is an important industry in the large cities. A cannery is at Walkerton. The railroads furnish much employment on the tracks and in the shops. Sometimes the prosperity of these industries competes with agriculture, resulting in scarcity of farm labor and a consequent expanded market for agricultural products, particularly garden, dairy, and poultry products.

TRANSPORTATION AND MARKETS

Transportation facilities are exceptionally good. Ten steam railways and one electric railway cross the county and serve practically every part, and most of them converge at Chicago. The county is well supplied with hard-surfaced highways, and practically all the county roads are graveled and in good condition the greater part of the year. The 1940 census reports 1,125 farms on hard-surfaced roads; 1,220 on gravel, shale, or shell; 214 on improved dirt; and only 109 on unimproved dirt roads. Establishment of a good system of Federal and State highways, together with increased use of motortrucks, has changed the marketing methods within the county, as most of the livestock, livestock products, and crops are marketed by motortruck.

CULTURAL DEVELOPMENT AND IMPROVEMENT

An excellent system of consolidated schools has been established. Although the majority of the churches are in the cities and towns, there are several rural churches. Free mail delivery service is available to all districts, as is telephone service, and the 1940 census reported 958 farms served by telephone. Electric service is available to a large part of the county. In 1940, electric distribution lines were within a quarter mile of 2,329 farm dwellings, 2,095 of which received current from power lines and 41 from home plants. Many farm dwellings have running water and some have bathroom facilities.

AGRICULTURE

Before settlement by white men the agriculture of the Indians consisted largely of growing small tracts of corn in the vicinity of their villages. The first white settlers lived largely by trapping and fur trading, but they also cleared small tracts, and a few acres of corn and potatoes were grown for food. They traded food and liquor to the Indians for furs and used game as an important source of meat. The influx of settlers was steady, and with the increase in population came an expansion in agriculture.

Settlement was first confined to the well-drained areas, principally in the vicinity of the St. Joseph River, but as it increased, the poorly drained areas were artificially drained and used for crop production. A large part of the county was in the Kankakee River marshlands, and agricultural development of this area did not take place until after 1900, when the river was dredged and straightened and a system of auxiliary ditches developed.

During the early decades forestry was nearly as important as agriculture. The land suitable for farming was cleared, the more valuable timber species were marketed, and a large part of the less desirable timber was burned. The production of corn, wheat, and oats, together with the raising of livestock, was followed in the earlier period. A general farming system, including dairying and poultry and livestock raising, now furnishes the principal source of income. Rapid increase in population has brought about a corresponding increase in dairy products, poultry, and vegetable crops, with a decline in some types of livestock raising, especially sheep and swine.

CROPS

Grain crops are produced on the former marshlands of the Kankakee River and Grapevine Creek and on the extensive upland area in the southeastern part of the county, where a diversified system of grain-and-dairy farming is followed. Federal census records show that the acreage used for cereal crops reached its peak in 1919, when 106,879 acres were in corn, oats, wheat, and rye, but in 1939 the acreage in these crops declined to 75,126.

The acreage in corn has fluctuated somewhat since 1879. Although a maximum of 46,181 acres was harvested for grain in 1909, the yield obtained was 303,921 bushels less than in 1939. Corn yields vary somewhat with climatic conditions, but the introduction and extensive use of hybrid seed has contributed greatly to generally higher yields in recent years. In 1939 the average yield was about 47 bushels an acre. Corn is grown extensively on the dark-colored soils of the Kankakee Valley and less extensively on the sandy soils of the outwash plains. It is grown on most of the farms, however, as it is the basic feed on livestock and dairy farms.

Land used for corn is usually plowed in fall or spring, depending upon the soil type, degree of slope, and weather conditions. Before seeding, the land is thoroughly disked and smoothed with a harrow, drag, or cultipacker. Power-driven machinery, including two- and four-row corn planters, is in general use. Corn is usually drilled on the upland areas, and the common practice is to check plant it on the dark-colored former marsh areas to control weeds more effectively. Fertilizer of varying quantity and analysis, depending upon soil type and economic conditions, is usually used under corn. The quantity ranges from 65 to 150 pounds or more an acre, and in recent years some farmers have plowed under much fertilizer. The analysis used varies from 2–12–6,[4] 0–14–6, or 0–12–12 on the light-colored upland and associated soils to 0–8–24 or muriate of potash on the muck soils. A higher proportion of potash is used on the loose and light-colored sandy soils than on those of heavier texture. On the dark-colored sandy soils 0–14–14 or 0–20–20 mixtures are used.

Methods of harvesting vary according to the use of the corn—it may be husked in the field either by hand or by mechanical pickers, cut and placed in shocks in the field to be harvested later, cut for silage, or hogged or grazed by putting hogs in the field. Mechanical pickers are becoming more generally used, especially where the acreage is large. On the light-colored upland soils and the prairie soils corn is frequently cut and placed in shocks prior to wheat seeding, and the fodder is used for livestock feed and bedding. Practically all the corn grown is fed to livestock, but any surplus produced in the cash-grain farming areas finds a ready market on farms in adjoining counties.

The acreage in oats has fluctuated greatly since 1879, but has steadily decreased since 1909. This decline has been partly due to low prices and to the increase in soybean acreage. In 1939, 10,649 acres, or 9,351 less than in 1909, were harvested. Oats usually follow corn, but may also follow soybeans or special vegetable crops or be grown where hay crops have failed. They are sown as early in spring as weather conditions permit. Methods of harvesting are similar to those for wheat. The grain is either sold to local elevators or livestock feeders or fed on the farm, depending upon the need for additional feed.

Wheat was grown on 21,212 acres in 1939, or 27,395 acres less than in 1899, the year of greatest acreage. The smallest acreage was in 1929, when only 20,857 acres were grown. Wheat usually follows corn, oats, soybeans, or special crops in the rotation, and occasionally it may be sown on land where legumes have failed. When following corn it is usually drilled between the rows or after the corn is cut for fodder or silage. When wheat follows small grains the land is plowed and disked, and when it follows soybeans or special vegetable crops the land is usually disked. Seeding takes place late in September or in October, usually after the "fly-free" date (the date after which the hessian fly ceases to be a danger), as given by the Purdue University Agricultural Experiment Station.

A general practice is to fertilize wheat with applications of 100 to 200 pounds or more an acre. A mixture of 2–12–6 is common, but one with a higher proportion of potash is used on the sandy soils, and one with lower nitrogen content or no nitrogen on the dark-colored soils. Although not a common practice, some manure is used as a top dressing for wheat.

Harvesting is accomplished with binders, the wheat being placed in shocks to be threshed later, or with mechanical combines. The use of combines is increasing, especially on farms having a large acreage of wheat. Most of the wheat harvested is sold to local elevators as a cash crop, only a small proportion being used for livestock feed and seed.

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[4] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

Minor cereal and grain crops grown to a limited extent are rye, spelt, barley, buckwheat, and cowpeas. These crops usually do not have a definite place in the rotation system but are often grown as emergency crops where others have failed. Rye and spelt usually take the place of wheat in the rotation, especially on the light-colored sandy soils. Barley, buckwheat, and cowpeas are usually grown in small individual areas.

Soybeans were introduced about 1910 and quickly became popular as a hay crop. Their use as a grain crop began about 1922, after an oil-extraction plant was built at Decatur, Ill. The acreage in soybeans increased from 1,214 in 1929 to 15,166 in 1939, of which 6,772 acres were harvested for beans. The demand for oil has further increased the acreage, and the beans are grown throughout the county but to a greater extent on the loose sandy soils, which have a somewhat limited adaptation for other crops. They are sown late in May or in June on land that has been prepared by plowing or disking. Formerly most of the beans were drilled with grain drills in rows 6 or 8 inches apart, but in recent years an increasing quantity has been planted with bean drills or corn planters in rows 21 to 39 inches apart. The seed should be inoculated until the soil in the producing field carries abundant inoculation and it should be well developed in the pod for maximum feeding value of the hay. Harvesting the seed is accomplished almost entirely with combines. Most of the beans are marketed as a cash crop, although some are retained on the farm for seed and livestock feed.

Since 1879 the total acreage in hay crops has varied greatly. In 1899, the year of the greatest acreage, 33,370 acres were in hay crops, and in 1939 only 27,470 acres. Radical changes in the kinds of hay grown have been caused by the rapid increase in the acreage used for alfalfa and the reduction in clover grown alone.

The increase in the alfalfa acreage from 17 acres in 1899 to 8,032 in 1939 is due largely to a more general knowledge of the feeding quality of alfalfa and the knowledge that liming a large part of the soils is a prerequisite. Few farmers attempt to grow it until the soil has received sufficient applications of lime, usually in the form of ground limestone. Alfalfa is grown extensively on the upland soils, including Miami, Galena, Hillsdale, Coloma, and associated soils, and it is necessary to lime most of these for successful growth and for the storage of nitrogen in the roots of the plants. It is usually sown in fall (about September 1) on these soils, after the land has been plowed and disked several times to control weeds, and in spring it is seeded with small grain crops on the heavier textured soils. Alfalfa is grown both for pasture and hay, depending largely on the type and quantity of livestock on the farm.

Owing to the desirable practice of seeding a mixture of clover, timothy, alfalfa, alsike, and other seed, the acreage used for clover alone has decreased greatly. Clover requires a slightly acid to neutral soil for best growth, and most of the light-colored soils as well as some of the dark-colored ones need applications of lime for good yields. Both red and mammoth clovers are extensively grown in the hay mixture. Sweetclover is increasing in importance for hay, seed, or intercrop for soil improvement.

The minor hay crops—lespedeza, millet, Sudan grass, and small grains cut for hay—are grown only to a limited extent, and millet and Sudan grass especially are emergency hay crops.

Fruits, vegetables, and special crops are important sources of farm income because of the soil character and the proximity of markets. The large population of South Bend and Mishawaka and the nearness to Chicago provide excellent markets for vegetables. The acreage of vegetables harvested for sale in 1939, excluding potatoes and sweetpotatoes, was 694, and that of potatoes alone was 2,677. Other important vegetable crops were sweet corn, 157 acres; cabbage, 103; and tomatoes, 72. Potatoes, onions, and carrots are crops best suited to the organic soils developed extensively throughout the Kankakee River basin.

Grapes have become an important crop on the sandy soils of the Coloma and Hillsdale series. The number of vines in the county in 1940 was 67,999, with a production of 462,970 pounds in 1939. The chief cultural practice required in grape culture on sandy soils is the growth of a fall-seeded cover and green-manure crop, as rye, to prevent the soil from blowing and to build up the organic content. Applications of nitrate of soda are occasionally made to correct the nitrogen deficiency. Complete fertilizers are not generally used. Spraying is practiced to control dry rot.

Mint harvested for oil was grown on 1,724 acres in 1939, producing a total of 35,934 pounds of oil. Practically all the mint is grown on areas of muck or associated dark-colored soils.

The acreages of the principal crops, as reported by the Federal census for the years 1879 to 1939, are given in table 2.

TABLE 2.—*Acreage of the principal crops in St. Joseph County, Ind., in stated years*

Crop	Acres, 1879	Acres, 1889	Acres, 1899	Acres, 1909	Acres, 1919	Acres, 1929	Acres, 1939
Corn harvested for grain	27, 746	30, 734	39, 886	46, 181	36, 026	27, 078	41, 595
Oats threshed	8, 048	15, 145	9, 468	20, 000	19, 997	15, 106	10, 649
Wheat	41, 765	40, 350	48, 607	29, 171	40, 228	20, 857	21, 212
Rye	261	1, 318	2, 585	2, 699	10, 628	1, 377	1, 670
Soybeans						1, 214	15, 166
Hay, total	21, 844	32, 976	33, 370	26, 919	26, 923	24, 707	27, 470
Timothy or clover, alone or mixed				23, 283	19, 820	13, 113	11, 421
Clover alone			12, 446	2, 041	2, 320	4, 314	[1] 116
Alfalfa			17	272	3, 416	5, 545	8, 032
Small-grain hay			633	151	600	77	323
Legume hay					122	1, 344	7, 312
Other hay			20, 274	1, 172	645	314	266
Potatoes		2, 556	2, 284	4, 149	2, 940	2, 322	2, 677
Other vegetables (for sale)				1, 780	906	907	694

[1] Sweetclover only.

The values of certain crops and livestock products produced in the county in 1929 and 1939 are given in table 3.

TABLE 3.—*Value of specified agricultural products in St. Joseph County, Ind., in 1929 and 1939*

Product	1929	1939
Cereals	$1, 212, 208	$1, 389, 456
Corn harvested for grain	589, 248	961, 196
Wheat threshed	406, 717	296, 116
Other cereals	216, 243	132, 144
Other grains and seeds	45, 368	104, 518
Hay and forage	463, 252	461, 339
All vegetables (excluding potatoes and sweetpotatoes)	143, 533	96, 258
For sale	102, 109	35, 858
For home use	41, 424	60, 400
Potatoes and sweetpotatoes	246, 321	166, 713
Fruits and nuts	39, 396	61, 156
Horticultural specialties sold	88, 848	75, 962
All other crops	414, 213	80, 325
Forest products sold	14, 597	4, 196
Dairy products sold	1, 012, 349	934, 448
Whole milk	940, 553	875, 945
Cream [1]	43, 111	55, 670
Butter	28, 685	2, 833
Poultry raised and chicken eggs produced	506, 318	392, 272
Poultry	257, 492	231, 736
Chicken eggs	248, 826	160, 536
Livestock sold or slaughtered	(2)	719, 607
Cattle and calves	(2)	287, 085
Hogs and pigs	(2)	418, 343
Sheep and lambs	(2)	14, 179
Wool shorn	11, 636	5, 168
Honey produced	6, 227	912

[1] Sweet cream and sour cream (butterfat).
[2] Not available.

ROTATIONS AND FERTILIZERS

Rotations commonly followed on the light-colored soils of the uplands, including the Miami, Galena, Hillsdale, and associated soils, vary from 3 to 5 years or more, depending on the pasture and hay requirements and the soil productivity. The rotations include corn, wheat or oats, and hay crops; corn, oats, soybeans, and hay crops; and corn 1 or 2 years, wheat or oats, soybeans, and alfalfa 1 to 3 years. Legumes are grown less frequently on the glaciofluvial outwash plain areas, especially where a grain system of farming is followed. Corn, oats, and wheat are the dominant crops, with soybeans increasing in importance.

A mixed grain-and-livestock system is followed on the soils of the Tracy series, and the rotation system is less systematic. Alfalfa and some redtop are more generally used as hay crops, and sweetclover as a pasture crop. Rotations on the prairie outwash plains include a predominance of corn, wheat or oats, and soybeans ,with less hay crops. Corn is occasionally grown for two consecutive years, followed by oats

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or wheat and an intercrop of sweetclover. A large part of the vegetables, as well as mint, is grown on the muck soils, the rotation including several years of different vegetables, with corn grown in rotation, especially with potatoes.

In 1939 (1940 census) 1,222 farms, or 43.9 percent of all farms, used 2,902 tons of commercial fertilizer at a total expenditure of $85,307, an average of $69.81 a farm. In addition 7,377 tons of liming materials were purchased by 362 farms at a total cost of $14,483. Use of fertilizer, mostly ready-mixed, has greatly increased in the last few decades. A considerable quantity of superphosphate or muriate of potash is used alone, with a trend toward the higher analyses. Much of the fertilizer is purchased cooperatively through farmer organizations. Special crops, as vegetables, are heavily fertilized, and it is a common practice to fertilize corn and wheat. A few farmers plow under heavy applications of fertilizer before planting soybeans and corn, and some indirectly fertilize legumes by applying larger quantities of fertilizer with wheat, oats, and other small grains.

Supplementing commercial fertilizer with barnyard manure is a common practice. Most of it is applied to the light-colored soils before the land is plowed for corn, with smaller quantities used as a top dressing for wheat. Sweetclover is occasionally grown as an intercrop to be plowed under before planting corn, and some rye is grown as a green-manure crop.

The value of lime for correcting soil acidity is becoming more generally recognized, and an increasing quantity, chiefly in the form of ground limestone or marl, is used. Several marl beds in the county have been a local source of liming material. In determining the lime requirements of a soil or of the soils in a given field, it is important that an accurate test be made—this can be done with acidity indicators. The best procedure is to take samples of both the surface soil and subsoil of the different soils in the field concerned and mail or take them to the county agricultural agent at South Bend or mail them to the Purdue University Agricultural Experiment Station, La Fayette, Ind.

PERMANENT PASTURES

Little attention has been given to permanent pasture improvement in the county, although the need is great, particularly on the rolling sandy upland and the strongly acid outwash plains. Improvement can be effected by liming and fertilizing poor run-down pastures and then disking and reseeding them. When reseeding, a mixture of grasses and legumes is superior to one kind of grass, as the legumes improve the palatability and nutrition of the pasture and encourage a quicker and better stand. Permanent pastures are frequently grazed too early in the season, and overgrazing results in thinning the stand and in consequent erosion. Pasture improvement in wooded areas is usually ineffective, because the trees use a large part of the fertilizer applied.

LIVESTOCK AND LIVESTOCK PRODUCTS

Livestock and livestock products furnish a large part of the farm income in this county and are the medium through which the greater part of the crops is used.

Increased use of power farm machinery has been responsible for the steady decline in the number of horses and mules in the last 20 years. On April 1, 1940, there were 4,765 horses and mules over 3 months old on farms, compared with 8,848 of all ages on January 1, 1920. Part of the work stock is raised in the county and part purchased from adjacent areas. Practically all the feed, principally oats and hay, is grown on the farms.

The present trend toward soil conservation, which includes growing more semipermanent pastures and legumes for pasture and hay and improving permanent pastures, has encouraged the raising of more cattle. On April 1, 1940, 18,872 cattle over 3 months of age were on farms, compared with 14,844 of the same age on April 1, 1930.

The breeds most commonly raised for beef production are Shorthorn, Aberdeen Angus, and Hereford. In 1940 only 597 cows and heifers over 2 years old were kept mainly for beef production. A number of feeder cattle are purchased outside the county when small, grazed during summer and early fall, and then fattened on corn, commercial feeds, and hay. They are marketed at Chicago and nearby markets.

Of the total number of cattle on farms in 1940, 12,169 were cows and heifers 2 years old or more kept mainly for milk production. Specialized dairying, on farms where dairying is the principal source of income, and general farm dairying, on farms that keep a few milk cows as part of a more generalized livestock program, are followed. A large part of the dairy cattle is Holstein-Friesian, with some Guernseys and Jerseys. The value of dairy products sold in 1939 was $934,448, the greater part of which represents the value of whole milk. In 1939 a total of 6,809,691 gallons of milk was produced. Trucks from South Bend and other cities and towns come to the farms at regular intervals for dairy products, and most of the whole milk is retailed in South Bend and Mishawaka.

Swine are raised principally south of South Bend, where farms raising 100 or more head are not uncommon. The principal breeds are Hampshire, Duroc-Jersey, Chester White, and Berkshire. Since 1880 there has been a gradual decline in the number of swine on farms. The total number in 1880 was 30,347, and on April 1, 1940, the number over 4 months old was 16,613. In 1939, 6,549 hogs and pigs were bought, 24,187 were sold alive, and 5,315 were slaughtered on farms. Swine are marketed in Chicago or in South Bend and other local markets.

Sheep raising is relatively unimportant. Many farmers keep some sheep, but there are few large flocks. Only 3,106 sheep over 6 months old were on farms on April 1, 1940. They are raised mostly in the general livestock and grain areas in the eastern and southern parts of the county and are marketed in Chicago and South Bend.

This county is an important poultry producing area. Almost every farm has a few dozen to more than 100 laying hens, and several farms specializing in poultry have several hundred. In 1939, 301,524 chickens were raised and 129,708 sold, and 1,003,350 dozen eggs were produced. The number of poultry other than chickens is not large and consists of a few hundred each of turkeys, geese, ducks, and guineas. The 142 farms specializing in poultry have principally Leghorn and other high-producing breeds, but the majority of the other farms have a wide variety of both mixed and pure breeds. Most of the poultry and poultry products are marketed locally, especially in South Bend and Mishawaka.

The number and value of livestock on farms, as reported by the Federal census in 1920, 1930, and 1940, are given in table 4.

TABLE 4.—*Number and value of livestock on farms in St. Joseph County, Ind., in 1920, 1930, 1940*

Livestock	1920		1930		1940	
	Number [1]	*Value*	*Number* [2]	*Value*	*Number*	*Value*
Horses	8, 667	$742, 138	5, 570	$513, 657	[3] 4, 517	$371, 170
Mules	181	19, 785	196	18, 794	[3] 248	21, 252
Cattle	17, 897	1, 170, 457	17, 379	1, 009, 544	[3] 18, 872	1, 068, 528
Swine	20, 702	317, 506	16, 488	180, 778	[4] 16, 613	152, 921
Sheep	5, 566	71, 094	8, 579	65, 514	[5] 3, 106	19, 830
Goats	51	311	100	361	[4] 216	972
Chickens	158, 421	178, 076 (chickens and other poultry)	[3] 124, 426 (chickens and other poultry)	107, 006	[4] 130, 992	91, 694
Other poultry	4, 360		([6])	([6])	[4] 2, 100	3, 343
Bees....hives	431	2, 227	1, 057	4, 228	325	1, 145

[1] All ages on Jan. 1.
[2] All ages on Apr. 1, except chickens over 3 months old.
[3] Over 3 months old on Apr. 1.
[4] Over 4 months old on Apr. 1.
[5] Over 6 months old on Apr. 1.
[6] Data not available.

TYPES OF FARMS

The 1940 Federal census classified the farms by major source of income in 1939. Accordingly, in this county 894 farms were classified as deriving their major source of income from farm products used by farm households; 646 from dairy products; 613 from field crops; 272 from livestock; 142 from poultry and poultry products; 36 from fruits and nuts; 25 from vegetables harvested for sale; 23 from horticultural specialties; 6 from other livestock products; and 2 from forest products. Eighty farms were classified as having no products sold, traded, or used by farm households in 1939, and 44 were unclassified.

LAND USE

The most extensive agricultural development was reached about 1900, when 90.6 percent of the county was in farms, of which 79 percent was improved land. The total land in farms increased from 210,983 acres in 1929 to 232,450 in 1939, with an increase in cropland harvested from 111,273 to 124,052 acres. Crop failure land decreased in the same decade from 3,655 to 2,290 acres, but idle or fallow cropland increased from 21,581 to 25,822, and plowable pasture from 30,650 to 32,926. Woodland occupied 19,759 acres in 1929 and 20,221 in 1939. Of the total area in farms, 185,090 acres, or 79.6 percent, were available for crops in 1939, but only 126,342 acres were used.

In 1940 the farms ranged in size from less than 3 acres to more than 1,000, about 35 percent containing 30 to 99 acres and about 45 percent containing less than 10 to 40. A total of 316 farms ranged from 180 to 999 acres in size, and 3 contained 1,000 acres or more.

Selected farm data from the United States census for the years 1880 to 1940, inclusive, are given in table 5.

TABLE 5.—*Number of farms, land in farms, and farm tenure in St. Joseph County, Ind., in stated years*

Year	Farms		Land in farms			Operated by—		
	Number	Average size	Proportion of county	Improved land per farm		Owners	Tenants	Managers
		Acres	*Percent*	*Acres*	*Percent*	*Percent*	*Percent*	*Percent*
1880	2, 414	102. 2	83. 8	70. 1	68. 6	81. 3	18. 7	
1890	2, 247	107. 9	82. 4	84. 1	77. 9	70. 9	29. 1	
1900	2, 598	102. 7	90. 6	81. 1	79. 0	70. 0	29. 0	1. 0
1910	2, 460	103. 0	86. 1	83. 6	81. 1	70. 9	27. 5	1. 6
1920	2, 678	96. 3	87. 6	80. 4	83. 4	69. 4	29. 0	1. 6
1930	2, 039	103. 5	71. 7	82. 0	79. 2	72. 9	25. 8	1. 3
1940	2, 783	83. 5	77. 8	66. 5	79. 6	75. 7	23. 8	. 5

FARM TENURE

The 1940 census reported 75.7 percent of the farms in the county operated by owners, 23.8 percent by tenants, and only 0.5 percent by managers. The percentage of farms operated by owners decreased sharply from 81.3 percent in 1880 to 70.9 percent in 1890 and then remained fairly stationary until 1920, after which it increased steadily. In 1940, of the tenant farms, 51.4 percent were operated on the share-tenant and cropper basis and 33.4 percent on a cash basis. When land is rented for cash the price varies with the productivity of the soil, farm improvements and facilities, and current economic conditions. On the share-tenant and cropper basis the tenant usually receives a third to a half of the crop produced, a variable proportion of seed and fertilizer are furnished, and living quarters are provided. Where livestock is produced the same variations exist.

TYPES OF FARMING

The agricultural land of this county is divided on the basis of use and major source of income into three types of farming areas—grain-and-dairy farming of the upland areas, grain farming with limited dairying and muck crop specialization, and urban areas (part-time farming).

Dairying is the major farm enterprise throughout the southern and northwestern upland areas. It is also important on the sandy and gravelly soils of the outwash plains near the urban areas. Economic factors that have favored the development of the dairy industry are the large market for fluid milk in the rapidly growing urban centers and good roads for rapid transportation by large tank trucks. The soil factors that tend to localize dairying in the upland area are the ability to produce abundant supplies of both grain and roughage economically and the size of farm units, which in turn limits the use of power machinery. In the dairy area the soils are adapted to grain, hay, and pasture. Two rotations commonly followed produce abundant supplies of feed—corn, wheat, and mixed hay; or corn, oats or soybeans, wheat, and mixed hay. Legumes are easily and widely grown.

The dairy part of the county is subdivided into three parts: (1) The nearly level area, consisting principally of the Brookston, Crosby, and Otis soils; the dark-colored soils with their abundant supply of plant nutrients and moisture are especially well suited to corn. (2) The undulating to rolling subdivision, consisting largely of the Miami, Galena, and some Hillsdale soils, such as are developed extensively south of South Bend; these soils are susceptible to considerable sheet erosion, consequently a higher proportion of small-grain, meadow, pasture, and other close-growing crops are grown. (3) The rolling sandy subdivision, consisting principally of Hillsdale and Coloma soils; the Hillsdale soils are susceptible to serious sheet erosion and the Coloma to wind erosion on exposed locations; small-grain and meadow crops, especially rye and alfalfa, are better suited because of their ability to use the limited moisture supply more efficiently; alfalfa is well suited, when the moderate acidity is corrected; grapes, apples, and other fruit crops can be successfully grown, although apples require sites having favorable air drainage to reduce frost damage.

The outwash plains and associated marshland soils bordering the St. Joseph and Kankakee River valleys vary widely in crop adaptability, although a grain type of farming has predominated there since settlement. On the high-ground soils, including both dark-colored prairie soils and light-colored medium-textured timbered soils, soil acidity and limited moisture supply favors a grain type of farming. The level topography allows extensive use of power machinery, resulting in low unit-production costs.

On some areas a mixed grain-and-dairy type of farming is followed. Dairying is increased partly because of proximity to the urban area and also because of the necessity to maintain fertility by growing legume and meadow crops and of following a crop rotation system. The predominant soils, Tracy loam and Tracy fine sandy loam, are nearly level but strongly acid and have a limited moisture-holding capacity. Corn, oats, or soybeans and wheat are the main crops, with some alfalfa, timothy, and permanent pasture.

On areas of Tracy loamy fine sand and Tracy loamy sand a general type of farming is followed. Both grain and roughage supplies are limited. The low moisture-holding capacity and low fertility and organic content are limiting factors for corn, wheat, and soybeans, the principal crops. Alfalfa is grown to some extent when the soil has been limed. Onions, potatoes, and other special crops adapted to mineral soils also are grown. Pastures are generally poor and have low carrying capacity.

The dark-colored sandy soils of the Maumee and Granby series and such organic soils as Carlisle, Houghton, and Edwards mucks, formerly marshland, are made tillable by drainage. They are level, slightly acid, and rich in organic matter and nitrogen but deficient in phosphorus and potash, especially potash on the organic soils. As a group, these soils are suited to grain and special-crop systems of farming. On the mineral soils corn, wheat, and soybeans are the principal grain crops, together with clover and mixed hay. The land is almost entirely tillable and only a small acreage is used for pasture. Potatoes are extensively grown as a special crop. Corn and soybeans are the main crops on the muck soils. The organic and nitrogen content of these soils is too high for small grains and leguminous hay crops. A variety of special crops, including mint, potatoes, onions, and carrots, are extensively grown. Small grains are not well adapted, owing to the low grain and high straw yields. A large proportion of the organic soils is used for permanent bluegrass pasture.

Many part-time or subsistence-type farms are located in urban areas and near the larger cities.

FARM INVESTMENT AND EXPENDITURE

The average value of land and buildings in 1940 was $6,466 a farm and $77.41 an acre, compared with $10,947 and $105.80, respectively, in 1930. The average value of implements and machinery increased from $649 a farm in 1930 to $694 in 1940.

In 1940, 1,063 tractors were reported on 1,023 farms, 596 motortrucks on 564 farms, and 2,893 automobiles on 2,364 farms. Much of the farming operations, especially plowing and preparation of seedbeds, is accomplished with power machinery. A large part of the corn is harvested with mechanical pickers, and an increasing quantity of small grain and soybeans is harvested with combines. In 1939, 844 farms reported an expenditure of $354,418 for farm implements and machinery.

A total expenditure of $273,333 for feed in 1939 was reported by 1,720 farms, an average of $158.91 each. The purchase of 2,902 tons of commercial fertilizer in 1939 was reported by 1,222 farms at a cost of $85,307, an average of $69.81 each. In addition, 7,377 tons of liming materials were purchased by 362 farms for $14,483, or an average of slightly more than $40 a farm.

A total of $209,119 was paid for labor (exclusive of housework and contract construction work) on 799 farms in 1939, an average of $261.73 a farm. About 52 percent of this was for labor hired by the month, more than 38 percent for labor hired by the day or week, and the rest for other labor, including piece work and contract labor. Competition between farmers and manufacturers tends to make farm labor scarce and the rates high, especially during periods of industrial prosperity.

SOIL SURVEY METHODS AND DEFINITIONS

In making a soil survey the soils are examined, classified, and mapped in the field and their characteristics recorded, particularly in regard to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings made, and highway or railroad cuts and other exposures studied. Each exposes a series of layers, or horizons, termed collectively the soil profile. Each horizon, as well as the underlying parent material, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The chemical reaction of the soil and its content of lime are determined by simple tests.[5] Other features taken into consideration are the drainage, both internal and external, the relief, or lay of the land, and the interrelations of soil and vegetation.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features that influence the adaptation of the land to the production of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped into classification units, the principal three of which are (1) series, (2) type, and (3) phase. Some areas that have no true soil—Gravel pits and Made land—are termed (4) miscellaneous land types.

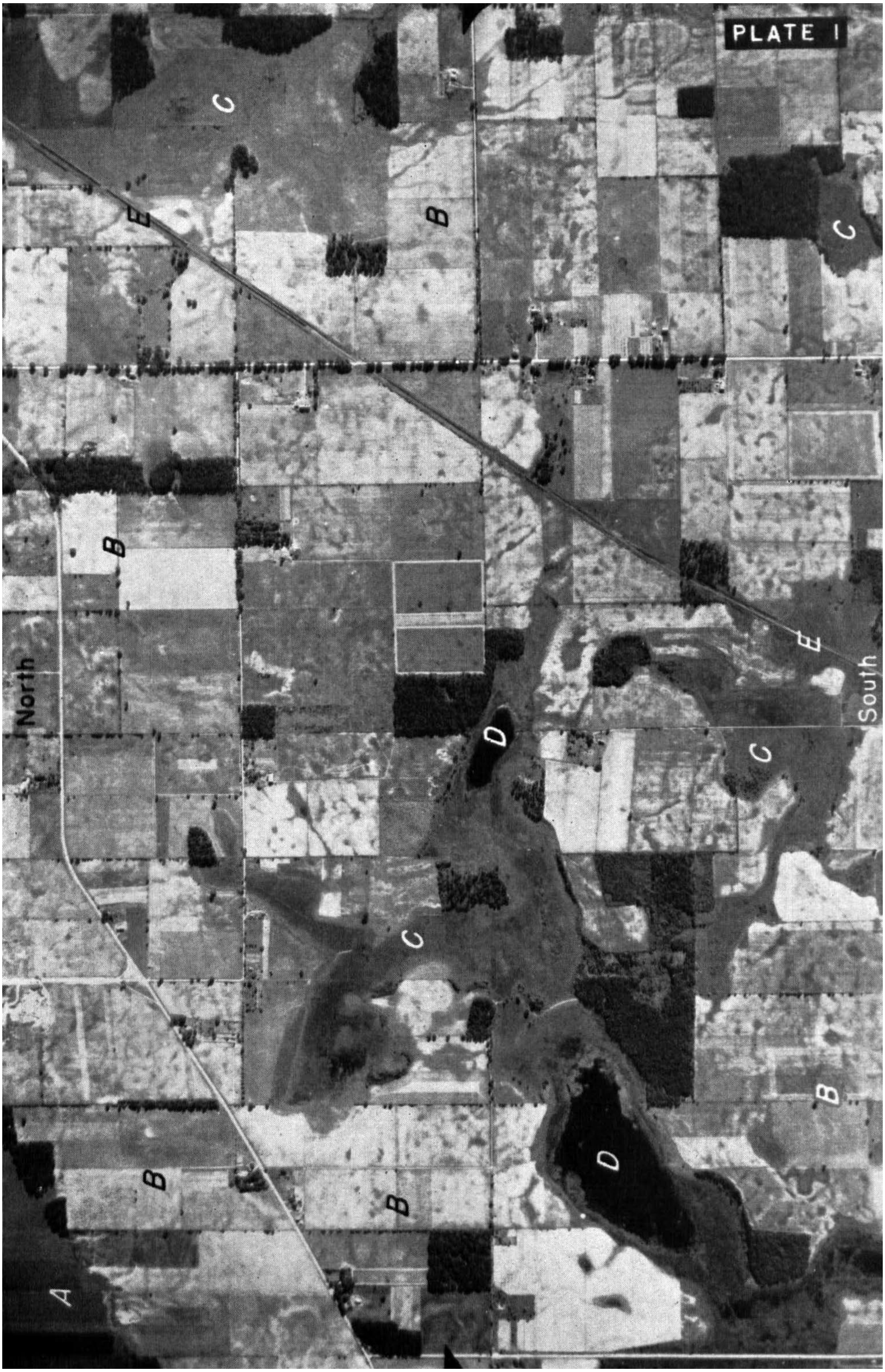
The series is a group of soils having the same genetic horizons, similar in their important characteristics and arrangement in the profile and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage, and other important internal characteristics and the same range in relief. The texture of the upper part of the soil, especially to plow depth, may vary within a series. The series are given geographic names taken from localities near which they were first identified. Miami, Crosby, Brookston, Tracy, and Fox are names of important soil series in this county.

Within a soil series are one or more types, defined according to the texture of the upper part of the soil. Thus, the class name of this texture—sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, or clay—is added to the series designation to give a complete name to the soil type. Tracy loam and Tracy fine sandy loam are soil types within the Tracy series. Except for the texture of the surface soil, these types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the unit to which agronomic data are definitely related. In comparisons of the type and phases of that type, to avoid the repetition of their complete names, the type is sometimes referred to as the normal phase.

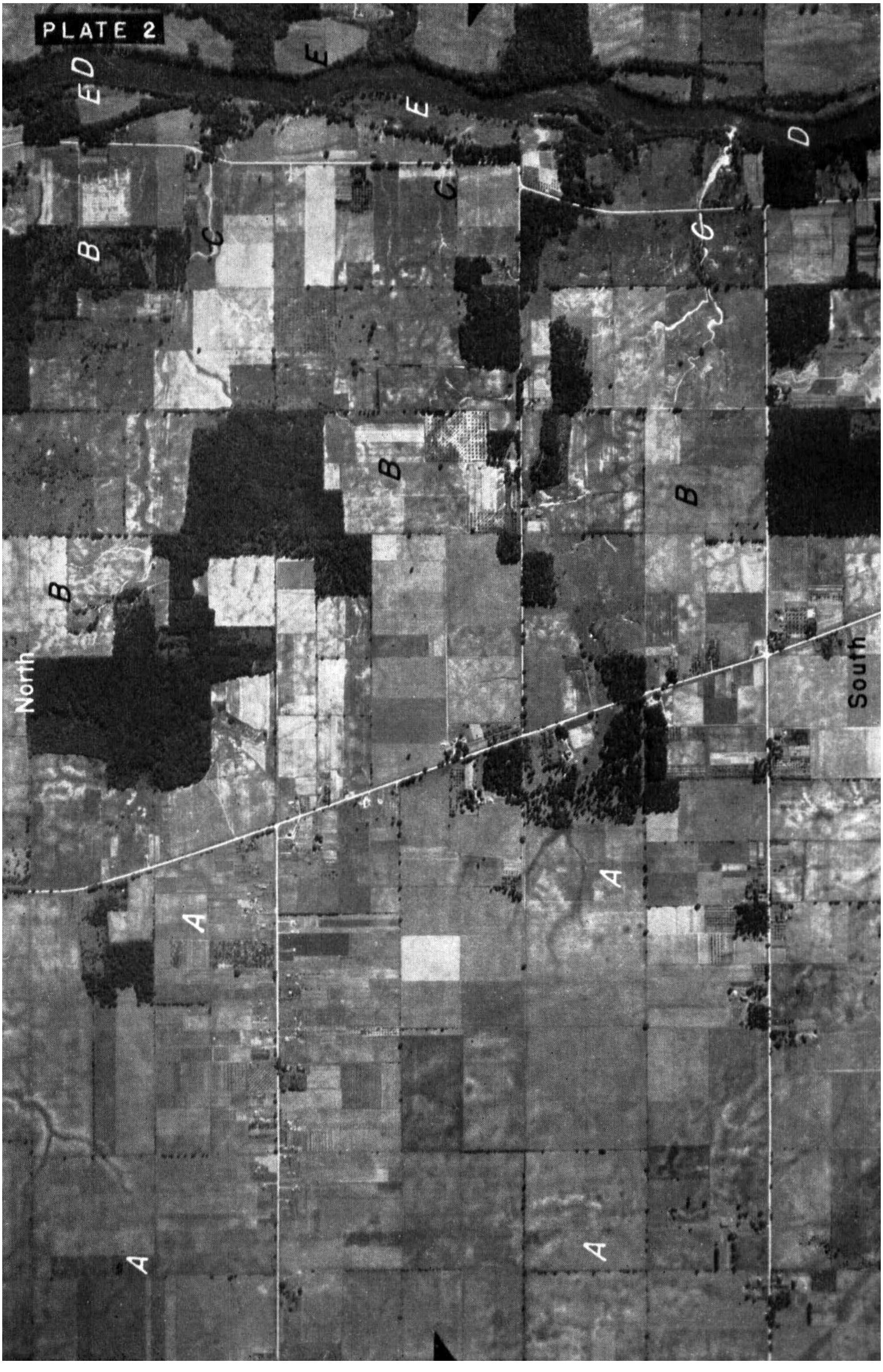
A soil phase specifically named is a variation within the type, differing from the normal phase of that type in some minor feature, gen-

[5] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. Indicator solutions are used to determine the chemical reaction. The presence of lime is detected by the use of a dilute solution of hydrochloric acid. Terms used to describe the reaction of soils of known pH are as follows:

	pH		*pH*
Extremely acid	<4.5	Neutral	6.6–7.3
Very strongly acid	4.5–5.0	Mildly alkaline	7.4–8.0
Strongly acid	5.1–5.5	Strongly alkaline	8.1–9.0
Medium acid	5.6–6.0	Very strongly alkaline	>9.0
Slightly acid	6.1–6.5		



Vertical aerial view of a part of the extensive outwash plain area in southwestern St Joseph County, Ind *A*, Carlisle muck *B*, Nearly level areas of Tracy soils (small dark-colored areas scattered throughout are shallow depressions) *C*, Undrained areas of Carlisle muck used largely for pasture. *D*, Lakes. *E*, Railroad.



Vertical aerial view in northern St Joseph County, Ind *A*, Nearly level dark-colored Door soils with small areas of moderately dark-colored Lydick soils *B*, Light-colored Tracy soils having nearly level to undulating relief except adjacent to small drainageways and to the valley of the St Joseph River *C*, Small drainageways that have worked headward into the outwash plain of Tracy soils *D*, St Joseph River *E*, Griffin loam along alluvial flood plain of St. Joseph River.

erally external, that may be of special practical significance. For example, within the normal range of relief for a soil type some areas may be adapted to the use of machinery and the growth of cultivated crops and others may not. Differences in relief and degree of accelerated erosion may be shown as phases. Even though no important differences may be apparent in the soil itself or in its ability to grow native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instances the more sloping parts of the soil type may be segregated on the map as a sloping or a steep phase.

Aerial photographs (pls. 1 and 2), taken at an elevation of about 13,500 feet, are used as a base in mapping the soils in Indiana. Each picture covers an area of about 4½ square miles, and the scale is about 3.17 inches to a mile. The photographs are covered with sheets of cellulose acetate, a thin transparent material, on which soil boundaries, streams, roads, houses, and other features are drawn in the field (pls. 3 and 4). After the entire county is mapped the cellulose acetate sheets or maps are reduced to a scale of 2 inches to the mile and assembled on a base map prepared on the same scale. The assembled map is printed in colors, with each soil separation having a distinguishing color, letter, and ruling designation.

SOILS

SOIL ASSOCIATIONS

The soils of St. Joseph County vary widely in slope, texture, color, drainage, susceptibility to erosion, fertility, and acidity. These characteristics are significant in determining soil productivity, and one or more of them are often the limiting factors in the agricultural use of the various soil types and phases. Soil types embodying different combinations of these characteristics are often closely associated, and many field units contain a wide range of soil conditions. This makes it difficult to apply individual systems of crop rotation, fertilization, and other soil improvements to the individual soils, and thus more general methods of management are used where such conditions exist.

The principal soil types within each association together with the symbol for each association (as given in figures 3 to 6) are as follows:

Ac2, Crosby silt loam and loam, Brookston silty clay loam, and Conover, Miami, and Galena silt loams and loams.

Ac2L, Crosby loam, Brookston silty clay loam and loam, and Conover and Miami loams.

Ac4, Miami silt loam, Bellefontaine sandy loam, and Crosby silt loam.

Ac8, Brookston and Clyde silty clay loams, Brookston loam, Otis and Crosby silt loams and loams, and Galena and Miami silt loams and loams.

Dh9, Maumee, Granby, and Newton fine sandy loams and loams, Carlisle muck, Willvale and Hanna fine sandy loams and loams, and Griffin loam.

Dn5, Fox and Warsaw sandy loams and loams.

Gq2, Otis silt loam, Brookston silty clay loam, and Galena silt loam and loam.

Gq2L, Otis loam, Brookston silty clay loam, Galena loam and silt loam.

Gq4, Galena and Otis silt loams and Brookston silty clay loam.

Gq4L, Galena loam, Otis and Hillsdale loams, and Brookston silty clay loam.

Gr4, Hillsdale fine sandy loam and loam, Galena and Otis loams, Washtenaw silt loam, and Coloma loamy fine sand.

Gs5, Coloma loamy fine sand, Hillsdale fine sandy loam, and Bellefontaine sandy loam.

Kq8, Lapaz loam and Walkerton and Argos loams and fine sandy loams.
Ks5, Tracy loamy sand and Tracy, Hanna, and Willvale loamy fine sands.
Kv5S, Tracy loamy fine sand, Tracy loamy sand, and Tracy and Hanna fine sandy loams.
Kv2, Willvale and Hanna loamy fine sands, fine sandy loams, and loams and Newton, Maumee, and Tracy fine sandy loams.
Kv5, Tracy loam, fine sandy loam, silt loam, and loamy fine sand, Washtenaw silt loam, and Hanna and Willvale loams.
Lv5, Lydick silt loam and loam, Door and Tracy silt loams and loams, and Pinola silt loam.
Mv5, Door silt loam and loam, Lydick silt loam and loam, and Pinola and Alida silt loams.
1M, Carlisle, Houghton, and Edwards mucks, Peat, and Maumee fine sandy loam.

The characteristic predominant slope, color of surface soil, natural internal drainage, and lime requirements of the soil types that make up the various soil associations of the county are shown in figures 3 to 6.

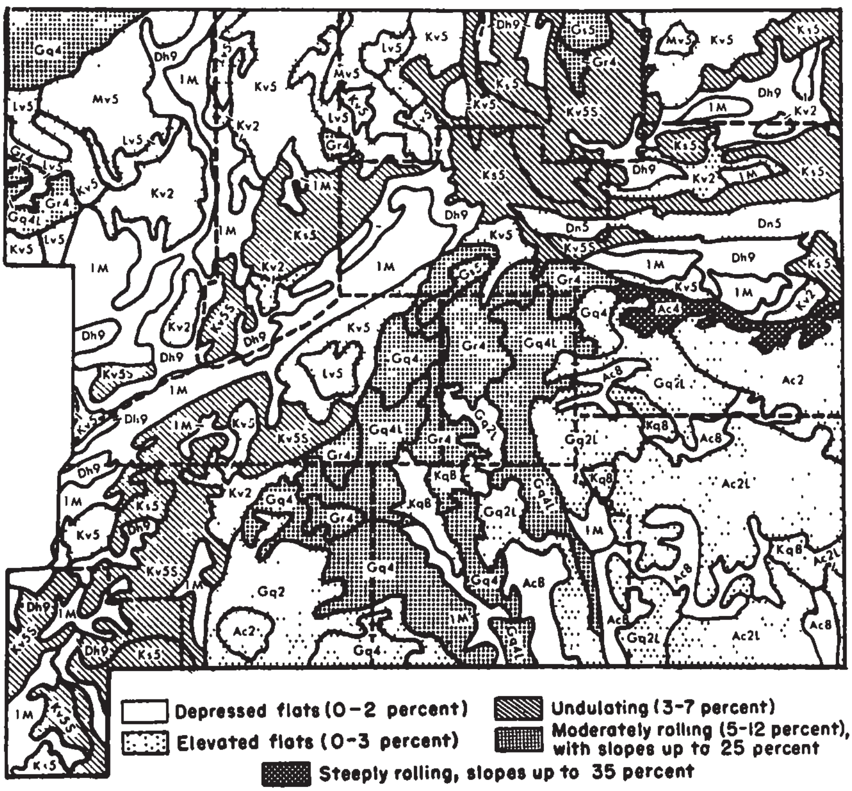


FIGURE 3.—Slopes of the soil associations, St. Joseph County, Ind.

The predominant slopes are given for each group (fig. 3), although other relief groups often occur to a minor extent.

The surface soil ranges from loamy sand to silty clay loam, and the subsoil from loose sand to silty clay. The substratum, or underlying material, ranges from loose sand or gravel to plastic silty clay glacial till.

Color of the surface soil ranges from light gray in the poorly drained soils of the outwash plains to very dark brownish gray in the depressional soils and nearly black in the organic soils (fig. 4). The subsoil color varies from gray or mottled gray, yellow, and rust brown in the poorly and imperfectly drained soils to dark gray in the very poorly drained depressional soils and some of the mucks.

Natural drainage ranges from excessive to very poor, or to ponded conditions. The five groups (fig. 5) refer to internal drainage before artificial drainage is installed, and many soils included as having very poor or poor natural drainage are at present artificially drained sufficiently for crop production. Usually a direct correlation exists between natural drainage and the kind of soil profile developed.

Water erosion is potentially severe on the sloping and steep relief, and where clean-cultivated crops are extensively grown without much thought to erosion control, accelerated erosion is severe. Wind erosion is moderate to severe on the light-textured sandy soils and especially on the muck soils.

The surface soil of the dark-colored soils is relatively high in organic matter, whereas that of the light-colored soils is relatively low. About 89.8 percent of the soils is classified as mineral and 10.2 percent as organic.

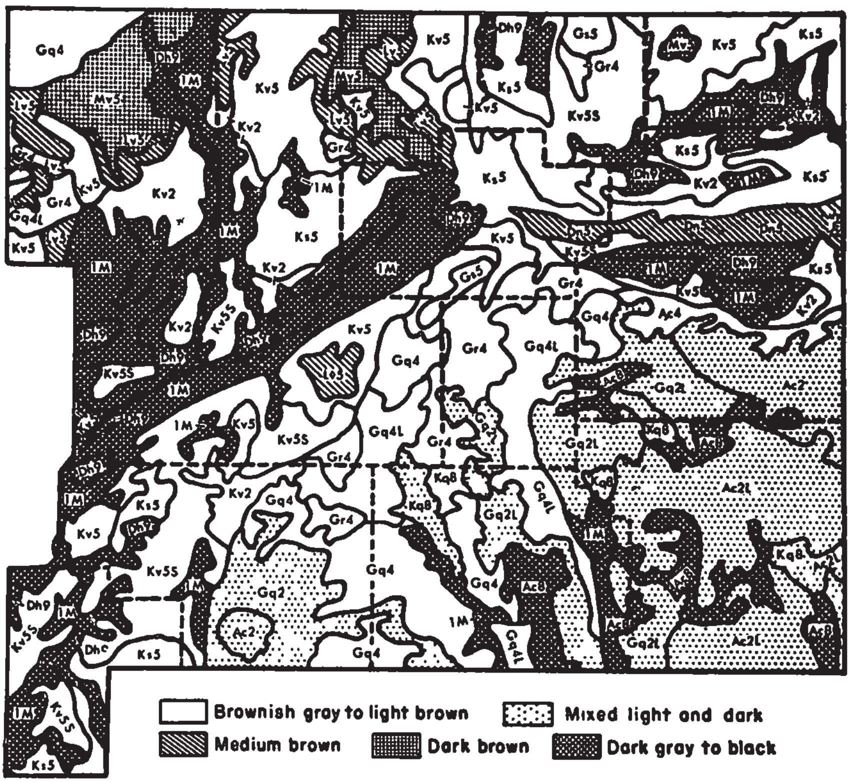


FIGURE 4.—Color of surface soils within soil associations, St. Joseph County, Ind.

In figure 6 the soils are grouped according to the quantity of ground limestone required per acre for the successful growth of clover and alfalfa. Relatively small areas having somewhat different lime requirements occur within a group; thus, the four groupings are applicable only in a general way and not to specific or local areas.

The soils of the Tracy, Door, and Lydick catenas of the glaciofluvial outwash plains and terraces and the Newton soils of the glacial outwash and lake deposits are strongly to very strongly acid; the rest are medium acid to mildly alkaline. The liming program for specific farms should be based on individual field tests.

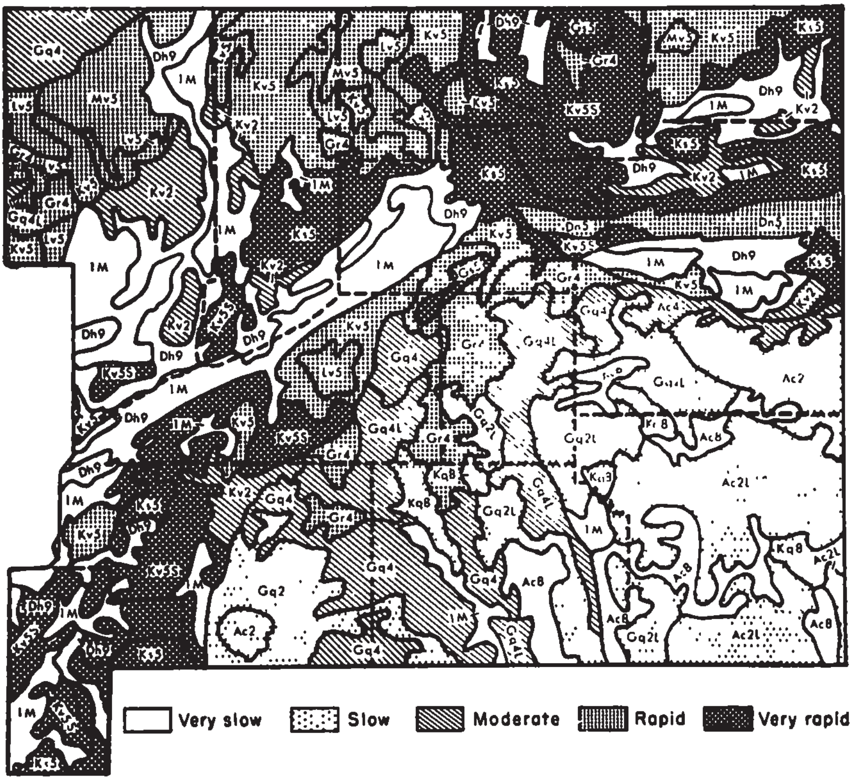
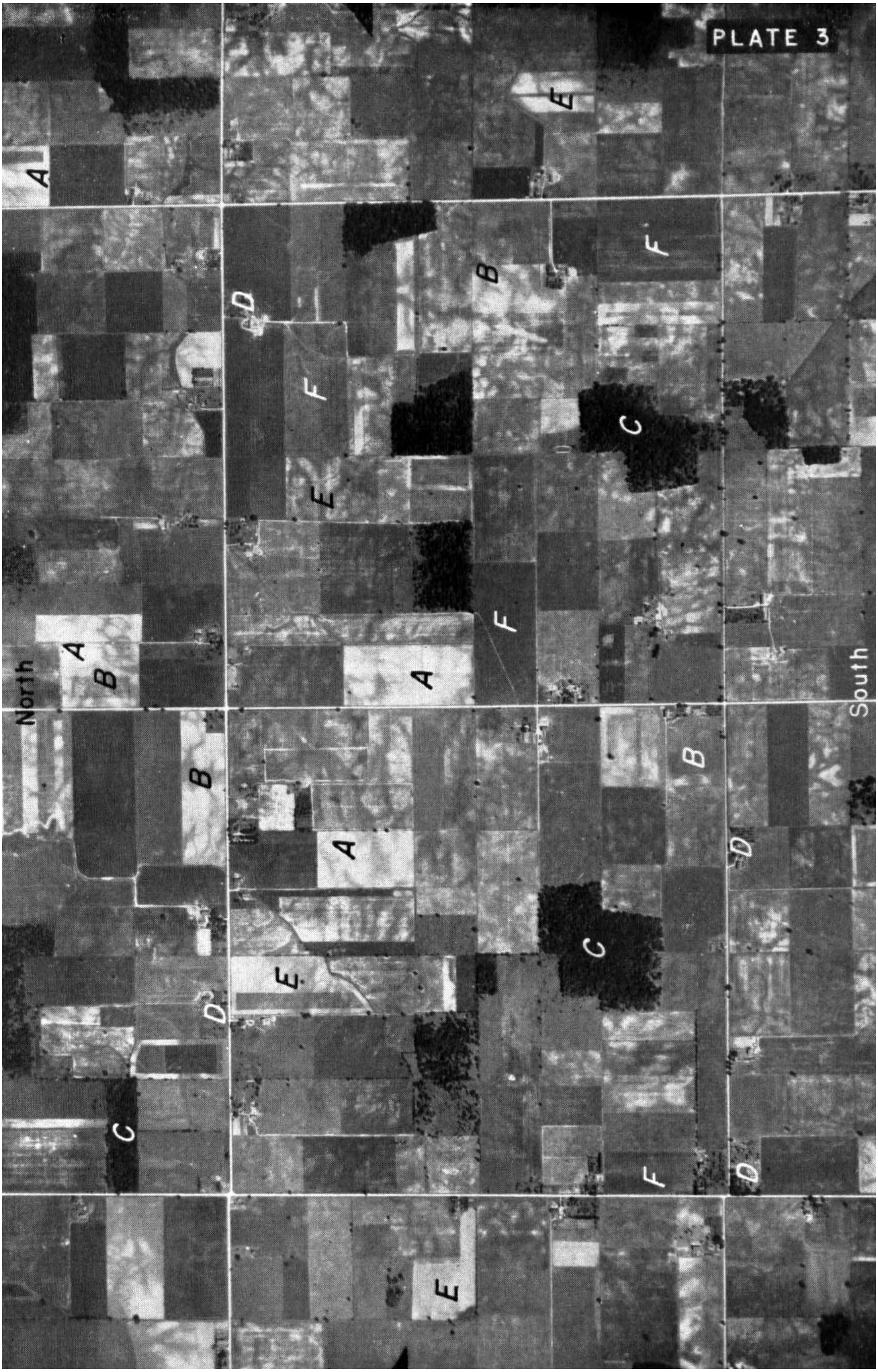


FIGURE 5.—Natural internal drainage conditions, St. Joseph County, Ind.

SOIL SERIES AND THEIR RELATIONS

Soil series listed horizontally in the key to the soil series of St. Joseph County (table 6) are developed on similar parent material, differences in profile development being largely dependent on natural drainage during development. Such a grouping of soil series is called a soil catena. The soil series listed under a given Roman numeral, or drainage profile, have similar natural drainage, but differences in profile characteristics are due almost entirely to the kinds of parent material on which they are developed or on the native vegetation. The great soil groups follow the classification of soils as given in the Yearbook



Vertical aerial view in southwestern St Joseph County, Ind., showing intricate pattern of Crosby and Brookston soils *A*, Light-colored Crosby soils *B*, Dark-colored Brookston soils. *C*, Forest or woodland pasture *D*, Farmsteads *E*, Clean-cultivated fields probably in corn or soybeans. *F*, Rotation or permanent pasture.

Vertical aerial view in southwestern St. Joseph County, Ind. *A*, Light-colored Tracy fine sandy loam surrounded by dark-colored soils (homestead shown along river). *B*, Kankakee River. *C*, Griffin loam and Kerston muck near river, with many drainageways—meanders of the river before dredging—prominent. *D*, Carlisle and Houghton mucks. *E*, Open ditches draining muck areas. *F*, Dark-colored Maumee soils. *G*, Light-colored Tracy soils, the boundary between these and the muck soils being very pronounced, as is the contrast in color.

of Agriculture (Soils and Men) 1938.[6] The Roman numerals are based on the Indiana system of soil profile designation.[7]

Five main divisions are made of the soils of the county: (1) Soils of the uplands, (2) soils of the glaciofluvial outwash plains and terraces, (3) soils of the glacial outwash and lake deposits, (4) mineral soils of the flood plains, and (5) organic soils.

SOILS OF THE UPLANDS

The soils of the uplands, covering 37.4 percent of the county, are developed on glacial drift of Late Wisconsin age, but the drift differs

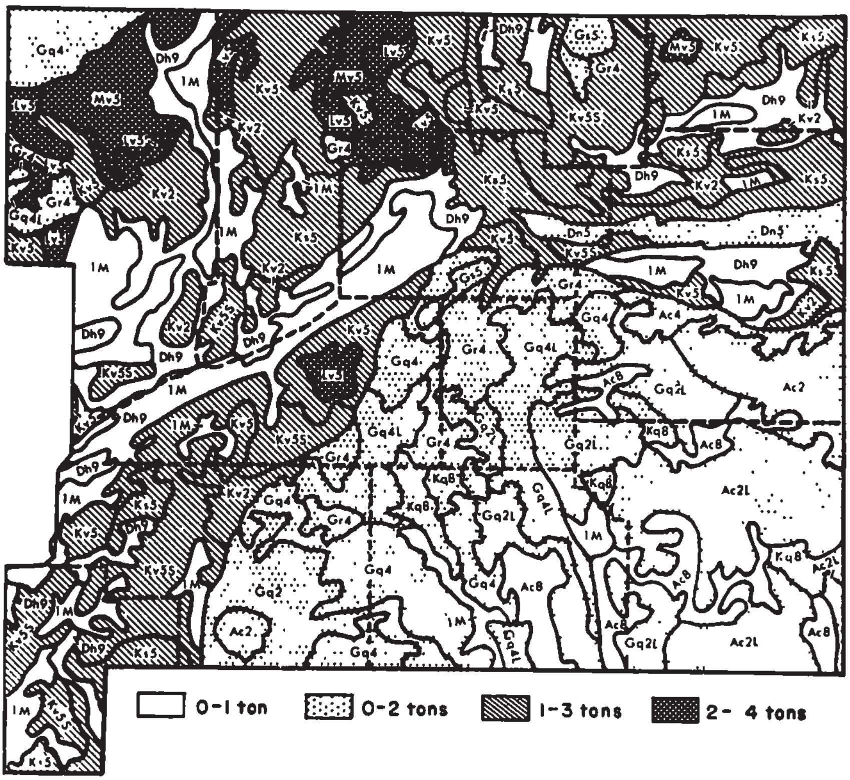


FIGURE 6.—Lime requirements in tons per acre for soil types within soil associations, St. Joseph County, Ind.

widely in texture, mineralogical composition, and structure. They are grouped, therefore, on these bases into soils developed on (1) moderately heavy to light textured highly calcareous glacial drift; (2) moderately heavy to heavy textured calcareous glacial till containing a high proportion of shale; and (3) light textured calcareous and noncalcareous siliceous glacial drift.

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[6] BALDWIN, M., KELLOGG, C. E., and THORP, J. SOIL CLASSIFICATION. *In* U. S. Dept. Agr. Yearbook 1938 (Soils and Men): 979–1001. 1938.

[7] BUSHNELL, T. M. THE STORY OF INDIANA SOILS. Purdue Univ. Agr. Expt. Sta. Spec. Cir. 1, 52 pp., illus. 1944.

TABLE 6.—*Key to the soil series of St. Joseph County, Ind.*[1]

[Major drainage profiles (based on Indiana system of profile designation) shown by Roman numerals]

Soils and soil characteristics	Gray-Brown Podzolic and Prairie soils			Semi-Planosols		Wiesenboden and Half Bog soils		Bog soils
	V	IV	III	II	I	VIII	IX	X
Drainage	Slow external, rapid to very rapid internal	Moderate to very rapid external, moderate internal	Moderate to very slow external, moderate to slow internal.	Slow to very slow external; slow internal.	Very slow external; slow to very slow internal	Very slow to ponded external; slow to rapid internal	Ponded external, very slow to rapid internal	Ponded external; very slow to rapid internal.
Color of Surface soil [2]	Light yellowish brown to grayish brown (Prairie soils—dark grayish brown)	Light yellowish brown to grayish brown	Light yellowish brown to brownish gray	Brownish gray to light brownish gray.	Light gray	Dark gray to very dark brownish gray.	Very dark gray to black	Very dark gray to black
Subsurface soil	Light yellowish brown to yellowish brown (Prairie soils—dark grayish brown)	Light yellowish brown to yellowish brown	Light yellowish brown to light brownish yellow.	Light brownish gray to brownish gray.	Light gray to gray, with light - yellow blotches and mottles.	Dark gray to dark brownish gray.	Very dark gray	Do
Upper subsoil	Yellowish brown to weak reddish brown.	Yellowish brown to brownish yellow.	Light brownish yellow.	Mottled gray, yellow, and rust brown.	Mottled gray, yellow, and rust brown.	Mottled gray, yellow, and rust brown.	Light gray	Do
Lower subsoil	do	do	Mottled gray, yellow, and rust brown.	do	do	do	Mottled gray, yellow, and rust brown.	Very dark gray to light brownish yellow
SOILS OF THE UPLANDS, GLACIOFLUVIAL OUTWASH PLAINS AND TERRACES, AND GLACIAL OUTWASH AND LAKE DEPOSITS								
Soils of the uplands. Parent material derived from—								
Moderately heavy textured highly calcareous Late Wisconsin glacial till.		Miami	(3)	Crosby		Brookston	Clyde	
				Conover [4]				
Light-textured (gravel and sand) highly calcareous Late Wisconsin glacial drift.						Washtenaw [5]	Washtenaw [5]	
	Bellefontaine							

Moderately heavy to heavy textured calcareous Late Wisconsin glacial till containing a high proportion of Devonian shale and a relatively small proportion of limestone.		Galena		Otis		Brookston		
Light-textured siliceous and moderately calcareous Late Wisconsin glacial till.		Hillsdale						
Noncalcareous Late Wisconsin glacial drift composed largely of quartz sand.	Coloma							
Soils of the glaciofluvial outwash plains and terraces.								
Parent material derived from—								
Highly calcareous stratified gravel and sand.	Fox							
	Warsaw [6]							
Stratified sand and gravel containing a high proportion of Devonian shale and a small proportion of limestone.	Tracy		Hanna	Willvale	Quinn			
	Door [6]					Pinola [7]	Pinola [7]	
	Lydick [8]		Alida [8]					
Relatively thin assorted sandy and silty outwash material (4 to 6 feet) over light- to medium-textured glacial till containing a high proportion of Devonian shale.		Argos		Walkerton		Lapaz		
Soils of the glacial outwash and lake deposits								
Parent material derived from—								
Calcareous stratified sands of the glaciofluvial outwash plains and lake deposits.						Granby	Maumee	
Acid stratified sands of the glaciofluvial outwash plains and lake deposits.						Newton		

See footnotes at end of table.

TABLE 6.—*Key to the soil series of St. Joseph County, Ind.*[1]—Continued

ALLUVIAL SOILS[9]

[Major drainage profiles (based on Indiana system of profile designation) shown by Roman numerals]

Soils and soil characteristics	Gray-Brown Podzolic and Prairie soils			Semi-Planosols		Wiesenboden and Half Bog soils		Bog soils
	V	IV	III	II	I	VIII	IX	X
Mineral soils of the flood plains:								
Parent material from—								
Slightly acid to slightly alkaline sandy alluvium from Late Wisconsin glacial drift regions.			Griffin	Griffin				

ORGANIC SOILS

Soils and soil characteristics	V	IV	III	II	I	VIII	IX	X
Organic soils of the uplands, outwash plains, and bottoms:								
Mixed woody and grassy or sedgy peat material								Carlisle
Thin (3 feet or less) deposit of muck over marl.								Edwards
Fibrous peats from reeds, grasses, and sedges containing little or no woody material.								Houghton
Alternate layers of muck and alluvial sands and silts								Kerston.
Undecomposed grassy or sedgy peat.								Peat.
Thin (8 to 30 inches) accumulation of light-colored silty mineral material over muck								Wallkill.

[1] Based on The Story of Indiana Soils, Special Circular 1, by T. M. Bushnell, with some modifications.
[2] Refers to color of moist soil in cultivated areas.
[3] Soils that key into many of the blank spaces in this key have been mapped elsewhere in the State.
[4] Conover soils have dark brownish-gray surface soils.
[5] Washtenaw soils consist of an accumulation of light-colored material over Brookston or Clyde soils.
[6] Warsaw and Door soils are the Prairie analogs of Fox and Tracy soils, respectively. They have a dark grayish-brown surface soil and upper subsoil.
[7] Pinola soil consists of an accumulation of dark-colored material over dark-colored soils of the depressions
[8] Lydick and Alida soils are the Prairie-border analogs, respectively, of Tracy and Willvale soils. Lydick soils have moderately dark grayish-brown surface soils, and the Alida soil has a dark brownish-gray surface soil.
[9] Alluvial soils resemble those in the columns above them in color and drainage characteristics, but they do not have well-defined horizons.

SOILS DEVELOPED ON MODERATELY HEAVY TO LIGHT TEXTURED HIGHLY CALCAREOUS GLACIAL DRIFT

The soils developed on moderately heavy to light textured highly calcareous glacial drift are the Miami, Crosby, Conover, Brookston, Clyde, Bellefontaine, and Washtenaw. These soils occur principally in the eastern and southeastern parts of the county, but relatively small areas also occur in the central and southern parts, with small areas of Brookston soils in the northwest. Relief ranges from steep to nearly level or depressed. With the exception of the Bellefontaine soils, which are formed on loose calcareous gravel and sand, all are developed on highly calcareous glacial till composed of unassociated silt, clay, sand, and rock fragments. Free lime carbonates have been leached to an average depth of about 36 inches. As the soils of this group are complexly associated, a field unit often includes two or more series.

The well-drained Miami soils occur on undulating to steep relief. Water erosion is potentially severe, especially on the steeper areas. These soils have grayish-brown to light yellowish-brown surface soil and yellowish-brown to brownish-yellow subsoil. Gray and yellow calcareous glacial till occurs at an average depth of about 36 inches. Both silt loam and loam types are mapped, and they often occur on slightly elevated knolls and on slopes adjacent to drainageways.

Erosion is not a serious problem on the light-colored imperfectly drained Crosby soils, which occupy nearly level to gently undulating relief. They have brownish-gray to light brownish-gray surface soil and mottled-gray, yellow, and rust-brown subsoil. The underlying gray and yellow highly calcareous glacial till occurs at an average depth of about 36 inches.

Conover soils differ from Crosby soils in having a darker colored surface soil higher in organic content and usually in having a somewhat lighter textured subsoil. They occur on relief similar to that of the Crosby soils and grade into the Brookston soils of the depressions.

The dark-colored very poorly drained Brookston soils occupy slight depressions and rather broad flats. The surface soil is dark gray to very dark brownish gray, relatively high in organic content, and extends to an average depth of about 14 inches; the subsoil is mottled gray, yellow, and rust brown; and the underlying highly calcareous glacial till occurs at a depth of 40 to 60 inches or more.

The very dark-colored, very poorly drained Clyde soil occupies the deeper depressions, usually in association with Brookston soils. The surface soil and upper subsoil, to a depth of about 16 to 18 inches, are very dark gray to nearly black and high in organic content; the lower subsoil is gray to light gray, becoming mottled gray, yellow, and rust brown below a depth of 24 to 30 inches; and the highly calcareous glacial till lies at a depth of 40 to 60 inches or more.

Bellefontaine soils are well to excessively drained and occur on undulating to strongly rolling relief, often on kames and eskers. The surface soil is grayish brown to light yellowish brown, and the subsoil yellowish brown to weak reddish brown. Gray and yellow loose highly calcareous stratified gravel and sand occur at a depth of 36 to 45 inches.

The poorly to very poorly drained Washtenaw soil occupies depressions in association with light-colored soils. It consists of an accu-

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mulation of light-colored mineral material, 8 to 24 inches thick, over the dark-colored Brookston or Clyde soils.

SOILS DEVELOPED ON MODERATELY HEAVY TO HEAVY TEXTURED CALCAREOUS GLACIAL TILL CONTAINING A HIGH PROPORTION OF SHALE

The soils developed on moderately heavy to heavy textured calcareous glacial till containing a high proportion of Devonian shale and a small proportion of limestone fragments include the Galena, Otis, and Brookston. They occur on nearly level to steep relief, with the greater proportion on nearly level to gently undulating relief. With the exception of the associated Brookston soils, the soils are light-colored and relatively low in organic content. The content of lime carbonate and other bases in the parent till material is low and has been leached to a depth of 36 to 60 inches or more. These soils occupy the greater proportion of the central and south-central parts of the county and a relatively small area in the extreme northwestern part.

The well-drained Galena soils occur on nearly level to steep relief, and erosion is potentially severe on the steeper areas. They have grayish-brown to light yellowish-brown surface soil and yellowish-brown to brownish-yellow subsoil. Moderately calcareous glacial till lies at a depth of 36 to 60 inches or more. Both the silt loam and loam types are mapped. The loam contains more siliceous sand than the silt loam, and the depth of leaching, or the depth to calcareous till, is generally greater.

The light-colored imperfectly drained Otis soils occur on nearly level to gently undulating relief, and erosion is not a serious problem in their management. They are similar to Crosby soils in profile characteristics, except they are more acid and contain more shale fragments.

Brookston soils associated with the Galena and Otis are similar to those associated with soils of the Miami catena, except that they probably contain a somewhat higher proportion of shale fragments and are less extensively developed.

SOILS DEVELOPED ON LIGHT TEXTURED CALCAREOUS AND NONCALCAREOUS SILICEOUS GLACIAL DRIFT

Soils developed on light textured calcareous and noncalcareous siliceous glacial drift are members of the Hillsdale and Coloma series.

The Hillsdale soils are developed on light-textured calcareous glacial drift that contains a high proportion of siliceous sandy material. They are well drained and generally occur on undulating to rolling morainic relief, with numerous small depressions or kettle holes between the ridges or knolls. The more extensive areas are north and southwest of South Bend. The surface soil is grayish brown to light yellowish brown, and the subsoil brownish yellow to yellowish brown. The underlying moderately calcareous sandy glacial till occurs at a depth of 60 inches or more.

The Coloma soils are developed on loose noncalcareous sandy material on areas exposed to wind action. They usually occupy the slightly higher positions on the uplands, and occasionally occur as kames, knolls, or dunes. The more extensive areas are northeast of Roseland, and smaller ones are south of South Bend. The surface soil is grayish brown to light yellowish brown, and the subsoil brownish yellow. The underlying loose noncalcareous sand extends to a depth of 5 feet or more.

SOILS OF THE GLACIOFLUVIAL OUTWASH PLAINS AND TERRACES

The soils of the glaciofluvial outwash plains and terraces, occupying 39.7 percent of the county area, are divided into soils developed on (1) highly calcareous stratified gravel and sand, (2) noncalcareous to slightly calcareous sand and gravel containing a high proportion of Devonian shale fragments, and (3) thin deposits (4 to 6 feet) of glaciofluvial outwash material over glacial till.

SOILS DEVELOPED ON HIGHLY CALCAREOUS STRATIFIED GRAVEL AND SAND

The soils developed on highly calcareous stratified gravel and sand of the glaciofluvial outwash plains and terraces include the Fox soils, which developed under timber vegetation, and the Warsaw soils, which developed under a prairie vegetation.

The Fox soils occur on nearly level relief, except for a few narrow sloping areas. They occupy principally a relatively narrow east-west belt in the eastern part of the county. Drainage is good to excessive, and erosion is not a serious management problem. The surface soil is grayish brown to light yellowish brown, the upper subsoil yellowish brown, and the lower subsoil weak reddish brown. Loose stratified highly calcareous gravel and sand lies at a depth of about 36 to 40 inches.

The Warsaw soils are Prairie analogs of the Fox soils and similar to them in profile characteristics, except that the surface soil and upper subsoil are darker colored and higher in organic content. They occur in the eastern part of the county adjacent to the Fox soils.

SOILS DEVELOPED ON NONCALCAREOUS TO SLIGHTLY CALCAREOUS SAND AND GRAVEL CONTAINING A HIGH PROPORTION OF DEVONIAN SHALE FRAGMENTS

The soils developed on noncalcareous to slightly calcareous sand and gravel containing a high proportion of Devonian shale fragments include those developed under timber, prairie, and prairie-timber or prairie-border vegetation. The parent material was originally low in lime, and it has been leached to a depth of 60 to 90 inches or more.

The soils developed under a timber vegetation are members of the Tracy, Hanna, Willvale, and Quinn series. They occur in relatively large areas in the northeastern, northern, central, and western parts of the county. The content of black or dark-gray Devonian shale fragments in the underlying sand and gravel is high, with siliceous material prominent under the lighter textured types. The surface and subsoil layers are strongly to very strongly acid.

The Tracy soils are somewhat excessively to excessively drained and occur principally on nearly level to undulating relief, with a relatively small proportion on sloping and steep relief. The surface soil is grayish brown to light yellowish brown and the subsoil yellowish brown to weak reddish brown. The underlying sand and gravel is gray and light yellow.

The moderately well drained Hanna soils occur on nearly level relief. They have a light brownish-yellow to brownish-gray surface soil, light yellowish-brown to light brownish-yellow upper subsoil, and mottled gray, yellow, and rust-brown lower subsoil. The underlying sand and gravel is mottled gray, yellow, and rust brown.

Willvale soils are imperfectly drained and occur on nearly level relief. They have a brownish-gray to light brownish-gray surface soil and mottled gray, yellow, and rust-brown subsoil and substratum.

The poorly drained Quinn soils occur on nearly level relief. They have a gray to light-gray surface soil and mottled gray and yellow subsoil. The underlying material is mottled gray, yellow, and rust brown.

The soils developed under a prairie vegetation are represented by the Door and Pinola series. The Door soils are similar to the Tracy, except that the surface and upper subsoil layers are darker colored and have a considerably higher content of organic matter. The Pinola soil occupies depressions and consists of dark-colored material washed from sloping areas of dark-colored soil.

The soils developed under a prairie-border vegetation belong to the Lydick and Alida series. The Lydick soils are similar to the Tracy, but the content of organic matter in the surface and upper subsoil layers is intermediate between that of the Tracy and Door series. The Alida soil is comparable, including drainage, to the Hanna soils, except that the surface and upper subsoil layers contain a somewhat higher quantity of organic matter.

SOILS DEVELOPED ON THIN DEPOSITS (4 TO 6 FEET) OF GLACIOFLUVIAL OUTWASH MATERIAL OVER GLACIAL TILL

The soils developed on thin deposits of glaciofluvial outwash material over glacial till represent the Argos, Walkerton, and Lapaz series. They occur principally on nearly level relief in the south-central part of the county, occupying basins and relatively narrow glacial outwash areas within the areas of glacial till. Erosion is not a problem in management.

The well-drained Argos soils occur on nearly level relief, with only a few sloping areas. The surface soil is grayish brown to light yellowish brown, and the subsoil, consisting of somewhat stratified and weathered glacial outwash sand and silt, is yellowish brown to brownish yellow. Yellowish-brown to brownish-yellow unassorted glacial till occurs at a depth of 4 to 6 feet or more.

The Walkerton soils are imperfectly drained and occur on nearly level relief. They resemble the Willvale soils in the character of the surface and subsoil layers, but are underlain at a depth of 4 to 6 feet by shallow deposits of stratified noncalcareous to slightly calcareous silt, sand, and gravel over the glacial till.

The dark-colored very poorly drained Lapaz soil occupies slight depressions in association with Argos and Walkerton soils. The surface and upper subsoil layers are relatively high in organic content and resemble those of Brookston soils, except that the content of rounded gravel and sand is greater and that there is some evidence of stratification in the lower part.

SOILS OF THE GLACIAL OUTWASH AND LAKE DEPOSITS

The soils developed on glacial outwash and lake deposits represent the Granby and Maumee series, developed on calcareous stratified sands, and the Newton series, developed on loose strongly acid sands. They occupy 11.2 percent of the county, occurring principally in the basin of the Kankakee River and to less extent in the eastern and northern parts of the county.

To a depth of about 14 inches the very poorly drained Granby soils are dark-colored, as the organic content of the surface and upper subsoil layers is relatively high. They occur on nearly level to slightly depressed relief, usually in rather extensive individual areas. They have a dark-gray to very dark brownish-gray surface soil and mottled gray and yellow subsoil. Loose calcareous gray and yellow sand occurs at a depth of about 48 inches.

The very poorly drained very dark-colored Maumee soils occur in close association with the Granby and Newton soils. The content of organic matter in the surface and upper subsoil layers is higher than in the Granby soils, as is the total depth of the organic layers. To a depth of about 18 inches the surface and upper subsoil layers are very dark gray to nearly black, and the subsoil is light gray to gray, becoming mottled gray, yellow, and rust brown below a depth of 24 to 30 inches. The underlying calcareous loose sand occurs at a depth of about 50 inches.

The Newton soils are developed on strongly acid loose sands of the lake deposits. They are similar to the Granby soils, except that the reaction is strongly to very strongly acid throughout.

MINERAL SOILS OF THE FLOOD PLAINS

The mineral soils of the flood plains are represented by only one type in this county—Griffin loam. It occupies 1.3 percent of the county and occurs in relatively narrow areas adjacent to the larger drainageways. Drainage is moderately good to imperfect. The surface soil is brownish gray to light brownish gray, and the subsoil highly blotched and mottled with light yellow. The mottled gray, yellow, and rust-brown underlying material usually becomes sandy with depth.

ORGANIC SOILS

The organic soils of the county are Carlisle, Edwards, Houghton, and Kerston mucks, Peat, and Wallkill silt loam. They occur most extensively in the central and western parts of the county, principally in the valley of the Kankakee River and adjacent to lakes.

Carlisle muck is developed principally on a mixture of woody and grassy peat material. The surface and upper subsoil layers are nearly black and somewhat thoroughly decomposed to a depth of about 18 to 24 inches and are underlain by plant remains of reeds, sedges, grasses, and trees. Edwards muck consists of 3 feet or less of nearly black muck over gray marl. Houghton muck is composed chiefly of reeds, sedges, and grasses and is somewhat more friable than Carlisle muck. Kerston muck consists of alternate layers of muck and sandy material and occurs principally adjacent to or in the flood plains of the drainageways. Peat includes relatively undecomposed material and is differentiated from the mucks by the lack of decomposition of the organic matter. The Wallkill soil consists of an accumulation (8 to 36 inches or more) of light-colored silty mineral material over muck.

DESCRIPTIONS OF SOIL UNITS

In the following pages the soil types,[8] phases, and land types are described in detail and their agricultural relations discussed. Their location and distribution are shown on the accompanying map, and their acreage and proportionate extent are given in table 7.

TABLE 7.—*Acreage and proportionate extent of the soils mapped in St. Joseph County, Ind.*

Soil type	Acres	Percent
Alida silt loam	704	0.2
Argos fine sandy loam	512	.2
Argos loam	896	.3
Eroded sloping phase	256	.1
Bellefontaine sandy loam	192	.1
Eroded hilly phase	448	.2
Brookston loam	1,600	.5
Brookston silty clay loam	24,256	8.2
Carlisle muck	13,888	4.7
Shallow phase over clay	1,152	.4
Shallow phase over sand	8,000	2.7
Clyde silty clay loam	4,352	1.5
Coloma loamy fine sand	1,728	.6
Eroded phase	256	.1
Eroded steep phase	320	.1
Steep phase	256	.1
Conover loam	1,856	.6
Conover silt loam	128	(1)
Crosby loam	10,560	3.5
Crosby silt loam	5,376	1.8
Door loam	1,280	.4
Door silt loam	8,384	2.8
Edwards muck	1,024	.3
Fox loam	320	.1
Fox sandy loam	1,408	.5
Sloping phase	512	.2
Galena loam	7,808	2.6
Level phase	3,456	1.2
Galena silt loam	7,360	2.5
Eroded phase	3,456	1.2
Eroded steep phase	640	.2
Level phase	832	.3
Severely eroded phase	832	.3
Severely eroded steep phase	1,472	.5
Steep phase	512	.2
Granby fine sandy loam	1,152	.4
Granby loam	2,624	.9
Gravel pits	512	.2
Griffin loam	4,032	1.3
Gullied land (Tracy soil material)	320	.1
Hanna fine sandy loam	704	.2

[1] Less than 0.1 percent.

[8] When a soil type has been subdivided into phases, that part of the type that bears no phase name is referred to as the normal phase of the type.

TABLE 7.—*Acreage and proportionate extent of the soils mapped in St. Joseph County, Ind.*—Continued

Soil type	Acres	Percent
Hanna loam	320	0. 1
Hanna loamy fine sand	1, 408	. 5
Hillsdale fine sandy loam	4, 288	1. 4
Eroded phase	1, 216	. 4
Eroded steep phase	512	. 2
Level phase	384	. 1
Severely eroded phase	320	. 1
Steep phase	320	. 1
Hillsdale loam	1, 856	. 6
Eroded phase	448	. 2
Eroded steep phase	256	. 1
Gullied phase	192	. 1
Level phase	512	. 2
Severely eroded steep phase	256	. 1
Houghton muck	4, 800	1. 6
Kerston muck	1, 024	. 3
Lapaz loam	1, 728	. 6
Lydick fine sandy loam	448	. 2
Lydick loam	4, 160	1. 4
Eroded sloping phase	576	. 2
Sloping phase	704	. 2
Lydick silt loam	1, 984	. 7
Eroded sloping phase	320	. 1
Sloping phase	640	. 2
Made land	128	(1)
Maumee fine sandy loam	12, 672	4. 3
Mucky phase	5, 952	2. 0
Maumee loam	6, 976	2. 3
Miami loam	768	. 3
Miami silt loam	960	. 3
Eroded phase	640	. 2
Severely eroded phase	512	. 2
Severely eroded steep phase	448	. 2
Newton fine sandy loam	2, 496	. 8
Newton loam	1, 152	. 4
Otis loam	9, 088	3. 1
Otis silt loam	6, 208	2. 1
Peat	384	. 1
Pinola silt loam	896	. 3
Quinn loam	2, 368	. 8
Quinn silt loam	128	(1)
Tracy fine sandy loam	10, 240	3. 4
Eroded sloping phase	1, 728	. 6
Sloping phase	1, 792	. 6
Steep phase	320	. 1
Tracy loam	3, 200	1. 1
Eroded sloping phase	832	. 3
Eroded steep phase	1, 088	. 4
Severely eroded sloping phase	256	. 1
Severely eroded steep phase	1, 408	. 5
Sloping phase	1, 920	. 6
Steep phase	640	. 2
Tracy loamy fine sand	13, 824	4. 6
Eroded sloping phase	2, 944	1. 0
Eroded steep phase	1, 792	. 6
Sloping phase	3, 840	1. 3
Steep phase	256	. 1

[1] Less than 0.1 percent

TABLE 7.—*Acreage and proportionate extent of the soils mapped in St. Joseph County, Ind.*—Continued

Soil type	Acres	Percent
Tracy loamy sand	26, 624	8. 9
Eroded sloping phase	768	. 3
Sloping phase	4, 416	1. 5
Tracy silt loam	192	. 1
Walkerton fine sandy loam	384	. 1
Walkerton loam	704	. 2
Wallkill silt loam	192	. 1
Warsaw loam	320	. 1
Warsaw sandy loam	320	. 1
Washtenaw silt loam	3, 328	1. 1
Willvale fine sandy loam	2, 240	. 7
Willvale loam	3, 200	1. 1
Willvale loamy fine sand	2, 048	. 7
Willvale silt loam	320	. 1
Total	296, 960	100. 0

Alida silt loam.—A total of 704 acres of this moderately well-drained soil is mapped on nearly level to gently undulating relief, principally on the lower terrace positions in the vicinity of New Carlisle. It developed on glaciofluvial outwash plains and terraces underlain by stratified sand and gravel containing a high proportion of siliceous sand and black Devonian shale. The slightly imperfect drainage condition that exists on a few of the areas is due partly to seepage from the adjacent higher terraces. Most of the rainfall is removed internally, and artificial drainage is necessary in some areas for successful growth of most farm crops. As the underlying sand and gravel are porous, open ditches or tile drains can be used easily. Originally the native vegetation probably consisted of tall prairie grasses, but forest encroached upon the soil and the timber vegetation was principally bur oak, with some white oak, ash, and elm. This soil occupies a transitional position between the prairie and timber areas, and the content of organic matter is intermediate between that of the Hanna and Door soils.

Following is a profile description in cultivated areas:

0 to 7 inches, dark grayish-brown to dark brownish-gray friable medium-granular silt loam, moderately high in organic content. Reaction, strongly to very strongly acid.

7 to 10 inches, moderately dark-brown to brownish-gray heavy silt loam that breaks into coarse granules or fine subangular aggregates. Reaction, strongly to very strongly acid.

10 to 20 inches, light brownish-yellow to pale-yellow silty clay loam to clay loam containing some small gravel; compact in place, but breaks into subangular aggregates; hard when dry and easily broken when moist Reaction, strongly to very strongly acid.

20 to 34 inches, mottled gray, yellow, and rust-brown silty clay loam to clay loam; compact in place, but breaks into medium-sized subangular aggregates. Reaction, strongly to very strongly acid.

34 to 80 inches, mottled gray, yellow, and rust-brown slightly coherent sandy loam, fine sand, and sand with an occasional thin layer of gravel and clay loam. Reaction, strongly to very strongly acid in the upper part and medium to slightly acid in the lower.

80 inches +, mottled gray and yellow, with blotches and streaks of rust-brown, loose, slightly calcareous stratified sand and gravel containing a high proportion of siliceous sand and black shale fragments.

Variations are in the color, texture, and thickness of the various layers and depth to and composition of the underlying sand and gravel.

Mapped with this soil are a few imperfectly drained areas east of Hamilton and south of Mishawaka. The surface soil of this inclusion is moderately dark brownish gray, underlain at a depth of 10 to 14 inches by mottled gray, yellow, and rust-brown subsoil. Also included are a few small areas, usually associated with the Door soils, having a higher organic content in the surface and upper subsoil layers.

Use and management.—Alida silt loam occurs in association with Lydick and Door soils, and rotations and crops grown are similar to those on the associated soils. In the areas where a cash-grain system of farming is practiced, rotations include corn, wheat, oats, and soybeans, with an intercrop of sweetclover or a green-manure crop of rye occasionally grown. Rotations on areas where a livestock system of farming, principally dairying, is practiced include corn, wheat or oats, soybeans, and hay crops. The greater part of this soil has been artificially drained sufficiently for growing crops, but a few included areas need additional drainage.

Corn yields range from 30 to 50 bushels an acre, with higher yields obtained when seasonal conditions are favorable and the better management practices used. An increasing acreage of corn is fertilized, with the quantity of fertilizer ranging from 60 to 150 pounds or more an acre. Sweetclover or rye occasionally is used as a green-manure crop before plowing the land for corn.

Wheat follows corn, oats, or soybeans in the rotation. Usually, applications of 100 to 150 pounds or more of commercial fertilizer an acre are made. Some injury to wheat results from winterkilling on the less well-drained areas. Oats, grown either as a field or a cash crop, occasionally take the place of wheat.

Soybeans are extensively grown on areas where a cash-grain system of farming is followed and to a less extent where a livestock system is practiced. They usually follow corn or small grains in the rotation and are used mostly for hay in the livestock farming areas.

Hay crops include either a mixture of clover, alfalfa, and timothy, or clover or alfalfa grown alone. Sufficient lime applications are necessary to neutralize the soil acidity for the successful growth of both clover and alfalfa.

Argos loam.—This well-drained soil developed on thin deposits (4 to 6 feet) of assorted stratified sand, silt, and gravel over unassorted glacial till—essentially a thin deposit of Tracylike material over Galena material. It is the well-drained member of the soil catena that also includes the imperfectly drained Walkerton series and the very poorly drained dark-colored Lapaz. A total of 896 acres is mapped in shallow glacial outwash plains associated with upland areas, principally in the vicinity of Lakeville. The relief is nearly level to gently undulating, with most of the slopes being less than 3 percent. Most of the rainfall is removed internally. The native vegetation consists chiefly of deciduous trees, including oak, hickory, elm, and ash.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown friable loam, relatively low in organic content. Reaction, strongly to very strongly acid.

7 to 12 inches, yellowish-brown heavy loam containing a few small, rounded pieces of gravel and an appreciable quantity of sand. Reaction, strongly to very strongly acid.

12 to 36 inches, yellowish-brown to brownish-yellow sandy clay loam to clay loam containing an occasional boulder and some rounded gravel. Reaction, strongly to very strongly acid.

36 to 50 inches, yellowish-brown to brownish-yellow slightly coherent sandy loam to moderately coherent sand. The material is often stratified with alternating relatively thin layers of heavy- and light-textured material. Reaction, medium to strongly acid.

50 inches +, gray and yellow unassorted clay loam to silty clay loam glacial till. Reaction, medium to slightly acid in the upper part and calcareous below a depth of 60 to 80 inches.

Variations in the profile are in the color, texture, and thickness of the layers and the depth to unassorted glacial till. Where areas of this soil grade into Galena or Hillsdale soils the deposit of outwash material is somewhat thinner. In some areas the upper part of the soil profile is developed from glacial till with strata of assorted sand below 3 feet or more.

Use and management.—Nearly all of Argos loam is cleared and cultivated. The principal crops are corn, wheat, and mixed hay, although some soybeans and special field crops are grown. Hay crops include some alfalfa and a mixture of timothy, clover, and alsike. Commercial fertilizer is commonly used with both corn and wheat. Sufficient lime applications are necessary to neutralize the soil acidity in order to grow successfully clover and alfalfa. The moisture-holding capacity of this soil is not so good as in the Galena soils, and corn may suffer somewhat from drought.

Argos loam, eroded sloping phase.—Most of the areas of this soil occur on slopes of 3 to 8 percent, although the gradient ranges from 3 to about 12 percent. Accelerated erosion has removed 25 to 75 percent or more of the surface soil, and the yellowish-brown to brownish-yellow heavier textured subsoil is exposed in a few areas. To a depth of 6 or 7 inches the present surface soil is grayish-brown to brownish-yellow heavy loam to light clay loam, extremely low in organic content. This phase has poorer tilth than the normal phase of the type but is similar to it in all other characteristics. A total of 256 acres is mapped in relatively narrow areas in association with the normal phase.

This phase is cropped in conjunction with the associated soils, but yields are somewhat lower than on the normal phase, owing to erosion and to less favorable moisture relations.

Argos fine sandy loam.—This well to somewhat excessively drained soil developed on thin deposits (6 feet or more) of outwash material over unassorted glacial till. A total of 512 acres is mapped, principally in the narrow outwash channels in the vicinity of Lakeville, associated with Argos loam, and Walkerton, Lapaz, and Galena soils. The profile characteristics are similar to those of Argos loam, except that the surface texture differs and the subsoil is considerably lighter.

The clay content is variable and low. At 2 to 4 feet the subsoil consists of slightly coherent reddish-brown clayey sand to light clay loam containing a few rounded glacial boulders. At lower depths, the subsoil consists of loose reddish-brown assorted sand occasionally containing glacial rocks and silt and clay and extending to the underlying glacial till at 6 to 10 feet or more.

About the same crops are grown as on Argos loam, but yields are considerably lower because of the somewhat droughty condition. A high proportion of the type is used as pasture and meadowland.

Bellefontaine sandy loam.—This well to somewhat excessively drained soil, developed on Late Wisconsin glacial drift of calcareous stratified gravel and sand, occupies scattered knolls and ridges frequently rising 30 to 50 feet above the surrounding areas. The relief is undulating to sloping, with slopes of 3 to about 12 percent. External drainage is slow to moderate, and internal drainage rapid, owing to the porous nature of the surface soil and the underlying loose gravel and sand. Native vegetation consisted chiefly of white and red oaks and hickory, with a few walnut, maple, elm, and other associated trees.

A total of 192 acres is mapped on the moraine south and southwest of South Bend in association with Miami, Hillsdale, and Galena soils.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown loam to sandy loam, relatively low in organic content. A few small rounded stones and large boulders are on the surface. Reaction, medium to slightly acid.

7 to 12 inches, light yellowish-brown to yellowish-brown heavy sandy loam, slightly compact when dry but crushes easily. Reaction, medium acid.

12 to 30 inches, yellowish-brown to weak reddish-brown gravelly and somewhat waxy clay loam, somewhat plastic and sticky when wet and hard when dry. Reaction, medium acid.

30 to 36 inches, dark grayish-brown to dark-brown waxy and gravelly clay loam, sticky when wet and hard when dry but breaks easily into angular pieces when moist. There is an abrupt change from the above layer to this material, and tongues or lenses of this layer extend into the underlying material. Reaction, slightly acid to neutral.

36 inches +, gray and yellow loose stratified calcareous gravel and sand. Cross bedding is usually prominent.

Variations in the above profile are in color, texture, and thickness of the layers and depth to the loose calcareous sand and gravel. In some areas, especially those west of South Bend, the subsoil is neither so waxy nor plastic as in the normal type but is relatively loose sand and gravel. Accelerated erosion has removed part of the surface soil from some areas, causing extremely low organic content. Where this soil is associated with Galena soils the content of lime in the underlying gravel and sand is lower than normal, and that of shale fragments is higher throughout the profile.

Use and management.—About half of Bellefontaine sandy loam is cultivated, chiefly to corn, wheat, and hay crops. Susceptibility to erosion under cultivation, especially on the steeper areas, makes it important that close-growing crops, particularly hay crops, form a large part of the rotation. Because of its elevated position and rapid internal drainage the soil is too droughty for the successful growth of many farm crops; therefore, water is often the limiting factor in crop yields.

Corn usually follows hay in the rotation, and the highest yields are obtained under better management practices and favorable weather conditions. Wheat usually follows corn and is generally fertilized with 100 to 150 pounds or more an acre of commercial fertilizer. Rye occasionally takes the place of wheat, but little if any commercial fertilizer is used. Only a very small acreage of oats is grown because of the droughty condition of the soil during the growing season.

Hay crops include a mixture of clover, alfalfa, timothy, and alsike, or clover or alfalfa grown alone. Alfalfa is better suited than other hay crops, as the roots are able to reach the available moisture. For the best growth of alfalfa, however, lime applications are necessary to correct the soil acidity. Much of this soil is in permanent bluegrass pasture, but the livestock carrying capacity is low. Pastures are not well taken care of and become dry during the summer.

Bellefontaine sandy loam, eroded hilly phase.—This phase occurs on slopes of 12 to 25 percent or more. Much of the surface soil has been removed from most areas by accelerated erosion, exposing the yellowish-brown subsoil in many places.

Steep slopes, susceptibility to further erosion, and droughtiness limit the adaptibility of this phase to clean-cultivated crops. The soil is better suited to alfalfa, permanent bluegrass pasture, or forest.

Several small areas that have been retained in timber or close-growing pasture or meadow crops are not eroded but have been included with this phase.

Brookston silty clay loam.—Mapped on a total of 24,256 acres, this dark-colored soil of the "black and clay land" is most extensively developed in the southeastern part of the county. It is the very poorly drained dark-colored member of the soil catena that also includes the well-drained Miami, imperfectly drained Crosby, and the very poorly drained very dark-colored Clyde soils, and it usually occurs in slight depressions or relatively broad flats in close association with them. The closely associated or intricately mixed soil pattern of this soil with the Crosby and Otis soils causes most field units to be composed of a mixture of these and other associated soils. Under natural drainage conditions most of the areas were ponded for a considerable part of the year, making artificial drainage necessary for crop production. Such drainage is now sufficient in most areas. The native vegetation consisted of marsh grasses and water-tolerant trees, chiefly red maple, elm, and ash.

Following is a profile description in cultivated areas:

0 to 7 inches, dark gray to very dark brownish-gray silty clay loam, relatively high in organic content. Reaction, neutral to slightly acid.

7 to 14 inches, dark-gray to dark brownish-gray silty clay loam to clay loam, with some light-yellow or rust-brown mottlings in the lower part; relatively high in organic content; easily penetrated by roots. The material breaks into irregular-sized angular pieces that are hard when dry but easily broken down when moist. Reaction, neutral.

14 to 48 inches, mottled gray, yellow, and rust-brown plastic gritty silty clay in the upper part and clay loam in the lower part and containing an occasional boulder and various-sized rock fragments. It breaks into large angular pieces that become hard when dry. Reaction, neutral.

48 inches +, mottled gray, yellow, and rust-brown clay loam to sandy clay calcareous glacial till, composed of unassorted silt, clay, sand, and rock fragments.

Variations in the profile are in the texture and thickness of the various layers and the depth to calcareous till. The shallower depressions and those parts of the larger areas bordering the associated light-colored soils have a heavy silt loam surface texture and are somewhat lower in organic content than normal. Areas of this soil associated with the Galena and Otis soils are less extensive, probably contain a somewhat higher proportion of Devonian shale fragments, and have a greater depth than normal to calcareous till.

Use and management.—Owing to its close association with Crosby, Miami, Galena, and other soils, Brookston silty clay loam is usually cropped about the same as the associated soils. This includes a rotation of corn, wheat or oats, and hay crops, with an increasing quantity of soybeans. Where field units consist largely or wholly of this soil, the rotation usually includes 2 years or more of corn, a larger percentage of soybeans, and less small grain and hay crops. A few special crops, as tomatoes and other vegetables, are grown, particularly close to the larger cities.

Corn usually follows hay crops or soybeans in the rotation, or it may be grown on land where small grains have failed. Where this soil occurs in irregularly shaped and relatively small individual areas, it is fertilized about the same as the associated soils. It is well adapted to growing corn and is considered one of the best soils in the State for this crop. Corn yields 40 to 60 bushels an acre under present management, and when weather conditions are favorable, yields of 80 bushels are common. Where this type comprises the greater part of a field unit, a fertilizer high in phosphate and potash and relatively low in nitrogen or without nitrogen is used.

Wheat usually follows corn or soybeans in the rotation, Commercial fertilizer at the rate of 100 to 150 pounds an acre is used with wheat, but little or no manure is applied as a top dressing. Yields range from 15 to 30 bushels an acre. Oats follow corn, soybeans, or wheat in the rotation, and yields are 25 to 50 bushels an acre or more. Some losses result from the lodging of the grain because of the high nitrogen and organic content of the soil. Very little fertilizer is used with oats.

Soybeans, grown for both grain and hay (mostly grain), are well adapted to this soil. Excellent stands of alfalfa and clover can be secured without the use of lime, and yields usually are high. Some damage to alfalfa and clover results from winterkilling, and many farmers grow a mixture of alfalfa, clover, timothy, and alsike rather than alfalfa or clover alone. Such special crops as sweet corn and tomatoes are well suited, although only a relatively small acreage is grown. Excellent stands of permanent bluegrass can be obtained, and the livestock carrying capacity is high.

Brookston loam.—This soil, developed on highly calcareous glacial till of Late Wisconsin age, is the very poorly drained dark-colored member of the soil catena that also includes the well-drained Miami, the imperfectly drained Crosby, and the very poorly drained very dark-colored Clyde series; it is also a member of the soil catena that includes the well-drained Galena and imperfectly drained Otis series. It occurs principally in association with Galena and Otis loams in the central and south-central parts of the county and with Crosby and Miami loams in the eastern part. A total of 1,600 acres is mapped.

The color and organic content of the surface soil and the number and arrangement of layers are comparable to those of Brookston silty clay loam, but the surface soil is lighter textured and contains a higher proportion of sandy material; the subsoil is also lighter textured, and the depth to calcareous till usually somewhat greater.

Areas associated with the Galena and Otis soils have a higher proportion of black shale fragments and greater depth to calcareous till than those associated with the Crosby soils.

This soil is cropped about the same as the associated soils, with crop yields somewhat lower than on Brookston silty clay loam.

Carlisle muck.—A very poorly drained organic soil developed on a mixture of woody and grassy or sedgy peat material. The material was deposited in shallow to relatively deep lakes and ponds and represents an accumulation of the plant remains of sedges, fern, moss, and reeds, which was replaced by a dense timber growth as the ponds became shallower. As a result woody material is mixed with the grassy or sedgy material in the first 2 or 3 feet of the profile. Sufficient artificial drainage for crop production has been accomplished on most areas largely by open ditches. A total of 13,888 acres is mapped in relatively large areas in the north-central and western parts of the county, principally in the basin of the Kankakee River.

Following is a profile description in cultivated areas:

0 to 7 inches, very dark-gray to black granular muck. Reaction, medium to slightly acid.

7 to 36 inches, nearly black to very dark-brown firm finely divided organic material. Reaction, medium acid to neutral.

36 inches +, brown to brownish-yellow macerated organic material composed of partly decomposed reeds, sedges, ferns, and other vegetation. Stems and leaves of plants are usually not easily distinguishable.

Variations are in the thickness of the dark-gray to black surface soil and subsoil and the color and composition of the underlying material.

Use and management.—Much of Carlisle muck has had sufficient artificial drainage for crop production. Corn, soybeans, and bluegrass are the principal crops, but vegetable crops also are grown, especially in the vicinity of South Bend. The soil is extremely high in organic matter, relatively high in nitrogen, and deficient in phosphorus and potash. After a few crops have been grown, relatively large applications of commercial fertilizer high in phosphate and potash, particularly potash, are necessary for the successful growth of both corn and vegetables.

Land for corn usually receives 150 to 300 pounds of commercial fertilizer high in potash, as 0–9–27 or 0–10–20. Under good management yields average about 50 bushels an acre and frequently are as high as 70 bushels. Yields are often dependent on weather and moisture relations. Frost injury on this soil is more frequent than on the higher lying areas that have better air drainage; consequently, late frost in spring and early frost in fall sometimes severely damage corn. Early maturing varieties, planted after June 1, are commonly grown. Soybeans are well adapted and extensively grown, yields averaging 22 to 25 bushels an acre. Small grains are not grown because the large nitrogen supply results in excessive straw growth with consequent lodging and loss of crop. Timothy and redtop are better suited grasses for meadows. Legumes are not suitable because of the drainage conditions. Kentucky bluegrass is the principal permanent pasture grass. These pastures have a high carrying capacity, furnishing abundant feed, even during July and August when bluegrass is usually dormant.

This soil is well suited to vegetables, including potatoes, cabbage, sweet corn, onions, carrots, and other small vegetables. Potatoes are the most extensively grown, with the yields ranging from 150 to 300 bushels an acre. They are usually fertilized with 300 to 700 pounds of fertilizer high in potash (0–9–27). The acreage of mint, once a very important crop, is again increasing. Mint is usually fertilized with 150 to 300 pounds of 0–20–20 or 0–10–20 fertilizer. On muck, which has been under cultivation a long time, a higher analysis of potash is used. Yields of oil range from 15 to 50 pounds an acre and average about 22.

Carlisle muck, shallow phase over clay.—This soil differs from the normal phase of the type in that it consists of about 12 to less than 36 inches of black muck over clay. It occurs in association with the normal phase, commonly as a fringe or along the margins of the larger muck areas. A total of 1,152 acres is mapped, usually as relatively narrow elongated areas.

Areas of this phase are not so easily overdrained as are those of the normal phase, and it is about as well adapted to vegetables and probably somewhat better adapted to corn.

Carlisle muck, shallow phase over sand.—This type consists of about 18 to less than 36 inches of nearly black muck, similar to the surface and upper subsoil layers of the normal phase of the type, over loose sand that is usually gray. An aggregate area of 8,000 acres occurs principally as relatively narrow elongated areas along the margin of the normal phase, often in a position intermediate between areas of the normal phase and Maumee or Granby soils. Essentially, it is a transition between the muck soils and the dark-colored sandy mineral soils.

This phase is well adapted to corn, soybeans, and special crops. Land-use studies indicate that a higher proportion of such crops are grown than on the normal phase. Some areas, however, may be slightly droughty due to being overdrained, and the crop yields are therefore slightly less. Yields may be reduced on some areas in wet seasons where drainage may be retarded by the plastic clayey sand substratum.

Clyde silty clay loam.—This soil is developed on highly calcareous Late Wisconsin glacial till. It is the very poorly drained, very dark-colored member of the soil catena that also includes the well-drained Miami, the imperfectly drained Crosby, and the very poorly drained dark-colored Brookston series. It occurs in relatively small depressional areas, usually closely associated with Brookston soils. Some areas are associated with the well-drained Galena and imperfectly drained Otis soils, which are developed on moderately heavy-textured calcareous glacial till relatively high in Devonian shale. A total of 4,352 acres is mapped.

Natural drainage is very poor, and most areas were in a ponded condition before being artificially drained. At present some areas have sufficient artificial drainage, but many need more adequate drainage for the best crop production. Water stands on the land during periods of excessive moisture. Native vegetation consisted of marsh grasses and water-loving trees. At present several undrained areas have a growth of sycamore trees and marsh grasses.

Following is a profile description in cultivated areas:

0 to 7 inches, very dark-gray to nearly black silty clay loam, relatively high in organic matter. Reaction, neutral to slightly acid.

7 to 18 inches, dark-gray to very dark-gray gritty silty clay loam to silty clay, relatively high in organic matter. An occasional large boulder is present, and the content of sand and fine gravel is variable. The material breaks into angular pieces that become hard when dry. Reaction, neutral.

18 to 28 inches, gray to light-gray silty clay to silty clay loam, with some pale-yellow mottlings in lower part. Breaks into coarse blocky aggregates, plastic when moist and hard when dry. The content of sand and fine gravel is variable, and an occasional boulder is present. Reaction, neutral.

28 to 50 inches, mottled gray, yellow, and rust-brown clay loam to sandy clay, breaking into larger angular pieces. Plastic when moist and very hard when dry. Reaction, neutral.

50 inches +, mottled gray, yellow, and rust-brown compact calcareous glacial till consisting of unassorted silt, clay, sand, and rock fragments.

Variations from the above profile characteristics are in texture and thickness of the layers, in depth to calcareous till, and in organic content of the surface and upper subsoil layers. Included with this soil are a few small areas that have a silt loam and loam texture. The silt loam variation is usually associated with the Galena soils. The deeper depressional areas and those that adjoin areas of muck have a higher organic content that normal. A thin deposit of relatively light-colored silty material occurs on a few areas.

Use and management.—Areas of Clyde silty clay loam having adequate artificial drainage are cropped about the same as the associated Brookston, Crosby, and other soils. Corn yields are equal to or slightly higher than on Brookston silty clay loam in years of normal or abnormally low rainfall, but during years of abnormally high rainfall, crops are occasionally drowned out. The average yield over a period of years, therefore, is somewhat lower than on that soil.

Wheat, oats, and other small grains are frequently grown but are often severely damaged by winterkilling or by drowning out. Lodging of small grains also is common. When sufficiently artificially drained the soil is well adapted to soybeans.

Liming is not necessary to secure good stands of clover and alfalfa, but damage to these crops from winterkilling is occasionally severe. Areas that are not sufficiently drained are idle during some years, especially when moisture conditions are abnormally high in spring and early in summer.

Coloma loamy fine sand.—This soil is developed on noncalcareous Late Wisconsin glacial drift composed largely of quartz sand that has been reworked by wind action. It covers a total of 1,728 acres. Numerous areas occur on the uplands, the more extensive ones lying northeast of Roseland and smaller ones adjacent to and south of South Bend. The relief ranges from 3 to 12 percent, except for a few small areas on nearly level relief, as the one northeast of Roseland in section 8. The soil often occurs in low dunelike areas that are slightly higher than the adjacent upland areas. Most of the rainfall on this soil is removed internally, as the loose porous sandy material allows free downward movement of moisture, causing excessive drainage for most cultivated crops. The native vegetation consisted of a mixed hardwood forest, with black and white oaks predominant.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown loose loamy fine sand containing a small quantity of silt and clay, which gives the material a very slight degree of coherence when moist. Relatively low in organic content. Reaction, medium to slightly acid.

7 to 50 inches +, brownish-yellow fine sand containing streaks and lenses of deep-yellow loamy sand. Roots penetrate this material easily; water moves downward rapidly. Reaction, medium acid to neutral below a depth of 50 inches.

The quantity of stones and pebbles on and in the profile is variable but never large.

Use and management.—Approximately 90 percent of Coloma loamy fine sand once was cleared and cultivated, but at present only about 60 percent is cultivated and about 30 percent is idle, chiefly because of low crop yields.

The principal crops are wheat, rye, and alfalfa, with some corn and special field and vegetable crops. Rye is the main small grain, as it is better adapted to the sandy condition. Alfalfa produces fair to good stands, but sufficient lime is necessary to correct the acidity for successful growth. Both small grains and alfalfa are occasionally damaged by the wind blowing the loose sand. Owing to the droughty condition, this soil is not well adapted to corn, but it is well adapted to grapes, melons, and fruits, although only a small acreage is planted to these crops.

Coloma loamy fine sand, eroded phase.—Accelerated erosion, chiefly by wind, has removed 25 to 50 percent or more of the surface soil from some areas of this soil. The pale-yellow or brownish-yellow subsoil is exposed in numerous small areas, and the organic content is extremely low. A total of 256 acres is mapped in association with the normal phase of the type.

Use and management.—Cultivated crops on Coloma loamy fine sand, eroded phase, include principally wheat, rye, and alfalfa, with a smaller quantity of corn, special field crops, and truck and fruit crops. Crop yields are considerably lower than on the normal phase, and therefore all available organic matter should be turned under and crop rotations should include a predominance of small grains and hay crops, so as to control wind erosion and to maintain and increase productivity. This soil is well adapted to melons, grapes, and other small fruits, but at present only a small part is used for these crops.

Coloma loamy fine sand, steep phase.—A total of 256 acres of this soil is mapped on slopes of 12 to 35 percent or more. It occurs in association with the other phases or the normal phase of the type, principally in the central part of the county south of South Bend. Often it is largely under timber cover on the leeward side of dunelike areas. The profile characteristics are essentially the same as those of the normal phase.

Owing to the steep slope cultivated crops are not well suited to this soil. Grapes, apples, and other fruits are somewhat adapted, although very little acreage is used for them.

Coloma loamy fine sand, eroded steep phase.—Accelerated wind erosion has removed approximately 50 percent or more of the surface

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soil of this phase, exposing the subsoil in numerous places. The slopes range from 12 to 35 percent or more.

All the areas were cleared of timber and placed under cultivation or in permanent pasture; at present, however, only a small proportion is cultivated. Because of droughty conditions and injury to crops from wind blowing the sandy surface material, crop yields are extremely low, and the soil is better adapted to fruit crops or to forest than to cultivated crops. On several hilly areas exposed to wind action, the wind has formed irregular holes as much as 2 feet deep. Such areas are not suitable for cropping.

Conover silt loam.—An imperfectly drained moderately dark-colored soil developed on highly calcareous Late Wisconsin glacial till. It occurs in close association with Crosby, Miami, and Brookston soils, principally in the eastern part of the county. The relief is nearly level to gently undulating, with slopes usually less than 3 percent. Drainage conditions are similar to those on the Crosby soils, and artificial drainage is necessary for the production of most crops. At present most areas are sufficiently drained. Native vegetation consisted of maple, elm, ash, oak, and associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, dark brownish-gray friable silt loam, relatively high in organic content. Reaction, medium to slightly acid.

7 to 10 inches, dark brownish-gray to moderately dark-gray heavy silt loam having a somewhat lower organic content than the above layer. Reaction, medium acid.

10 to 18 inches, mottled gray, yellow, and rust-brown silty clay loam to clay loam, breaking into subangular aggregates that are slightly sticky when moist and plastic when wet. Reaction, medium acid.

18 to 36 inches, highly mottled gray, yellow, and rust-brown silty clay loam containing numerous small rock fragments. It breaks into medium-sized subangular aggregates that are sticky when moist, plastic when wet, and hard when dry. Reaction, medium acid in the upper part and grading gradually to slightly acid or neutral in the lower.

36 inches +, gray and yellow moderately compact highly calcareous glacial till consisting of a mixture of sand, silt, clay, and rock fragments.

Variations in the profile are in the color of the surface soil and the thickness and texture of the subsoil and underlying material. Where this soil grades into Brookston soils the organic content is somewhat higher and the texture somewhat heavier than normal, and where it grades into Crosby soils the surface soil is somewhat lighter colored.

Use and management.—Owing to the close association of Conover silt loam with Miami, Crosby, and Brookston soils, the crops and management practices are about the same as on the associated soils. Large enough areas for a field unit to be composed entirely of this soil rarely occur. Artificial drainage is necessary for the satisfactory production of farm crops, and most areas are sufficiently drained. Yields of corn and soybeans are considerably higher than on Crosby silt loam, chiefly because of the higher organic content of the surface soil, but yields of other crops are only slightly higher.

Conover loam.—This is an imperfectly drained moderately dark-colored soil developed on highly calcareous Late Wisconsin glacial till. It occurs in association with Crosby and Miami loams and Brookston silty clay loam, chiefly northeast, east, and southeast of Wyatt. A total of 1,856 acres is mapped. The profile characteristics are similar to those of Conover silt loam, except that the surface soil texture differs and the subsoil and underlying calcareous till are somewhat lighter and contain more sandy material. The content of organic matter in the surface soil is about the same as in the silt loam, and where areas of this soil grade into Brookston soil the organic content is somewhat higher than normal.

Use and management.—Conover loam is well adapted to most farm crops of the area, chiefly corn and soybeans. Crop yields are somewhat lower than on Conover silt loam but are, in general, higher than on Crosby loam and silt loam. The organic material appears to be rather stable, and little manure is applied.

Crosby silt loam.—This soil, developed on highly calcareous Late Wisconsin glacial till, is the imperfectly drained member of the soil catena that also includes the well-drained Miami, the very poorly drained dark-colored Brookston, and the very poorly drained very dark-colored Clyde series. It covers a total of 5,376 acres and is the principal soil on the uplands south of Mishawaka. Locally it is known as "clay land," whereas the dark-colored Brookston soils are known as "black land." The native vegetation consisted chiefly of beech and sugar maple with smaller quantities of oak, ash, elm, and walnut. The topography is nearly level, slopes rarely exceeding 2 percent. External drainage is slow, and internal drainage moderate to slow. Artificial drainage, preferably by tile drains, is usually necessary for the best yields of cultivated crops.

Following is a profile description in cultivated areas:

0 to 7 inches, brownish-gray to light brownish-gray friable granular silt loam containing varying quantities of grit and small pebbles. The material is composed of firm but not hard, easily crushed, medium-sized granules. Organic-matter content is variable, though usually low. In undisturbed wooded areas the 2- to 3-inch surface layer is dark brownish gray and relatively high in organic matter. Reaction, slightly to medium acid.

7 to 10 inches, light brownish-gray friable silt loam, breaking into coarse-granular aggregates. Reaction, medium acid.

10 to 15 inches, mottled gray, yellow, and rust-brown heavy silt loam to silty clay loam, breaking into ¼- to ½-inch subangular or nuciform aggregates, easily broken down into coarse granules. Numerous pebbles and an occasional boulder are present. Reaction, medium acid.

15 to 36 inches, mottled gray, yellow, and rust-brown gritty silty clay loam, breaking into ½- to 1½-inch subangular aggregates. Somewhat impervious to moisture movement. Reaction, medium acid.

36 inches +, mottled gray, yellow, and rust-brown compact calcareous till composed of unassorted silt, clay, sand, and rock fragments—the parent material.

Variations in the profile are in the texture and thickness of layers and the depth to calcareous till. Where this soil grades into Brookston silty clay loam, the surface soil usually is somewhat darker and slightly heavier textured. The surface soil and subsoil in a few areas are only slightly acid.

Use and management.—About 95 percent or more of Crosby silt loam has been cleared, and probably 85 percent or more is cultivated. Since it occurs in close association with the Miami, Brookston, and Conover soils, it is cropped about the same as those soils. The crop rotation usually consists of corn, wheat or oats, and hay crops, with an increasing quantity of soybeans. Corn usually follows hay crops in the rotation. An increasing number of farmers are using commercial fertilizer with corn, at the rate of 65 to 150 pounds or more an acre. Most of the barnyard manure is applied to this soil before planting corn, and an occasional green-manure crop, as rye or sweetclover, is turned under before plowing.

Wheat usually follows corn or oats in the rotation but occasionally may follow soybeans or special crops. From 100 to 150 pounds or more an acre of commercial fertilizer, usually 2–12–6, is used with wheat. Oats take the place of wheat in the rotation on many farms and are sown in spring, following either corn or soybeans. Fertilizer is not commonly used with oats, although a few farmers use relatively large quantities at the time of seeding, primarily as a fertilizer for the hay crop, which is sown at the time of the oats. Rye is occasionally grown both for a green-manure and grain crop.

Hay crops include either a mixture of clover, alfalfa, timothy, and alsike, or clover or alfalfa grown alone. Sufficient fertilizer and lime applications are necessary for the successful growth of both alfalfa and clover, especially alfalfa. A mixture of hay crops is in common use, chiefly because a better stand is produced than that for alfalfa or clover grown alone. Soybeans are increasing in importance in the rotation and are grown after corn or small grains both for hay and seed, in recent years largely for seed. This soil is well adapted to permanent bluegrass pasture, if sufficient lime applications are made to correct the acidity, and sufficient applications of commercial fertilizer, especially of one high in phosphate, are used.

Crosby loam.—This light-colored soil developed on highly calcareous Late Wisconsin glacial till is the imperfectly drained member of the soil catena that also includes the well-drained Miami, the very poorly drained dark-colored Brookston, and the very poorly drained very dark-colored Clyde series. A total of 10,560 acres is mapped in association with Miami and Conover loams and Brookston silty clay loam in the eastern and southeastern parts of the county. The profile characteristics are similar to those of Crosby silt loam, except that the surface-soil texture is loam and the subsoil and underlying calcareous glacial till are lighter textured and contain a somewhat higher proportion of sandy material.

Use and management.—Management practices and crops grown on Crosby loam are essentially the same as on Crosby silt loam, with yields slightly lower. The somewhat lighter texture of this soil makes it less well adapted to withstanding the droughty conditions occurring in summer and early in fall, and crops, especially corn, are more likely to be affected adversely by extreme drought. Somewhat less corn and more wheat and pasture are grown than on Crosby silt loam.

Door silt loam.—A well-drained soil developed on the glaciofluvial outwash plains and terraces that are underlain by stratified sand and gravel containing a high proportion of shale and siliceous material and relatively little limestone. It is developed under a tall-grass prairie vegetation and is the Prairie analog of the Tracy soils. It is mapped in three prairie areas in the county—Terre Coupee, Portage, and Sumption Prairies—and usually occurs in relatively large areas, the largest and most uniform being on the Terre Coupee Prairie. Slopes rarely exceed 3 percent. A few shallow depressions or kettle holes, which are not sufficiently deep to prohibit cultivation, occur throughout the areas. A total of 8,384 acres is mapped. Most of the rainfall is removed internally, and little accelerated erosion occurs because of lack of surface runoff. Native vegetation included tall prairie grasses, chiefly big bluestem, little bluestem, and bluejoint.

Following is a profile description in cultivated areas:

0 to 7 inches, dark grayish-brown to dark-brown medium-granular friable silt loam, relatively high in organic content. The rather stable organic material has persisted under a prolonged period of cropping, although some depletion has occurred since the soil was first cultivated. Reaction, medium to strongly acid.

7 to 17 inches, dark grayish-brown to dark-brown heavy silt loam to light silty clay loam, relatively high in organic content. The material breaks into large granular to small subangular aggregates. Reaction, medium to strongly acid.

17 to 36 inches, moderately dark-brown to yellowish-brown moderately compact silty clay loam to clay loam containing a small quantity of sand, gravel, and shale fragments. The material is compact in place but when moist breaks into ½- to 1½-inch subangular to angular aggregates. Roots and moisture easily penetrate it. There is gradual change from the above layer to this one, and an occasional tongue or lens of the darker colored material penetrates for several inches into this layer. Reaction, strongly to very strongly acid.

36 to 72 inches, yellowish-brown to brownish-yellow light clay loam to sandy loam containing thin layers and lenses of fine sand and gravel. With depth the clay content decreases and the sand and gravel increases. Reaction, strongly to very strongly acid in the upper part and medium to slightly acid in the lower.

72 inches +, gray and yellow loose stratified sand and gravel containing a high proportion of black Devonian shale and siliceous sand and a relatively small proportion of limestone.

Variations in the profile are in the color, texture, and thickness of the layers; the color and organic content of the surface soil; and the composition of the underlying stratified sand and gravel. In the vicinity of the Bendix Airport and on the Sumption Prairie the underlying material contains more gravel, and the lime content is considerably higher than normal.

Use and management.—Approximately 95 percent of Door silt loam is cultivated, principally to corn, wheat, oats, and soybeans, with an occasional intercropping of sweetclover and an occasional hay crop. Dairying is carried on extensively near the cities.

Corn, the most important crop, usually occupies about 35 percent of this soil annually. The relatively high organic content of the surface soil and subsoil is favorable for its growth. Some fertilizer is used for corn, the analysis of which is low in nitrogen or without nitrogen and relatively high in phosphate and potash.

Wheat usually follows soybeans or corn in the rotation, and 125 to 200 pounds of commercial fertilizer are used. Usually, little manure is available for a top dressing, but in some areas sweetclover is sown with wheat in spring, allowed to remain during summer and winter, and turned under as a green-manure crop the following spring. This shortens the rotation and adds organic matter to the soil. Oats occasionally take the place of wheat in the rotation, following either corn or soybeans, but commercial fertilizer is not commonly used. Oats are more adversely affected than wheat by the somewhat droughty conditions that may exist in summer.

Soybeans follow corn or small grains and are well adapted. They are grown for seed and hay, with the greater acreage for seed. Hay yields 1 to 3 tons an acre, but better yields of both hay and grain are obtained after sufficient lime has been applied to neutralize the soil acidity.

About 10 percent of the crop acreage is in hay crops and permanent pasture. Owing to the strong acidity of the surface soil and subsoil, lime applications are needed to neutralize the acidity in order to grow clover and alfalfa successfully. These crops are usually sown with oats or wheat in spring. Pastures are fair to good, but the livestock carrying capacity could be materially increased by applying sufficient lime and commercial fertilizer and by reseeding with a mixture of grass and legumes where necessary.

Door loam.—This soil has developed on glaciofluvial outwash plains and terraces underlain by slightly calcareous stratified sand and gravel containing a relatively high proportion of siliceous sand and black shale material. It is well to somewhat excessively drained; most of the rainfall is removed internally. The soil was formed under a tall prairie grass vegetation, and the supply of organic matter in the surface and upper subsoil layers is relatively high, although the organic content probably has been decreased considerably since the land was brought under cultivation. Very little surface runoff occurs on this nearly level soil, the principal areas of which are mapped on the Sumption and Portage Prairies. It occurs in association with Door silt loam and is similar to it, except in having a loam surface soil and a somewhat lighter textured subsoil containing more sand and fine gravel.

This soil is somewhat more droughty than Door silt loam because of the lighter textured layers. It is used largely for cash-grain crops, with yields somewhat lower than those obtained on the silt loam.

Edwards muck.—Composed of 12 to less than 36 inches of nearly black muck over gray marl, this soil varies in depth to the soft marl mineral, and where marl is encountered at the shallower depths, the mucky surface may be calcareous and contains snail shell fragments. The surface soil and upper subsoil are similar in color, structure, and degree of decomposition to Carlisle muck, except the reaction is usually neutral to slightly alkaline. It occurs in association with the other muck soils, occasionally in rather large-sized areas, the larger areas being in the valley of the Kankakee River and the outwash plain area that extends southwestward from South Bend. Included are a few small areas where the marl lies at the surface without an organic covering.

Use and management.—In areas where the marl lies at greater depths, Edwards muck is cultivated to corn and vegetable crops, with yields slightly lower than on Carlisle muck. Areas that contain free lime are not so well adapted to potatoes because their alkaline condition encourages potato scab diseases, and because the soil is also somewhat more deficient in potash than Carlisle muck.

Fox loam.—This well to somewhat excessively drained soil is developed on highly calcareous gravel and sand of the glaciofluvial outwash plains. The relief is nearly level, with a few gently undulating areas. Very little surface runoff occurs, and most of the rainfall is removed internally. The nature of the soil profile, especially the loose, porous substrata of gravel and sand, allows relatively free movement of water downward, and consequently a somewhat droughty condition for some crops results. A total of 320 acres is mapped, principally near the Sumption Prairie and northeast of South Bend. Native vegetation consisted of a mixture of deciduous trees, principally oak and hickory.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown friable loam having a variable content of small rounded gravel; usually low in organic content. Reaction, slightly to medium acid.

7 to 12 inches, yellowish-brown gritty heavy loam containing some small rounded gravel and an occasional larger rounded stone. Reaction, slightly to medium acid.

12 to 20 inches, yellowish-brown to brownish-yellow gritty silt loam to light clay loam, breaking into small-sized subangular to angular pieces; slightly plastic when wet and hard when dry. Reaction, medium acid.

20 to 32 inches, weak reddish-brown to yellowish-brown waxy and gravelly clay loam, breaking into medium- to large-sized irregularly shaped aggregates that are hard when dry. Reaction, medium acid.

32 to 38 inches, dark grayish-brown to dark brownish-gray gravelly and waxy clay loam that breaks into irregularly sized and shaped pieces. From the above layer to this material and from this to the underlying material are abrupt changes; tongues or lenses of this layer extend downward. Reaction, slightly acid to neutral.

38 inches +, gray and light-yellow highly calcareous gravel and sand, usually horizontally stratified.

Variations in the profile are in the color, texture, and thickness of the layers and the depth to calcareous gravel and sand. Depth to the calcareous material varies from 36 to 50 inches.

Use and management.—Because of the nearly level relief of Fox loam erosion is not a hazard in management, and practically all the soil is cultivated. The rotation followed includes corn, wheat, soybeans, and hay crops, with an occasional crop of rye or vegetables.

Corn usually follows hay crops in the rotation, and it is common practice to use 60 to 150 pounds or more an acre of commercial fertilizer. For growing corn this soil is somewhat droughty, and yields are materially reduced when droughts occur late in the summer or early in fall.

Wheat, better adapted to this soil than oats, is the major small-grain crop grown. From 100 to 150 pounds or more an acre of commercial fertilizer is used. Rye sometimes takes the place of wheat in the rotation but is seldom fertilized. Oats are not well adapted to this soil, owing to the droughty conditions that usually exist during the growing season.

In recent years the soybean acreage has increased considerably. Soybeans are usually grown after corn or small grains in the rotation, both for hay and seed, with the recent increase in acreage almost entirely for seed. Yields of hay range from 1 to 2 tons or more an acre.

Hay crops include a mixture of alfalfa, clover, timothy, and alsike, or alfalfa or clover grown alone. Alfalfa is probably better adapted to this soil than is clover, but for the best growth of either crop lime applications are usually necessary to correct the acidity. Alfalfa is rather extensively grown, for it can withstand the somewhat droughty conditions better than other hay crops.

Fox sandy loam.—This is a somewhat excessively drained soil developed on highly calcareous stratified gravel and sand of the outwash plains. A total of 1,408 acres is mapped on nearly level relief, principally north and east of South Bend and near the east county line. Surface drainage is slow to very slow, and most of the rainfall is removed internally. The porous nature of the surface and substratum makes the soil somewhat droughty for the production of most farm crops. Native vegetation included deciduous trees, principally oak and hickory.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown slightly coherent sandy loam, relatively low in organic content. Reaction, medium to slightly acid.
7 to 12 inches, yellowish-brown sandy loam to loam containing an occasional small rounded gravel, and an occasional larger stone. Reaction, medium to slightly acid.
12 to 20 inches, yellowish-brown to light brownish-yellow clay loam to heavy loam that breaks into small irregularly sized and shaped pieces; somewhat coherent when moist, but breaks easily into smaller aggregates. Reaction, medium acid.
20 to 34 inches, weak reddish-brown to brown waxy and gravelly light clay loam, breaking into medium to large irregularly sized pieces that are somewhat plastic when wet and hard when dry. Reaction, medium acid.
34 to 40 inches, dark grayish-brown to dark brownish-gray waxy and gravelly clay loam. From the above layer to this material and from this to the underlying material are abrupt changes. Tongues or lenses of this layer extend downward into the underlying material. Reaction, slightly acid to neutral.
40 inches +, gray and yellow highly calcareous stratified gravel and sand containing a relatively high proportion of limestone.

Variations are in color, thickness, and texture of the various layers and the depth to calcareous gravel and sand. Where this soil grades into Fox loam, the surface soil is slightly heavier textured. The depth to calcareous gravel and sand varies from 36 to 50 inches.

Use and management.—Fox sandy loam is practically all under cultivation to about the same crops as is Fox loam, although it is somewhat less well adapted, especially to corn, and yields are somewhat lower. Crop yields are materially reduced when droughts occur during the growing season. Alfalfa, soybeans, and wheat are probably better adapted to this soil than are other crops.

Fox sandy loam, sloping phase.—This soil occurs on relatively narrow slopes of 5 to about 20 percent along the edges of terraces. A total area of only 512 acres is mapped.

Use and management.—The less steep areas of this soil are usually farmed in association with Fox soils, but crop yields are somewhat lower than on the nearly level areas. Moisture conditions are very unfavorable for growing corn and small grains. Alfalfa is fairly well adapted, and either it or bluegrass pasture is probably the best use for the milder slopes. The steeper slopes are better suited to timber than to cultivated crops. Because of the low relief, usually less than 15 feet, tillage operations are often performed across the slope to adjacent fields or areas.

Galena loam.—An aggregate area of 7,808 acres of this soil has developed on moderately heavy textured moderately calcareous Late Wisconsin glacial till, which contains a relatively high proportion of black Devonian shale and a small proportion of limestone fragments. It is the well-drained member of the soil catena that also includes the imperfectly drained Otis and the very poorly drained dark-colored Brookston soils. Areas occur on undulating to gently sloping relief, with a 3- to 12-percent gradient. The larger areas are south and southwest of South Bend in association with the Otis, Brookston, and Hillsdale soils. Surface runoff is moderate to somewhat rapid on the more sloping areas, and internal drainage is moderate, with much rainfall removed internally. The native vegetation consisted of deciduous trees, including white, black, and red oaks, hickory, ash, elm, and walnut.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown, friable loam, relatively low in organic content. Reaction, medium acid.

7 to 12 inches, yellowish-brown to brownish-yellow friable gritty heavy loam to silt loam, breaking into medium-sized granules or small subangular aggregates. Reaction, medium acid.

12 to 18 inches, brownish-yellow to yellowish-brown gritty silty clay loam to clay loam containing fine gravel; compact in place, but breaks into medium-sized subangular aggregates slightly plastic when moist and hard when dry. Reaction, medium acid.

18 to 40 inches, brownish-yellow to yellowish-brown silty clay loam to silty clay, more compact than the above layer. Small partly weathered shale fragments are noticeable and increase with depth. Reaction, medium acid.

40 to 54 inches, brownish-yellow clay loam, somewhat more friable than the above layer and containing an increasingly large quantity of sand and gravel. Reaction, medium acid in the upper part and slightly acid to neutral in the lower.

54 inches +, gray and yellow moderately compact moderately calcareous glacial till containing a high proportion of shale fragments and sand and a lower proportion of limestone.

Variations in the profile are in the color, texture, and thickness of the various layers, the content of organic matter in the surface layer, and the depth to calcareous till. Depth to till varies from 42 to 70 inches or more, with the greater depths occurring in areas where the content of sandy material is higher than normal. Where areas of this soil are associated with areas of Hillsdale loam, small areas of Hillsdale loam are often included.

Use and management.—Most of Galena loam has been cleared and is cultivated to the general farm crops. The rotation usually includes corn, wheat or oats, soybeans, and hay crops, with an occasional crop of rye and special vegetables. The naturally low organic content makes it necessary to plow under all available organic material and to use lime to correct the soil acidity and commercial fertilizer to maintain and increase fertility and production.

Corn usually follows hay crops in the rotation, and 75 to 150 pounds or more an acre of commercial fertilizer commonly are used. Wheat is probably better adapted than oats, although oats are sometimes grown in place of wheat. Most of the wheat grown is fertilized with 100 to 150 pounds or more an acre of commercial fertilizer, commonly 2–12–6; whereas very little fertilizer is used with oats. Rye occasionally takes the place of wheat in the rotation, but fertilizer usually is not used.

Soybeans are increasing in importance and usually follow corn or small grains in the rotation. They are used both for hay and for beans, with the increased acreage being grown principally for beans. Soybean hay yields 1 to 2 tons an acre.

Hay crops include a mixture of clover, alfalfa, timothy, and alsike, or clover or alfalfa grown alone. Better stands of alfalfa and clover are obtained after sufficient lime is applied to correct the soil acidity and after the use of sufficient commercial fertilizer, especially one high in phosphate. Permanent pasture consists principally of bluegrass, but the carrying capacity is usually medium to low. A pasture improvement system including the use of sufficient lime and fertilizer and reseeding with a mixture of grasses and legumes would greatly increase the livestock-carrying capacity.

On a number of areas of Galena loam accelerated erosion has removed 25 to 50 percent of the surface, resulting in the heavier textured subsoil being exposed in many places. This condition exists on approximately 1,100 acres of this soil, chiefly on slopes of 3 to 12 percent. In these places the surface soil, varying from 3 to 7 inches deep, is a grayish-brown to brownish-yellow heavy silt loam to light silty clay loam, low in organic matter. The exposure of the underlying yellowish-brown silty clay loam subsoil in small areas is confined chiefly to the steeper slopes.

These eroded areas are largely cultivated, but crop yields are lower than on the normal phase of the type because of poorer tilth conditions and declining fertility. Corn, wheat, and mixed hay are the principal crops in the rotation, but a higher proportion of close-growing crops are needed to reduce erosion. All available organic matter should be turned under to improve the physical condition and increase the fertility of the soil.

Galena loam, level phase.—Erosion is not a serious management problem on this soil, for it occurs on nearly level relief with slopes less than 3 percent. The more favorable natural drainage is due to strata of sand and other permeable material within 5 to 10 feet of the surface. In profile characteristics it is similar to the normal phase of the type.

Practically all this phase is cultivated to the general farm crops, and yields are equal to or slightly higher than those obtained on the normal phase. Tilth conditions, as well as the organic and plant nutrient supply, are more easily maintained on this phase.

Galena silt loam.—A well-drained soil developed on moderately heavy to heavy-textured moderately calcareous Late Wisconsin glacial till relatively high in Devonian shale and low in limestone. It occurs on slopes of about 3 to 12 percent, principally on the upland areas extending south of South Bend to the south county line and in the extreme northwestern part of the county. It is usually associated with Galena loam and Otis and Brookston soils (pl. 5). Surface drainage is moderate to somewhat rapid on the more sloping areas, and internal drainage is moderate to slow. A total of 7,360 acres is mapped. The native vegetation included a mixture of white, red, and black oaks, hickory, ash, elm, and walnut, with other associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish brown to light yellowish-brown friable medium-granular silt loam, relatively low in organic content. Reaction, medium acid.

7 to 12 inches, yellowish-brown to brownish-yellow coarse-granular heavy silt loam. Reaction, medium acid.

12 to 20 inches, yellowish-brown to brownish-yellow heavy silty clay loam, breaking into medium-sized subangular to blocky aggregates plastic when wet and hard when dry. The content of glacial gravel and boulders is variable but never large.

20 to 50 inches, pale-yellow to light brownish-yellow silty clay loam to silty clay, becoming slightly mottled with gray and rust brown below a depth

of 36 inches. The material is plastic when wet and hard when dry and contains an appreciable quantity of small partly weathered black shale fragments.

50 inches +, mottled gray and yellow heavy silty clay to silty clay loam—moderately calcareous glacial till containing a high proportion of black Devonian shale.

Areas of this soil vary from the above description in color, texture, and thickness of the various layers, the content of organic matter in the surface layer, the quantity of stones and shale fragments throughout the profile, and the depth to calcareous till. The texture of the surface soil as well as the subsoil and underlying material is somewhat lighter where the soil grades into either Hillsdale or Galena loam, and the depth to calcareous till is usually greater than normal.

Use and management.—Most of Galena silt loam is cultivated to corn, oats or wheat, soybeans, and hay crops, with a small proportion in permanent bluegrass pasture and forest. This soil often occurs in close association with the darker colored more productive Brookston soils, and crop rotations and management practices are about the same on the two soils, owing to the intimate association. The greater part of the barnyard manure and other organic material is applied to this soil, and an occasional green-manure crop is grown.

Corn usually follows hay crops in the rotation but also occasionally soybeans or small grains. The best yields are obtained under favorable moisture conditions and with better management practices. An increasingly larger percentage of the corn grown is fertilized, with the analyses of the fertilizer varying from 2–12–6 to 0–12–12, and the quantity from 60 to 150 pounds or more an acre.

Wheat follows corn, soybeans, or oats in the rotation, and usually 100 to 150 pounds or more an acre of commercial fertilizer are used. Oats take the place of wheat in the rotation, but very little commercial fertilizer is used.

Soybeans are grown both for hay and grain but largely for grain. Commercial fertilizer usually is not used with soybeans, although some farmers plow under 200 to 300 pounds before planting the seed. Soybean hay yields 1 to 2 tons an acre.

Hay crops include a mixture of clover, timothy, alfalfa, and alsike, or clover or alfalfa grown alone. Lime applications are necessary to correct the soil acidity for the more successful growth of clover and alfalfa. Sweetclover is occasionally grown for hay or seed, or it is used as a green-manure crop.

Permanent pasture is of good to fair quality on this soil and could be improved greatly by the use of a pasture-improvement system including the use of sufficient lime and commercial fertilizer and reseeding when necessary.

Galena silt loam, level phase.—This phase occurs on nearly level relief, with slopes less than 3 percent. The profile characteristics are similar to those of the normal phase of the type, except that the surface soil is slightly thicker and the organic content somewhat higher. Internal drainage is better than on the normal phase due to occasional strata of sand and other permeable material within 5 to 10 feet of the surface.

Practically all this soil (832 acres) is cultivated to the general farm crops of the county. The organic and plant nutrient supplies as well as tilth conditions are more easily maintained than on the normal phase and the other phases of the type. Crop yields are equal to or slightly higher than on the normal phase.

Galena silt loam, eroded phase.—Accelerated erosion has removed 25 to about 50 percent of the surface soil. Small areas where the heavier textured subsoil is exposed occur in many places. A total of 3,456 acres is mapped on slopes of about 3 to 12 percent in association with the normal phase of the type. The surface 6 or 7 inches is grayish-brown to brownish-yellow heavy silt loam to light silty clay loam, low in organic content.

Tilth conditions are not so good as on the normal phase, and crop yields are somewhat lower. Rotations should contain a high proportion of close-growing crops, as pasture, meadow, and small grains, and all available organic matter should be turned under to maintain and increase fertility and to assist in erosion control.

Galena silt loam, severely eroded phase.—This soil, occurring on slopes of 3 to about 12 percent, has lost 50 percent or more of the surface soil or all the surface soil and part of the subsoil by accelerated erosion. A few shallow gullies occur in numerous areas, and there are some gullies more than 3 feet deep. A total of 832 acres of this phase is mapped in association with the normal phase of the type and its other phases.

Use and management.—All areas of Galena silt loam, severely eroded phase, have been cleared of timber and cultivated, which has resulted in the severely eroded condition. Rotations are about the same as on the normal phase of the type, but crop yields are low. This phase is probably best suited to semipermanent and permanent pasture, with a small proportion of clean-cultivated crops grown in the rotation.

Galena silt loam, steep phase.—Areas of this phase occur on slopes of 12 to 25 percent or more, usually in small tracts adjacent to drainageways or adjacent to the depressions, or kettle holes. A total of only 512 acres is mapped. Most of this soil is in timber or permanent pasture, its best use. Under cultivation it is susceptible to serious injury from accelerated erosion. After a few years of cultivation crop yields decline because of erosion and such areas will be essentially eroded phases.

Galena silt loam, eroded steep phase.—Accelerated erosion has removed 25 to about 50 percent of the surface soil of this phase, and an occasional small spot occurs where the heavier textured subsoil is exposed. A total of 640 acres is mapped on 12- to 25-percent slopes in association with the normal phase of the type and its other phases, principally adjacent to drainageways and small kettle holes. Surface runoff is rapid, and only a small part of the rainfall is removed internally. A few areas included with this soil have a loam texture.

Use and management.—All areas of Galena silt loam, eroded steep phase, have been cleared and most of them cultivated at one time; however, a large part is in permanent pasture at present. Owing to susceptibility to erosion and somewhat unfavorable moisture conditions, it is not well suited to cultivated crops. Crop yields are relatively low, especially of corn and small grains. After sufficient lime and commercial fertilizer have been applied, this phase may be suited to alfalfa, especially if it is allowed to remain for several years.

Vertical aerial view of a part of the glacial till plain 2½ miles west of Dixie Highway on the south county line, which is typical of Galena and Otis silt loams and Brookston silty clay loam. *A*, The small dark-colored areas of Brookston soil in the light-colored fields were used for corn, soybeans, and small grains *B*, Light-colored areas near streams represent erosion on Galena silt loam *C*, Timbered areas *D*, Meadow and pasture land

Vertical aerial view of the Hillsdale soils northwest of the proving ground. *A*, Short drainageways. *B*, Kettle holes, which characterized the topography of these soils. *C*, Intermittent ponds. *D*, Soil terraces which are members of the Lydick and Tracy series. *E*, Proving ground, southwest of which are extensive areas of Carlisle muck

Galena silt loam, severely eroded steep phase.—Numerous areas of this phase occur where the heavier textured brownish-yellow subsoil is exposed and shallow gullies are present. This soil is on slopes of 12 to about 25 percent, and 50 percent or more of the surface soil or all of the surface soil and part of the subsoil have been removed by accelerated erosion. A total of 1,472 acres is mapped, principally in association with the steep phase of Galena silt loam, adjacent to the drainageways or small kettle holes. Most of the rainfall is removed externally.

Use and management.—Galena silt loam, severely eroded steep phase, has been cleared of timber and once was largely under cultivation. At present, however, only a small proportion is cultivated to the general farm crops. Owing to the removal of a large part of or all the surface soil and the resultant loss of the greater part of the organic matter and plant nutrient supply and to the unfavorable moisture relations, crop yields are extremely low. The soil is probably better suited to permanent pasture, alfalfa, or forest than to cultivated crops. Good conservation practices should be installed so as to control further loss from erosion.

Granby loam.—Areas of this soil have developed on lake deposits and glaciofluvial outwash plains from calcareous sand high in siliceous material. A total of 2,624 acres is mapped on nearly level to slightly depressed relief associated with soils of the glaciofluvial outwash plains and muck soils. Natural drainage is very poor, and before artificial drainage, water is usually at or near the surface. Most of the drainage is internal, and artificial drainage is easily established where outlets are available. The native vegetation consisted of marsh grasses and water-tolerant trees.

Following is a profile description in cultivated areas:

0 to 7 inches, dark-gray to very dark brownish-gray friable loam, relatively high in organic content. Reaction, slightly acid to neutral.

7 to 14 inches, dark-gray friable heavy loam containing an appreciable quantity of siliceous sand. Reaction, slightly acid to neutral.

14 to 30 inches, mottled gray and yellow sandy loam to clay loam with thin layers or lenses of fine sand. Reaction, neutral.

30 to 48 inches, mottled gray and yellow sand to fine sand with blotches and streaks of rust brown. Reaction, neutral.

48 inches +, mottled gray and yellow calcareous stratified sand.

Variations are in the color, texture, and thickness of the layers and depth to calcareous sand. Included are a few small areas that have a clay loam surface texture and a somewhat heavier textured subsoil. Also included are a few areas where the underlying calcareous material consists of stratified sand and fine gravel with some shale material.

Use and management.—The principal crops grown on Granby loam are corn, wheat, oats, and soybeans, with a minor acreage in hay crops. On areas where a cash-grain system of farming is followed, crops usually include corn, oats, wheat, and soybeans, with an occasional intercrop of sweetclover or rye. Where a livestock system of farming is practiced, a more systematic crop rotation including legumes for hay is used. Drainage is adequate on most areas for the production of the general farm crops, and a few areas may have been overdrained by the draining of adjacent areas of muck. Although the soil is well adapted to growing vegetables, only a small acreage is used.

Corn usually follows hay crops, soybeans, or wheat in the rotation. Some fertilizer is used, although it is not a general practice. Sweetclover and, to some extent, rye are used as green-manure crops and are turned under before planting the land to corn.

Wheat follows corn, oats, or soybeans in the rotation, and 100 to 150 pounds or more an acre of commercial fertilizer are used. Soybeans are well adapted to this soil and are probably more extensively grown on areas where a cash-grain system of farming is followed. They are used mainly for hay in areas where a livestock system prevails. Oats are probably not so well adapted as wheat. Some danger of loss from lodging of small grains is due to the relatively high organic content of the surface soil.

Hay crops include a mixture of timothy, alfalfa, and clover, or alfalfa or clover grown alone. On most areas of this soil lime is not necessary for the successful growth of legumes, although a few areas may be benefited by relatively light applications. Some injury results to clover and alfalfa from winterkilling.

Granby fine sandy loam.—This dark-colored very poorly drained soil is developed on calcareous sand, although in the vicinity of Mishawaka a few areas are underlain by limy fine gravel. It occurs on nearly level to slightly depressed areas throughout the lake and outwash plains, often in a position intermediate between areas of muck and moderately well drained to well-drained soils of the outwash plains. Natural drainage conditions are very poor, but artificial drainage permits the growing of most farm crops on most of the soil. The profile characteristics are similar to those of Granby loam, except that the surface and subsoil layers have a lighter texture.

About the same crops are grown as on Granby loam, but yields are lower, especially of corn. Some areas are slightly overdrained, owing to drainage of the adjacent muck areas.

Gravel pits.—Ranging in size from a few to over 100 acres, these pits cover areas where gravel has been removed for road building, industrial use, railroad ballast, and other purposes. They total 512 acres, occurring principally in former areas of Warsaw, Tracy, and Fox soils. Some are 30 feet deep or more, with water standing in most of the larger and deeper ones.

Griffin loam.—A light-colored moderately well to imperfectly drained soil of the alluvial flood plains. A total of 4,032 acres is mapped, principally adjacent to the St. Joseph River and the various smaller streams of the county, and to a minor extent in the flood plains of the Kankakee River. Natural drainage is extremely variable within short distances, and the soil is subject to overflow. Its relief is nearly level, although small areas occur in old drainage channels and slight depressions within the flood plains. Ash, elm, and maple are the most common trees in wooded areas. Honeylocust is a common tree in pastures and is an indicator of nonacid soils.

Following is a profile description in cultivated areas:

0 to 7 inches, brownish-gray to light brownish-gray heavy to light loam with a variable quantity of yellowish-brown or rust-brown mottles. Organic content is variable. Reaction, slightly acid to neutral.

7 to 12 inches, gray and light-yellow, highly stained and blotched with rust brown and yellow, friable loam to fine sandy loam. Reaction, slightly acid to neutral.

12 inches +, mottled gray, yellow, and rust-brown sandy loam to clay loam, with thin layers representing old depositional layers distinguishable. Reaction, neutral to slightly alkaline.

Variations are in the texture and color of the layers. Included are a few small areas, especially in the flood plains of Potato Creek, having a sandy clay loam surface soil and a somewhat heavier subsoil to a depth of 12 to 14 inches. Also included are small areas having a loose fine sandy loam surface soil and subsoil. The depth to and intensity of the rust-brown and yellow mottling varies from 6 to 14 inches, and the organic content of the surface soil is also variable. Where this soil grades into muck the organic content is considerably higher than normal.

Several areas in the St. Joseph River valley occur on slightly elevated positions where they are not subject to overflow and have better internal drainage. The surface soil is reddish brown and the subsoil is reddish yellow to brown and mottle-free to a depth of 3 feet or more.

Use and management.—Most of Griffin loam is used for pasture, the quality varying with drainage conditions and the frequency of overflow. The larger areas, particularly in the flood plains of the St. Joseph River, are used principally for corn, although some wheat and soybeans are grown. Areas of this soil lying slightly higher than the lower parts of the flood plains are not so frequently overflowed and are more intensively used. Some areas remain in forest.

Gullied land (Tracy soil material).—Erosion has removed practically all the surface soil, and numerous deep gullies have developed on this soil. The gullies often form an intricate network, with small sheet-eroded areas between them. This type occurs on slopes of 10 to 25 percent or more in association with the sloping phases of the Tracy soils. Under present economic conditions it is not suited to crop production and is idle land with a sparse cover of briers, various weeds, and small shrubs.

Hanna fine sandy loam.—This soil developed on glaciofluvial outwash plains and terraces underlain by stratified sand and gravel is composed chiefly of siliceous material and light Devonian shale. It is the moderately well drained member of the soil catena that also includes the well to excessively drained Tracy, the imperfectly drained Willvale, and the poorly drained Quinn series. It occurs in association with the other members of the catena, the larger areas being in the northwestern and west-central parts of the country. Individual areas vary in size but are usually fairly extensive. The aggregate area is 704 acres. The native vegetation included a predominance of black, white, and pin oaks, with minor quantities of assorted species.

Following is profile description in cultivated areas:

0 to 7 inches, light brownish-yellow to brownish-gray slightly coherent fine sandy loam, relatively low in organic content. Reaction, strongly to very strongly acid.

7 to 12 inches, light brownish-yellow to pale-yellow heavy fine sandy loam containing somewhat more silty material, making the material slightly coherent. Reaction, strongly to very strongly acid.

12 to 20 inches, light brownish-yellow to pale-yellow clay loam; sufficiently heavy and compact to retain considerable moisture. Reaction, strongly to very strongly acid.

20 to 36 inches, mottled gray, yellow, and rust-brown clay loam; slightly sticky when wet and hard when dry; breaks into subangular to irregularly sized and shaped fragments. Reaction, strongly to very strongly acid.

36 to 90 inches mottled gray, yellow, and rust-brown slightly coherent sandy loam to fine sand with seams or thin lenses of silty clay loam to clay loam. Reaction, strongly to very strongly acid in the upper part and medium to slightly acid in the lower.

90 inches +, mottled gray and yellow, with spots and blotches of rust brown, stratified sand and gravel. Slightly alkaline to slightly calcareous.

Variations are in the color, thickness, and texture of the layers and the depth to and composition of the underlying layer of stratified sand and gravel. The content of limestone and calcareous material in this layer is variable but usually low; in some areas the material is noncalcareous to a depth of 10 feet or more.

Use and management.—Hanna fine sandy loam is almost entirely under cultivation, with corn, wheat, hay crops, and soybeans the principal crops. Moisture relations are more favorable than on the Tracy soils having a similar texture, but some accelerated wind erosion of the light-textured surface soil may cause some injury to crops. As the relief is nearly level, erosion is not a problem. Most areas are sufficiently drained naturally for crop production, but additional drainage may be obtained by using open ditches at infrequent intervals or by using tile drains. Establishment of these open ditches readily lowers the water table, owing to the ease of draining the underlying loose gravel and sand.

Corn usually follows hay crops in the rotation. Wheat follows corn or soybeans, and 150 to 200 pounds an acre of commercial fertilizer (usually 2–12–6) are used. Soybeans are increasing in importance and are grown mainly for seed. Hay crops include a mixture of clover, timothy, and redtop, with some areas of alfalfa or clover grown alone. Sufficient lime is necessary to neutralize the acidity of this soil in order to grow alfalfa and clover successfully.

Hanna loam.—An aggregate area of 320 acres of this soil is mapped on nearly level relief, principally in the vicinity of Community Garden in the northwestern part of the county. It is a moderately well drained soil developed on glaciofluvial outwash plains and terraces underlain by noncalcareous to slightly calcareous sand and gravel composed chiefly of shale and siliceous material. Most areas are sufficiently drained for growing general farm crops, but some areas would be benefited by additional drainage, which can be accomplished by open ditches or tile drains at infrequent intervals. The native vegetation consisted chiefly of black, white, and pin oaks, with smaller quantities of associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, light brownish-yellow to brownish-gray friable loam, relatively low in organic content. Tilth is good, and the organic content is slightly higher than in the lighter textured members of the Hanna series. Reaction, strongly to very strongly acid.

7 to 12 inches, light brownish-yellow to pale-yellow loam to heavy loam. Reaction, strongly to very strongly acid.

12 to 20 inches, pale-yellow to light brownish-yellow clay loam to heavy clay loam, breaking into irregularly sized and shaped pieces. The material is slightly compact in place, sticky when wet, and hard when dry. Reaction, strongly to very strongly acid.

20 to 40 inches, mottled gray, yellow, and rust-brown compact sandy clay loam to silty clay loam. Reaction, strongly to very strongly acid.

40 to 84 inches, mottled gray, yellow, and rust-brown stratified sand and gravel, with thin layers or lenses of clay loam and sandy loam material. Reaction, strongly to very strongly acid in the upper part and medium to slightly acid in the lower.

84 inches +, mottled gray and yellow, with rust-brown blotches and streaks, loose stratified slightly calcareous sand and gravel.

Variations from the above profile are in color, texture, and thickness of the layers and depth to and composition of the underlying stratified sand and gravel. The depth to mottling varies from 14 to about 24 inches.

Use and management.—Hanna loam is cropped about the same as the other members of the Hanna series and as the associated soils. Owing to the heavier texture of the surface and subsoil layers, this soil has better moisture relations than the lighter-textured soils and is better adapted to crops. Crop yields are materially above those on Hanna fine sandy loam.

Hanna loamy fine sand.—This soil developed on glaciofluvial outwash plains and terraces is underlain by stratified gravel and sand containing a high proportion of siliceous and shale material. It is the moderately well-drained member of the soil catena that also includes the well to excessively drained Tracy, the imperfectly drained Willvale, and the poorly drained Quinn series. It is on level relief, and a total of 1,408 acres occurs in association with the above-mentioned soils, principally north of Mishawaka. The native vegetation included chiefly black, white, and pin oaks, and small quantities of associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, light brownish-yellow to brownish-gray loose loamy fine sand, relatively low in organic content. Reaction, strongly to very strongly acid.
7 to 10 inches, yellowish-brown to brownish-yellow loamy fine sand slightly more coherent than the surface soil. Reaction, strongly to very strongly acid.
10 to 20 inches, light brownish-yellow to pale-yellow loam to sandy clay loam containing sufficient clay to make it slightly sticky when wet and hard when dry. Reaction, strongly to very strongly acid.
20 to 30 inches, mottled gray, yellow, and rust-brown clay loam to sandy clay loam variable in clay content. The material breaks into irregularly sized and shaped pieces that are easily broken down when moist but are slightly sticky when wet and hard when dry. Reaction, strongly to very strongly acid.
30 to 90 inches, mottled gray, yellow, and rust-brown loose loamy fine sand to fine sand with an occasional lens or thin layer of gravel and clay loam. Reaction, strongly to very strongly acid in the upper part and strongly to slightly acid in the lower.
90 inches +, mottled gray and yellow, with blotches of rust brown, loose stratified slightly calcareous sand and gravel composed chiefly of siliceous material.

Variations are in the thickness, texture, and color of the layers and the depth to and composition of the underlying stratified sand and gravel. The depth to mottling varies from 14 to about 26 inches. In a few areas the underlying material is noncalcareous to a depth of 10 feet or more and is composed largely of quartz sand.

Use and management.—Much of Hanna loamy fine sand is cleared and cultivated. Corn and wheat are the principal crops, although some attempt is made to follow a systematic rotation including corn, wheat, soybeans, and hay crops. Most areas of the soil are at present sufficiently drained for growing general farm crops, but a few areas have been slightly overdrained because of the lowering of the general water table in attempts to drain the lower lying more poorly drained areas.

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The highest yields of corn are obtained under a systematic rotation program which includes growing hay crops and turning under all available organic matter. Wheat usually follows corn or soybeans, and 150 pounds an acre of 2–12–6 fertilizer commonly are used. Soybeans are increasing in importance and are grown largely for seed. Hay crops include a mixture of timothy, redtop, and clover, with a few areas of clover or alfalfa grown alone. Because of the strong to very strong acidity of the surface and subsoil layers it is necessary to apply sufficient lime for the successful growth of either clover or alfalfa.

Hillsdale fine sandy loam.—This soil, developed on light-textured siliceous and moderately calcareous Late Wisconsin glacial till, is mapped south, north, and northwest of South Bend (pl. 6). It occurs on the upland areas associated principally with Coloma and Galena soils, chiefly in the west-central part of the county and south of South Bend. The aggregate area is 4,288 acres. The relief is undulating to gently sloping, with slopes of 3 to about 12 percent. Surface drainage is moderate to slow, and the greater part of the rainfall is removed internally, owing to the somewhat porous nature of the surface soil, subsoil, and underlying material. The native vegetation consisted chiefly of white and red oaks and hickory, with a smaller proportion of walnut, ash, elm, and associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown fine sandy loam, relatively low in organic content. Several small rounded pebbles are on the surface but are not numerous enough to interfere with cultivation. Reaction, medium acid.

7 to 17 inches, brownish-yellow to yellowish-brown heavy fine sandy loam to loam, breaking below 10 inches into large granules or small subangular aggregates that easily are crushed. Reaction, medium acid.

17 to 40 inches, brownish-yellow clay loam, breaking into medium-sized subangular aggregates. Sufficient clay is present to hold the material together when moist and make it moderately retentive of moisture. Reaction, medium acid.

40 to 60 inches, brownish-yellow to pale-yellow slightly coherent sandy loam to heavy loam, with pockets and lenses of sand. Reaction, medium acid in the upper part and slightly acid in the lower.

60 inches +, brownish-yellow and gray medium calcareous loam to sandy loam glacial till containing a high proportion of siliceous or quartz sand.

Variations are in color, texture, and thickness of the layers and depth to calcareous till. In a few areas the lower subsoil, below a depth of 36 inches, is slightly mottled gray and yellow.

Use and management.—Hillsdale fine sandy loam is almost entirely under cultivation, with a grain-and-livestock system of farming usually followed. The rotation includes corn, soybeans, wheat, and hay crops, with occasionally rye, special field crops, and vegetables. The moisture-holding capacity and organic-matter content is relatively low; thus it is essential that all available organic matter, including barnyard manure and green-manure crops, be turned under.

Corn usually follows hay crops in the rotation, and applications of 60 to 150 pounds an acre of commercial fertilizer are used. The highest yields are obtained under good management practices and favorable climatic conditions.

Wheat follows corn or soybeans, and commercial fertilizer (usually 2–12–6) at the rate of 100 to 150 pounds or more an acre is applied. Rye occasionally takes the place of wheat in the rotation, but commercial fertilizer is used only on a few areas. This soil is not well adapted to oats because of somewhat droughty conditions during the growing season; however, a relatively small acreage is sown.

Hay crops include a mixture of clover, alfalfa, timothy, and alsike, or clover or alfalfa grown alone. Alfalfa is probably better suited than clover to the soil, but sufficient lime should be applied to correct the soil acidity for the successful growth of either crop. Soybeans follow corn or small grains in the rotation and yield 1½ to 2 tons of hay an acre.

Apples and other fruits are well suited to this soil, especially where air drainage is favorable. Although the soil is not extensively used for these crops in this county, it is used extensively for fruits in adjacent areas, especially in Michigan.

Hillsdale fine sandy loam, level phase.—Erosion is not a serious problem in the management of this phase, as it occurs on slopes of less than 3 percent. A total of 384 acres is mapped, principally in the vicinity of and south of South Bend, associated with the normal phase and the other phases of the type and with Galena soils. The profile characteristics are essentially the same as those of the normal phase, but this soil is better suited to cultivation.

Crop rotations include principally corn, soybeans, wheat, and hay crops, with yields equal to or slightly higher than on the normal phase.

Hillsdale fine sandy loam, eroded phase.—Accelerated erosion has removed 25 to about 50 percent of the surface soil of this phase, exposing the subsoil in a few areas. The soil occurs on slopes of 3 to about 12 percent. The loss of a fourth to a half of the surface soil has decreased the organic content as well as the plant nutrient supply.

The greater part of the 1,216 acres mapped is cultivated, but crop yields are materially below those obtained on the normal phase of the type. It is necessary to plow under all available organic matter and to practice a rotation system that includes less clean-cultivated crops and more hay crops in order to maintain and increase fertility and to control erosion.

Hillsdale fine sandy loam, severely eroded phase.—This phase, occurring on slopes of 3 to about 12 percent, has lost 50 percent or more of the surface soil or all the surface soil and part of the subsoil by accelerated erosion. A total of 320 acres is mapped. The heavier-textured brownish-yellow subsoil is exposed in numerous places, and small gullies are occasionally present. The removal of a large part of or all the surface soil and part of the subsoil in numerous areas has greatly lowered fertility and tilth.

Use and management.—A large part of Hillsdale fine sandy loam, severely eroded phase, is cultivated, but crop yields are low. Management practices should include erosion control methods and also turning under of all available organic matter and growing more hay and other close-growing crops. Some areas of the soil are in permanent bluegrass pasture, but the livestock carrying capacity is low. It is necessary to apply sufficient lime to correct acidity, sufficient commercial fertilizer, and in many cases to reseed the pastures in order to improve the stands.

Hillsdale fine sandy loam, steep phase.—An aggregate area of 320 acres of this phase is mapped on slopes of 12 to 25 percent or more, principally adjacent to the drainageways, associated with other Hillsdale soils. The areas are practically all forested, except a few in permanent bluegrass pasture. As the soil is susceptible to erosion under cultivation, its best use is probably forest.

Hillsdale fine sandy loam, eroded steep phase.—A total of 512 acres of this soil is mapped on slopes of 12 to 25 percent or more in association with other Hillsdale soils. About half or more of the surface soil or all the surface soil and part of the subsoil have been removed by accelerated erosion. The surface 6 to 7 inches is brownish-yellow heavy loam to clay loam, extremely low in organic content.

Use and management.—In general Hillsdale fine sandy loam, eroded steep phase, is too steep for economic production of cultivated crops and is better suited to permanent pasture or forest. Crop yields are much lower than on the normal phase of the type. Erosion control methods should be established on this phase, and all available organic matter should be turned under in order to maintain fertility and prevent further loss of surface soil and plant nutrients.

Hillsdale loam.—This well-drained soil is developed on light-textured moderately calcareous Wisconsin glacial till containing a relatively high proportion of siliceous sand and a small proportion of limestone fragments. It occupies slopes of 3 to 12 percent, the larger areas occurring south of South Bend in association with Hillsdale fine sandy loam and Galena loam. A total of 1,856 acres is mapped. Surface runoff is moderate to somewhat rapid on the steeper areas, and internal drainage is moderate. Accelerated water erosion is potentially severe on the more sloping areas. The native vegetation consisted of a mixture of deciduous trees, including white and black oaks, hickory, elm, maple, and ash.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown friable medium-granular loam, relatively low in organic content. Reaction, medium acid.

7 to 12 inches, brownish-yellow to yellowish-brown friable coarse-granular heavy silt loam. Reaction, medium acid.

12 to 30 inches, brownish-yellow clay loam to silt loam, breaking into small to medium-sized subangular aggregates. This material is somewhat compact in place but breaks into medium-granular aggregates when moist and is slightly plastic when wet. Reaction, medium acid.

30 to 60 inches, brownish-yellow somewhat friable clay loam to sandy clay loam, slightly compact in place but breaks easily into minute particles when moist. It becomes lighter textured and less compact with depth, and lenses or pockets of sandy material are common. Reaction, medium acid in the upper part and slightly acid to neutral in the lower.

60 inches +, moderately calcareous sandy loam to loam glacial till containing a high proportion of siliceous sandy material.

Variations are in color, texture, and thickness of the various layers, the organic content of the surface soil, and the depth to calcareous till. Where this soil grades into Coloma soils or Hillsdale fine sandy loam the surface texture is somewhat lighter, and where it grades into Galena loam the content of black Devonian shale throughout the profile is greater. South and southeast of South Bend this soil is intricately associated with Galena loam, and small areas of that soil are included with Hillsdale loam as mapped.

Use and management.—Practically all of Hillsdale loam is cultivated, and it has better moisture-holding capacity and higher crop yields than Hillsdale fine sandy loam. The rotation system includes corn, wheat, soybeans, and hay crops, with occasionally rye, a special field crop, and vegetables. To maintain and increase the productivity on this soil all available organic matter should be turned under, sufficient commercial fertilizer used, and crop rotations, including a predominance of small grains and hay crops, practiced.

Corn usually follows hay crops in the rotation and returns the highest yields in years of favorable moisture conditions and under the better management practices. Much of the corn grown is fertilized with 75 to 150 pounds or more of commercial fertilizer.

Wheat, the principal small grain, usually follows corn or soybeans in the rotation. From 100 to 150 pounds or more of commercial fertilizer are used. Yields are dependent on the state of soil fertility and on weather conditions. Rye occasionally takes the place of wheat in the rotation, but very little if any fertilizer is used. Oats are not so well adapted to this soil, owing to the somewhat droughty condition during the growing season, but a relatively small acreage is grown.

Soybeans are increasing in importance in the rotation and usually follow corn or small grains. Soybean hay yields 1 to 2 tons an acre.

Hay crops include a mixture of clover, alfalfa, timothy, and alsike, or clover or alfalfa grown alone, the larger acreage probably including the hay mixture. For the most successful growth of clover and alfalfa it is necessary to apply sufficient lime to neutralize the acidity of the surface soil. Alfalfa is probably better adapted than clover to the somewhat droughty condition of this soil, especially late in summer and early in fall.

Permanent bluegrass pasture is of fair to good quality. The livestock carrying capacity could be greatly increased, however, by a pasture improvement program involving the use of sufficient lime to neutralize the soil acidity; sufficient commercial fertilizer, especially one high in phosphate; and reseeding with a mixture of grasses and legumes where necessary.

Hillsdale loam, level phase.—Although similar in profile characteristics to the normal phase of the type, this phase differs in occurring on nearly level relief, with slopes less than 3 percent. Erosion therefore is not a serious problem, and the soil is better adapted than the more sloping areas to a more intensive cropping system. Practically all the soil is cultivated, mainly to corn, wheat, soybeans, and hay crops, and occasionally to vegetables. Fertility and production are more easily maintained than on the more sloping Hillsdale soils, and crop yields are equal to or slightly higher than on the normal phase.

Hillsdale loam, eroded phase.—Accelerated erosion has removed 25 to 75 percent or more of the surface soil of this phase, and the brownish-yellow subsoil is exposed in places. The removal of part of the surface soil and occasionally part of the subsoil has resulted in the loss of a large part of the organic matter and plant nutrients and in lowered fertility and tilth. A total of 448 acres of this phase is mapped on 3 to 12 percent slopes in association with the normal phase of the type and Galena loam.

Use and management.—Most of Hillsdale loam, eroded phase, is cultivated to general farm crops. Crop yields are somewhat lower than on the normal phase. Erosion control methods and good management practices, which include the incorporation of all available organic matter, the use of sufficient fertilizer, and the use of a rotation system with a large proportion of close-growing crops, are necessary to control erosion and maintain and increase fertility.

Hillsdale loam, eroded steep phase.—As this phase occurs on slopes of 12 to 25 percent or more, about 25 to 50 percent of the surface soil has been removed by accelerated erosion except on a few small included forested areas. To a depth of 6 or 7 inches the surface soil is brownish-yellow heavy loam, extremely low in organic content and poor in tilth.

This phase is not well adapted to general farm crops, nor to the rotation system in general use on the less sloping areas. It is better adapted to close-growing crops, as hay and small grains, than to corn. Moisture conditions are less favorable than on the smoother areas, and crop yields are naturally lower.

Hillsdale loam, severely eroded steep phase.—Scattered gullies 3 feet or more deep are common on this phase, which occurs on slopes of 12 to 25 percent or more. About 50 percent or more of the surface soil or all the surface soil and part of the subsoil have been removed by accelerated erosion. A total of 256 acres is mapped.

This phase is not adapted to the production of cultivated crops, but under present economic conditions it is probably better adapted to permanent pasture or forest. The organic content of the surface soil is extremely low, and tilth is poor, owing to the presence of the heavier-textured subsoil on a large part of the soil. Crop yields are extremely low.

Hillsdale loam, gullied phase.—This phase occurs on 3 to 12 percent slopes, and 50 percent or more of the surface soil has been removed by accelerated erosion, with numerous gullies occurring throughout. Most of the gullies are shallow; however, when they have once penetrated the clay loam subsoil into the underlying loose gravel and sand, they undercut and enlarge rapidly, forming wide, deep gullies that are difficult to control. A total of only 192 acres is mapped in association with the other phases of Hillsdale loam, usually in small scattered areas.

Use and management.—Hillsdale loam, gullied phase, once was cleared and cultivated, causing the severely eroded and gullied condition, which is due chiefly to lack of proper management and rotations that have included a large proportion of clean-cultivated crops. At present, only small areas are cultivated to crops, with the larger ones being in permanent pasture or idle land. It is probably possible to fill in most of the gullies that occur on this phase, but good management and erosion control practices are necessary to prevent further erosion loss. Probably the best use is hay crops, especially alfalfa, or permanent pasture.

Houghton muck.—Developed from plant remains of reeds, sedges, grasses, and moss, this muck differs from Carlisle muck in containing practically no woody material and in being slightly less granular in the surface 6 or 8 inches. To a depth of 7 or 8 inches the surface soil consists of very dark-gray to black finely divided muck, having a medium to slightly acid reaction. This material is underlain by dark-gray to nearly black coarse-textured mucky material that grades into pale-yellow to brownish-yellow macerated muck or peaty material at a depth of 14 to 20 inches. Below this is well-decomposed plant remains of reeds, sedges, grasses, and moss. A total of 4,800 acres of this soil is mapped, principally in the Kankakee River basin in the southwestern part of the county (pl. 7).

Use and management.—Most areas of Houghton muck have sufficient artificial drainage for the production of crops, chiefly corn, soybeans, and vegetables. Crop yields are about equal to those obtained on Carlisle muck.

Kerston muck.—In association with Griffin loam and with other muck soils this soil occurs principally in the flood plains of the Kankakee River and Grapevine Creek. Natural drainage is extremely poor. It has no definite profile and is characterized by alternating layers of black muck and sandy material, which are variable in thickness and sequence. A total of 1,024 acres is mapped.

Use and management.—A large part of Kerston muck has been artificially drained and used for corn, vegetables, and soybeans. Crop yields are variable, depending upon the thickness of the organic layers and drainage conditions. Where the surface 12 to 14 inches consists of muck material the crop yields are only slightly lower than on Carlisle muck, shallow phase over sand. At present many areas are undrained and used largely for pasture.

Lapaz loam.—This soil occurs on slight depressions of relatively narrow outwash plains, associated with the Walkerton and Argos soils, and in old narrow glacial channels in association with the Galena and Otis soils of the uplands. It developed on relatively thin deposits (4 to 6 feet thick) of assorted sand and silt over unassorted glacial till and is the dark-colored very poorly drained member of the soil catena that also includes the well-drained Argos and the imperfectly drained Walkerton series. A total of 1,728 acres is mapped, principally in the vicinity of Lakeville. Natural drainage is very poor, but most of the soil is sufficiently drained artificially for crop production. The native vegetation consisted chiefly of marsh grasses and water-tolerant trees.

Following is a profile description in cultivated areas:

0 to 7 inches, dark-gray to very dark brownish-gray friable loam, relatively high in organic content. Reaction, moderately acid to neutral.

7 to 15 inches, dark-gray heavy loam to clay loam, relatively high in organic content. Reaction, moderately acid to neutral.

15 to 36 inches, mottled gray, yellow, and rust-brown plastic clay loam, slightly sticky when wet and hard when dry. It breaks into irregularly sized and shaped chunks that are easily crushed when moist. Reaction, slightly acid to neutral.

36 to 60 inches, mottled gray, yellow, and rust-brown slightly coherent fine sand, sand, and silt, with an occasional thin layer of silty clay and clay. The thickness and sequence of the various layers are variable within a short distance. Reaction, slightly acid to neutral in the upper part and neutral to slightly alkaline in the lower.

60 inches+, gray and yellow calcareous sand and silt underlain at shallow depths by unassorted moderately heavy calcareous glacial till.

Variations are in the color and thickness of the surface and upper subsoil layers, the texture of the various layers, and the depth to unassorted glacial till. The surface soil in a number of included areas ranges from silt loam to silty clay loam. The thickness of the dark-colored subsoil varies from 14 to 20 inches or more, and depth to unassorted till ranges from 5 to 10 feet.

Several included areas in the vicinity of Wyatt and Lakeville have deeper and darker gray surface soils and are underlain by bluish-gray clay loam subsoils. They are richer in organic matter and originally had poorer natural drainage.

Use and management.—Lapaz loam is cultivated to corn, wheat, oats, and hay crops, with some soybeans and other field crops. Owing to its occurrences in relatively narrow and irregularly shaped areas in close association with Walkerton, Argos, and other soils, it is cropped about the same as the associated soils. The relatively high content of organic matter in the surface and upper subsoil layers makes the soil well adapted to corn and soybeans, but because of occasional drowning out and lodging of the grains it is not so well adapted to small grains.

The best corn yields are obtained during years of favorable weather conditions and under good management. Some loss of wheat from lodging of the grain occurs unless sufficient commercial fertilizer is used. Although it is usually not necessary to apply lime for the successful growth of clover and alfalfa, a few areas of this soil are in need of light lime applications.

Lydick loam.—This is a well to somewhat excessively drained soil developed on glaciofluvial outwash plains and terraces underlain by slightly calcareous stratified sand and gravel containing a high proportion of siliceous sand and shale fragments. It is developed on prairie-border, or transitional, areas between the prairie and timber areas. Originally the vegetation probably was prairie grasses, but trees, principally bur oak, have encroached upon the grasses to such an extent that the organic content of the surface and upper subsoil layers is considerably less than in similar layers in the Door soils. In color and organic content of the surface and upper subsoil layers the soil is intermediate between the dark-colored Door soils and the light-colored Tracy soils. The relief is nearly level, with few slopes over 3 percent, and most of the rainfall is removed internally. A few shallow depressions or kettle holes are present, but not so numerous as in the Door and Tracy soils. This soil usually occurs between areas of those soils, principally on the boundary of the prairie areas. A total of 4,160 acres is mapped.

Following is a profile description in cultivated areas:

0 to 7 inches, moderately dark-brown to dark grayish-brown friable gritty loam, moderately high in organic content. Reaction, strongly to very strongly acid.

7 to 10 inches, dark grayish-brown to moderately dark-brown heavy loam, lower in organic content than the above layer. Reaction, strongly to very strongly acid.

10 to 18 inches, yellowish-brown to brownish-yellow clay loam to sandy clay loam, with imperfectly developed coarse-granular to fine subangular aggregates. Reaction, strongly to very strongly acid.

18 to 36 inches, yellowish-brown to brownish-yellow clay loam, having well-developed ½- to 1½-inch subangular aggregates. It contains a considerable quantity of sand and is somewhat compact in place. Reaction, strongly to very strongly acid.

36 to 80 inches, yellowish-brown to brownish-yellow friable sandy loam to light clay loam, with thin layers and lenses of loose sand and gravel. The clay content decreases with depth. Reaction, strongly to very strongly acid in the upper part and medium to slightly acid in the lower.

Vertical aerial view in St. Joseph County, Ind. *A*, Kankakee River ditch on St. Joseph-La Porte County line southwest of Crumstown. *B*, Old meandering course of Kankakee River. *C*, Lateral ditches recently dredged. *D* and *E*, Lighter colored Griffin loam bordering the old channel. *F*, Adjacent dark muck. *G*, Maumee soils. *H*, Purdue University Agricultural Experiment Station experimental field for special crops on Houghton muck. *I*, Woodland on imperfectly drained Hanna soil. *J*, Woodland on imperfectly drained Willvale soils. *K*, Excessively drained Tracy soils. *L*, A cloud. *M*, Shadow of the cloud.

80 inches +, light brownish-yellow to light-brown slightly calcareous stratified sand and gravel, relatively high in siliceous sand and shale and low in limestone.

Variations are in color, texture, and thickness of the various layers, the organic content of the surface soil and upper subsoil, and the depth to and composition of the underlying sand and gravel. This soil is essentially a transition from Tracy loam to Door loam, and the boundary between it and those soils is arbitrarily drawn in many areas. Depth to the slightly calcareous sand and gravel varies from 5 to 7 feet or more.

Use and management.—A large part of Lydick loam is cultivated, with a cash-grain system of farming being followed on the greater part. Grain crops are grown on about 80 percent of the type and about 15 percent is used for meadow and pasture. Depletion of the organic content and the declining fertility are resulting in increased growth of legumes and following a systematic crop rotation. Crops grown include corn, wheat, oats, soybeans, and hay.

Corn follows soybeans or small grains on areas where a cash-grain system of farming is followed. On many areas sweetclover is sown with small grains in spring and turned under the following spring and the land planted to corn. This helps maintain the organic content of the soil and allows a shorter rotation to be followed. The best corn yields are obtained during seasons of favorable weather conditions and under good management practices. Commercial fertilizer is more generally used with corn than formerly, with the quantity varying from 60 to 150 pounds or more an acre.

Wheat follows corn, oats, or soybeans, and the greater part receives 100 to 150 pounds or more an acre of commercial fertilizer. Oats occasionally take the place of wheat and are grown largely as a cash-grain crop. Rye sometimes is sown in corn in fall and turned under as a green-manure crop in spring. An increasing acreage is used for soybeans.

Hay crops include a mixture of clover, alfalfa, timothy, and alsike, or clover or alfalfa alone. For successful growth of clover and alfalfa it is necessary to apply sufficient lime to neutralize the strong acidity of the surface soil and subsoil. In areas where livestock farming, particularly dairying, is followed, the proportion of hay in the rotation is higher than where a cash-grain system is practiced.

Lydick loam, sloping phase.—The slopes of this phase are 3 to about 12 percent, predominantly about 5 to 8 percent. The soil covers a total of 704 acres, principally around the small kettle holes or depressions, chiefly northwest of South Bend. The areas are usually relatively narrow, and, as they occur closely associated with Lydick and Door loams, they are frequently cropped about the same as those soils. This phase is similar in profile characteristics to the normal phase of the type, except that the organic content of the surface soil is usually somewhat less and the various layers are thinner. It is somewhat more droughty than the nearly level normal phase, and crop yields are somewhat lower. Included are a few areas having fine sandy loam surface soils and more friable subsoils.

Lydick loam, eroded sloping phase.—Accelerated erosion has removed 25 to 75 percent or more of the surface soil of this phase, and the subsoil is exposed in an occasional small area. A total area of

576 acres is mapped on 3 to 12 percent slopes, principally around the depressions and kettle holes in association with the normal phase of the type and with the Door soils.

A considerable proportion of the soil is cultivated to the same crops as grown on the normal phase, but yields are lower because of the eroded condition and the less favorable moisture conditions.

Lydick fine sandy loam.—A somewhat excessively drained soil developed on glaciofluvial outwash plains and terraces that are underlain by stratified sand and gravel composed chiefly of siliceous sand and black Devonian shale. It occupies a transitional position between the areas of Door soils and the Tracy and Hillsdale soils. A total of 448 acres is mapped on nearly level relief, with the larger areas mapped south of New Carlisle and northeast of North Liberty in section 11.

In profile characteristics this soil is similar to Lydick loam, except that the surface and subsoil layers are lighter textured and contain a higher proportion of siliceous sand and a lower proportion of clay and the moisture relations are somewhat less favorable. Owing to the light texture of the surface and subsoil layers, most of the rainfall is removed internally.

Use and management.—The principal crops grown on Lydick fine sandy loam are soybeans, corn, wheat, rye, and alfalfa, with a higher proportion of soybeans, rye, and alfalfa than on the heavier textured Lydick and Door soils. This soil is somewhat droughty for most of the crops, and yields are considerably lower than on Lydick loam, especially those of corn. Owing to the strong acidity of the surface and subsoil layers, legumes, including alfalfa and clover, cannot be successfully grown without the application of sufficient lime. Red clover is not so well adapted as alfalfa, and losses from drought are occasionally high. The soil is probably better adapted to small grains, particularly rye and wheat, and to soybeans and alfalfa than to corn and oats.

Lydick silt loam.—This is a well to somewhat excessively drained soil developed on glaciofluvial outwash plains and terraces underlain by stratified sand and gravel that is relatively high in siliceous sand and black Devonian shale fragments. It occurs on nearly level relief with slopes less than 3 percent and occupies a transitional position between the Door soils developed under prairie vegetation and the Tracy soils developed under timber vegetation. A total of 1,984 acres is mapped, the larger areas occurring on Portage Prairie.

In profile characteristics this soil is similar to Lydick loam, but the surface texture differs, and the subsoil is somewhat heavier textured and contains more clay. The organic content of the surface and upper subsoil layers is comparable to that of Lydick loam, but the moisture relations are somewhat more favorable because of the heavier texture.

This soil is cultivated to about the same crops as Lydick loam with a considerable proportion used for cash-grain crops. Due to its higher productivity and better moisture relations this soil is almost completely used for crops. A cash-grain type of farming is generally followed, although dairying and livestock farming are increasing in importance. Wheat and corn are the most important crops. Oats are grown to a considerable extent as a feed crop. Alfalfa and red clover are more commonly grown because of the higher moisture-holding capacity of the soil. Crop yields are somewhat higher than those obtained on the lighter textured Lydick loam.

Lydick silt loam, sloping phase.—This soil occurs on slopes of about 3 to 12 percent, principally around the small kettle holes or depressional areas on Portage Prairie. This phase is associated with the nearly level normal phase of the type and a large part is cultivated in connection with it, but crop yields are somewhat lower. The soil is somewhat susceptible to erosion, and moisture relations are not so good as on the nearly level areas. It is better adapted to small grains, hay crops, and pasture than to clean-cultivated crops.

Lydick silt loam, eroded sloping phase.—From 25 to 75 percent of the surface soil of this phase has been removed by accelerated erosion, with occasional small areas occurring where the heavier textured subsoil is exposed. The soil occurs on slopes of 3 to about 12 percent in association with the normal phase of the type, principally on Portage Prairie, and also in association with Door silt loam adjacent to the small depressions or kettle holes.

Use and management.—Much of Lydick silt loam, eroded sloping phase, is cultivated to the crops common to the associated soils, but erosion and less favorable moisture conditions have reduced crop yields, making them considerably lower than on the normal phase. The soil is probably better adapted to small grains, hay crops, and pasture than to clean-cultivated crops, but it is often impractical to farm these areas different from the associated soils because of the small size of the individual areas.

Made land.—Only one large area of this land type, totaling 128 acres, is about 2½ miles northwest of South Bend, adjacent to and including a part of the Bendix Airport. Soil has been brought in from other areas and placed on top of the original surface soil, and the depth of the additions is variable, in places several feet thick.

Maumee fine sandy loam.—This soil, developed on calcareous sand, occurs on nearly level to slightly depressed areas that were former drainageways or broad basins. A total of 12,672 acres is mapped, often in relatively extensive areas. The water table is at or near the surface for the greater part of the year, but most areas are sufficiently drained at present to permit cultivation. The organic content of the surface and upper subsoil layers is higher than in the associated Granby soils. Natural drainage conditions are very poor as the soil usually occupies somewhat deeper depressional areas, but artificial drainage is easily established where outlets are available, owing to the porous nature of the underlying sand. The native vegetation consisted chiefly of marsh grasses, with some water-tolerant trees.

Following is a profile description in cultivated areas:

0 to 7 inches, very dark-gray to nearly black fine sandy loam, relatively high in organic content. In undisturbed areas the surface 2 or 3 inches may be muck. Reaction, medium acid to neutral.

7 to 18 inches, dark-gray fine sandy loam, high in organic content. Reaction slightly acid to neutral.

18 to 30 inches, light-gray to gray, with a few rust-brown streaks and blotches, light clay loam to loam. Reaction, slightly acid to neutral.

30 to 50 inches, mottled gray, yellow, and rust-brown loose sand and fine sand containing a small quantity of gravel. Reaction, neutral.

50 inches +, yellow and gray calcareous loose sand and fine sand.

Variations are in the content of organic matter in the surface and upper subsoil layers, the acidity of the surface soil, and the depth to calcareous sand. In a few areas the surface soil is medium to strongly acid to a depth of 15 inches or more.

Use and management.—Most of Maumee fine sandy loam is under cultivation and is cropped to corn, oats, wheat, and soybeans, with a smaller proportion of hay crops. Corn is usually fertilized with 80 to 125 pounds or more an acre of commercial fertilizer, as 0–12–12. It is common practice to use 100 to 150 pounds or more an acre of commercial fertilizer with wheat. Oats are not so well adapted as wheat. Soybeans are grown both for hay and grain, and fertilizer is not generally used. Soybean hay yields average 2 tons or more an acre. Hay crops include a mixture of timothy, redtop, and clover, or alfalfa alone. One-third of this soil is sufficiently acid to require applications of lime for the most successful growth of legumes. An extensive system of open ditches has been installed to drain this soil and other former marshland soils. This included dredging the Kankakee River and its tributaries and numerous lateral ditches throughout the marshlands.

Maumee fine sandy loam, mucky phase.—Occurring in positions intermediate between the normal phase of the type and areas of muck soils, this soil occupies level to depressed areas in old glacial channels of the outwash plains. The material is deposited largely by water action, and the soil differs from the normal phase in that the surface 7 to 14 inches is very dark-gray to black sandy muck, high in organic matter, and it differs from muck soils in containing a considerable proportion of fine quartz sandy material. The rest of the profile is about the same as that of the normal phase.

Use and management.—Maumee fine sandy loam, mucky phase, is cultivated to about the same crops as the associated normal phase, and yields of field crops are about the same or slightly higher. It is, however, better adapted to corn, timothy, bluegrass, and vegetable crops, and fertilizer relatively high in potash is necessary for most crops grown.

Maumee loam.—This is a very dark colored very poorly drained soil developed on the lake and outwash plains underlain by calcareous sand. It occurs on level to depressional areas in association with Granby soils and areas of muck. Natural drainage is very poor, and water stands at or on the surface much of the year. Most areas at present, however, are sufficiently drained artificially to permit cultivation. The soil is relatively easy to drain where outlets are available because of the loose porous nature of the underlying sand. A total area of 6,976 acres is mapped, principally west and northwest of South Bend, the larger areas occurring in association with other Maumee soils and Granby soils and with areas of muck throughout the Kankakee River valley. In profile characteristics this soil is similar to Maumee fine sandy loam, but the texture of the surface soil and subsoil is somewhat heavier—the surface soil is loam, and the subsoil heavy loam to clay loam. Moisture conditions are also more favorable for sustained high corn yields.

Included with this soil are several areas in which rusty-brown blotches and bog iron ore concretions occur on the surface and throughout the profile. Such areas are usually neutral in reaction and better adapted to the growth of clover than the normal phase of the type.

Use and management.—Maumee loam is cultivated to corn, soybeans, and vegetable crops, with a small acreage planted to small grains. It is better suited to corn and soybeans than to small grains, owing to the danger of winterkilling of fall-sown grains and to the high organic content, which causes considerable damage from lodging. Crop yields are somewhat higher than on Maumee fine sandy loam.

Miami silt loam.—A total of 960 acres of this undulating to gently sloping soil has developed on highly calcareous Late Wisconsin glacial till. It is the well-drained member of the soil catena that includes the imperfectly drained Crosby, the very poorly drained dark-colored Brookston, and the very poorly drained very dark-colored Clyde series. It occurs on the upland areas in the eastern part of the county in association with those soils, principally adjacent to the drainageways and on slight knolls or elevations above the surrounding areas. External drainage is moderate to somewhat rapid, and internal drainage moderate. Erosion is somewhat of a problem in the management of this soil, especially on the more sloping areas. The native vegetation consisted chiefly of sugar maple, white oak, hickory, walnut, elm, and ash. Only a small part of the soil is now in woodland.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown friable granular silt loam, relatively low in organic matter. Reaction, slightly to medium acid.

7 to 10 inches, yellowish-brown to brownish-yellow friable coarse-granular heavy silt loam, lower in organic content than the above layer. Reaction, medium acid.

10 to 30 inches, yellowish-brown to reddish-yellow brown silty clay loam, breaking into ¼- to ¾-inch subangular or nuciform aggregates in the upper part and ½- to 1½-inch subangular aggregates in the lower. These aggregates are hard when dry but may be easily broken down into coarse granules when moist. Reaction, medium acid.

30 to 36 inches, yellowish-brown to dark yellowish-brown silty clay loam, slightly more friable than the above layer but generally neutral to slightly acid.

36 inches +, gray and yellow compact calcareous glacial till composed of unassorted silt, clay, sand, and rock fragments.

Variations are in color, texture, and thickness of the various layers and the depth to calcareous till. Where this soil grades into Crosby silt loam the surface soil is light brownish yellow to brownish gray and the subsoil may be mottled below a depth of 21 to 30 inches. The content of organic matter in the surface soil is variable, as is the quantity of stones or boulders on the surface.

Included are a few level areas in which permeable sand or gravel seams in the substrata provide unusually good internal drainage.

Use and management.—Most of Miami silt loam has been cleared and is largely in cultivation or in semipermanent pasture. About 62 percent is used for grain crops, 18 percent for meadow crops, and 14 percent for pasture. The rotation in common use includes corn, oats or wheat, and hay crops, with soybeans increasing in importance. The hay crop consists of either a mixture of timothy, clover, alfalfa, and alsike, or clover or alfalfa alone.

Corn usually follows hay crops in the rotation or it may be planted on areas where fall-sown small grains have failed. It is commonly fertilized with 60 to 150 pounds or more an acre of 2–12–6 or 0–12–12 fertilizer.

Wheat usually follows corn or soybeans in the rotation. Practically all the wheat grown on this soil is fertilized with 100 to 200 pounds an acre of 2–12–6 fertilizer, and some areas receive a top dressing of manure early in spring. Oats follow corn or soybeans in the rotation. Very few areas of oats are fertilized at present, although a few farmers apply fertilizer at the time of seeding, not so much as a fertilizer for the oats as for the grass and legume seed that is usually sown at the same time. Rye occasionally takes the place of wheat or oats in the rotation and is usually not fertilized. It is used partly as a green-manure crop and partly for pasture early in spring and is turned under and the land planted to corn. Some areas are harvested for grain.

Hay crops are sown with oats in spring or in wheat or rye in spring. Alfalfa, however, is occasionally sown late in summer, usually in August. It is necessary to apply sufficient lime to correct the acidity of the surface soil for the successful growth of alfalfa and clover. Soybeans are increasing in importance on this soil and the associated ones and usually follow corn or small grains in rotation. They are grown both for hay and seed, with the large increase in recent years mainly for seed. Permanent pasture is of variable quality and usually can be improved substantially by applications of lime and commercial fertilizer.

Miami silt loam, eroded phase.—Accelerated erosion has removed 25 to about 50 percent of the surface soil of this phase. The yellowish-brown subsoil is exposed in some places, reducing tilth conditions and lowering the fertility of the soil. The eroded condition is usually a result of improper management practices, mainly the growing of too great a proportion of clean-cultivated crops. A total of 640 acres of the soil is mapped on 2 to about 12 percent slopes, principally in close association with the normal phase of the type.

Use of management.—Most of the general farm crops are grown on Miami silt loam, eroded phase, but yields are considerably lower than on the uneroded normal phase. Improved management practices should be used including (1) plowing under organic matter, (2) applying the proper quantity and quality of commercial fertilizer and lime, and (3) using erosion control measures to maintain and increase fertility. Some of the areas are in permanent bluegrass pastures, but the livestock carrying capacity is medium to low, and little effort is made to improve them. A pasture improvement program including the use of lime and fertilizer would greatly improve the quality and quantity of pasture on these areas.

Miami silt loam, severely eroded phase.—The greater part of the surface soil and part of the subsoil of this phase have been removed by accelerated erosion. Over a large part of the area the heavier textured yellowish-brown subsoil is exposed, and it has been mixed with the remaining surface soil. As a result the present surface soil is heavy silt loam to light silty clay loam extremely low in organic content.

Use and management.—Tilth conditions are poor and productivity relatively low on Miami silt loam, severely eroded phase. The physical condition is unfavorable for crop growth, for the soil occurs on gently sloping areas with a few shallow gullies present, and in some areas the gullies are deep enough to prohibit the use of farm machinery. A few included areas have been badly dissected by shallow gullies. Areas associated with Miami loam usually have a higher content of sandy material in the subsoil. Part of this soil is cultivated to the crops common to the area, but yields are extremely low. In greater part the areas are in permanent pasture, and a few areas are idle. On such areas the pasture is poor and the livestock carrying capacity low.

Miami silt loam, severely eroded steep phase.—Most of the surface soil and a considerable part of the subsoil of this phase have been removed by accelerated erosion. The present surface soil to a depth of 6 inches is yellowish-brown heavy silt loam to silty clay loam, extremely low in organic content. Tilth conditions are extremely poor, and it is difficult to prepare a satisfactory seedbed. Numerous small gullies occur in most of the areas, and some gullies 3 feet deep or more cannot be crossed by farm machinery. This eroded condition has resulted from cultivating the steep slopes (12 to about 25 percent or more) that are unsuited to clean-cultivated crops.

Included are a few small forested areas on which accelerated erosion has not developed. Here the profile is similar to that of the normal phase of the type, except the layers are thinner. These areas occur principally adjacent to the drainageways, particularly the bluffs of the valley of the St. Joseph River.

Use and management.—Practically no attempt is made to cultivate areas of Miami silt loam, severely eroded steep phase, and they usually support a thin weed or brush cover with practically no grasses, other crops, or erosion control measures to stabilize the erosion. This phase is better suited to forestry or to permanent bluegrass pasture than to cultivated crops. The less severely eroded areas and less steeply sloping areas can probably be used for permanent pasture after sufficient lime and commercial fertilizer have been applied and the areas seeded to a mixture of grasses and legumes.

Miami loam.—This is the well-drained member of the soil catena that also includes the imperfectly drained Crosby, the very poorly drained dark-colored Brookston, and the very poorly drained very dark-colored Clyde series, developed on highly calcareous Late Wisconsin glacial till. An aggregate area of 768 acres is mapped principally in association with Crosby loam in the eastern and southeastern parts of the county. The relief is undulating to gently sloping, with a slope of 2 to about 10 percent. External drainage is moderate to somewhat rapid on the steeply sloping areas, and internal drainage moderate. The profile characteristics are similar to those of Miami silt loam, except the texture of the surface soil differs and the subsoil and underlying calcareous till are somewhat lighter textured. A few level areas occur in which a sand or gravel substratum has improved natural drainage conditions of the soil.

Use and management.—Management practices and crops grown are similar to those on Miami silt loam. Yields, however, especially of corn, are somewhat lower, as this crop is somewhat more susceptible to drought damage than when it is grown on the heavier textured silt loam.

Newton fine sandy loam.—Widely scattered areas of this soil occur in the lake and outwash plains as narrow belts bordering the elevated soils of the Tracy group and the depressional Granby, Maumee, and muck soils, with the larger areas in the northeastern part of the county.

A total of 2,496 acres of this soil, developed on strongly acid sands, is mapped. Natural drainage is very poor, and water stands at or near the surface for a considerable part of the year. Low areas have sufficient artificial drainage to permit cropping. The native vegetation consisted chiefly of marsh grasses and water-loving trees.

Following is a profile description in cultivated areas:

0 to 10 inches, dark-gray to very dark brownish-gray fine sandy loam, relatively high in organic content. Reaction, strongly to very strongly acid.

10 to 14 inches, dark brownish-gray to rusty-brown fine sandy loam to light loam containing an appreciable quantity of organic material. Reaction, strongly to very strongly acid.

14 to 30 inches, highly mottled gray, yellow, and rust-brown heavy loam to clay loam that becomes more sandy and friable with depth. Reaction, strongly to very strongly acid.

30 inches +, mottled gray and yellow loose fine sand to sand. Reaction, strongly to very strongly acid. At a depth of 5 feet or more the sand may become neutral in reaction.

Variations occur in the color and organic content of the surface soil and upper subsoil, the texture of the subsoil, and the acidity of the surface soil. Although there is a distinct difference in the acidity of this soil and Granby fine sandy loam, these two soils occasionally occur adjacent to each other, and some areas of this soil have a somewhat less acid condition in the surface and subsoil layers. The boundary between these soils may be arbitrarily drawn.

Use and management.—At one time most of Newton fine sandy loam was under cultivation, but owing to the strong acidity and low fertility a considerable proportion is idle, with the present vegetation on the larger areas consisting largely of briers, broomsedge, cinquefoil, and sheep sorrel. Corn, wheat, and timothy are the principal crops. Alfalfa and clover are not adapted, because of the strong acidity of the soil. Both timothy and redtop produce fair to good yields. Some soybeans and oats are grown, and rye is probably better adapted than wheat.

Newton loam.—This is a dark-colored very poorly drained soil developed on strongly acid sands. A total of 1,152 acres is mapped on nearly level to slightly depressional areas, principally in the basin adjacent to Grapevine Creek. It is similar to Newton fine sandy loam in profile characteristics, including number and arrangement of layers, acidity, content of organic matter in the surface and upper subsoil layers, and natural drainage conditions; but the texture of the surface soil differs, and the subsoil is somewhat heavier textured and contains a higher proportion of clay. The acidity is somewhat more variable than in the fine sandy loam, with a few areas adjacent to the Granby soils being medium acid.

A few included areas located northeast of Hamilton in sections 5 and 17 and south of New Carlisle have a gritty silt loam surface soil and a heavier subsoil. Clods form more easily and more power is required for tillage operations. The heavier textures have stronger acidity and consequently reduced adaptability to the growth of legumes and grasses.

Use and management.—Most areas of Newton loam have sufficient artificial drainage for crop production, although a few areas need more adequate drainage. Crops grown are about the same as those on Newton fine sandy loam, but yields are slightly higher. The principal adverse conditions affecting crop growth are strongly to very strongly acid reaction and the somewhat loose porous nature of the profile.

Otis silt loam.—This soil has developed on heavy-textured moderately calcareous Late Wisconsin glacial till containing a relatively high proportion of black Devonian shale and a small proportion of limestone fragments. It is the imperfectly drained member of the soil catena that also includes the well-drained Galena and the very poorly drained dark-colored Brookston series. It occurs on the upland areas on nearly level relief in association with the Galena, Hillsdale, and Brookston soils. A total of 6,208 acres is mapped, the more extensive areas in the regions lying southeast of North Liberty and extending eastward to the vicinity of Lakeville. Surface runoff is slow to moderate, and internal drainage slow; consequently, it is necessary to drain this soil artificially, preferably with tile drains, for the successful growth of most of the farm crops of the area. The native vegetation consisted chiefly of maple, elm, ash, walnut, and associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, brownish-gray to light brownish-gray friable medium-granular silt loam, relatively low in organic content. Reaction, medium acid.

7 to 12 inches, light brownish-gray to mottled gray, yellow, and rust-brown heavy silt loam, breaking into large granules or small subangular aggregates. Reaction, medium acid.

12 to 36 inches, mottled gray, yellow, and rust-brown heavy silty clay loam to silty clay, plastic when wet and hard when dry. The material breaks into medium to large-sized blocky aggregates, plastic when wet and hard when dry. This layer is somewhat impervious to moisture movement and to plant roots. The content of small partly weathered shale fragments is variable, as is the content of various-sized glacial gravel and boulders. Reaction, medium acid.

36 to 54 inches, mottled gray, yellow, and rust-brown silty clay loam containing an appreciable quantity of partly weathered shale fragments. The material is somewhat more friable than the above layer. Reaction, medium acid in the upper part and slightly acid to neutral in the lower.

54 inches +, mottled gray and yellow silty clay loam to silty clay moderately calcareous glacial till containing a relatively high proportion of shale fragments.

Variations are in color, texture, and thickness of the various layers, the content of organic matter in the surface layer, and the depth to calcareous till. Where areas of Otis silt loam grade into Galena silt loam, the depth to the mottled subsoil is greater than normal. The surface soil is somewhat higher in organic content where areas of this soil grade into Brookston soils.

Use and management.—Otis silt loam is closely associated with Brookston silty clay loam and with Galena soils and usually forms a part of the field unit with them. It receives more barnyard manure and green-manure crops than the associated Brookston soils. Crop rotations include corn, wheat or oats, soybeans, and hay crops, with an occasional crop of rye or other field crops and an occasional vegetable crop.

Corn usually receives from 50 to 150 pounds or more an acre of commercial fertilizer, and some farmers plow under large quantities of fertilizer before planting. Wheat usually follows corn or soybeans in the rotation and is fertilized with from 100 to 150 pounds

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or more an acre of commercial fertilizer. Little fertilizer is used with oats. Rye occasionally takes the place of wheat or oats in the rotation and is used either for grain or as a green-manure crop. Soybeans, grown both for hay and grain, follow either corn or small grains. Soybeans yield 1 to 2 tons an acre.

Hay crops include a mixture of clover, timothy, alfalfa, and alsike, or clover or alfalfa alone. Use of sufficient lime is necessary to correct the soil acidity for the successful growth of either clover or alfalfa. Better stands and higher yields also are obtained when sufficient commercial fertilizer is used, either directly with the seed or as large applications at the time of seeding of small grain crops.

Permanent bluegrass pasture is of medium to good quality, but the livestock carrying capacity could be greatly improved by the use of lime and commercial fertilizer, especially a fertilizer high in phosphate, and by reseeding with a mixture of grass and legume seed where necessary.

Otis loam.—For the successful production of most crops, it is necessary to drain this soil artificially, usually with tile drains. This soil developed on moderately heavy textured moderately calcareous Late Wisconsin glacial till that contains a relatively high proportion of Devonian shale and a small proportion of limestone fragments. It is the imperfectly drained member of the soil catena that also includes the well-drained Galena and the very poorly drained dark-colored Brookston series. A total of 9,088 acres is mapped on nearly level relief with slopes less than 3 percent. The larger areas occur south of South Bend to the south county line in association with Brookston and Galena soils. Native vegetation included a mixture of beech, maple, ash, oak, elm, and associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, brownish-gray to light brownish-gray medium-granular loam, relatively low in organic content. Reaction, medium acid.

7 to 12 inches, pale-yellow to mottled yellow, gray, and rust-brown heavy silt loam, breaking into medium to large granules. Reaction, medium acid.

12 to 30 inches, mottled gray, yellow, and rust-brown silty clay loam to clay loam, breaking into medium subangular aggregates that are somewhat plastic when wet and hard when dry. Reaction, medium acid.

30 to 54 inches, mottled gray, yellow, and rust-brown loam to silty clay loam, somewhat more friable than the above layer. The material breaks into subangular to ill-defined blocky aggregates that are somewhat plastic when moist and hard when dry. Moisture movement and plant roots are restricted by the somewhat impervious nature of this layer. Reaction, medium acid in the upper part and slightly acid to neutral in the lower.

54 inches +, mottled gray and yellow moderately heavy textured moderately calcareous glacial till containing a relatively high proportion of shale fragments and a small proportion of limestone fragments.

Variations are in color, texture, and thickness of the layers, the organic content of the surface soil, and the depth to calcareous till. Where this soil grades into Galena loam the surface soil contains less gray and more brown, and the depth to the mottled material is somewhat greater than normal. Where it grades into the Brookston soils the organic content of the surface soil is somewhat higher and the color darker. The depth to calcareous till varies from 40 to 60 inches or more.

Use and management.—Otis loam is cropped about the same as Otis silt loam, but yields are slightly lower. The rotation includes corn, wheat or oats, soybeans, and hay crops, with some special field crops and an occasional vegetable crop.

Peat.—Areas of undecomposed brown to brownish-yellow plant remains, totaling 384 acres, compose this soil. The surface soil to a depth of 3 to 8 inches usually consists of a dark-brown spongy fibrous mass of roots grading into a brown to yellowish-brown mass of roots and stems in various stages of decomposition. The acidity is generally so high that the cost of improving the soil for general farming is prohibitive. The larger areas occur principally in sections 1 and 35, Warren Township; section 6, Portage Township; and sections 15, 21, and 35, Lincoln Township. A vegetative cover of buttonbush and an occasional tamarack tree around the margins, with a thick growth of huckleberry, cinquefoil, ferns, and moss, generally is on the soil. A few areas are cropped to corn and soybeans, but pasture is the principal use, although it is of a poor quality and has a very low livestock carrying capacity.

Pinola silt loam.—This soil consists of an accumulation of moderately dark-colored material over dark- to very dark-colored soils. A total of 896 acres occurs in shallow to deep depressions and kettle holes on the prairie areas of the county, principally associated with the Door and Lydick soils. Natural drainage is variable, ranging from fair to poor, although a few of the shallow depressions are moderately well drained. Native vegetation consisted chiefly of marsh grass.

Following is a profile description in cultivated areas:

0 to 7 inches, moderately dark-brown to dark brownish-gray friable silt loam. Reaction, medium to slightly acid.

7 to 24 inches, dark-brown silt loam with thin layers of sand, loam, and clay loam. Reaction, medium to slightly acid.

24 inches +, dark-gray to very dark-gray clay loam that represents the former surface soil.

Variations are chiefly in color and thickness, which ranges from 10 to 40 inches or more, of the accumulated material. The material is washed from surrounding areas of well-drained outwash-plain soils of the prairies and prairie borders.

Use and management.—Pinola silt loam usually occurs in relatively small individual areas and is cropped about the same as the associated soils, especially those areas that are crossable with farm machinery. It is probably better adapted to corn and soybeans than to small grains, but since it is farmed in conjunction with the associated soils the crops grown are similar to those on the Door, Lydick, and other associated soils.

Quinn loam.—An aggregate area of 2,368 acres of this soil is mapped on nearly level relief. It has developed on outwash plains and terraces underlain by noncalcareous to slightly calcareous stratified sand and gravel, composed largely of siliceous sand and shale. It is the poorly drained member of the soil catena that also includes the well to excessively drained Tracy, the moderately well drained Hanna, and the imperfectly drained Willvale series. Under natural drainage conditions, or before artificial drainage was installed, the water table was at or only slightly below the surface during much of the year. This soil is relatively easy to drain artificially where outlets are available, because of the loose porous nature of the underlying sand and gravel. Some areas have had sufficient artificial drainage to permit cultivation, but more adequate drainage is necessary on a large part for the more successful growth of farm crops. The soil occurs throughout the outwash plains and southwest of South Bend with the larger areas occurring northeast of North Liberty and in the broad basin occupied by Grapevine Creek. The native vegetation consisted chiefly of pin, white, and black oaks, with minor quantities of associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, gray to light-gray friable gritty loam containing a few light-yellow blotches and mottlings. Organic content is low, and the surface soil tends to puddle on drying. Reaction, strongly to very strongly acid.

7 to 12 inches, light-gray, faintly mottled with yellow, medium-granular gritty heavy loam. A few small rounded glacial pebbles are present. Reaction, strongly to very strongly acid.

12 to 18 inches, light-gray, faintly mottled with yellow and rust brown, gritty clay loam to silty clay loam. The material breaks into subangular to angular medium-sized aggregates that are compact in place but easily crushed when moist. Reaction, strongly to very strongly acid.

18 to 32 inches, mottled light-gray and yellow, with blotches and streaks of rust brown, gritty clay loam to sandy clay loam containing numerous small rounded pebbles. The material breaks into irregularly sized angular pieces, plastic when wet and hard when dry. Reaction, strongly to very strongly acid.

32 to 60 inches, mottled gray, yellow, and rust-brown sandy clay loam with lenses or thin layers of silty clay and layers of fine sand. Reaction, strongly to medium acid.

60 to 90 inches, mottled gray, yellow, and rust-brown slightly coherent sand, with lenses or relatively thin layers of gravel and an occasional thin layer of clay loam. Reaction, medium to slightly acid.

90 inches +, mottled gray and yellow loose slightly calcareous sand and gravel containing a high proportion of siliceous material and a small proportion of limestone.

Variations are in color, texture, and thickness of the various layers and the depth to and composition of the underlying sand and gravel. In numerous areas this material is noncalcareous to depths of 10 feet or more.

Use and management.—Quinn loam is not used so extensively as the associated Willvale and Hanna soils, and less than 50 percent of the cleared land is under cultivation. A large proportion of the cleared land is idle or in low-grade pasture. Crops grown include corn, soybeans, and hay crops, with a small acreage of wheat. Corn yields are usually low, except in years of abnormally low moisture conditions. Wheat is grown occasionally in the rotation, but owing to the high water table in winter and early in spring there is danger of serious injury from drowning out and heaving. Soybeans probably do as well or better than other crops since they are planted usually after the periods of high moisture conditions. Hay crops usually include a mixture of redtop and timothy with some red clover. Red clover or alfalfa grown alone is attempted on some areas, but sufficient lime applications are necessary to correct the soil acidity for their successful growth.

Quinn silt loam.—This light-colored poorly drained soil developed on glaciofluvial outwash plains and terraces underlain by noncalcareous to slightly calcareous stratified sand and gravel. It occurs on practically level relief, and under natural drainage conditions the water table is at or near the surface for a considerable part of the year. Where outlets are available, the soil is relatively easy to drain because of its loose porous underlying material, and at present part of it has had sufficient artificial drainage to permit cultivation. The profile characteristics are similar to those of Quinn loam, especially in color and acidity, but the surface soil differs in texture, and the subsoil to a depth of 40 inches or more is heavier textured and contains a higher proportion of clay. This soil is cultivated to about the same crops as Quinn loam, with similar yields. The surface soil tends to bake and puddle to a slightly greater degree than does the surface soil of Quinn loam, and the addition of all available organic matter is necessary to correct this condition.

Tracy fine sandy loam.—Scattered areas of this soil occur throughout the valleys of the St. Joseph and Kankakee Rivers, with the most extensive areas in the vicinity of Granger. It has developed on stratified sand and gravel of the glaciofluvial outwash plains and terraces, and the material is relatively high in shale and quartz sand but relatively low in limestone. The relief is nearly level to very gently undulating, with few areas having a slope greater than 3 percent. Very little rainfall runs off this soil; most of it is removed internally. The somewhat open and porous nature of the surface soil and underlying material allows free moisture movement downward. A total of 10,240 acres is mapped. The native vegetation consisted of deciduous forest, including principally oaks and hickory, with smaller quantities of associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown fine sandy loam, low in organic content. Reaction, strongly to very strongly acid.

7 to 12 inches, yellowish-brown to brownish-yellow fine sandy loam to light loam. Reaction, strongly to very strongly acid.

12 to 20 inches, yellowish-brown to weak reddish-brown loam to light clay loam, slightly plastic when wet and somewhat hard when dry. Moisture and plant roots penetrate this material with ease.

20 to 36 inches, weak reddish-brown to yellowish-brown slightly waxy and sandy clay loam, breaking into irregularly sized and shaped pieces; somewhat plastic when wet and hard when dry. Reaction, strongly to very strongly acid.

36 to 70 inches, brownish-yellow to weak grayish-brown light clay loam to heavy loam containing a variable quantity of rounded gravel and a few larger rounded stones. Content of clay and finer-textured material decreases with depth. Reaction, strongly to very strongly acid in the upper part and slightly acid to neutral in the lower.

70 inches +, gray and light-yellow slightly calcareous stratified gravel and sand containing a high proportion of shale and siliceous material, with a small proportion of limestone.

Variations are in the color, texture, and thickness of the layers, the content of organic matter in the surface soil, and the depth to and composition of the underlying sand and gravel.

Use and management.—Approximately 90 percent of Tracy fine sandy loam has been cleared and brought under cultivation. The principal crops are corn, wheat, soybeans, and hay crops including a mixture of timothy, redtop, and clover.

Corn usually follows hay crops in the rotation, although it occasionally follows wheat or soybeans. Most of the manure available is applied to the land to be plowed for corn, and the use of commercial fertilizer is increasing, with applications of 50 to 125 pounds or more an acre. The best corn yields are obtained during seasons of favorable moisture conditions and under better management practices.

Wheat usually follows corn or soybeans, and it is a common practice to use 125 to 200 pounds an acre of commercial fertilizer, usually 2-12-6. Owing to the droughty condition that usually exists late in summer, wheat is probably better adapted than oats to this soil. Rye occasionally takes the place of wheat in the rotation and is grown both for grain and for a green-manure crop, but very little fertilizer is used. Soybeans follow corn or small grains.

Hay crops on the unlimed areas usually consist of a mixture of timothy and redtop. Lime applications of 2 to 3 tons an acre are necessary to correct the soil acidity for the successful growth of clover. Clover is occasionally grown as a part of the hay mixture or grown alone but is frequently killed by drought. Because of the somewhat droughty conditions it is difficult to establish good permanent pasture on this soil, especially during summer months.

Tracy fine sandy loam, sloping phase.—This phase occurs on slopes of 3 to about 12 percent, with dominant slopes of 5 to about 7 percent. A total of 1,792 acres is mapped in association with the normal phase of the type, usually on the sloping areas adjacent to the kettle holes or depressions in the outwash plains. The more extensive areas are north of Lydick and south of New Carlisle. The profile characteristics are essentially the same as those of the normal phase, except that the surface layer is usually thinner and the organic content somewhat lower. Where the lighter areas occasionally border Hillsdale fine sandy loam they are similar to it in profile characteristics.

Use and management.—A large part of Tracy fine sandy loam, sloping phase, is under cultivation to corn, wheat, soybeans, and hay crops. Crop yields are somewhat lower than on the normal phase, and this soil is not used so extensively as the nearly level areas. Some areas are either idle or in permanent pasture.

Tracy fine sandy loam, eroded sloping phase.—Accelerated erosion has removed 25 to 75 percent or more of the surface soil of this phase. It occurs more extensively adjacent to drainageways in the northeastern part of the county, with numerous small areas occurring throughout the outwash plains in association with the normal phase of the type. A total of 1,728 acres is mapped on slopes of 3 to about 12 percent.

Use and management.—A large part of Tracy fine sandy loam, eroded sloping phase, is cultivated, but it is less intensively used for grain crops, with the higher proportion in hay crops and pasture. The eroded condition and the more droughty and poor moisture relations make this phase less favorable than the nearly level normal phase for crops; therefore, crop yields are materially lower.

Tracy fine sandy loam, steep phase.—This phase occurs on slopes of 12 to 25 percent or more in relatively narrow areas adjacent to the deeper kettle holes and lakes northwest of South Bend and south of New Carlisle. Most of the 320 acres mapped is in forest or permanent pasture. The soil is better adapted to forest or crops that furnish adequate protection from accelerated erosion. Under present economic conditions it is not adapted to cultivated crops.

Tracy loam.—This well to somewhat excessively drained soil has developed on noncalcareous to slightly calcareous stratified sand and gravel of the glaciofluvial outwash plains and terraces. The relief is nearly level, with slopes rarely exceeding 3 percent. Very little of the rainfall is removed externally, as the somewhat porous nature of the profile, especially the underlying loose sand and gravel, permits a somewhat rapid downward moisture movement. A total of 3,200 acres is mapped in widely scattered areas throughout the outwash plains but principally in the northern part of the county. The largest individual area lies west of South Bend. Native vegetation consisted of a mixture of deciduous trees, including oaks, hickory, maple, and associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, light grayish-brown to light yellowish-brown friable gritty loam, relatively low in organic content. Reaction, medium to strongly acid.

7 to 12 inches, light yellowish-brown to brownish-yellow loam to heavy loam. Reaction, medium to strongly acid.

12 to 20 inches, yellowish-brown to brownish-yellow light clay loam, breaking into irregularly sized and shaped particles containing some rounded gravel. Reaction, medium to strongly acid.

20 to 30 inches, weak reddish-brown to yellowish-brown clay loam, breaking into irregularly sized and shaped pieces; somewhat plastic when wet and hard when dry. Reaction, medium to strongly acid.

30 to 70 inches, yellowish-brown to brownish-yellow light clay loam that gradually changes to slightly coherent gravel and sand. The upper part of the layer is somewhat plastic when wet but becomes increasingly friable with depth. Reaction, medium to strongly acid in the upper part and slightly acid in the lower.

70 inches +, gray and light-yellow slightly calcareous stratified gravel and sand containing a high proportion of siliceous material and shale fragments.

Variations are in texture, color, and thickness of the layers, the depth to loose sand and gravel, and the composition of the slightly calcareous material. The content of limestone in the underlying gravel and sand is somewhat higher than normal in a few areas, and consequently a somewhat more waxy and decidedly weak reddish-brown lower subsoil develops. A few areas bordering the Lydick soils have a slightly darker-colored surface soil containing a higher proportion of organic matter than normal.

Use and management.—Most of Tracy loam is under cultivation, with corn and wheat the principal crops. Timothy and redtop are occasionally seeded in the wheat as a meadow crop on the unlimed areas. Where lime has been applied to the soil, red clover usually forms a part of the hay mixture, although it is frequently killed by drought. Corn follows hay crops or wheat in the rotation. The greater part of the wheat acreage is fertilized with 100 to 150 pounds or more an acre of commercial fertilizer. Lime applications of 2 to 3 tons are necessary for the successful growth of clover. Very little alfalfa is grown, although it is probable that with sufficient liming this crop could be grown.

Tracy loam, sloping phase.—This phase occurs on 3 to 12 percent slopes, with dominant slopes between 5 and 8 percent. It is most extensively developed on the highly pitted outwash plain north of Lydick, where kettle holes or small depressions are numerous and a few lakes occur. A total of 1,920 acres is mapped. The soil is susceptible to accelerated erosion, especially on the steeper slopes, and therefore some variation in the depth of surface soil results. A few sloping areas associated with Tracy silt loam have been included.

Probably a higher proportion of this phase than of the nearly level normal phase of the type is used for small grains, hay, and pasture.

Moisture relations are not so good as on the normal phase, and crop yields are somewhat lower. The steeper areas are probably better suited to pasture than to cultivated crops.

Tracy loam, eroded sloping phase.—Accelerated erosion has removed 25 to 50 percent of the surface soil, and the subsoil is exposed on several small areas. A total of 832 acres is mapped, principally in the outwash plain north of Lydick. The slopes are 3 to 12 percent, but predominantly 5 to 8 percent. Profile characteristics are similar to those of the normal phase of the type, except the surface soil is grayish-brown to yellowish-brown heavy loam that is low in organic content.

Most of this phase is cultivated to corn, wheat, and hay crops, with crop yields averaging somewhat less than on the normal phase. The moisture-holding capacity and tilth conditions are poorer than on the uneroded soil; hence, crops are more affected by droughty conditions.

Tracy loam, severely eroded sloping phase.—An aggregate area of 256 acres of this phase is mapped, principally north of Lydick, on 3 to 12 percent slopes. Half of the surface soil or all the surface soil and part of the subsoil have been removed by accelerated erosion. Consequently a large part of the organic matter and plant nutrients has been removed, and tilth conditions are extremely poor. A few gullies occur in numerous areas. Those areas associated with Tracy fine sandy loam have more friable surface soil and subsoil.

Crops are more susceptible to injury from drought than on the uneroded areas. Corn, wheat, and hay crops are grown, but yields are extremely low. Corn is affected by the eroded condition and the droughty nature of this phase to a greater extent than are other crops. The soil is probably better suited to pasture, with the more severely eroded and steeper slopes probably better suited to forest.

Tracy loam, steep phase.—This phase occupies a total of 640 acres on slopes of 12 to 25 percent or more. The soil is mapped on the relatively narrow areas bordering drainageways and deeper kettle holes, principally north of Lydick.

The greater part of this phase is in forest or permanent bluegrass pasture, the use to which it is probably best suited. It has not been under cultivation, and therefore any appreciable accelerated erosion has been prevented. Under cultivation it is highly susceptible to accelerated erosion.

Tracy loam, eroded steep phase.—This phase occurs on slopes of 12 to 25 percent or more, and 25 to 50 percent of the surface soil has been removed by accelerated erosion. Areas occur on the outwash plains, principally north of Lydick, in association with the normal phase of the type and, in a few instances, with Tracy and Lydick silt loams. A total of 1,088 acres is mapped.

Use and management.—The principal crops grown on Tracy loam, eroded steep phase, include small grains and hay crops, with several areas of permanent bluegrass pasture. Numerous small areas adjacent to depressional areas of the outwash plains are farmed in connection with the nearly level normal phase, but crop yields are materially lower. A considerable part is idle at present, largely because of the low crop yields obtained. The soil is probably better suited to permanent pasture or forest than to cultivated crops.

Tracy loam, severely eroded steep phase.—Accelerated erosion has removed 50 percent or more of the surface soil or all the surface soil and part of the subsoil. A total of 1,408 acres is mapped on slopes of 12 to 25 percent or more, principally north of Lydick, occurring adjacent to drainageways or to the deeper depressional areas within the outwash plain.

Erosion has greatly reduced tilth conditions, and fertility and crop yields are extremely low. This phase is probably better suited to permanent pasture or forest, and erosion control practices must be maintained to assist in the prevention of further serious damage.

Tracy loamy fine sand.—This excessively drained soil has developed on glaciofluvial outwash plains and terraces underlain by noncalcareous to slightly calcareous sand composed chiefly of siliceous sand and shale. It occurs on nearly level relief, with slopes less than 3 percent. Most of the rainfall is removed internally as the open porous nature of the surface and subsoil material allows rapid downward movement of moisture. A total of 13,824 acres is mapped, principally northeast and southwest of South Bend and in the southwestern part of the county. Native vegetation consisted chiefly of oaks and hickory.

The profile characteristics are similar to those of Tracy fine sandy loam, except that the texture of the surface soil differs and the subsoil to a depth of 30 to 40 inches is considerably lighter textured and contains less clay. In local areas the subsoil varies from clay loam to slightly coherent clayey sand.

In the vicinity of the county infirmary several included areas of this soil have reddish-brown surface soils and reddish-yellow to brown clay loam subsoils. The underlying material consists of incoherent fine sand. Several areas in the vicinity of Walkerton, South Bend, and eastward in the St. Joseph River valley have reddish-brown subsoils and are underlain at 4 to 6 feet with gray limy gravel.

Use and management.—The light texture of the surface soil, subsoil, and underlying material of Tracy loamy fine sand results in a rapid downward movement of moisture and a droughty condition for most of the crops grown. This soil is better adapted to rye, wheat, soybeans, and alfalfa than to corn and oats, although a considerable acreage of corn is grown. Crop yields are considerably below those obtained on Tracy fine sandy loam. Sufficient lime applications to neutralize the soil acidity are necessary for the successful growth of alfalfa. The soil is subject to accelerated wind erosion, and small crops are occasionally damaged by the blowing sand.

Tracy loamy fine sand, sloping phase.—This phase occurs on slopes of 3 to 12 percent. In profile characteristics it is similar to the normal phase of the type, except that the surface layer is usually lower in organic content and somewhat thinner. Internal drainage is very rapid, and the soil is somewhat more droughty than the nearly level normal phase.

This phase is not so intensively cultivated as is the normal phase, and crop yields are lower. It is probably better adapted to alfalfa, small grains, or forest than to clean-cultivated crops, and at present much of it is idle or in forest.

Tracy loamy fine sand, eroded sloping phase.—From 25 to 75 percent or more of the surface soil of this phase has been removed by accelerated wind erosion. An occasional blow-out occurs where the wind has scooped out the surface soil and subsoil to a depth of 2 feet or more. Slopes are about 3 to 12 percent.

This phase is not well adapted to cultivated crops, except possibly alfalfa or rye. The organic content is extremely low, and the soil is very droughty.

Tracy loamy fine sand, steep phase.—An aggregate area of 256 acres of this soil is mapped on slopes of 12 to 25 percent or more. It often occupies the leeward side of the dunelike areas and is along the slopes of the outwash plains. In profile characteristics it is similar to the normal phase of the type, but owing to the steep sloping condition, it is probably more susceptible to wind erosion, and moisture relations are less favorable. Most of this phase is in forest, with only an occasional small area in pasture or under cultivation.

Tracy loamy fine sand, eroded steep phase.—Accelerated wind erosion has removed 25 to 75 percent or more of the surface soil of this phase. Numerous pockets, or blow-outs, occur where the wind has scooped out the surface and subsoil material to a depth of 2 to 3 feet or more. These blow-outs vary considerably in size and shape and are occasionally 50 feet or more in diameter. Slopes of this phase are 12 to 25 percent or more.

Practically all this phase has been cleared, but only a few small areas are under cultivation. It is better adapted to forest than to cultivated crops, although rye and alfalfa—especially alfalfa—probably would produce fair yields after sufficient lime has been applied to neutralize the soil acidity.

Tracy loamy sand.—This excessively drained soil has developed on stratified sand and gravel of the glaciofluvial outwash plains and terraces. The material consists chiefly of siliceous sand and Devonian shale, with a very small percentage of limestone in some areas. It occurs on nearly level relief, mostly on slopes of less than 3 percent. A total of 26,624 acres is mapped in broad areas throughout the outwash plains, with the larger areas occurring in the vicinity of South Bend and northeastward. Very little of the rainfall is removed externally; most of it is removed internally, as the surface soil, subsoil, and the underlying material allow rapid downward movement of moisture. Native vegetation consisted principally of black and white oaks, with some hickory and other associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown feebly coherent loamy sand to loamy fine sand, extremely low in organic content. Reaction, strongly to very strongly acid.

7 to 30 inches, brownish-yellow slightly coherent loamy sand to loamy fine sand containing an occasional pocket or lens of sandy clay loam and an occasional lens of fine gravel or coarse sand. Reaction, strongly to medium acid.

30 to 85 inches +, pale-yellow to light brownish-yellow loose sand, with an occasional pocket or lens of sandy loam, coarse sand, gravel, and shale. The material is variable in composition but is usually high in siliceous material and shale fragments. Reaction, usually medium acid.

Variations are in the color of the various layers and in the reaction of the material below depths of 6 to 8 feet. The underlying material below these depths occasionally contains a small percentage of lime or is neutral to slightly calcareous.

Use and management.—Approximately 85 percent of Tracy loamy sand has been cleared and cultivated. At the present time, however, about one-third of the cleared area is idle and about two-thirds is cultivated. The principal crops include corn, soybeans, wheat or rye, and hay crops. Corn is not well adapted, and the yields are usually very low, owing to the droughty condition and poor moisture relations. The soil is better adapted to wheat or rye than to other small grains. Soybeans are grown both for hay and grain, with hay yielding ¾ to 1½ tons an acre. Sufficient lime applications are necessary to correct the soil acidity for the successful growth of alfalfa, sweetclover, and red clover. Alfalfa and sweetclover are more extensively grown for hay and pasture than are other legumes and grasses. Potatoes possibly would produce good returns and probably should be grown in place of corn in the rotation, following the alfalfa crop.

This soil is not well adapted to permanent bluegrass pasture, as it is difficult to maintain stands and to prevent the grass from "burning out" during the dry summer periods. The carrying capacity is usually low. Most crops are injured by wind erosion—the blowing and shifting of the sandy surface material by the wind.

Tracy loamy sand, sloping phase.—A total of 4,416 acres of this phase is mapped, principally adjacent to the depressions, or kettle holes, and the drainageways; but some also occur on the slopes of the dunelike areas, which are the result of wind action. The slopes are 3 to 12 percent or more, but dominantly 5 to 8 percent.

This phase is less intensively used for cultivated crops than the nearly level normal phase of the type, and the crop yields are somewhat lower.

Tracy loamy sand, eroded sloping phase.—This phase occurs on slopes of 3 to 12 percent, and 25 to 75 percent or more of the surface soil has been removed by accelerated wind erosion. A total of 768 acres is mapped, principally in association with the normal and sloping phases of the type, on the low dunelike areas or knolls.

The organic content of the present surface soil is extremely low, as are crop yields. The soil is not used as extensively as the nearly level normal phase, and several areas are idle. It is not well suited to the production of cultivated crops, especially corn, and is probably better suited to rye and alfalfa after sufficient lime has been applied to neutralize the soil acidity. The steeper sloping areas are probably best suited to forest.

Tracy silt loam.—This well-drained soil is developed on outwash plains and terraces on stratified gravel and sand containing much Devonian shale and little limestone. To a depth of 5 to 7 feet or more it has been leached of lime and other carbonates. A total of 192 acres is mapped on nearly level to gently undulating relief, in small individual areas in the vicinity of Deer Lake and southward. The profile characteristics are similar to those of Tracy loam, but the surface texture differs and the subsoil is heavier textured and contains more clay. Moisture relations are better than on the lighter textured Tracy soils, and the general farm crops and a systematic rotation are better adapted.

Use and management.—Crop rotations on Tracy silt loam include corn, wheat, hay, and soybeans, with an occasional crop of rye. It is common practice to use 100 to 150 pounds or more an acre of commercial fertilizer under wheat, and most farmers apply 60 to 125 pounds or more an acre under corn. In the surface soil and subsoil this soil is extremely acid, and sufficient lime applications are necessary to correct the acidity for the more successful growth of clover and alfalfa. The hay crops grown at present include a mixture of clover, timothy, and redtop, or of timothy and redtop. The best soybean yields are obtained under good management practices, which include sufficient lime applications.

Walkerton loam.—This soil developed on thin deposits (4 to 6 feet thick) of outwash silts and sands (Willvalelike material) over unassorted glacial till (Otislike material). It is the imperfecty drained member of the soil catena that also includes the well-drained Argos and the dark-colored very poorly drained Lapaz series. Areas occur on nearly level relief in association with the Argos and Lapaz soils and also the Otis and Crosby soils of the uplands. The larger areas occur in the vicinity of Lakeville. The native vegetation consisted chiefly of oak, elm, ash, maple, and beech.

Following is a profile description in cultivated areas:

0 to 7 inches, brownish-gray to light brownish-gray friable gritty loam, relatively low in organic content. Reaction, strongly to very strongly acid.

7 to 10 inches, brownish-gray heavy loam to silt loam composed of medium to large granules containing an occasional small rounded gravel. Reaction, strongly acid.

10 to 18 inches, mottled gray, yellow, and rust-brown clay loam to silty clay loam that breaks into medium-sized subangular aggregates. Reaction, strongly acid.

18 to 40 inches, mottled gray, yellow, and rust-brown compact clay loam to silty clay loam containing an appreciable quantity of small rounded gravel and an occasional larger stone. Somewhat more compact material than the above layer that breaks into subangular to angular medium-sized aggregates. Reaction, strongly to very strongly acid.

40 to 50 inches, mottled yellow and gray slightly coherent sandy loam to sand, with thin lenses or layers of clay loam. Reaction, medium acid.

50 inches +, gray and yellow unassorted glacial till. Reaction, medium acid in the upper part and calcareous below a depth of 60 inches or more.

Variations are in color, texture, and thickness of the layers and the depth to unassorted glacial till. Where areas of this soil grade into the Crosby and Otis soils, the deposits of silts and sands are somewhat thinner than normal.

Included with Walkerton loam are about 100 acres of soil, much of it occurring north of Lakeville, which has an ashy-gray surface soil and a rust-brown, gray, and yellow mottled subsoil. The texture ranges from silt loam to fine sandy loam, and natural drainage conditions are very poor. In other respects it is similar to Walkerton loam.

Use and management.—The greater part of Walkerton loam is under cultivation to corn, wheat, and hay crops, with some soybeans and other field crops. Artificial drainage is necessary on most areas for the production of farm crops. Most of the areas have been sufficiently drained, although a few acres need more adequate drainage. Crop yields are somewhat lower than on Otis loam in years of abnormally low moisture conditions but are about equal to or slightly higher than on Otis loam in years of abnormally high moisture conditions. Corn and wheat usually receive 100 to 150 pounds an acre of commercial fertilizer. Sufficient lime is necessary to correct the soil acidity for the successful growth of clover and alfalfa, and soybean yields also are increased by the use of lime.

Walkerton fine sandy loam.—An imperfectly drained soil developed on thin deposits (4 to 6 feet or more thick) of stratified sand and silt over unassorted glacial till. It is similar to Walkerton loam in profile characteristics, but both the surface soil and subsoil are lighter textured. Areas occur in association with Walkerton loam, Lapaz and Argos soils, and occasionally the soil grades into areas of Otis soils.

This soil is cultivated to practically the same crops as Walkerton loam, but the somewhat lower crop yields are due to the lighter texture of the surface soil and subsoil and to the less favorable moisture conditions.

Wallkill silt loam.—A light-colored mineral material has washed from surrounding slopes of upland and terrace soils over areas of muck to form this soil. A total of 192 acres occurs on level to depressional areas, usually as a border between areas of muck and areas of well-drained upland soils. Drainage is poor to very poor.

Following is a profile description in cultivated areas:

0 to 7 inches, light brownish-gray to light grayish-brown friable silt loam, variable in organic content but usually relatively low. Reaction, medium acid to neutral.

7 to 24 inches, brownish-gray to yellowish-brown friable silt loam with thin layers of sandy material and silty clay loam. It is usually possible to distinguish thin depositional layers of contrasting texture in this horizon. Reaction, medium acid to neutral.

24 inches +, nearly black to black granular muck.

Variations are in color, texture, and organic content of the accumulated material and the depth to black muck.

Use and management.—As Wallkill silt loam occurs in relatively small scattered areas, it is usually cultivated about the same as the dominant soils with which it comprises a field unit. Where drainage is adequate, the soil is well adapted to corn and soybeans, and yields are relatively high. The best corn yields are obtained when sufficient commercial fertilizer is used. Small grains are not well adapted, because of injury from drowning out and lodging of the grain. A considerable part of this soil has not been drained sufficiently for crops and has remained in forest.

Warsaw loam.—This dark-colored well-drained to somewhat excessively drained soil developed on highly calcareous stratified gravel and sand. It is the Prairie analog of the Fox soils and has developed under a tall-grass prairie vegetation. A total of 320 acres is mapped, principally on the Sumption Prairie southwest of South Bend. The relief is nearly level, and there is very little runoff, with somewhat excessive internal drainage. The downward movement of moisture is rapid enough to make this soil somewhat droughty for farm crops.

Following is a profile description in cultivated areas:

0 to 7 inches, dark grayish-brown friable granular loam, relatively high in organic content. Reaction, slightly to medium acid.
7 to 12 inches, moderately dark-brown heavy loam to gritty silt loam containing some small rounded gravel. Reaction, slightly to medium acid.
12 to 20 inches, light yellowish-brown to light-brown heavy loam to light clay loam, slightly plastic when wet and hard when dry. Reaction, medium to slightly acid.
20 to 32 inches, weak reddish-brown to light-brown waxy gravelly clay loam, breaking into irregularly sized angular pieces that are hard when dry. Reaction, slightly acid.
32 to 38 inches, dark grayish-brown waxy and gravelly clay loam that breaks into irregularly sized and shaped pieces. Reaction, slightly acid to neutral.
38 inches +, gray and light-yellow highly calcareous stratified gravel and sand.

The principal variations are in color and organic content of the surface soil and upper subsoil, the thickness and texture of the various layers, and the depth to the underlying gravel and sand. In a few areas the underlying gravel and sand contain a relatively high proportion of shale fragments and thus resemble the Door series in kind of parent material.

Use and management.—Practically all of Warsaw loam is cultivated to the general farm crops—corn, wheat, and hay, principally alfalfa and clover. This soil is somewhat droughty for corn, and yields are materially reduced when droughts occur in summer or early in fall. It is better adapted to wheat than to oats, as the moisture conditions are usually more favorable in spring and early in summer than late in summer. Wheat usually receives 100 to 150 pounds or more of commercial fertilizer an acre. Soybeans are increasing in importance in the rotation and are grown both for hay and for grain. Soybean hay yields average 1 to 2 tons an acre.

The organic content of the surface soil and upper subsoil is usually sufficient to maintain good tilth and to supply a large part of the nitrogen needed for growing most of the crops, but the somewhat unfavorable moisture conditions are usually the factor limiting crop yields.

Warsaw sandy loam.—This somewhat excessively drained soil has developed under a tall-grass prairie vegetation on highly calcareous stratified gravel and sand of the glaciofluvial outwash plains and terraces. A total of 320 acres is mapped, chiefly northwest of Osceola. The relief is nearly level, with few areas having a slope of more than 3 percent; erosion therefore is not a problem in farm management. Very little rainfall is removed by surface drainage, the greater part being removed internally. In profile characteristics this soil is similar to Warsaw loam, but the surface soil and subsoil are lighter textured.

Use and management.—The light texture of the surface soil and subsoil makes Warsaw sandy loam somewhat less desirable for the common farm crops than Warsaw loam. It is not well adapted to corn, and yields are considerably less than on the loam type, but it is better adapted to wheat and alfalfa than to other field crops. In other parts of the State and in Michigan this soil is used extensively for vegetables, but in this area it is used only to a limited extent.

Washtenaw silt loam.—Light-colored mineral wash from the surrounding Miami, Galena, Hillsdale, other soils of the uplands, and

Tracy soils of the outwash plains accumulates over dark-colored Brookston, Clyde, and other dark-colored soils to form this soil. It occupies shallow to deep depressions, principally in the upland areas, but to a lesser extent on the outwash plain areas. Natural drainage conditions range from fair to very poor, and under natural conditions water will stand on many of the areas for a few hours to a few days after heavy rains; thus artificial drainage is necessary for cropping. In some areas situated in deep kettle holes surrounded by relatively high knolls drainage is impractical. A total of 3,328 acres is mapped in relatively small individual areas. Native vegetation consisted of marsh grasses and water-loving trees.

Following is a profile description in cultivated areas:

0 to 7 inches, grayish-brown to light yellowish-brown friable granular silt loam, variable in organic content. Reaction, slightly acid to neutral.

7 to 20 inches, brownish-yellow to pale-yellow friable silt loam to silty clay loam that breaks into medium-sized granules. Thin plates representing depositional layers are usually distinguishable. The lower part of this layer occasionally is slightly mottled gray and yellow. Reaction, slightly acid to neutral.

20 inches +, dark-gray to dark brownish-gray silt loam to silty clay loam. This represents the former surface soil of Brookston, Clyde, and other dark-colored soils of the depressions.

The chief variations are in color and organic content of the surface soil, the thickness of the silty accumulated material, and the color of the underlying material.

Use and management.—Washtenaw silt loam is used for general farm crops after sufficient artificial drainage has been installed. Variations in crop yields are due to the differences in degree of drainage and the susceptibility to the accumulation of water on the surface, which is usually governed by the position of the soil area in relation to surrounding soils. Where drainage is sufficient, crop yields are about equal to those on Brookston loam. This soil is better adapted to corn and soybeans than to small grains, as danger of drowning out and heaving of the small grains, especially fall-sown ones, exists. Much of this soil is in permanent bluegrass pasture, and small areas are in forest. Where the soil occupies deep kettle hole positions, forest is probably the best use, owing to the cost of establishing adequate artificial drainage.

Willvale loam.—This soil has developed on glaciofluvial outwash plains and terraces underlain with slightly calcareous stratified sand and gravel composed chiefly of siliceous sand and shale material. It is the imperfectly drained member of the soil catena that also includes the well to excessively drained Tracy, the moderately well drained Hanna, and the poorly drained Quinn series. The larger ones occur in the northwestern and west-central parts of the county in association with the members of the catena. The nearly level relief limits surface runoff, and most of the rainfall is removed internally. Artificial drainage is needed on most areas so as to permit successful cropping. This has been effected largely by the establishment of large open ditches that have lowered the general water table of the area. The loose nature of the underlying sand and gravel allows relatively free water movement, and it is only necessary to maintain open ditches at infrequent intervals to have sufficient drainage. The native vegetation consisted chiefly of white and pin oaks, with smaller quantities of associated species.

Following is a profile description in cultivated areas:

0 to 7 inches, brownish-gray to light brownish-gray friable gritty loam that is somewhat lighter colored when dry. Organic-matter content is low, and tilth conditions are usually good. Reaction, strongly acid.

7 to 10 inches, brownish-gray heavy loam. Reaction, strongly acid.

10 to 20 inches, mottled gray, yellow, and rust-brown clay loam to silty clay loam, plastic when wet and hard when dry. The material breaks into irregularly sized and shaped pieces that crush rather easily when moist. Reaction, strongly acid.

20 to 40 inches, mottled gray, yellow, and rust-brown slightly plastic clay loam to sandy clay that breaks into irregular lumps. Reaction, strongly acid.

40 to 80 inches, mottled gray, yellow, and rust-brown stratified sand and loamy sand, with an occasional thin layer or lens of clay loam and gravel. Reaction, strongly acid in the upper part and medium to slightly acid in the lower.

80 inches +, mottled gray and yellow, with streaks and blotches of rust brown, stratified slightly calcareous sand and gravel. The material contains a relatively high proportion of siliceous sand and shale fragments and a small proportion of limestone.

Variations are in color, thickness, and texture of the layers and the depth to and composition of the underlying sand and gravel. The depth to mottling varies from 7 to 12 inches. The underlying sand and gravel is noncalcareous to a depth of 10 feet or more in some areas.

Use and management.—Management practices and crop rotations on Willvale loam are about the same as on Hanna loam, although it is somewhat less intensively cropped. Corn, wheat, and soybeans are grown, with a somewhat smaller proportion of hay crops than on the Hanna soils except where field units consist of the two soils.

Corn usually follows soybeans or hay crops in the rotation, with the highest yields obtained under better management practices and favorable weather conditions. Wheat usually follows corn or soybeans, and generally 100 to 200 pounds an acre of commercial fertilizer is used. Soybeans are increasing in importance in the rotation, and yields obtained are probably increased by the application of lime. It is necessary to apply sufficient lime to neutralize the soil acidity for the successful growth of clover and alfalfa. A mixture of timothy, redtop, and clover is more extensively grown than either clover or alfalfa alone.

Willvale fine sandy loam.—An aggregate area of 2,240 acres of this soil has developed on glaciofluvial outwash plains and terraces underlain by slightly calcareous stratified sand and gravel. The larger areas occur in the northeastern and west-central parts of the county. The nearly level relief and natural imperfect drainage are such as to require artificial drainage for the successful growth of most farm crops. Most areas have had sufficient artificial drainage, although a few are in need of more adequate drainage. Areas of this soil are relatively easy to drain because of the loose porous nature of the underlying sand and gravel.

In profile characteristics the soil is similar to Willvale loam, but the texture of the surface soil differs, and the subsoil is somewhat lighter textured and contains a higher proportion of sand.

Use and management.—Nearly all of Willvale fine sandy loam is under cultivation to corn, wheat, soybeans, and hay crops, but crop yields are somewhat lower than on Willvale loam. All available organic matter should be plowed under, sufficient lime should be applied to neutralize the soil acidity, and sufficient commercial fertilizer should be used in order to maintain and increase the productivity of this soil.

Willvale loamy fine sand.—A total of 2,048 acres of this soil is mapped in association with Hanna loamy fine sand and Newton and Maumee soils, chiefly north of Mishawaka. The parent material, relief, drainage, and profile characteristics are similar to Willvale loam, but the layers are lighter textured throughout. The surface soil is loose loamy fine sand, extremely low in organic content, and the subsoil is slightly coherent fine sand to sandy clay loam. Below a depth of 30 inches is loose stratified sand, with some gravel.

Use and management.—A higher proportion of Willvale loamy fine sand is idle than of the heavier textured Willvale soils. About the same crops are grown as on Willvale loam, but yields are materially lower. During seasons of limited moisture it is not uncommon for yields of corn to be extremely low, with an occasional near failure.

Willvale silt loam.—Natural drainage conditions are imperfect on this soil, and most areas have been drained artificially to permit cultivation. A few areas, however, are in need of more adequate drainage, but this can be easily accomplished because of the loose porous nature of the underlying sand and gravel. The soil is similar to Willvale loam in parent material, relief, and profile characteristics, especially in color and acidity, but texture of the surface soil differs, and the subsoil to a depth of about 40 inches is somewhat heavier textured and contains more clay.

Use and management.—Corn, wheat, soybeans, and hay are the principal crops on Willvale silt loam, and with adequate drainage yields are somewhat higher than on Willvale loam. The heavier texture of the surface soil and subsoil makes this type more retentive of moisture and organic material than the lighter textured Willvale soils.

ESTIMATED YIELDS AND PRODUCTIVITY RATINGS

The estimated average acre yields of the principal crops are given for each soil under both common and improved practices in table 8.

The estimates in columns A indicate yields obtained under the prevailing practices, which, on most of the soils, include the use of small to moderate quantities of commercial fertilizers but which generally do not include careful and intensive practices of soil management in regard to the control of erosion, the incorporation of organic matter, and the maintenance and increase of soil fertility and soil productivity. Yields under more careful and intensive practices are given in columns B. These practices consist of a regular crop rotation including the growing of legumes where possible, the use of barnyard and green manures, the application of lime and liberal quantities of suitable commercial fertilizers, the installation of artificial drainage where necessary, the use of improved varieties and high-quality seed and, where needed, the use of such mechanical measures as contour tillage, strip cropping, and terracing or constructing diversion ditches for the control of erosion.

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TABLE 8.—*Estimated average acre yields of the principal crops on each soil in St. Joseph County, Ind.*

[Yields in columns A indicate the average crop obtained under prevailing practices, which include crop rotations, some erosion control practices, and the use of some legumes, commercial fertilizers, lime, and barnyard and green manures; those in columns B indicate the average crop obtained with improved methods of management, which include the more intensive use of the prevailing practices. Absence of a yield figure indicates that the crop is not commonly grown]

Soil [1]	Corn		Wheat		Oats		Rye		Soybeans		Alfalfa		Red clover		Mixed hay		Potatoes	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*
Alida silt loam	30	40	15	20	30	40	15	20	17	22	1.0	2.0	1.0	1.8	1.2	1.8	60	80
Argos fine sandy loam	25	32	12	16	20	32	12	16	12	16	1.0	2.0	1.0	1.6	1.0	1.4	70	110
Argos loam	30	37	15	20	30	40	15	18	15	18	1.0	2.0	1.0	1.6	1.2	1.6	80	120
Eroded sloping phase	20	30	10	15	20	30	10	15	10	15	.8	1.6	.8	1.2	.8	1.2	----	----
Bellefontaine sandy loam	25	35	12	17	15	20	12	17	12	17	2.4	3.0	.8	1.2	.8	1.2	----	----
Eroded hilly phase	----	----	7	10	----	----	7	10	----	----	1.2	2.0	----	----	----	----	----	----
Brookston loam:																		
Drained	47	55	17	25	35	45	17	22	21	23	2.8	3.6	1.7	1.9	1.9	2.4	150	200
Undrained	25	----	5	----	15	----	15	----	12	----	----	----	1.4	----	1.6	----	50	----
Brookston silty clay loam:																		
Drained	50	60	17	25	37	47	17	22	22	25	3.0	3.8	1.8	2.0	2.0	2.5	150	180
Undrained	25	----	5	----	15	----	5	----	12	----	----	----	1.4	----	1.6	----	50	----
Carlisle muck:																		
Drained	45	55	10	15	20	30	10	15	22	25	----	----	----	----	1.2	1.8	160	220
Undrained	20	----	----	----	----	----	----	----	10	----	----	----	----	----	----	----	----	----
Shallow phase over clay:																		
Drained	40	55	10	15	20	30	10	15	20	22	----	----	----	----	1.2	1.8	140	180
Undrained	20	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Shallow phase over sand:																		
Drained	30	40	7	12	15	25	7	15	12	17	----	----	----	----	1.0	1.6	120	160
Undrained	15	----	----	----	----	----	----	----	7	----	----	----	----	----	----	----	----	----
Clyde silty clay loam:																		
Drained	45	55	17	20	37	45	17	20	22	25	2.8	3.6	1.7	1.7	2.0	2.5	120	160
Undrained	10	----	----	----	----	----	----	----	10	----	----	----	1.0	----	1.0	----	60	----

Coloma loamy fine sand	20	30	7	12	-----	-----	10	15	8	12	1. 2	2. 0	. 5	. 8	. 6	1. 0	80	120
Eroded phase	15	22	6	10	-----	-----	6	10	7	10	1. 0	1. 8	. 4	. 7	-----	-----	60	100
Eroded steep phase	-----	-----	3	5	-----	-----	3	5	-----	-----	1. 4	6. 0	-----	-----	-----	-----	-----	-----
Steep phase	-----	-----	5	6	-----	-----	5	6	-----	-----	1. 6	8. 0	-----	-----	-----	-----	-----	-----
Conover loam:																		
Drained	40	50	17	22	32	42	17	22	21	26	2. 8	3. 6	1. 5	1. 9	1. 9	2. 3	120	160
Undrained	22	-----	11	-----	20	-----	11	-----	15	-----	1. 6	-----	1. 0	-----	1. 4	-----	80	-----
Conover silt loam:																		
Drained	42	52	17	22	32	42	17	22	22	27	2. 8	3. 6	1. 6	2. 0	2. 0	2. 4	120	160
Undrained	22	-----	11	-----	20	-----	11	-----	15	-----	1. 6	-----	1. 1	-----	1. 4	-----	80	-----
Crosby loam:																		
Drained	32	42	15	20	27	37	15	20	18	23	2. 2	3. 0	1. 3	1. 7	1. 7	2. 0	110	150
Undrained	20	-----	10	-----	20	-----	10	-----	12	-----	1. 2	-----	1. 0	-----	1. 2	-----	70	-----
Crosby silt loam:																		
Drained	35	45	15	20	30	40	15	20	20	25	2. 4	3. 2	1. 4	1. 8	1. 8	2. 2	100	140
Undrained	20	-----	10	-----	20	-----	10	-----	12	-----	1. 2	-----	1. 0	-----	1. 5	-----	60	-----
Door loam	35	45	18	23	30	40	17	22	20	25	-----	-----	-----	-----	1. 2	1. 6	100	160
Door silt loam	37	47	20	25	30	40	17	22	20	25	-----	-----	-----	-----	1. 2	1. 6	100	160
Edwards muck:																		
Drained	40	50	10	15	20	30	10	15	20	22	-----	-----	-----	-----	1. 0	1. 5	80	120
Undrained	20	-----	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	-----	-----	-----	-----	-----
Fox loam	30	40	15	20	25	30	15	20	17	21	3. 2	4. 0	1. 2	1. 6	1. 2	1. 6	120	160
Fox sandy loam	25	35	12	17	20	25	12	17	15	18	2. 8	3. 6	1. 0	1. 4	1. 0	1. 4	100	140
Sloping phase	-----	-----	10	15	-----	-----	10	15	-----	-----	2. 6	3. 4	-----	-----	. 9	1. 3	-----	-----
Galena loam	33	40	17	22	35	45	17	22	17	22	2. 8	3. 6	1. 4	1. 8	1. 8	2. 2	100	150
Level phase	35	45	17	22	35	45	17	22	17	22	2. 8	3. 6	1. 4	1. 8	1. 8	2. 2	100	150
Galena silt loam	35	45	15	20	35	45	15	20	17	22	2. 6	3. 4	1. 4	1. 8	1. 8	2. 2	100	150
Eroded phase	30	37	12	17	30	40	12	17	15	20	2. 4	3. 2	1. 2	1. 6	1. 6	2. 0	80	120
Eroded steep phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2. 2	2. 8	-----	-----	-----	-----	-----	-----
Level phase	37	47	16	21	35	45	15	20	17	22	2. 6	3. 4	1. 4	1. 8	1. 8	2. 2	100	150
Severely eroded phase	20	25	10	12	20	25	10	12	10	15	1. 6	2. 4	. 8	1. 2	. 8	1. 2	-----	-----
Severely eroded steep phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Steep phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2. 4	2. 8	-----	-----	-----	-----	-----	-----
Granby fine sandy loam:																		
Drained	30	37	12	16	20	27	12	16	15	20	2. 4	3. 0	1. 2	1. 5	1. 1	1. 4	120	160
Undrained	15	-----	-----	-----	10	-----	-----	-----	7	-----	-----	-----	-----	-----	-----	-----	-----	-----

See footnote at end of table.

TABLE 8.—*Estimated average acre yields of the principal crops on each soil in St. Joseph County, Ind.*—Continued

[See headnote on p. 98]

Soil [1]	Corn		Wheat		Oats		Rye		Soybeans		Alfalfa		Red clover		Mixed hay		Potatoes	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Granby loam:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu*	*Bu*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*
Drained	32	42	15	20	20	27	15	20	17	22	2.6	3.2	1.4	1.7	1.4	1.7	120	160
Undrained	15				10													
Griffin loam	30	40			20	27			15	20					1.5	2.0	100	140
Gullied land (Tracy soil material)																		
Hanna fine sandy loam	30	37	12	17	25	35	12	17	15	18	1.6	2.4	.8	1.2	1.2	1.6	110	140
Hanna loam	35	42	15	20	30	40	15	20	17	21	1.8	2.6	.9	1.3	1.3	1.7	120	150
Hanna loamy fine sand	25	32	11	16	12	20	11	13	12	15	1.4	2.2	.7	1.1	1.0	1.3	90	120
Hillsdale fine sandy loam	30	35	12	17	20	30	12	17	13	18	2.4	3 2	1.2	1.5	1.4	1.8	100	150
Eroded phase	20	30	10	15	17	25	10	15	11	15	2.0	2.8	1.0	1.3	1.2	1.6	80	120
Eroded steep phase			6	10			6	10			1.6	2.2						
Level phase	25	35	12	17	20	30	12	17	13	18	2.4	3.2	1 2	1.5	1.4	1.8	100	150
Severely eroded phase	15	22	7	12	15	22	7	11	8	11	1.4	2 0	.8	1.2	.8	1.2		
Steep phase			8	13			7	11			1.8	2.4						
Hillsdale loam	30	40	15	20	30	40	15	20	16	21	2.8	3.6	1.3	1.7	1.6	2.0	110	140
Eroded phase	25	35	12	17	25	35	12	17	13	18	2.4	3.2	1.1	1.5	1.4	1.8	90	130
Eroded steep phase	15	25	10	15			10	15	10	13	2.0	2.6						
Gullied phase																		
Level phase	30	40	15	20	30	40	15	20	16	21	2.8	3.6	1.3	1.7	1.6	2.0	120	175
Severely eroded steep phase											1.6	2.2						
Houghton muck:																		
Drained	45	55	10	15	20	30	10	15	22	25	2.0	3.0	1.2	1.8	1.2	1.8	160	220
Undrained	20								10									
Kerston muck:																		
Drained	40	50	10	15	15	25	10	15	22	25			1.2	1.6	1.1	1.7	160	220
Undrained	20								10									

Lapaz loam:																		
Drained	47	55	17	25	35	45	17	22	21	23	2.4	3.2	1.7	1.9	1.7	2.0	150	200
Undrained	25	-----	5	-----	15	-----	5	-----	12	-----	1.6	-----	1.2	-----	1.2	-----	50	-----
Lydick fine sandy loam	25	35	15	20	25	35	15	20	16	21	1.2	2.0	.6	1.0	.8	1.2	70	110
Lydick loam	30	40	17	22	30	40	17	22	18	23	.6	2.8	.8	1.4	1.0	1.4	80	120
Eroded sloping phase	20	25	12	16	20	25	12	16	13	17	1.0	2.0	.5	.8	.6	.9	-----	-----
Sloping phase	22	27	13	17	22	27	13	17	15	18	1.2	2.2	.6	1.0	.8	1.1	-----	-----
Lydick silt loam	37	42	18	23	30	40	17	22	18	23	1.8	3.0	.8	1.4	.1	1.4	80	120
Eroded sloping phase	20	25	12	16	20	25	12	16	13	17	1.0	2.0	.5	.8	.6	.9	-----	-----
Sloping phase	22	27	13	17	22	27	13	17	15	18	1.2	2.2	.6	1.0	.8	1.1	-----	-----
Maumee fine sandy loam:																		
Drained	30	40	15	20	20	27	15	18	16	21	2.4	3.0	1.2	1.5	1.1	1.4	130	170
Undrained	15	-----	-----	-----	-----	-----	-----	-----	7	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mucky phase:																		
Drained	30	42	16	21	20	27	15	18	17	22	2.4	3.0	1.2	1.5	1.1	1.4	140	180
Undrained	15	-----	-----	-----	-----	-----	-----	-----	8	-----	-----	-----	-----	-----	-----	-----	-----	-----
Maumee loam:																		
Drained	40	50	16	21	22	30	16	21	20	25	2.6	3.2	1.4	1.7	1.4	1.7	150	180
Undrained	15	-----	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	-----	-----	-----	-----	-----
Miami loam	32	42	17	25	35	40	17	22	17	22	2.8	3.6	1.6	2.0	1.8	2.2	110	160
Miami silt loam	35	45	17	25	35	40	17	22	17	22	2.8	3.6	1.6	2.0	1.8	2.2	100	150
Eroded phase	30	40	15	20	30	35	15	17	15	20	2.4	3.2	1.4	1.8	1.6	1.9	80	120
Severely eroded phase	22	30	11	15	22	30	11	15	11	15	2.0	2.8	1.0	1.4	1.0	1.4	-----	-----
Severely eroded steep phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.6	2.4	-----	-----	.8	1.2	-----	-----
Newton fine sandy loam:																		
Drained	15	35	10	15	15	30	12	17	11	16	-----	-----	-----	-----	.7	1.1	80	150
Undrained	7	-----	-----	-----	7	-----	-----	-----	6	-----	-----	-----	-----	-----	-----	-----	-----	-----
Newton loam:																		
Drained	20	37	10	15	20	35	12	17	12	17	-----	-----	-----	-----	.9	1.3	80	150
Undrained	10	-----	-----	-----	10	-----	-----	-----	7	-----	-----	-----	-----	-----	-----	-----	-----	-----
Otis loam:																		
Drained	32	42	15	20	27	37	15	20	17	22	2.4	3.2	1.4	1.8	1.8	2.2	100	140
Undrained	20	-----	10	-----	20	-----	10	-----	11	-----	1.2	-----	1.0	-----	1.5	-----	60	-----
Otis silt loam:																		
Drained	35	45	15	20	30	40	15	20	20	25	2.4	3.2	1.4	1.8	1.8	2.2	100	140
Undrained	20	-----	10	-----	20	-----	10	-----	12	-----	1.2	-----	1.0	-----	1.5	-----	60	-----

See footnote at end of table.

TABLE 8.—*Estimated average acre yields of the principal crops on each soil in St. Joseph County, Ind.*—Continued

[See headnote on p. 98]

Soil [1]	Corn		Wheat		Oats		Rye		Soybeans		Alfalfa		Red clover		Mixed hay		Potatoes	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Peat:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*
Drained	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Undrained	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pinola silt loam:																		
Drained	40	50	15	20	30	40	15	20	20	25	1.6	2.4	1.0	1.4	1.4	1.8	100	140
Undrained	10	----	----	----	10	----	----	----	7	----	----	----	----	----	----	----	----	----
Quinn loam:																		
Drained	20	30	10	15	15	25	10	15	10	15	----	----	.8	1.2	.8	1.2	----	----
Undrained	----	----	----	----	----	----	----	----	5	----	----	----	----	----	----	----	----	----
Quinn silt loam:																		
Drained	25	35	10	15	15	25	10	15	12	17	----	----	.8	1.2	.8	1 2	----	----
Undrained	10	----	----	----	----	----	----	----	5	----	----	----	----	----	----	----	----	----
Tracy fine sandy loam	20	30	12	17	17	25	12	17	12	17	1.2	2.4	.6	1.2	.8	1.2	80	120
Eroded sloping phase	12	17	7	12	----	----	7	11	7	11	.8	1.8	.4	.7	.5	.8	----	----
Sloping phase	15	22	10	15	----	----	10	15	10	13	1.0	2.0	.5	.9	.6	1.0	----	----
Steep phase	----	----	----	----	----	----	----	----	----	----	.8	1.6	----	----	----	----	----	----
Tracy loam	25	35	16	21	25	35	16	21.	17	22	1.6	2.8	.8	1.4	1.0	1.4	80	120
Eroded sloping phase	18	22	12	17	17	27	12	17	12	16	1.2	2.0	.6	1.0	.8	1.2	----	----
Eroded steep phase	----	----	7	10	----	----	7	10	----	----	1.0	1.6	----	----	----	----	----	----
Severely eroded sloping phase	----	----	10	12	----	----	7	10	----	----	.8	1.6	.4	.8	.6	.8	----	----
Severely eroded steep phase	----	----	----	----	----	----	----	----	----	----	.8	1.2	----	----	----	----	----	----
Sloping phase	20	27	14	19	20	30	14	19	14	22	1.4	2.2	.7	1.1	.9	1.3	----	----
Steep phase	----	----	----	----	----	----	----	----	----	----	1.2	1.8	----	----	----	----	----	----
Tracy loamy fine sand	17	27	10	15	10	20	10	15	10	15	1.0	2.0	----	----	.6	1.5	60	150
Eroded sloping phase	----	----	5	7	----	----	5	9	----	----	.6	.8	----	----	----	----	----	----

Eroded steep phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sloping phase	-----	-----	6	9	-----	-----	7	11	7	11	.8	1.6	-----	-----	.4	.8	-----	-----
Steep phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tracy loamy sand	15	25	7	12	7	15	7	12	7	12	.8	1.6	-----	-----	.5	.9	60	100
Eroded sloping phase	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sloping phase	-----	-----	5	7	-----	-----	5	7	-----	-----	.6	1.2	-----	-----	-----	-----	-----	-----
Tracy silt loam	27	37	17	22	25	35	17	22	17	22	1.6	2.8	.8	1.4	1.0	1.4	80	120
Walkerton fine sandy loam:																		
Drained	25	35	12	16	25	35	12	17	12	17	1.6	2.4	1.0	1.4	1.4	1.8	80	120
Undrained	15	-----	6	-----	12	-----	6	-----	7	-----	1.0	-----	.5	-----	1.0	-----	-----	-----
Walkerton loam:																		
Drained	30	40	15	20	30	40	15	20	15	20	2.0	2.8	1.2	1.6	1.6	2.0	100	140
Undrained	15	-----	7	-----	15	-----	7	-----	7	-----	1.2	-----	.6	-----	1.2	-----	-----	-----
Wallkill silt loam:																		
Drained	37	47	12	17	25	35	12	17	20	25	2.4	3.2	1.2	1.6	1.6	2.0	150	180
Undrained	20	-----	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	-----	-----	-----	-----	-----
Warsaw loam	35	45	15	20	25	30	15	20	20	25	3.2	4.0	1.2	1.6	1.2	1.6	120	160
Warsaw sandy loam	30	40	12	17	20	25	12	17	15	21	2.8	3.6	1.0	1.4	1.0	1.4	100	140
Washtenaw silt loam:																		
Drained	40	50	17	22	35	45	20	22	17	22	2.8	3.6	1.6	2.0	1.2	1.6	120	160
Undrained	15	-----	5	-----	15	-----	10	-----	10	-----	1.2	-----	.8	-----	-----	-----	-----	-----
Willvale fine sandy loam:																		
Drained	25	35	10	15	20	30	10	15	10	15	.8	2.4	.8	1.6	1.0	1.6	-----	-----
Undrained	10	-----	5	-----	10	-----	5	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	-----
Willvale loam:																		
Drained	30	40	12	17	25	35	12	17	12	17	1.0	2.0	1.0	1.8	1.2	1.8	60	100
Undrained	15	-----	5	-----	10	-----	5	-----	7	-----	-----	-----	-----	-----	.6	-----	-----	-----
Willvale loamy fine sand:																		
Drained	15	25	7	12	15	22	7	12	7	12	.6	1.2	.6	1.2	.6	1.0	40	80
Undrained	10	-----	5	-----	7	-----	4	-----	4	-----	-----	-----	-----	-----	-----	-----	-----	-----
Willvale silt loam:																		
Drained	30	40	12	17	25	35	12	17	15	20	1.0	2.0	1.0	1.8	1.2	1.8	60	100
Undrained	15	-----	5	-----	10	-----	5	-----	7	-----	-----	-----	-----	-----	.6	-----	-----	-----

[1] The terms "drained" and "undrained" refer to artificial drainage.

These estimates are based primarily on interviews with farmers, the county agent, and members of the Purdue University Agricultural Experiment Station; on direct observation by members of the soil survey party; and on results obtained on experimental farms by the experiment station. They are presented only as estimates of the average production over a period of years, according to the two broadly defined types of management, and may not apply directly to specific tracts of land for any particular year because management practices differ slightly from farm to farm and climatic conditions fluctuate from year to year. On the other hand, the estimates are as accurate as can be obtained without further detailed and lengthy investigations. Their main value is that they serve to bring out the relative productivity of the soils mapped.

The soils are listed in table 9 by groups, arranged in approximate order of general productivity, conforming in general to the color groups on the soil map. The rating compares the productivity of each of the soils for each crop with a standard of 100. This standard index represents the approximate average acre yield obtained without the use of amendments on the more extensive and better soil types of the regions of the United States in which the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as the soil with the standard index. The standard yield for each crop, except vegetables, tree fruits, and pasture, is given at the head of its column. Soils given amendments, as lime and commercial fertilizers, or special practices, as drainage and protective levees, and unusually productive soils have productivity indexes of more than 100 for some crops.

Indexes for vegetables, tree fruits, and pasture are comparative only for the soils within the county, not conforming necessarily to standards set up for the country as a whole. Vegetables are important commercially, especially on the areas of muck soils and to some extent on the associated dark-colored soils. Because of the great variety of pasture uses in the county, the apparent lack of a well-planned pasture program on many areas, and the extreme difficulty in estimating cow-acre-days or pounds of beef to the acre in a year, the pasture ratings are based on less definite criteria and evidence than those for most crops.

The column "General use and use limitations" gives additional information regarding the individual soils in relation to their use for agriculture.

The crop productivity indexes cannot be interpreted into land values, except in a very general way. Distance to market and other costs of production, relative prices of farm products, and other factors influence the value of land. Productivity, as measured by yields, is not the only consideration that determines the relative worth of a soil for growing crops. Ease or difficulty of both tillage and maintenance of productivity are examples of physical considerations other than productivity that influence the general desirability of a soil for agricultural use.

WATER CONTROL ON THE LAND

Low relief and flat topography have always been sources of a serious problem in drainage in St. Joseph County, especially on the extensive

TABLE 9.—*Productivity ratings of the soils in St. Joseph County, Ind.*

[Indexes in columns A refer to average yields obtained under prevailing practices, which include crop rotations, erosion control practices, and the use of legumes, commercial fertilizers, lime, and barnyard and green manure; those in columns B to average yields obtained with improved methods of management, which include the more intensive use of the prevailing practices. Absence of an index indicates that the crop is not commonly grown.]

Soil	Crop productivity index [1] for— Corn (100=50 bu.)		Wheat (100=25 bu.)		Oats (100=50 bu.)		Rye (100=25 bu.)		Soybeans (100=25 bu.)		Alfalfa (100=4 tons)		Red clover (100=2 tons)		Mixed hay (100=2 tons)		Potatoes (100=200 bu.)		Vegetables [2]		Tree fruits [2]		Pasture [2]		General use and use limitations
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
Nearly level very poorly drained dark-colored soils of the upland depressions underlain by moderate to heavy-textured materials:																									Grain and livestock farming; 3- to 4-year rotation of corn, small grains, soybeans, and legumes; corn, small grains, and truck crops especially suitable; some corn, small grains, and soybeans on Washtenaw silt loam, especially where associated with Door and Lydick soils. Artificial drainage required but difficult for some areas of Washtenaw silt loam; moderate quantities of commercial fertilizer high in phosphate and potash necessary for small grains and corn. Occasional winterkilling and frost-heaving of fall-sown crops and legumes, drowning of crops by standing water, lodging of small grains, danger of impaired soil tilth when cultivated wet.
Brookston silty clay loam:																									
Drained [3]	100	120	70	100	75	95	70	90	90	100	75	95	90	100	100	125	75	90	70	100			90	100	
Undrained [4]	50		20		30		20		50				70		80		25		30				80		
Brookston loam:																									
Drained	95	110	70	100	70	90	70	90	85	95	70	90	85	95	95	120	75	100	75	100			90	100	
Undrained	50		20		30		20		50				70		80		25		30				80		
Clyde silty clay loam:																									
Drained	90	110	70	80	75	90	70	80	90	100	70	90	70	85	100	125	60	80	55	75			90	100	
Undrained	20								40				50		50		30						80		
Washtenaw silt loam:																									
Drained	80	100	70	90	60	80	70	80	70	80	60	70	70	90	60	100	60	80			90	100	80	100	
Undrained	30		20		30		40		40				40								70		70		
Nearly level very poorly drained soils in depressions of outwash plains and terraces developed on low-lime materials:																									Grain, livestock, and cash-grain farming; 2- to 4-year rotation of corn, small grains, soybeans, and legumes; corn, small grains, and truck crops especially suitable; corn, small grains, and soybeans on Pinola silt loam, especially where associated with Door and Lydick soils. Artificial drainage required; moderate quantities of commercial fertilizer high in phosphate and potash necessary for small grains and corn. Occasional winterkilling and frost-heaving of fall-sown crops and legumes, drowning of crops by standing water, lodging of small grains.
Lapaz loam:																									
Drained	95	110	70	100	70	90	70	90	85	95	60	80	85	95	85	100	75	100	75	100			90	100	
Undrained	50		20		30		20		50		40		60		60		25		30				80		
Pinola silt loam:																									
Drained	80	100	60	80	60	80	60	80	80	100	40	60	50	70	70	90	50	70	50	70			60	70	
Undrained	20				20				30														40		
Very poorly drained organic soils:																									Grain and truck farming; irregular rotation of corn, vegetables, soybeans, small grains, and hay crops; corn and vegetables especially suitable. Artificial drainage required but impractical for most peat areas; moderate to large quantities of commercial fertilizer high in phosphorus and potash necessary. None to moderate wind erosion, early frost damage in some areas, subject to droughtiness (especially for corn and potatoes), and fire hazard, especially from power tillage equipment.
Carlisle muck:																									
Drained	90	110							90	100					60	90	80	110	80	110			90	100	
Undrained	40								40														80		
Shallow phase over clay:																									
Drained	80	110							80	90					60	90	70	90	75	100			90	100	
Undrained	40								40														80		
Shallow phase over sand:																									
Drained	60	80							60	70					50	80	60	80	70	90			85	95	
Undrained	30								30														75		
Houghton muck:																									
Drained	90	110							90	100					60	90	80	110	80	110			90	100	
Undrained	40								40														80		
Edwards muck:																									
Drained	80	100							80	90					50	90	40	60	70	100			90	100	
Undrained	40								40														80		
Kerston muck:																									
Drained	80	100							90	100					55	85	80	110	80	110			90	100	
Undrained	40								40														80		
Wallkill silt loam:																									
Drained	75	95	50	70	50	70	50	70	80	100	60	80	60	80	80	100	75	90	80	100			80	90	
Undrained	40								40														70		
Peat:																									
Drained																									
Undrained																									
Nearly level very poorly drained dark-colored soils of lake and outwash plains developed on calcareous sand:																									Grain, livestock, and cash-grain farming; 2- to 4-year rotation of corn, wheat, soybeans, legumes, and some oats and vegetables. Artificial drainage required and easily established where outlets are available, but some areas adjacent to large areas of drained muck soils may be overdrained; moderate applications of phosphate and potash fertilizers, occasional additions of organic matter, light applications of lime (0-1 ton) are necessary to some areas for legumes. Fall-sown and perennial (legume) crops subject to occasional damage by winterkilling and lodging.
Maumee loam:																									
Drained	80	100	65	85	45	80	65	85	80	100	65	80	70	85	70	85	75	90	90	105			70	80	
Undrained	30								40														60		
Granby loam:																									
Drained	65	85	60	80	40	70	60	80	70	90	65	80	70	85	70	85	60	80	75	85			70	80	
Undrained	30				20																		50		
Maumee fine sandy loam, mucky phase:																									
Drained	60	95	65	85	40	55	60	75	70	90					55	70	70	90	90	105			65	75	
Undrained	30								35														60		
Maumee fine sandy loam:																									
Drained	60	80	60	80	55	65	60	80	65	85	60	75	60	75	55	70	65	85	80	100			65	75	
Undrained	30										30												60		
Granby fine sandy loam:																									
Drained	60	75	50	70	50	65	50	70	60	85	60	75	60	75	55	70	60	80	75	85			65	75	
Undrained	30				20				30														50		
Nearly level well-drained soils of outwash plains and terraces developed on high-lime materials:																									General grain and livestock farming; 3- to 4-year rotation of corn, wheat, soybeans, legumes, and some vegetables; wheat and alfalfa more suitable than oats and clover. Applications of lime (1-2 tons) for legumes and moderate quantities of complete commercial fertilizers needed, also additions of organic matter to Fox soil, somewhat droughty for corn.
Warsaw loam	70	90	60	100	50	60	60	100	80	100	80	100	60	70	60	80	60	80	50	70	60	70	80	90	
Fox loam	60	80	60	100	50	60	60	100	70	85	80	100	60	70	60	80	60	80	50	70	60	70	70	80	
Warsaw sandy loam	60	80	50	90	40	50	50	90	65	85	70	90	50	60	50	70	50	70	45	65	50	60	65	75	
Fox sandy loam	50	70	50	80	40	50	50	80	60	75	70	90	40	55	50	70	50	70	45	65	50	60	65	75	
Nearly level imperfectly drained soils of the uplands developed on medium to heavy-textured calcareous till:																									General farming; 3- to 4-year rotation of corn, wheat, oats, soybeans, and hay crops including legumes. Artificial drainage required for most crops; applications of lime (0-2 tons) for legumes, moderate quantities of complete commercial fertilizers (equally high in phosphate and potash for pasture).
Conover silt loam:																									
Drained	85	105	70	90	65	85	70	90	90	110	70	90	80	100	100	120	60	80	50	70	40	50	90	100	
Undrained	45		45		40		45		60		40		55		70		40		40				80		
Conover loam:																									
Drained	80	100	70	90	65	85	70	90	85	105	70	90	75	95	95	115	60	80	50	70	40	50	90	100	
Undrained	45		45		40		45		60		40		50		70		40		30				80		
Crosby silt loam:																									
Drained	70	90	60	80	60	80	60	80	80	100	60	80	70	90	90	110	50	70	40	60	40	50	80	90	
Undrained	40		40		40		40		50		30		50		75		30		20				70		
Crosby loam:																									
Drained	65	85	60	80	55	75	60	80	75	95	55	75	65	85	85	100	55	75	45	65	40	50	80	90	
Undrained	40		40		40		40		50		30		50		60		35		20				70		
Otis silt loam:																									
Drained	70	90	60	80	60	80	60	80	80	100	60	80	70	90	90	110	50	70	40	60	40	50	80	100	
Undrained	40		40		40		40		50		30		50		75		30		20				70		
Otis loam:																									
Drained	65	85	60	80	55	75	60	80	70	90	60	80	70	90	90	110	50	70	40	60	40	50	80	100	
Undrained	40		40		40		40		45		30		50		75		30		20				70		
Nearly level well to excessively drained dark or moderately dark-colored prairie and prairie-border soils developed on lime glaciofluvial outwash sand and gravel:																									Cash-grain and some dairy farming; 2- to 4-year rotation of corn, oats, wheat, and soybeans; wheat more suitable than oats. Applications of lime (2-4 tons) for legumes, moderate quantities of commercial fertilizers high in phosphate and potash, and occasional additions of organic matter (particularly to Lydick soils) needed. Light-textured soils, especially Lydick fine sandy loam, somewhat droughty.
Door silt loam	75	95	80	100	60	80	70	90	80	100		65	10	80	60	80	50	80	45	65			70	80	
Door loam	70	90	75	95	60	80	70	90	80	100		55	10	70	60	80	50	80	50	70			70	80	
Lydick silt loam	65	85	75	95	60	80	70	90	75	95	45	75	40	70	50	70	40	60	45	65	50	60	70	80	
Lydick loam	60	80	70	90	60	80	70	90	75	95	40	70	40	70	50	70	40	60	40	60	50	60	70	80	
Lydick fine sandy loam	50	70	60	80	50	70	60	80	65	85	30	50	30	50	40	60	35	55	35	55	40	50	60	70	
Undulating to gently sloping well-drained soils of the uplands developed on light- to heavy-textured calcareous till:																									General grain, dairy, and livestock farming; 3- to 5-year rotation of corn, oats, wheat, soybeans, and hay crops including legumes. Applications of lime (1-2 tons) for legumes, moderate quantities of complete fertilizer high in phosphate, and additions of organic matter needed. Potential moderate to severe erosion on sloping areas; Hillsdale soil somewhat droughty.
Miami silt loam	70	90	70	100	70	80	70	90	70	90	70	90	80	100	90	110	50	75	40	70	70	80	80	100	
Miami loam	65	85	70	100	70	80	70	90	70	90	70	90	80	100	90	110	55	80	45	75	70	80	80	100	
Galena silt loam	70	90	60	80	70	90	60	80	70	90	65	85	70	90	90	110	50	75	40	60	50	60	80	90	
Galena loam	65	80	70	90	70	90	70	90	70	90	70	90	70	90	90	110	50	75	40	60	60	70	80	90	
Hillsdale loam	60	80	60	80	60	80	60	80	65	85	70	90	65	85	80	100	55	80	50	75	90	100	70	80	
Nearly level well-drained soils of the uplands developed on light- to heavy-textured calcareous till:																									General grain, dairy, and livestock farming; 3- to 5-year rotation of corn, oats, wheat, soybeans, and hay crops including legumes. Applications of lime (1-2 tons) for legumes, moderate quantities of complete fertilizer high in phosphate, and additions of organic matter needed. Not subject to serious erosion; Hillsdale soils somewhat droughty.
Galena silt loam, level phase	75	95	65	85	70	90	60	80	70	90	65	85	70	90	90	110	50	75	40	60	50	60	80	90	
Galena loam, level phase	70	90	70	90	70	90	70	90	70	90	70	90	70	90	90	110	50	75	40	60	60	70	80	90	
Hillsdale loam, level phase	60	80	60	80	60	80	60	80	65	85	70	90	65	85	80	100	60	85	50	75	80	90	70	80	
Hillsdale fine sandy loam, level phase	50	70	50	70	40	60	50	70	55	75	60	80	55	65	70	90	50	75	50	75	70	80	60	70	
Undulating to sloping excessively drained soils of the uplands developed on light-textured glacial drift:																									General and dairy farming; 3- to 4-year rotation of corn, wheat or rye, oats, soybeans, hay crops including legumes, special field crops, fruits, and vegetables. Hillsdale soil well suited to apple and peach production; Coloma soil to grapes, melons, and fruits, but acreage of these is limited. Applications of lime (1 to 2 tons) for legumes, moderate to large quantities of commercial fertilizer high in phosphorus, and liberal additions of organic matter needed. Potential moderate to severe water erosion on Hillsdale fine sandy loam and Bellefontaine sandy loam; wind erosion on Coloma loamy fine sand. Bellefontaine and Coloma soils subject to drought.
Hillsdale fine sandy loam	50	70	50	70	40	60	50	70	55	75	60	80	50	60	70	90	50	75	50	75	90	100	60	70	
Bellefontaine sandy loam	50	70	50	70	30	40	50	70	50	70	50	75	40	60	40	60							50	60	
Coloma loamy fine sand	40	60	30	50			40	60	35	50	30	50	10	30	30	50	40	60	50	65	70	80	40	50	
Mineral soils of the flood plains:																									General crop and livestock farming; irregular rotation of corn, soybeans, hay, and large acreage in permanent bluegrass pasture and forest; corn, soybeans, and permanent pasture most suitable crops. Subject to overflow, artificial drainage of some areas needed. Fall-sown small grains and perennial (legume) crops subject to damage from winterkilling, frost-heaving and drowning out.
Griffin loam	60	80			40	55			60	80							50	70	60	75			60	70	
Nearly level moderately well-drained soils developed on low-lime outwash sand and gravel:																									General crop and cash-grain farming; 2- to 4-year or irregular rotation of corn, wheat, oats, soybeans, and hay crops including legumes; mixed hay crops more suitable than alfalfa. Artificial drainage for some areas (particularly Alida soil); applications of lime (2-3 tons) for legumes, moderate applications of commercial fertilizer high in phosphorus, and occasional additions of organic matter necessary. Winterkilling of small grains and legumes in some inadequately drained areas; overdrainage of some areas of Hanna fine sandy loam; and slight to moderate wind erosion on light-textured Hanna soils.
Alida silt loam	60	80	60	80	60	80	60	80	70	90	25	50	50	90	60	90	30	40	50	70	40	50	50	70	
Hanna loam	70	85	60	80	60	80	60	80	70	85	45	65	45	65	65	85	60	75	50	65			60	80	
Hanna fine sandy loam	60	75	50	70	50	70	50	70	60	75	40	60	30	40	60	70	55	60	50	65			50	70	
Hanna loamy fine sand	50	65	45	65	40	55	45	55	50	60	35	55	25	30	50	65	35	45	40	50			40	60	
Nearly level imperfectly and poorly drained soils developed on low-lime outwash sand and gravel:																									General farming; 3- to 4-year rotation of corn, wheat, oats, soybeans, and hay crops including legumes; Quinn soils largely in woodland pasture. Artificial drainage required; applications of lime (2-3 tons) for legumes, moderate quantities of commercial fertilizers, and additions of organic matter needed. Inadequately drained areas subject to frost-heaving and drowning out of fall-sown small grains and perennial (legume) crops; overdrained areas of Willvale loamy fine sand subject to drought.
Walkerton loam:																									
Drained	60	80	60	80	60	80	60	80	60	80	50	70	60	80	80	100	50	70	40	60	40	50	60	80	
Undrained	30		30		30		30		30		30		30		60								50		
Willvale silt loam:																									
Drained	60	80	50	70	50	70	50	70	60	80	25	50	50	70	60	90	30	50	40	60	40	50	50	70	
Undrained	30		20		20		20		30						30								40		
Willvale loam:																									
Drained	60	80	50	70	50	70	50	70	50	70	25	50	50	70	60	90	30	50	40	60	40	50	50	70	
Undrained	30		20		20		20		30						30								40		
Walkerton fine sandy loam:																									
Drained	50	70	50	65	50	70	50	70	50	70	40	60	50	70	70	90	40	60	40	60	40	50	50	70	
Undrained	30		25		25		25		30		25		25		50								40		
Willvale fine sandy loam:																									
Drained	50	70	40	60	40	60	40	60	40	60	20	40	40	60	50	80	30	50	30	50	30	40	40	60	
Undrained	20		20		20		20		20														20		
Willvale loamy fine sand:																									
Drained	30	50	30	50	30	45	30	50	30	50	15	30	30	40	30	50	20	40	25	45	20	30	30	50	
Undrained	20		20		15		15		15														20		
Quinn silt loam:																									
Drained	50	70	40	60	30	50	40	60	50	70		30	40	60	40	60							40	60	
Undrained	20								20														30		
Quinn loam:																									
Drained	40	60	40	60	30	50	40	60	40	60		30	40	60	40	60							40	60	
Undrained									20														30		
Nearly level well to excessively drained light-colored soils developed on low-lime outwash sand and gravel and thin deposits of outwash over till:																									General farming; irregular rotation of corn, wheat, soybeans, and hay crops including legumes; rye and possibly alfalfa more suitable than other crops for Argos and Tracy fine sandy loams and Tracy loamy fine sand and loamy sand. Applications of lime (2-3 tons) for legumes, moderate quantities of commercial fertilizer high in phosphorus and potash, and liberal additions of organic matter needed. Subject to drought (especially Tracy loamy fine sand and loamy sand); slight to severe wind erosion on lighter textured soils.
Argos loam	60	75	60	80	60	80	60	85	60	90	40	70	40	70	60	70	40	60	50	70	55	65	50	70	
Tracy silt loam	55	75	70	90	50	70	70	90	70	90	40	70	40	70	50	70	40	60	45	65	50	60	60	80	
Tracy loam	50	70	65	85	50	70	65	85	70	90	40	70	40	70	50	70	40	60	45	65	45	65	55	75	
Argos fine sandy loam	50	65	50	65	40	65	55	65	50	65	25	50	40	60	50	70	35	55	45	65	60	70	45	65	
Tracy fine sandy loam	40	60	50	70	35	45	55	70	50	70	30	60	30	60	40	60	40	60	40	55	40	60	40	60	
Tracy loamy fine sand	35	55	40	60	20	40	40	60	40	60	25	50			30	50	30	50	30	50	35	50	30	40	
Tracy loamy sand	30	50	30	50	15	30	30	50	30	50	20	40			25	45	30	50	30	50	30	40	30	40	
Nearly level very poorly drained dark-colored soils of lake and outwash plains developed on strongly acid sand:																									General farming; 3- to 4-year rotation of corn, soybeans, oats, other field crops, and some hay crops; strong acidity discourages legume production. Artificial drainage required; moderate applications of commercial fertilizer high in phosphate and potash; lime requirement 3-4 tons for legumes. Subject to very slight to moderate wind erosion.
Newton loam:																									
Drained	40	75	40	60	40	70	50	70	50	70					45	65	40	50	40	50			45	65	
Undrained	20				20				30														20		
Newton fine sandy loam:																									
Drained	30	70	40	60	30	60	50	70	45	65					35	55	40	50	50	50			40	60	
Undrained	15				15				25														20		
Eroded phases of well-drained undulating to gently sloping soils of the uplands developed on light- to heavy-textured calcareous till:																									Grain and livestock farming (in conjunction with less eroded and uneroded associated soils): 3- to 5-year rotation of crops produced on associated soils; eroded phase of Coloma loamy fine sand best suited to long rotations including a predominance of hay crops, especially alfalfa. Liberal additions of organic matter and commercial fertilizer required for best results; 1-2 tons lime required for legumes. Potential moderate to very severe erosion.
Miami silt loam, eroded phase	60	75	60	80	60	70	60	70	60	80	60	80	65	80	75	85	40	60	35	60	50	60	70	90	
Galena silt loam, eroded phase	60	75	50	70	60	70	50	70	60	80	60	80	60	80	60	80	40	60			40	50	65	75	
Hillsdale loam, eroded phase	40	60	40	60	35	50	40	60	45	60	50	65	50	65	60	80	40	60	40	60	70	80	50	65	
Miami silt loam, severely eroded phase	45	50	45	60	45	55	45	60	30	50	50	65	40	55	40	60							40	70	
Galena silt loam, severely eroded phase	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	60							40	50	
Hillsdale fine sandy loam:																									
Eroded phase	40	60	40	60	35	50	40	60	45	60	50	70	45	55	60	80	40	60	40	60	80	90	50	65	
Severely eroded phase	30	45	30	50	30	45	30	45	35	45	35	50	40	60	40	60							30	50	
Coloma loamy fine sand, eroded phase	30	45	25	40			25	40	30	40	25	45	20	40			30	50			60	70	30	40	
Sloping and eroded sloping phases of well to somewhat excessively drained moderately dark-colored soils developed on low-lime outwash materials:																									General farming (in conjunction with more nearly level associated soils): 3- to 4-year rotation of rye, wheat, alfalfa, pasture, and other field crops although not well suited to them; too droughty for corn and oats; long rotations with a predominance of hay and pasture crops desirable. Applications of lime (2-4 tons) required for legumes on Lydick soils and liberal additions of organic matter and commercial fertilizer required for best results. Subject to moderate to severe erosion and droughtiness.
Lydick silt loam, sloping phase	50	70	55	70	45	65	55	70	60	75	30	60	30	50	40	55							50	60	
Lydick loam, sloping phase	45	60	55	70	45	55	55	70	60	75	30	55	30	50	40	55							50	60	
Lydick silt loam, eroded sloping phase	40	50	50	65	40	50	50	65	55	70	25	50	25	40	30	45							40	50	
Lydick loam, eroded sloping phase	40	50	50	65	40	50	50	65	55	70	25	50	25	40	30	45							40	50	
Sloping well-drained soils of outwash plains and terraces developed on high-lime materials:																									Irregular rotation—or similar to a rotation occasionally used for same crops on other sandy loam soils; better for alfalfa and bluegrass pasture. Lime for legumes; apply organic matter and fertilizer. Subject to erosion and drought.
Fox sandy loam, sloping phase			40	60			40	60			65	85			45	65					45	55	60	70	
Sloping and eroded sloping phases of well to excessively drained light-colored soils developed mainly on low-lime outwash material composed chiefly of quartz sand and some gravel:																									General farming (in conjunction with more nearly level associated soils): irregular rotation of rye, alfalfa, other field crops, and pasture; not suited to corn or oats; long rotations with a predominance of hay and pasture crops desirable. Apply 1-3 tons of lime for legumes and liberal additions of organic matter and commercial fertilizer for best results. Subject to moderate to severe erosion and droughtiness on heavy-textured soils.
Tracy loam:																									
Sloping phase	45	65	55	80	45	65	60	80	60	80	35	60	35	60	45	65	30	50	35	55	35	55	45	55	
Eroded sloping phase	40	55	50	70	35	55	50	70	50	70	30	50	30	50	40	60	30	40	30	45	30	50	40	50	
Argos loam, eroded sloping phase	40	60	40	60	40	60	40	60	40	60	20	40	40	60	40	60					40	50	40	60	
Tracy fine sandy loam:																									
Sloping phase	30	50	40	60	30	40	40	50	40	60	25	50	25	50	30	50					35	50	30	50	
Eroded sloping phase	25	40	30	50			30	45	30	50	20	45	20	35	25	40							25	45	
Tracy loamy fine sand:																									
Sloping phase			25	35			30	45	30	45	20	40			20	40							25	35	
Eroded sloping phase			20	30			20	35			15	35			20	35							20	30	
Tracy loamy sand:																									
Sloping phase			20	30			20	30	20	30	15	30			20	40							20	30	
Eroded sloping phase			15	25			15	25	15	25	15	25			15	35							15	25	
Tracy loam, severely eroded sloping phase			40	50			30	40			20	40	20	40	30	40							30	50	
Steep, hilly, and eroded excessively drained soils of the uplands developed on light- to heavy-textured calcareous drift:																									Largely nonagricultural; not suited to clean-cultivated crops, owing to rapid surface runoff and injury from erosion; better suited to alfalfa, permanent pasture, or forest.
Galena silt loam:																									
Steep phase											60	65											60	70	
Eroded steep phase											55	60											50	60	
Hillsdale loam, eroded steep phase			25	40			25	40			40	55									70	80	40	55	
Hillsdale fine sandy loam:																									
Steep phase			20	40			30	35			40	50									70	80	45	60	
Eroded steep phase			25	35			25	30			35	45									70	80	40	55	
Bellefontaine sandy loam, eroded hilly phase.			30	40			30	40			30	50											30	40	
Miami silt loam, severely eroded steep phase.											30	50			40	50							35	60	
Galena silt loam, severely eroded steep phase.																							30	40	
Hillsdale loam, severely eroded steep phase.											35	45											40	55	
Coloma loamy fine sand:																									
Steep phase			20	25			20	35			20	40											30	40	
Eroded steep phase			15	20			15	30			15	35											25	35	
Hillsdale loam, gullied phase																							20	35	
Steep and eroded phases of excessively drained soils developed on low-lime outwash sand and gravel:																									Largely nonagricultural; too steep and droughty for most crops, better suited to forest. Subject to destructive erosion under cultivation.
Tracy loam, steep phase			30	40	20	40	30	40			30	45		40	40	60							35	55	
Tracy fine sandy loam, steep phase											20	40											30	50	
Tracy loam:																									
Eroded steep phase			30	40			30	40			25	40											30	50	
Severely eroded steep phase																							20	30	
Tracy loamy fine sand:																									
Steep phase																							20	30	
Eroded steep phase																							15	25	
Gullied land (Tracy soil material)																							20	30	

[1] Indexes indicate the approximate average production of each crop in percentage of the standard of reference, which represents the approximate average yield obtained without the use of amendments on the more extensive and better soil types of those regions of the United States in which the crop is most widely grown; they are based largely on estimates of yields (see table 8), as yield data are too fragmental to be adequate.

[2] Indexes are only relative for the county and do not refer to the standard of reference because of a lack of data.
[3] Artificially drained.
[4] No artificial drainage.

marshlands. Approximately 40 percent of the soils occupy level or depressed areas and require artificial drainage for most efficient use for crops. About 16 percent are sufficiently sloping and sufficiently heavy to be susceptible to serious erosion by rapid runoff. On the rest the topography varies from sloping to level, and on the low-lying marshlands rainfall contributes only indirectly through subterranean drainage to the drainage problem.

Water erosion has not been a serious problem, owing to the moderate degree of slope and the sandy permeable character of most of the land. Dairying, crop rotation, good fertility practices, and use of large areas for meadow and pasture have retarded erosion in the more rolling parts. Erosion-control measures, such as contour tillage, strip cropping, and terracing, have not been much used to prevent loss of soil. Losses on the heavier soils, however, have now been sufficient to create considerable interest in water-control and soil-conservation practices, especially in the south-central part.

Artificial drainage has been necessary to bring under cultivation most of the dark-colored former marshland soils, as the mucks and the Granby, Maumee, and Brookston. The Kankakee Valley has been made almost entirely arable by an extensive system of dredged ditches. This river was dredged and straightened about 1900. Since then, lateral ditches have provided drainage for practically all the marshland areas of the outwash plains. The sandy and gravelly substratum makes it easy and feasible to drain large areas with a few open ditches. Tile drainage is used mainly on the heavy upland soils in the southeastern, southern, and south-central parts of the county. On the till plain and outwash plain Washtenaw, Wallkill, and Pinola soils have developed on many small kettle-hole areas. The drainage is inadequate, and it is often impossible to get lateral outlets for tiles. In such places, where gravel and sand are close to the surface, it may be feasible to use vertical tile drainage. By boring a hole to the underlying gravel and setting the tile in vertical position the water can be disposed of more quickly and with less damage to the crops.

Additional data on drainage operations in the county, based on the United States census of 1940, are presented in table 10.

TABLE 10.—*Length of ditches and tiles and the acreage covered by drainage enterprises in St. Joseph County, Ind., in 1940*

Drainage enterprise	Length of ditches	Length of tile	Area covered
	Miles	*Miles*	*Acres*
Ditches only	422. 2	--------	187, 544
Tile only	--------	50. 0	920
Ditches and tile	38. 0	21. 5	10, 829
Total	460. 2	71. 5	199, 293

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and development acting on the parent materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the material. The climate, and its influence on soil and plants, depends not only on temperature, rainfall, and humidity but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

St. Joseph County lies in the region of Gray-Brown Podzolic[9] soils of the east-central part of the United States. The soils have developed principally under a forest vegetation, but local prairie areas are present where the soils have developed under a tall prairie-grass vegetation. Most of the soils developed under a heavy forest cover of deciduous trees have sufficient rainfall to wet them to an indefinite depth, so that a moist condition, except in short periods, is maintained throughout the soil. The climatic and biologic conditions permit only a relatively thin surface accumulation of organic litter and a few inches of dark-colored soil in the upper part of the profile. The surface layer, or organic matter, is thinner than in the Podzol region to the north but thicker than in the Red and Yellow Podzolic regions to the south. All except the very poorly drained soils are light-colored and relatively low in organic content.

Soils developed under a prairie-grass vegetation have dark-colored surface and upper subsoil horizons. Although they have formed under practically the same climatic conditions and from parent material similar to that of the Gray-Brown Podzolic soils, the type of vegetation has resulted in the accumulation of a relatively high content of organic matter in the surface and upper subsoil horizons.

The soils have all developed on glacial drift of the Late Wisconsin glaciation, which include (1) glacial till, (2) glaciofluvial outwash material, and (3) alluvial material. On the basis of their characteristics they are classified and discussed in three groups: (1) Zonal soils, (2) intrazonal soils, and (3) azonal soils.[10]

The zonal soil group, which includes soils having well-developed characteristics reflecting the active factors of soil genesis, climate, and vegetation, is represented in this county by Gray-Brown Podzolic and Prairie soils.

The Gray-Brown Podzolic soils have a grayish-brown to light yellowish-brown eluviated A horizon; a yellowish-brown, brown, or brownish-yellow illuviated B horizon; and a C horizon composed of physically weathered and in some instances partly chemically weathered rock materials.

The Prairie soils have a dark grayish-brown to very dark grayish-brown eluviated A horizon; a dark-gray to dark grayish-brown illuviated upper B horizon and a brownish-yellow to yellowish-brown lower B horizon; and a C horizon similar to the timbered analog.

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[9] BALDWIN, M. THE GRAY-BROWN PODZOLIC SOILS OF THE EASTERN UNITED STATES. Internatl. Cong. Soil Sci. Proc. and Papers 4: 276–282. 1928.

[10] See footnote 6, p. 29.

The intrazonal soil group, consisting of soils having more or less well-developed soil characteristics reflecting the dominating influence of some local factor of relief, parent material, or age over the normal effect of climate and vegetation, include the semi-Planosols, Wiesenboden, Half Bog, and Bog soils.

The semi-Planosols have ABC or ABYC [11] profiles and include soils developed under both timber and prairie vegetations. They have more or less normal A, B, and C horizons, with a lower B horizon—designated as the Y horizon in the Indiana system of horizon designation—occurring between the main B horizon and the C horizon in some soils. Mottling occurs in the lower A horizon in the imperfectly drained soils and at the surface in the poorly drained ones.

The Wiesenboden are dark-colored soils of normally very poorly drained depressions, classified in the Indiana system of horizon designation as having an HMU profile. The H horizon is very dark brownish-gray to nearly black and high in humus content. It is underlain by the M horizon, which is characterized by a gray to light-gray color in the more poorly drained members of the group represented by the true Wiesenboden, and a mottled gray, yellow, and rust-brown color—the gray predominating—in the less poorly drained members represented by the timbered Wiesenboden. The U horizon represents the relatively unmodified underlying mineral material. A progressive transition probably occurs from the HMU profile to the ABC profile as drainage and relief change.

Half Bog soils (HMU profile) have developed largely under a swamp-forest type of vegetation, with mucky surface soil underlain by gray mineral soil. The water table is at or very near the surface most of the year.

Bog soils (HHH profile), developed in areas where water stands continually at or above the surface, have formed under swamp or marsh types of vegetation and consist of plant remains, including sphagnum moss, other mosses, reeds, grasses, and woody material. They have a muck or peaty surface soil underlain by muck, peat, or marl.

Azonal soils include those not having well-developed soil characteristics—the Alluvial soils. They are formed by recent deposits of material that are, in most cases, subject to additional water deposits. Except in some of the higher lying areas where there may be a slight development, soil-forming processes have not yet had time to bring about the development of eluviated and illuviated horizons.

A grouping of the soil series by great soil groups, natural drainage conditions, drainage group designation, profile designation, and underlying material is given in table 11.

GRAY-BROWN PODZOLIC SOILS

The Gray-Brown Podzolic group includes the well-drained, somewhat excessively drained, and excessively drained soils of the uplands and terraces—the Miami, Galena, Hillsdale, Bellefontaine, Coloma, Tracy, Fox, Argos, and Hanna series.

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[11] See footnote 7, p. 29.

TABLE 11.—*Soil series of St. Joseph County, Ind., arranged according to great soil groups, drainage, profile horizons, and underlying material*

ZONAL SOILS

Great soil groups and series [1]	Natural drainage conditions [2]	Drainage group designation [3]	Profile designation [4]	Underlying material
				LATE WISCONSIN GLACIAL AGE
Gray-Brown Podzolic soils:				
Argos	Well to somewhat excessively drained.	IV	ABYC	Thin deposits of stratified sand and silt over glacial till.
Bellefontaine	do	V	ABC	Drift of loose calcareous gravel and sand.
Coloma	Excessively drained	V	ABC	Noncalcareous glacial drift composed largely of quartz sand.
Fox	Somewhat excessively drained.	V	ABC	Highly calcareous stratified gravel and sand.
Galena	Well drained	IV	ABYC	Moderately heavy to heavy-textured calcareous till.
Hanna	Moderately well drained	III	ABYC	Noncalcareous to slightly calcareous stratified sand and gravel.
Hillsdale	Well to somewhat excessively drained.	IV	ABYC	Light-textured siliceous and moderately calcareous till.
Miami	Well drained	IV	ABC	Moderately heavy textured highly calcareous till.
Tracy	Well to excessively drained.	V	ABYC	Noncalcareous to slightly calcareous stratified sand and gravel.
Prairie soils:				
Door	Well to somewhat excessively drained.	V	ABYC	Slightly calcareous stratified sand and gravel.
Lydick	do	V	ABYC	Noncalcareous to slightly calcareous stratified sand and gravel.
Warsaw	do	V	ABC	Highly calcareous stratified gravel and sand.
Alida	Moderately well drained	III	ABYC	Slightly calcareous sand and gravel.

INTRAZONAL SOILS

				LATE WISCONSIN GLACIAL AGE
Semi-Planosols:				
Conover	Imperfectly drained	II	ABC	Light to moderately heavy textured highly calcareous till.
Crosby	do	II	ABC	Do.
Otis	do	II	ABC	Moderately heavy to heavy-textured calcareous till.
Quinn	Poorly drained	I	ABYC	Noncalcareous to slightly calcareous stratified sand and gravel.
Walkerton	Imperfectly drained	II	ABYC	Thin deposits of stratified sand and silt over glacial till.
Willvale	do	II	ABYC	Noncalcareous to slightly calcareous stratified sand and gravel.
Wiesenboden (timbered):				
Brookston	Very poorly drained	VIII	HMU	Calcareous till.
Lapaz	do	VIII	HMU	Thin deposits of stratified sand and silt over glacial till.
Granby	do	VIII	HMU	Do.
Newton	do	VIII	HMU	Acid stratified sands.
Pinola [5]	do	VIII or IX	DHMU	Noncalcareous to slightly calcareous stratified sand and gravel.
Washtenaw [6]	do	VIII or IX	DHMU	Glacial till and slightly calcareous stratified sand and gravel.
Wiesenboden: Clyde	do	IX	HMU	Late Wisconsin calcareous till.
Half Bog soils: Maumee	do	IX	HMU	Calcareous stratified sands.
Bog soils:				
Carlisle	do	X	HHH	Muck and peat.
Edwards	do	X	HHH	Muck and marl.
Houghton	do	X	HHH	Muck and peat.
Kerston	do	X	HDH	Muck and sand.
Peat	do	X	HHH	Peat.
Wallkill [7]	do	X	DHH	Muck and peat.

See footnotes at end of table.

TABLE 11.—*Soil series of St. Joseph County, Ind., arranged according to great soil groups, drainage, profile horizons, and underlying material*—Continued

AZONAL SOILS

Great soil groups and series [1]	Natural drainage conditions [2]	Drainage group designation [3]	Profile designation [4]	Underlying material
Alluvial soils: Griffin	Moderately well to imperfectly drained.	III	DDD	Slightly acid to slightly alkaline alluvium from Late Wisconsin drift.

[1] Grouping based on soil classification defined in Soils and Men, Yearbook of Agriculture, 1938.

[2] Drainage conditions existing before improvements; most areas having imperfect, poor, and very poor drainage conditions have been artificially drained sufficiently to permit cultivation.

[3] Based on The Story of Indiana Soils, by T. M. Bushnell, associate in agronomy, Department of Agronomy, Purdue University Agricultural Experiment Station. Group I includes nearly level poorly drained soils without organic accumulation and with eluviated and illuviated horizons; group II, nearly level to gently undulating imperfectly drained soils, with mottling in the lower A horizon; group III, nearly level moderately well-drained soils, with mottling in the B_1 or B_3 horizon; group IV, undulating to steeply sloping well-drained soils, group V, level to steeply sloping well to excessively drained soils, characterized by loose porous substratum of gravel or sand; groups VIII and IX, very poorly drained depressional soils with an accumulation of organic matter in the surface horizon; and group X, very poorly drained organic soils, representing an accumulation of peat and muck.

[4] Based on Indiana system of horizon designation; the Y horizon includes the lower B horizon, which is silty in character or between the main B and the C horizons; the H horizon designates the humus or organic-bearing horizons in the VIII and IX drainage profiles; the M horizon is the modified mineral subsoil below the H horizon; the U horizon is the unmodified geologic deposits below the M horizon; and the D horizons refer to various depositional layers of alluvium.

[5] Consists of moderately dark-colored mineral wash over dark-colored mineral material, underlain by sand and gravel; not a true Wiesenboden soil.

[6] Consists of light-colored mineral wash over dark-colored mineral material; not a true Wiesenboden soil.

[7] Consists of light-colored mineral wash over muck or peat.

Miami silt loam, a well-drained zonal soil developed on highly calcareous glacial till, has the following profile description in a wooded area:

A_0. About ½ inch, accumulated layer of partly decayed leaves, twigs, stems, and other forest litter. Reaction, neutral.

A_{11}. 0 to 2 inches, dark-gray or dark brownish-gray friable silt loam containing a high percentage of organic matter, largely decomposed and mixed with the mineral material, and numerous fine tree roots. Reaction, slightly acid.

A_{12}. 2 to 5 inches, dark grayish-brown friable medium-granular silt loam containing less organic matter than the above horizon; slight indication of a thin-platy structure. Reaction, slightly acid.

A_2. 5 to 13 inches, light yellowish-brown friable coarse-granular heavy silt loam. High worm activity. Reaction, medium acid.

B_{21}. 13 to 16 inches, light yellowish-brown to brownish-yellow silty clay loam breaking into small nuciform or subangular aggregates ¼ to ½ inch in diameter. Reaction, medium acid.

B_{22}. 16 to 31 inches, brownish-yellow to yellowish-brown heavy silty clay loam that breaks, when moist, into medium-sized nuciform or subangular aggregates ½ to 1½ inches in diameter. When wet the material is moderately plastic, and when dry it becomes hard. A thin coating of brown silty material is on many cleavage faces. Reaction, medium to strongly acid.

B_3. 31 to 34 inches, dark yellowish-brown silty clay loam, similar in structure to the horizon above but somewhat less compact. Reaction, slightly acid to neutral. This is the neutral horizon of the Miami soils and consists of leached and partly weathered parent material with some accumulated colloids.

C. 34 inches +, gray and yellow silty clay loam, unassorted highly calcareous till.

As mapped in this county, the Miami soils vary from the above description in texture, thickness, and color of the various horizons.

The Galena soils differ from the Miami in being developed on calcareous glacial till containing a relatively high proportion of Devonian shale in the silt loam type and of shale and siliceous sand in the loam type. The depth of leaching varies from 3 to 6 feet.

The following profile description is typical of Galena silt loam in a wooded area:

A_0. About ½ inch, accumulated layer of partly decayed leaves, twigs, stems, and other forest litter. Reaction, neutral.

A_{11}. 0 to 2 inches, moderately dark grayish-brown medium-acid mellow silt loam without well-defined structure.

A_{12}. 2 to 4 inches, dark grayish-brown friable medium-granular silt loam. Organic content is less than in the above horizon. Reaction, slightly acid.

A_2. 4 to 9 inches, yellowish-brown or brownish-yellow heavy silt loam that breaks into coarse granules. Reaction, medium to strongly acid.

B_1. 9 to 16 inches, brownish-yellow silty clay loam, breaking into ¼- to ½-inch angular blocky aggregates. Reaction, medium to strongly acid.

B_{21}. 16 to 22 inches, brownish-yellow silty clay loam that is heavier and more compact than the overlying material and breaks into ¾- to 1½-inch blocky aggregates. It is hard when dry and moderately plastic when wet; dark-brown shale fragments are noticeable. Reaction, medium to strongly acid.

B_{22}. 22 to 36 inches, brownish-yellow silty clay loam that is heavier and more compact than the overlying material. The material breaks into ¾- to 1½-inch blocky structure aggregates. It is hard when dry and moderately plastic when wet. Black shale fragments are present. Reaction, medium to strongly acid.

B_{3} (Y_1). 36 to 51 inches, brownish-yellow to pale-yellow silty clay loam, which increases in colloidal content with depth. Dark-brown shale fragments are noticeable, and a few gray mottlings are present. Reaction, medium acid in upper part gradually changing to slightly acid in the lower part.

C. 51 inches +, pale-yellow silty clay loam calcareous glacial till containing a relatively high proportion of shale fragments.

Variations within areas of Galena soils are in color, thickness, and texture of the various horizons and the depth to and composition of the calcareous till.

The nearly level to rolling Hillsdale soils differ from the Miami in that free lime carbonates occur at about twice the depth; internal drainage is more rapid, owing to a less compact B horizon; and the C horizon contains a relatively high proportion of quartz sand.

The Bellefontaine soils are characterized by waxy, clayey B_2 and B_3 horizons and by unconsolidated gravel and sand substrata.

Coloma soils consist of thick accumulations of sandy glacial till material. The A and B horizons are very slightly coherent sandy material, and the substratum consists of loose sand containing a high proportion of quartz material.

The Tracy soils are developed on glaciofluvial outwash plains and terraces, on sand and gravel high in Devonian shale and quartz sand. A typical description of Tracy loam in a wooded areas is as follows:

A_0. About ½ inch, partly decomposed leaves, twigs, and leafmold. Reaction, neutral.

A_1. 0 to 2 inches, dark-gray or dark brownish-gray loam with a high content of organic matter. Reaction, medium to slightly acid.

A_2. 2 to 5 inches, grayish-brown to yellowish-brown friable loam, relatively low in organic content. Reaction, strongly acid.

A_3. 5 to 11 inches, yellowish-brown to brownish-yellow friable granular loam. Reaction, strongly acid.

B_1. 11 to 15 inches, yellowish-brown loam to light clay loam that breaks into small nuciform or subangular aggregates. Reaction, strongly acid.

B_2. 15 to 26 inches, yellowish-brown to weak reddish-brown clay loam that breaks into well-developed ½- to 1-inch nuciform aggregates. The material is friable when moist, hard when dry, and moderately plastic when wet. Reaction, strongly acid.

B_3(Y_1). 26 to 60 inches, yellowish-brown to brownish-yellow stratified layers of sand, clay loam, and gravel. Reaction, strongly acid.

C. 60 inches +, gray and yellow loose stratified slightly calcareous sand and gravel containing a high proportion of quartz sand and Devonian shale material but a low proportion of limestone.

The loamy fine sand and loamy sand members of the Tracy series contain more quartz sand throughout the profile than does Tracy loam.

Fox soils are developed on highly calcareous stratified gravel and sand of the glaciofluvial outwash plains. They have a grayish-brown to yellowish-brown A horizon, yellowish-brown B_1 horizon, weak reddish-brown to yellowish-brown waxy and gravelly B_2 horizon, dark grayish-brown to dark brownish-gray waxy and gravelly B_3 horizon, and a highly calcareous stratified gravel and sand C horizon.

The Argos soils are developed on shallow deposits of Tracylike assorted outwash material (4 to 6 feet thick) over unassorted glacial till.

A typical profile description of the moderately well drained Hanna fine sandy loam in a wooded area is as follows:

A_0. About ¼ inch, accumulated layer of partly decomposed leaves and other forest litter. Reaction, neutral.
A_1. 0 to 3 inches, dark grayish-brown or dark brownish-gray fine sandy loam containing a high proportion of organic matter. Reaction, medium acid.
A_{21}. 3 to 6 inches, light yellowish-brown to grayish-brown fine sandy loam. Reaction, strongly acid.
A_{22}. 6 to 10 inches, light brownish-yellow to grayish-brown fine sandy loam, slightly plastic when wet. Reaction, strongly acid.
B_1. 10 to 16 inches, light brownish-yellow to pale-yellow light clay loam, slightly plastic when wet. Reaction, strongly acid.
B_{21}. 16 to 20 inches, pale-yellow to light brownish-yellow sandy clay loam or clay loam that breaks into subangular to nuciform aggregates. Reaction, strongly acid.
B_{22}. 20 to 30 inches, mottled gray, yellow, and rust-brown clay loam to heavy loam. Reaction, strongly acid.
B_{23} (Y_1). 30 to 48 inches, mottled gray, yellow, and rust-brown loose incoherent loamy fine sand to fine sand. Reaction, strongly acid.
B_{24} (Y_2). 48 to 62 inches, mottled gray, yellow, and rust-brown lenses and thin layers of sand, clay loam, and fine gravel. Reaction, medium acid.
C. 62 inches +, gray and yellow, mottled and blotched with rust brown, slightly calcareous stratified sand and gravel.

PRAIRIE SOILS

The well to somewhat excessively drained Prairie soils include the Door, Lydick, and Warsaw series and the moderately well-drained Alida.

Door soils are developed on stratified sand and gravel, similar to that on which the Tracy soils are formed. Owing to the prairie-grass vegetation under which they developed, the A horizons are very dark grayish brown to dark grayish brown and high in organic content, and the B_1 horizon contains a relatively high organic content.

The Lydick soils have developed under a tall prairie-grass cover on which bur oaks have recently encroached. They are intermediate in color of surface and upper subsoil horizons between Tracy and Door soils and represent a transition from prairie to timber soils. The C horizons are similar to those of the Tracy soils.

Warsaw soils are the Prairie analog of the Fox soils. They are similar to the Fox soils in profile characteristics, except that the surface and upper subsoil horizons are darker colored and contain more organic matter.

The Alida soil is a member of the Lydick catena, and is developed on geologic materials similar in character to those giving rise to the Hanna series. Originally it had a cover of tall prairie grass, but hardwood timber has encroached recently upon the grassland. The profile characteristics are similar to those of the Hanna soils, except the A horizon and B_1 horizon are darker colored and contain more organic matter.

SEMI-PLANOSOLS

The semi-Planosols include the imperfectly drained Crosby, Conover, Otis, Willvale, and Walkerton soils and the poorly drained Quinn.

The imperfectly drained soils of this group were developed on nearly level to gently undulating relief and subjected to periodic saturation during the process of soil formation.

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Crosby soils are developed on highly calcareous moderately heavy textured glacial till. A profile description of Crosby silt loam in a wooded area is as follows:

A_0. About ½ inch, accumulated layer of partly decomposed leaves, twigs, and other forest litter. Reaction, neutral.

A_{11}. 0 to 2 inches, dark brownish-gray to very dark brownish-gray friable fine-granular silt loam, high in organic matter. Reaction, slightly acid.

A_{12}. 2 to 5 inches, brownish-gray to dark brownish-gray friable silt loam, somewhat lower in organic content than the above horizon. Reaction, medium acid.

A_2. 5 to 10 inches, light brownish-gray medium-granular silt loam. Reaction, medium acid.

B_1. 10 to 14 inches, mottled gray, yellow, and rust-brown silty clay loam that breaks into ¼- to ¾-inch subangular to nuciform aggregates. When moist the material is easily crushed into medium to fine granules. Reaction, medium acid.

B_2. 14 to 36 inches, mottled gray, yellow, and rust-brown moderately plastic heavy silty clay loam, breaking into ½- to 2-inch nuciform to subangular aggregates that are somewhat plastic when wet and hard when dry. Reaction, medium acid.

C. 36 inches +, mottled gray, yellow, and rust-brown moderately compact highly calcareous clay loam or silty clay loam glacial till.

Variations of Crosby soils from the above profile description are in color, texture, and thickness of the various horizons and in the depth to and texture of the substrata of glacial till.

Conover soils are developed on highly calcareous glacial till similar to that on which the Crosby soils developed, and natural drainage conditions are about the same. They differ from the Crosby soils in having darker colored A horizons to a depth of 8 to 10 inches that are relatively high in organic content.

Otis soils are developed on moderately heavy to heavy-textured calcareous glacial till containing a relatively high proportion of dark-brown Devonian shale. They have A horizons similar to Crosby soils, but the B_1 and B_2 horizons are heavier textured, and the lower B_2 horizon, or Y horizon, extends to a depth of 40 to 70 inches or more when the calcareous till occurs at variable depths.

The Willvale series consists of imperfectly drained soils developed under a mixed hardwood forest on glaciofluvial outwash material. This material is composed of slightly calcareous stratified sand and gravel containing considerable quantities of shale and is leached of lime and other carbonates to depths of 70 to 80 inches or more. The Willvale soils have A, B, Y, and C horizons with variable quantities of clay accumulated in the B horizons. Mottling occurs immediately below the A_2 horizon.

Walkerton soils consist of thin deposits (4 to 6 feet) of glaciofluvial outwash material, similar to that of the Willvale soils, underlain by unstratified glacial till. They are imperfectly drained, with mottling occurring in the A_2 horizon.

The Quinn series—the poorly drained member of the Tracy catena—is developed on glaciofluvial outwash material similar to that underlying the Tracy, Hanna, and Willvale soils. They have gray to light-gray A horizons, with faint rust-colored mottles and blotches; mottled gray, yellow, and rust-brown B_1 and mottled gray and yellow B_2 horizons that are moderately heavy textured; lower B_2, or Y, horizons that consist of thin layers or lenses of sand, clay loam, and some gravel; and slightly calcareous C horizons of stratified sand and gravel containing a relatively high proportion of dark-brown Devonian shale. They are leached of lime and other carbonates to depths of 70 to 80 inches or more.

WIESENBODEN SOILS

The timbered Wiesenboden soils include the Brookston, Lapaz, Granby, and Newton series. They have HMU horizons, as shown by the Indiana system of profile designation.

Brookston soils occupy slight depressions and broad flats in the glacial till region where very poor natural drainage conditions exist. Before artificial drainage, water stood at or near the surface most of the year.

Following is a typical profile description of Brookston silty clay loam in wooded areas:

1. (H_1). ¼- to ½-inch accumulated layer of leaves, twigs, and other forest litter.
2. (H_2). 0 to ½ inch, very dark-gray fine-granular silt loam, containing a very high proportion of organic matter and numerous small feeder tree roots. Reaction, neutral.
3. (H_3). ½ to 5 inches, dark-gray or very dark brownish-gray coarse-granular silty clay loam, relatively high in organic content and containing numerous fine tree roots. Reaction, neutral.
4. (H_4). 5 to 14 inches, dark brownish-gray heavy silty clay loam or clay loam, breaking into ⅛- to ¾-inch angular pieces. Numerous small pebbles and an occasional boulder are present. Reaction, neutral.
5. (M_1). 14 to 21 inches, mottled gray, yellow, and rust-brown plastic silty clay, breaking into ½- to 2½-inch angular pieces and containing much grit, numerous pebbles, and an occasional boulder. The material is sticky when moist and hard when dry. Reaction, neutral.
6. (M_2). 21 to 60 inches, highly mottled gray and yellow plastic silty clay to sandy clay, breaking into 1- to 6-inch irregular angular pieces and containing numerous pebbles and rock fragments. Mottling often occurs in pockets or as blotches, and an occasional pocket of lighter textured material is present. Reaction, neutral.
7. (U). 60 inches +, gray and yellow compact calcareous glacial till composed of unassorted silt, clay, sand, and rock fragments.

Variations in the profile characteristics of Brookston soils are in color, texture, organic content, and acidity of the surface soil and in the thickness, texture, and color of the subsoil and substrata. Brookston soils associated with Galena and Otis soils have a slightly acid surface soil and contain a higher proportion of shale fragments than those associated with Miami and Crosby soils.

Lapaz loam is a dark-colored very poorly drained soil of the Argos catena. It occupies slight depressions and flats of the outwash plains and consists of relatively thin (4 to 6 feet) deposits of glaciofluvial outwash material over unstratified glacial till. The surface and upper subsoil horizons are similar to those of Brookston loam, but the subsoil below a depth of about 36 inches consists of assorted fine sand, sand, and silt. Calcareous till occurs below a depth of 54 to 60 inches.

The Granby soils are developed in slight depressions and flats, where the water table was at or near the surface most of the year. They have very dark brownish-gray or very dark-gray H horizons extending to a depth of 12 to 18 inches; mottled gray, yellow, and rust-brown M horizons; and U horizons, or underlying material, of calcareous stratified sand.

Newton soils have H, M, and U horizons very similar to those of the Granby soils, but the entire profile is strongly to very strongly acid in reaction. The Newton soils are developed in slight depressions and on slightly elevated flats where the water table fluctuated near the surface the greater part of the year. They have dark brownish-gray H_1 horizons grading at 8 inches into coffee-brown H_2 horizons at a depth of 15 inches or more. The M horizons are mottled gray, yellow, and rust-brown clay loams. The U horizon, or underlying material, consists of assorted sand and fine gravel that is usually moderately acid. The H and M horizons are strongly acid in reaction. The M horizons contain an abnormal accumulation of clay compared to the Newton soils in the western part of the Kankakee Valley where the parent material consists largely of acid sand and elsewhere remote from the areas having extensive outwash deposits. Some areas of this soil were probably developed under forest cover and other areas under a grass and sedge cover or true Wiesenboden.

Pinola and Washtenaw soils are grouped with the Wiesenboden soils, but they do not strictly belong to this group. Pinola silt loam consists of dark-colored colluvial material washed in from upland areas of Prairie soils over dark-colored very poorly drained soils. The thickness of the colluvial deposits varies from 10 to 30 inches. Washtenaw silt loam consists of an accumulation of light-colored material washed in from surrounding uplands of glacial till and, in some cases, outwash over dark-colored very poorly drained soils. The light-colored colluvial material varies from 10 to 30 inches or more in thickness.

The true Wiesenboden group is represented by Clyde silty clay loam, which occupies the depressional areas in the glacial till region. The H horizons are higher in organic content and thicker than those in the associated Brookston soils; the upper M horizon is gray; the lower M horizons are highly mottled gray, yellow, and rust brown; and the U horizon, or underlying material, consists of unassorted calcareous glacial till.

HALF BOG SOILS

The Half Bog group includes the Maumee soils. Maumee soils are developed under very poor natural drainage conditions on calcareous stratified sand of the glaciofluvial outwash plains and lake-laid material. Although the Maumee soils are classed as Half Bog soils, a part of them probably never was forested and may be Wiesenboden. They have very dark-gray to nearly black H horizons, with a thin layer of muck on the surface. The H horizon extends to a depth of 18 to 24 inches and is underlain by the upper M horizon of gray sand or clay loam material. The lower M horizons are mottled yellow and gray, and the U horizon, or underlying material, consists of calcareous stratified sand. The profile of Maumee soils closely associated with members of the Tracy catena contains a considerable quantity of Devonian shale fragments, and the surface soil is somewhat more acid than is normal for this series.

BOG SOILS

The Bog soils include Houghton, Carlisle, Edwards, and Kerston mucks, Peat, and Wallkill silt loam.

Houghton muck is a nearly neutral organic soil developed on a sedge-grass type of vegetation. The following profile description is typical:

1. (H_1). 0 to 7 inches, black granular well-decomposed muck. Reaction, neutral.
2. (H_2). 7 to 12 inches, black moderately compact well-decomposed muck that breaks into large lumps. A few brown fibrous remnants of roots are present. Reaction, very slightly acid.
3. (H_3). 12 to 24 inches, dark-brown to nearly black macerated plant remains that are soft when wet. This horizon contains considerable well-decomposed remnants of reeds and sedges. Reaction, very slightly acid.
4. (H_4). 24 inches +, brownish-yellow fibrous partly decomposed plant remains; twigs, leaves, and stems easily distinguishable. Reaction, slightly acid.

There is little difference in color or degree of decomposition between the Houghton and Carlisle mucks, although in Carlisle muck the water level may be slightly lower, decomposition somewhat further advanced, and the surface horizons deeper and darker. Woody remnants occur throughout the soil mass of Carlisle muck, indicating that the recent vegetative cover consisted of trees that were largely tamarack, birch, elm, maple, and basswood.

Edwards muck is similar in color, character, state of decomposition, and vegetative cover to Carlisle muck. It is underlain within 3 feet of the surface by soft-gray shelly calcareous marl.

Kerston muck, developed in alluvial bottom lands, receives occasional depositions of sand and silt. It consists of alternate layers of muck and sand of various thickness and, in some instances, might be classified as an Alluvial soil.

Peat deposits consist of raw relatively undecomposed organic materials developed under a high water table. They are very highly acid. The present vegetation of cinquefoil, huckleberry, ferns, moss, cotton grass, and briers, is bordered by buttonbush and a few tamarack trees. In most places the surface soil is a brown or black shallow layer of moderately decomposed fibrous organic matter. It is underlain by a fibrous spongy mass of comparatively undecomposed plant material.

Wallkill silt loam consists of an accumulation of light-colored mineral material 10 to 30 inches or more thick over muck or peat.

ALLUVIAL SOILS

Griffin loam, representing the Alluvial soils in this county, has a DDD profile. The surface soil is brownish gray to light brownish gray, highly blotched with yellow below a depth of 3 to 6 inches. The mottled gray, yellow, and rust-brown subsoil is extremely variable in composition, depending on the source and character of the sediments.

MANAGEMENT OF THE SOILS

By A. T. WIANCKO, Department of Agronomy, Purdue University Agricultural Experiment Station

Successful agriculture depends upon a productive soil. Every farmer knows that soils differ in natural productivity. His particular farm may have good soil or poor soil or some of each. Unless he is prepared to move, he has no choice but to work with what he has. To make the most of the soil that he has, he should understand its characteristics and learn to correct its deficiencies. This is not difficult, because the individual farm has only two or three, or at the most, four or five different kinds of soil. Each of these may present different problems as to treatment and general management. These problems must be studied and understood if crops are to be produced profitably.

The purpose of a discussion on soil management is to call attention to the deficiencies of the several soils and to outline the treatments most needed to yield satisfactory results. No system of soil management can be satisfactory unless in the long run it not only produces profitable returns but also maintains the productivity of the soil. Some soil treatments and methods of management may be profitable for a time but ruinous in the end. One-sided or unbalanced and inadequate treatments have been altogether too common in the history of farming in the United States. Most soils are being more and more depleted of fertility, and many have been ruined. Some, however, have been improved. By applying present-day knowledge, all soils that can be farmed at all can be improved and made profitably productive year after year. Properly balanced systems of treatment and crop management will continue to yield the farmer a satisfactory income, provided he operates a large enough acreage.

For considering the quality of the land in this county, and to get some idea of the soil treatments that may be needed in particular cases, basic information concerning the natural fertility status of the principal soils of the county is presented in tables 12 and 13.

FERTILIZER ELEMENTS IN THE SOILS

The approximate content of nitrogen, phosphorus, and potassium in the principal types of soil in this county, expressed in pounds of elements in an acre of plowed surface soil 6 to 7 inches deep (about 2,000.000 pounds), and the relative quantities of available phosphorus and potassium are shown in table 12.

TABLE 12.—*Approximate quantities of nitrogen, phosphorus, and potassium per acre in certain cultivated soils of St. Joseph County, Ind.*

[ELEMENTS IN POUNDS PER ACRE OF SURFACE SOIL 6 TO 7 INCHES DEEP, L=LOW; M=MEDIUM; H=HIGH]

Soil type	Total nitrogen	Total phosphorus [1]	Total potassium	Available phosphorus	Available potassium
	Pounds	*Pounds*	*Pounds*		
Alida silt loam	2,800	1,290	29,000	M	M
Argos loam	1,800	540	30,000	L	L
Argos fine sandy loam	1,600	410	25,000	L	L
Bellefontaine sandy loam	1,600	570	25,000	L	L
Brookston silty clay loam	6,400	1,150	39,000	M	M
Brookston loam	4,800	1,200	31,000	M	M
Carlisle muck [2]	25,600	1,290	3,000	L	L
Shallow phase over clay [2]	14,000	840	5,000	L	L
Shallow phase over sand [2]	22,800	900	4,000	L	L

See footnotes at end of table.

TABLE 12.—*Approximate quantities of nitrogen, phosphorus, and potassium per acre in certain cultivated soils of St. Joseph County, Ind.*—Continued

[See headnote on p. 118]

Soil type	Total nitrogen	Total phosphorus [1]	Total potassium	Available phosphorus	Available potassium
	Pounds	*Pounds*	*Pounds*		
Clyde silty clay loam	15, 200	1, 630	39, 000	M	M
Coloma loamy fine sand	1, 000	350	20, 000	L	L
Conover loam	4, 200	960	28, 000	M	M
Crosby silt loam	2, 600	720	30, 000	L	L
Crosby loam	2, 000	630	29, 000	L	L
Door silt loam	3, 600	1, 140	28, 000	L	L
Door loam	2, 600	820	31, 000	L	L
Edwards muck [2]	19, 400	1, 190	5, 000	L	L
Fox loam	1, 600	690	29, 000	L	L
Fox sandy loam	1, 200	720	2, 500	L	L
Galena silt loam	2, 400	410	39, 000	L	L
Galena loam	2, 400	520	33, 000	L	L
Granby loam	4, 200	1, 060	23, 000	L	L
Granby fine sandy loam	3, 000	720	18, 000	M	L
Griffin loam	4, 000	1, 100	23, 000	M	L
Hanna loam	2, 400	1, 000	29, 000	M	L
Hanna fine sandy loam	1, 400	940	26, 000	M	L
Hanna loamy fine sand	1, 200	720	22, 000	M	L
Hillsdale loam	2, 000	740	35, 000	M	L
Hillsdale fine sandy loam	1, 400	530	28, 000	L	L
Houghton muck [2]	24, 000	1, 240	5, 000	L	L
Kerston muck [2]	21, 000	900	8, 000	L	L
Lapaz loam	4, 000	890	29, 000	M	L
Lydick silt loam	3, 000	860	29, 000	L	L
Lydick loam	2, 200	610	32, 000	L	L
Maumee loam	4, 600	1, 360	25, 000	M	L
Maumee fine sandy loam	5, 400	1, 140	23, 000	L	L
Mucky phase [3]	18, 600	1, 380	9, 000	L	L
Miami silt loam	2, 400	560	34, 000	L	M
Miami loam	2, 000	530	30, 000	L	L
Newton loam	5, 000	1, 000	28, 000	M	L
Newton fine sandy loam	4, 800	810	24, 000	L	L
Otis silt loam	3, 000	740	37, 000	L	L
Otis loam	2, 400	560	34, 000	L	L
Peat [2]	17, 600	710	3, 000	L	L
Pinola silt loam	4, 400	1, 750	33, 000	H	H
Quinn silt loam	3, 000	700	25, 000	L	M
Quinn loam	3, 000	650	23, 000	L	L
Tracy loam	1, 800	730	32, 000	L	L
Tracy fine sandy loam	1, 200	610	28, 000	L	L
Tracy loamy fine sand	1, 000	660	23, 000	L	L
Tracy loamy sand	1, 000	630	23, 000	L	L
Walkerton loam	2, 200	420	22, 000	L	L
Wallkill silt loam	4, 200	1, 350	41, 000	M	H
Warsaw sandy loam	2, 800	840	18, 000	L	L
Washtenaw silt loam	4, 000	1, 350	40, 000	M	M
Willvale silt loam	3, 000	1, 040	28, 000	M	M
Willvale loam	2, 400	970	29, 000	M	M
Willvale fine sandy loam	1, 900	670	20, 000	L	L
Willvale loamy fine sand	1, 600	510	19, 000	L	L

[1] Soluble in strong hydrochloric acid (specific gravity 1.115).
[2] Based on 1,000,000 pounds per acre.
[3] Based on 1,500,000 pounds per acre.

The total content of nitrogen generally indicates the soil's need for that element. It generally indicates also the need for organic matter, because nitrogen and organic matter are closely associated in soils. Usually, the darker the soil the higher its content of both organic matter and nitrogen. Soils having a low total nitrogen content soon wear out, as far as that element is concerned, unless the supply is replenished by growing and turning under legumes or by applying nitrogenous fertilizer.

The total phosphorus in ordinary soils is usually about the same as that shown by a determination with strong acid. The supply of total phosphorus is low in most Indiana soils, and phosphatic fertilizers are generally needed.

The total potassium in the soil can seldom be taken as indicative of whether it needs potash fertilizer. Some Indiana soils that have more than 30,000 pounds of total potassium to the acre in the 6-inch surface layer fail to produce corn satisfactorily without potash applications because so little of the potassium they contain is in an available form. Sandy and muck soils are more often in need of potash than clay and loam soils. Poorly drained soils and soils with impervious subsoils usually need potash more than well-aerated deep soils.

Determinations of available phosphorus and potassium were made by means of the so-called quick tests and are expressed in terms indicating relative quantity, as low, medium, and high. In interpreting these terms it may usually be assumed that soils testing low will respond to fertilization with the element concerned. If the soil tests medium there may be doubt as to whether fertilization would pay on extensive crops. A soil testing high or very high would seem to be in no immediate need of application of the plant-food element concerned. Since the quick test is easily made, it is recommended that the soil or soils of each field of the farm be tested every few years, for the available supply of any particular element may change because of the cropping system, the quantities of crops removed, the manure returned, and the fertilizer added. Plant-tissue tests at critical periods in the development of the crop will show the nutrient status of a soil and which plant-food elements are lowest in supply and most in need of replenishing.

In considering what has just been said about the total and available supplies of plant nutrients in the soils, it should be recognized that there are many other factors that affect their crop-producing powers. These chemical data, therefore, are not intended to be the sole guide in determining the needs of the soil. Depth, physical character of the horizons of the profile, and previous treatment and management are all factors of great importance and should be taken into consideration. Tests indicate that nitrogen and phosphorus are much less available in subsurface soils and subsoils than in surface soils. On the other hand, potash in the subsoil seems to be of relatively high availability.

Crop growth depends largely on the quantity of plant nutrients available for root contact. If the crop can root deeply it may be able to make good growth on a soil of relatively low analysis. If the roots are shallow the crop may suffer from lack of nutrients, particularly potash, even on a soil of higher analysis. The better types of soils and those containing large quantities of plant-nutrient elements will endure exhaustive cropping much longer than the soils of the low plant-nutrient content.

The nitrogen, phosphorus, and potassium in a soil are by no means the only chemical indications of high or low fertility. One of the most important factors is the degree of acidity. Soils that are very acid will not produce well, even though there be no lack of plant nutrients. Although nitrogen, phosphorus, and potassium are of some value when added to acid soils, they will not be fully effective until after such soils are limed.

The percentage of nitrogen and the acidity of the principal soils of the county and the estimated lime requirement are shown in table 13.

TABLE 13.—*Nitrogen, acidity, and lime requirements of certain soils in St. Joseph County, Ind.*

Soil type	Depth	Nitrogen	pH	Average depth to neutral material	Indicated ground limestone requirements per acre
	Inches	*Percent*		*Inches*	*Tons*
Alida silt loam	0–6	0.14	5.1	75	3–4
	6–18	.12	5.0		
	18–36	.06	5.0		
Argos loam	0–6	.09	5.2	60	3–4
	6–18	.07	5.0		
	18–36	.06	5.1		
Argos fine sandy loam	0–6	.08	5.8	50	2–3
	6–18	.07	5.6		
	18–32	.06	5.5		
Bellefontaine sandy loam	0–6	.08	6.2	38	1–2
	6–18	.04	6.0		
	18–36	.04	5.9		
Brookston silty clay loam	0–6	.32	6.6	25	0
	6–18	.12	6.9		
	18–36	.05	7.2		
Brookston loam	0–6	.24	6.8	0	0
	6–18	.12	7.5		
	18–36	.04	7.6		
Carlisle muck	0–6	2.56	6.0	60	0
	6–18	3.36	6.3		
	18–36	2.24	6.6		
Shallow phase over clay	0–6	1.40	6.9	40	0
	6–18	2.08	6.4		
	18–36	--------	5.8		
Shallow phase over sand	0–6	2.28	7.0	45	0
	6–18	--------	5.8		
	18–36	--------	5.9		
Clyde silty clay loam	0–6	.76	7.3	0	0
	6–18	.63	7.3		
	18–36	.19	(1)		
Coloma loamy fine sand	0–6	.05	6.2	45	1–2
	6–18	.05	6.5		
	18–36	.04	6.6		
Conover loam	0–6	.21	6.5	20	0–2
	6–18	.18	6.8		
	18–36	.05	(1)		

[1] Calcium.

TABLE 13.—*Nitrogen, acidity, and lime requirements of certain soils in St. Joseph County, Ind.*—Continued

Soil type	Depth	Nitrogen	pH	Average depth to neutral material	Indicated ground limestone requirements per acre
	Inches	*Percent*		*Inches*	*Tons*
Crosby silt loam	0–6	0.13	6.0	30	1–2
	6–18	.08	5.9		
	18–36	.06	7.2		
Crosby loam	0–6	.10	6.1	31	1–2
	6–18	.08	6.2		
	18–36	1.03	7.5		
Door silt loam	0–6	.24	5.7	70	2–3
	6–18	.17	5.4		
	18–36	.10	5.2		
Door loam	0–6	.17	5.1	70	2–3
	6–18	.10	5.3		
	18–36	.08	5.5		
Edwards muck	0–6	1.94	6.0	20	0
	6–18	2.78	6.8		
	18–36	.52	(1)		
Fox loam	0–6	.08	5.7	40	1–2
	6–18	.05	5.9		
	18–36	.04	6.8		
Fox sandy loam	0–6	.06	5.8	40	1–2
	6–18	.05	5.7		
	18–36	.04	6.7		
Galena silt loam	0–6	.12	5.3	40	2–4
	6–18	.11	5.2		
	18–36	.06	5.2		
Galena loam	0–6	.12	6.0	50	2–3
	6–18	.09	6.0		
	18–36	.07	6.1		
Granby loam	0–6	.21	6.2	30	0–1
	6–18	.08	6.5		
	18–36	.04	7.0		
Granby fine sandy loam	0–6	.15	6.4	36	0–1
	6–18	.07	6.6		
	18–36	.04	6.6		
Griffin loam	0–6	.20	6.0	30	0–1
	6–18	.12	6.4		
	18–36	.08	7.0		
Hanna loam	0–6	.12	5.4	75	2–4
	6–18	.06	5.3		
	18–36	.05	5.2		
Hanna fine sandy loam	0–6	.07	5.5	80	2–4
	6–18	.05	5.1		
	18–36	.05	5.4		
Hanna loamy fine sand	0–6	.06	5.1	55	2–4
	6–18	.03	5.3		
	18–36	.02	5.5		
Hillsdale loam	0–6	.10	6.0	72	2–3
	6–18	.09	5.6		
	18–36	.06	6.1		
Hillsdale fine sandy loam	0–6	.07	5.9	60	2–3
	6–18	.07	5.4		
	18–36	.05	5.3		

[1] Calcium.

TABLE 13.—*Nitrogen, acidity, and lime requirements of certain soils in St. Joseph County, Ind.*—Continued

Soil type	Depth	Nitrogen	pH	Average depth to neutral material	Indicated ground limestone requirements per acre
	Inches	*Percent*		*Inches*	*Tons*
Houghton muck	0– 6	2. 40	6. 5	54	0
	6–18	3. 12	5. 9		
	18–36	2. 68	5. 9		
Kerston muck	0– 6	2. 10	6. 5	------	0
	6–18	2. 10	6. 5		
	18–36	. 90	6. 8		
Lapaz loam	0– 6	. 20	5. 6	60	2–3
	6–18	. 14	5. 7		
	18–36	. 05	5. 6		
Lydick silt loam	0– 6	. 15	5. 7	60	2–4
	6–18	. 14	5. 2		
	18–36	. 10	5. 5		
Lydick loam	0– 6	. 11	5. 6	35	2–4
	6–18	. 11	5. 3		
	18–36	. 11	5. 5		
Maumee loam	0– 6	. 23	6. 3	40	0–1
	6–18	. 18	6. 8		
	18–36	. 05	6. 9		
Maumee fine sandy loam	0– 6	. 27	5. 9	40	0–1
	6–18	. 09	6. 5		
	18–36	. 05	6. 6		
Mucky phase	0– 6	1. 24	6. 1	39	0–1
	6–18	. 26	6. 8		
	18–36	. 14	6. 7		
Miami silt loam	0– 6	. 12	6. 3	28	1–2
	6–18	. 05	5. 8		
	18–36	. 04	7. 0		
Miami loam	0– 6	. 10	6. 6	28	1–2
	6–18	. 05	6. 3		
	18–36	. 05	6. 5		
Newton loam	0– 6	. 25	5. 2	70	3–4
	6–18	. 07	5. 2		
	18–36	. 06	5. 4		
Newton fine sandy loam	0– 6	. 24	4. 8	70	3–4
	6–18	. 11	5. 1		
	18–36	. 04	5. 2		
Otis silt loam	0– 6	. 15	5. 4	48	2–4
	6–18	. 08	5. 0		
	18–36	. 06	5. 3		
Otis loam	0– 6	. 12	5. 8	45	2–3
	6–18	. 07	5. 9		
	18–36	. 06	6. 3		
Peat	0– 6	1. 76	3. 8	(2)	3–5
	6–18	2. 60	3. 8		
	18–36	2. 40	4. 7		
Pinola silt loam	0– 6	. 22	5. 8	80	1–2
	6–18	. 22	6. 4		
	18–36	. 27	6. 7		
Quinn silt loam	0– 6	. 15	5. 4	60	2–3
	6–18	. 07	5. 3		
	18–36	. 05	6. 0		

[2] All depths.

TABLE 13.—*Nitrogen, acidity, and lime requirements of certain soils in St. Joseph County, Ind.*—Continued

Soil type	Depth	Nitrogen	pH	Average depth to neutral material	Indicated ground limestone requirements per acre
	Inches	*Percent*		*Inches*	*Tons*
Quinn loam	0–6	0.15	5.3	60	2–3
	6–18	.07	5.3		
	18–36	.05	6.0		
Tracy loam	0–6	.09	5.4	70	2–3
	6–18	.06	5.2		
	18–36	.04	4.9		
Tracy fine sandy loam	0–6	.06	6.2	60	2–3
	6–18	.05	6.2		
	18–36	.05	6.4		
Tracy loamy fine sand	0–6	.05	5.6	75	2–3
	6–18	.04	5.7		
	18–36	.03	6.0		
Tracy loamy sand	0–6	.05	5.2	84	2–3
	6–18	.05	6.2		
	18–36	.03	6.2		
Walkerton loam	0–6	.11	6.0	45	2–3
	6–18	.10	5.6		
	18–36	.08	5.6		
Wallkill silt loam	0–6	.21	5.7	0	0
	6–18	--------	6.4		
	18–36	--------	6.5		
Warsaw sandy loam	0–6	.14	5.3	60	2–3
	6–18	.08	5.6		
	18–36	.07	5.9		
Washtenaw silt loam	0–6	.20	5.9	50	1–2
	6–18	.19	6.0		
	18–36	.19	6.0		
Willvale loam	0–6	.12	5.3	75	2–4
	6–18	.08	5.4		
	18–36	.04	5.1		
Willvale fine sandy loam	0–6	.11	5.1	75	2–4
	6–18	.06	5.2		
	18–36	.04	5.3		
Willvale loamy fine sand	0–6	.08	5.1	75	2–4
	6–18	.07	5.0		
	18–36	.05	5.4		

The acidity is expressed as pH, or approximate hydrogen-ion concentration. For example, pH 7 is neutral, and a soil with a pH value of 7 contains just enough lime to neutralize the acidity. If the pH value is more than 7 there is some lime (or other base) in excess. Soils testing between pH 6.9 and 6.0 are called slightly acid; between 5.9 and 5.5, medium acid; between 5.4 and 5.0, strongly acid; and below 5.0, very strongly acid. As a rule, the lower the pH value the more the soil needs lime. Samples were taken from the surface (0 to 6 inches), from the subsurface soil, and from the subsoil.

It is important to know the reaction not only of the surface soil but of the lower layers 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. The slighter the depth of acid soil, the less likely it is to need lime. Soils having the greater clay content will need a greater quantity of lime to neutralize them, given the same degree of acidity. The less phosphorus, calcium, and magnesium the soil contains, the more likely it is to need lime. It is well to remember that sweetclover, alfalfa, and red clover need lime more than other crops. As it is advisable to grow these better soil-improving legumes in the crop rotation, acid soils should be limed.

In interpreting the soil survey map and soil analyses, it should be borne in mind that a well-farmed and well-fertilized soil that is naturally low in fertility may produce larger crops than a soil naturally higher in fertility but poorly farmed.

SOIL MANAGEMENT [12]

For convenience in discussing the management of the several soils, they are arranged in groups according to certain important characteristics that indicate that in many respects similar treatment is required. For example, the light-colored loams and silt loams of the uplands and terraces, which have practically the same requirements as to soil treatment and crop management, may be conveniently discussed as a group, thus avoiding 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 in which he is particularly interested.

LIGHT-COLORED LOAMS AND SILT LOAMS OF THE UPLANDS AND TERRACES

The group of light-colored loams and silt loams of the uplands and terraces comprise the loams and silt loams of the Crosby, Galena, Lydick, Miami, Otis, Quinn, Tracy, and Willvale series; the loams of the Argos, Fox, Hanna, Hillsdale, and Walkerton series; and the silt loam of the Alida series. Together, they occupy 91,584 acres, or 31.1 percent of the county. The light-colored loams are classed with the silt loams rather than with the sandy loams, because for the most part their soil management problems coincide more nearly with the heavier types of soil.

The steep and severely eroded phases of the Argos, Galena, Miami, Hillsdale, Lydick, and Tracy soils that are unfit for cultivation are considered along with other nonarable soils in a separate part at the end of this discussion on soil management.

All the soils of this group are relatively low in organic matter, nitrogen, and total phosphorus. They are more or less deficient in available phosphorus and potassium, and all are in need of liming.

DRAINAGE

The Argos, Fox, Galena, Hillsdale, Lydick, Miami, and Tracy soils are naturally well drained. The Alida, Crosby, Hanna, Otis, Quinn, Walkerton, and Willvale soils are naturally imperfectly to poorly drained. Wherever there is a gray or grayish-mottled subsoil, it in-

[12] Better farming practices are constantly being developed. For latest information on these consult your county agricultural agent.

dicates insufficient drainage. Without tile drainage such soils cannot be managed in the most satisfactory way, and no other beneficial soil treatment can produce its full effect. Tile drainage facilitates soil aeration, which helps to make plant nutrients available and encourages deeper rooting. This enables the crops to withstand drought better as well as to obtain more plant nutrients from the subsoil.

Where land to be tiled is very flat, great care must be exercised to give the tile lines an even grade and uniform fall. Nothing less accurate than a surveyor's instrument should be used in establishing grades, and to make sure that all the water will flow to the outlet with no interruption or slackening of the current the individual lines should be accurately staked and graded before the ditches are dug. The rate of fall may be increased toward the outlet, but it should never be decreased without inserting a slit well, as checking the current may cause the tile to become choked. It is an excellent plan, before filling the ditches, to cover the tile to a depth of a few inches with straw, weeds, or grass. This prevents silt from washing into the tile at the joints while the ground is settling, thus insuring proper operation of the drains from the beginning.

EROSION CONTROL

On some cultivated areas of the Argos, Galena, Hillsdale, Lydick, Miami, and Tracy soils of this group certain erosion-prevention problems should receive attention. In many places much or all of the surface soil has been washed away. Such areas either should be taken out of cultivation or protected by some effective means of erosion prevention. Wherever possible, plowing and other tillage operations should extend crosswise of the slopes in order to prevent the formation of watercourses, which are certain to carry away valuable surface soil and may start serious gullies. Incipient gullies, or draws, forming natural waterways down the slopes should be kept permanently in grass with a good sod of sufficient width to allow the water to spread and thereby prevent soil cutting.

LIMING

All soils of this group are acid in the surface layer and upper part of the subsoil and therefore are more or less in need of liming. The lime requirements should be determined by a reliable soil-acidity test for each soil type. If the farmer himself cannot make the test, he can have it made by the county agricultural agent or by the Purdue University Agricultural Experiment Station at La Fayette. A strongly acid soil will not respond properly to other needed treatments until after it has been limed. The failure of clover to develop satisfactorily indicates a need of lime, although lack of thriftiness in clover may also be due to lack of available plant nutrients, insufficient drainage in the heavy or naturally wet soils, or to a bad physical condition of the soil due to lack of organic matter.

Ground limestone is usually the most economical form of lime to use, except where marl is handy. The Fox, Crosby, and Miami soils may require only 1 or 2 tons of ground limestone, or its equivalent in other liming material, to the acre. The other soils of this group, which are all moderately to strongly acid, may require 3 to 4 tons to the acre.

After that, 1 or 2 tons every second or third round of the crop rotation will keep the soil reasonably sweet. Where alfalfa or sweetclover is to be grown on an acid soil heavier liming may be needed.

ORGANIC MATTER AND NITROGEN

The soils of this group are relatively low in organic matter and nitrogen. The lighter their color the lower the content of these important constituents. Constant cropping without adequate returns to the land and more or less soil erosion are steadily making matters worse. In many cases the original supply of organic matter has become so reduced that the soil has lost much of its native mellowness and easily becomes puddled and baked. This condition in large measure accounts for the more frequent failure of clover and the greater difficulty in obtaining proper soil tilth.

Wherever these evidences of lack of organic matter occur, the only practical remedy is to plow under or otherwise work into the soil more organic matter than is used up in the processes of cropping. Decomposition is constantly going on and is necessary to the maintenance of soil productivity. Decomposing organic matter must also supply the greater part of the nitrogen required by crops. For this reason, legumes should provide as much as possible of the organic matter to be incorporated into the soil. To accomplish this satisfactorily, the land must first be put in condition to grow clover and other legumes. This means liming wherever the soil is acid. Wet land must also be tile-drained.

Clover or some other legume should appear in the crop rotation every 2 or 3 years, as much manure as possible should be made from the produce that can be utilized by livestock, and all produce not fed or used for bedding should be left on the land or returned to it directly. It must be remembered that legumes are the only crops that can add appreciable quantities of nitrogen to the soil, and then only in proportion to the quantity of top growth that goes back to the land, either directly or in the form of manure. Wherever clover seed crops are harvested, the haulm should be returned to the land.

Seeding rye as a cover crop in August or early in September on cornland that is to be plowed the following spring is good practice for increasing organic matter and conserving nitrogen. It is important to have some kind of a growing crop on these soils during fall and winter and until the land must be plowed in spring in order to take up the soluble nitrogen that otherwise would be lost through leaching. Without living crop roots to take up the nitrates from the soil water, large losses are likely to occur between the regular summer crop seasons, and there will be more soil erosion on slopes and hillsides. The rye should be plowed under before it heads and also in ample time to prepare a proper seedbed for the crop that follows.

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. When there is a 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, wheat or oats, and clover or mixed clover, alfalfa, and timothy constitute the best short rotation for general use on these soils, especially where the corn can be cut and the ground can be disked and properly prepared when wheat is the small-grain crop to follow. Corn, soybeans, wheat or oats, and mixed hay constitute an excellent 4-year rotation for these soils. The two legumes in this rotation will build up the nitrogen supply of the soil if some of the produce is left on the ground or returned either directly or in the form of manure.

With modern combine-harvesters, the soybean straw can be spread evenly on the ground and will not interfere with the seeding of wheat. When the soybean is first introduced, the seed should be carefully inoculated with the proper variety of nitrogen-gathering bacteria, and this inoculation should be applied at least 2 years in succession. If more corn is wanted, as on livestock farms, the 5-year rotation of corn, corn, soybeans, wheat or oats, and mixed hay can be used satisfactorily where the second corn crop, at least, can be given a good dressing of manure. Where enough livestock is kept to utilize all the feed grain and roughage in this rotation, there should be enough manure produced to make a fair application for each corn crop. A cover crop of rye for plowing under the following spring should be seeded in September on all the cornland not to be seeded to oats.

To guard against failures in the hay crop in any of the suggested rotations, which may be caused by unfavorable weather conditions even though the land has been properly limed and kept in a good state of fertility, it has proved to be a good plan to sow a mixture of seeds made up of 3 or 4 pounds each of red clover and alfalfa, 2 pounds of alsike, and 2 pounds of timothy to the acre. If this fails to make a satisfactory stand, soybeans make a good substitute hay crop.

Alfalfa and sweetclover may be grown by themselves on the better drained and more friable areas if the soil is properly inoculated and sufficiently limed to neutralize harmful acidity. These two crops are especially sensitive to soil acidity. Sweetclover is excellent for pasture and for soil-improvement purposes, and an alfalfa-bromegrass mixture is satisfactory for both hay and pasture. Special literature on the cultural requirements of these crops can be procured from the Purdue University Agricultural Experiment Station.

FERTILIZATION

The soils of this group are naturally low in phosphorus, and the available supply of this element is generally so low that what is required by crops should be wholly supplied in applications of manure and commercial fertilizers. The nitrogen supplies in these light-colored soils are also too low to meet the needs of corn, wheat, oats, and other nonleguminous crops satisfactorily, and provision for adding nitrogen should be an important part of the soil-improvement program. The total quantities of potassium in these soils are large, but in most of the cultivated acreage the available supplies are low, and more potash, in manure or commercial fertilizer, must be applied for the most satisfactory production of most crops. Without substantial provision for supplying all three of these fertilizer elements, the productivity of these soils will remain relatively low.

The problem of supplying nitrogen has been discussed in connection with provisions for supplying organic matter. Legumes and manure are the logical materials for supplying the greater part of the nitrogen, and they should be employed largely for this purpose. A system of livestock farming, with plenty of legumes in the crop rotation, is best for these soils. It will nearly always pay to have some nitrogen in the fertilizer for wheat, regardless of its place in the rotation. Even though wheat follows soybeans, it should receive some fertilizer containing nitrogen at seeding time to start the crop properly, because the nitrogen in the soybean residues does not become available quickly enough to be of much help to wheat in fall. The residues must first decay, and that does not take place to any considerable extent until the following spring.

Where a good clover or other legume sod is not available for the corn crop and little or no manure is applied, it will pay on the heavier soils having adequate moisture-holding capacity to plow under 300 to 400 pounds of ammonium sulfate or cyanamide along with liberal quantities of phosphate and potash, or about 500 pounds of a complete fertilizer, such as 8–8–8 or 10–6–4.

Phosphorus is the mineral plant-nutrient in which these soils are most deficient. In all, the natural supply is low and should not be drawn upon further. The only practical way to increase the supply of phosphorus is through the application of purchased phosphatic fertilizers, and since large proportions of the phosphates applied are fixed by the soil in forms not available to crops, much larger quantities than are actually needed should be used. Where manure is applied, it may be counted that each ton supplies about 5 pounds of phosphoric acid; therefore, a correspondingly smaller quantity need be provided in the commercial fertilizer.

The quantity of potash that should be supplied as fertilizer depends on the general condition of the soil and the quantity of manure used. According to the analysis in table 12, most of the soils of this group are so low in available potash that considerable quantities of this important plant nutrient must be applied. Where manure is applied, it may be counted that each ton supplies about 10 pounds of potash. The rest of the potash needs of crops not supplied by the soil must be provided in commercial fertilizer. The total quantities of potassium in these soils are large, and there would be no objection to drawing upon this natural store if it could be made available at a faster rate. As a rule it becomes available too slowly. The availability of the soil potash may be increased by good farming practices, including drainage where needed, proper tillage, the growing of deep-rooted legumes, and the plowing under of liberal quantities of organic matter.

In the practical fertilization of these soils, so far as the ordinary field crops are concerned, the manure should usually be plowed under for the corn crop, but where the crop rotation includes wheat, some of the manure, about 2 tons to the acre, may be applied profitably to this crop as a top dressing during winter. Manure so used not only benefits the wheat and lessens winter injury, but also helps to insure a stand of clover or other seeding that may be sown in the wheat in spring.

In addition to the manure plowed under, corn should receive 100 to 200 pounds an acre of a phosphate and potash mixture at least as good as 0–12–12 applied beside the hill or in the row at planting time. Where little or no manure is used and corn yields would be low without

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fertilizer, it will pay to plow under 400 to 600 pounds of 8–8–8 fertilizer and also use a row application of 3–12–12. Such applications have been found profitable on medium to heavy light-colored soils in other parts of the State.

Wheat should be given 300 to 400 pounds an acre of 3–12–12 or 3–9–18, using the latter analysis and the heavier application where clover or a grass-legume mixture for hay is to be seeded in spring and large applications of manure or fertilizer have not been made elsewhere in the rotation. In places where wheat is backward in spring a top dressing of about 100 pounds of a soluble nitrogen fertilizer should be applied soon after growth begins. Such top dressing generally will add several bushels an acre to the yield. Oats are not so responsive to fertilizer as wheat, but where small seeds are to be sown with the oats, a liberal application of at least a phosphate and potash mixture should be made.

Where soybeans follow heavily fertilized corn, as should usually be the case, they need not be specially fertilized. Without previous heavy fertilization, most of the fertilizer needed should be plowed under and only a small quantity applied with the seed at planting time because soybeans are sensitive to fertilizer injury during germination and early growth. Usually the 0–10–20 analysis should be used at the rate of 300 to 400 pounds an acre, of which two-thirds should be plowed under.

For special crops special fertilization will be needed. Specific fertilizer recommendations for different crops on different soils under different conditions can be procured from the Purdue University Agricultural Experiment Station.

LIGHT-COLORED SANDY SOILS OF THE UPLANDS AND TERRACES

The group of light-colored sandy soils of the uplands and terraces includes Hillsdale fine sandy loam, Coloma loamy fine sand, and Bellefontaine sandy loam on the uplands; the fine sandy loams of the Argos, Hanna, Lydick, Tracy, Walkerton, and Willvale series, the loamy fine sands of the Hanna, Tracy, and Willvale series, the sandy loam of the Fox series, and the loamy sand of the Tracy series on the terraces. Together, these soils occupy 88,448 acres, or 29.8 percent of the county. They are naturally low in total content of phosphorus, nitrogen, and organic matter. All except the Hanna soils are low in available phosphorus, all are low in available potassium, and all need more or less liming.

The steep and severely eroded phases of the Bellefontaine, Coloma, Hillsdale, and Tracy soils of this sandy soils group that are unfit for cultivation are considered along with other nonarable soils in a separate part at the end of this discussion on soil management.

DRAINAGE

Most of these sandy soils are so loose and open-textured to a considerable depth that natural drainage is excessive and droughtiness is a common fault. Some areas of the Hanna, Walkerton, and Willvale soils, which are naturally imperfectly drained, may need some more attention to drainage by either open ditches or tile.

LIMING

These light-colored sandy soils are all more or less acid and in need of liming. Bellefontaine sandy loam, Coloma loamy fine sand, and Fox sandy loam are generally slightly to medium acid, while the rest are medium to strongly acid. Liming should be one of the first treatments in the improvement of these soils in order that such deep-rooted lime-loving legumes as clover, alfalfa, and sweetclover may be satisfactorily employed in the cropping system where other growth factors are reasonably favorable.

The quantity of lime needed on any particular field should be determined by soil-acidity tests. If the farmer himself cannot make the test, he can have it made by the county agricultural agent or by the Purdue University Agricultural Experiment Station. Ground limestone is usually the most economical form of lime to use. In areas where Edwards muck has been mapped there are underlying deposits of marl, some of which is of high acid-neutralizing value and may be used instead of ground limestone.

ORGANIC MATTER AND NITROGEN

The sandy soils of this group are very low in organic matter and greatly in need of more of this constituent to improve their water-holding capacity, lack of which is their greatest weakness. They are very low in nitrogen also and should be put in condition to grow the more efficient nitrogen-gathering legumes, which should be used to provide as much as possible of the nitrogen needed by crops as well as to supply considerable high-quality organic matter.

The cheapest and most effective first aid on these poor sandy soils, if little money is available, is to grow a crop of soybeans. The soybean will tolerate considerable soil acidity. It will also respond to liming, however, and the land should be limed as soon as possible, certainly before attempting to grow clover or other lime-loving crops. Where grown for the first time, soybeans must be artificially inoculated with their particular nitrogen-fixing bacteria.

Since these soils are poor in available mineral plant nutrients as well as nitrogen, a phosphate and potash fertilizer, such as 0–10–20 or 0–9–27, should be applied at the rate of 100 to 150 pounds an acre beside the row or plowed under. Immediately after harvesting the soybeans, the ground should be seeded to rye or a mixture of rye and winter vetch fertilized with a high-grade complete fertilizer. If a combine-harvester with a straw spreader attachment is used, the straw will not interfere with rye seeding. If other means of harvesting are used, the straw should be spread on the rye for a winter cover and to supply organic matter. The rye should be plowed under the following spring and the land again seeded to inoculated soybeans.

If the droughty light-colored sandy soils can be limed and well fertilized with phosphate and potash, they will produce good yields of alfalfa and sweetclover, which are able to go deep for moisture, and these crops can be profitably used to build up the organic matter and nitrogen supplies. There is no better crop than sweetclover for green manuring.

A very important thing to remember in the management of these sandy soils is that they use up organic matter rapidly. Their loose, open, excessively aerated condition favors rapid decomposition and oxidation, or the burning out of the soil organic matter. For this reason more than ordinary quantities of organic material, such as manure, straw, or other crop residues, specially grown green-manure crops, and cover crops, should be added constantly. The land should never be left without something growing on it, for a cover reduces leaching and losses from both wind and water erosion.

CROP ROTATION

An excellent rotation for general farming on these sandy soils, after liming, is corn, soybeans, wheat or rye, and alfalfa 2 years or more. There should always be a legume sod or manure, or preferably both, for the corn crop. Wheat is a better cash crop than rye if the nitrogen and moisture supply are adequate. A light winter dressing of manure on the wheat will greatly increase the yield and help obtain a stand of alfalfa. On the Sand Experiment Field, near Culver in Marshall County, the most successful stands of alfalfa have been obtained from late July or early August seedings on disked small-grain stubble land. Late spring plowing, however, and summer fallowing until the middle of July, and then lightly drilling the seed with fertilizer, is increasingly favored for alfalfa seedings. A mixed seeding of alfalfa and bromegrass will provide a better ground cover and a higher yield of hay and pasture. An extra field to remain in alfalfa-bromegrass for several years is a wise precaution against failure to obtain a stand in some years on the rotated land.

Some of these sandy soils will produce high-quality potatoes, and when grown on old well-manured alfalfa sod and well fertilized they are a profitable cash crop for supplying home markets and may well be fitted into the rotation in place of some of the corn. On the less acid soil, such as Coloma, cantaloups are a good cash crop. Hillsdale fine sandy loam and Coloma loamy fine sand are adapted to fruit growing.

FERTILIZATION

The fact that these sandy soils are deficient in nitrogen emphasizes the importance of growing legumes on them to supply some of the nitrogen needs of the crops. Manure, of course, should be utilized to the fullest possible extent, and all crops residues not otherwise utilized should go back to the land. In most cases some nitrogen will be needed in the fertilizer for the nonlegume crops.

Phosphates are needed in considerable quantities because these soils are all naturally low in total content of phosphorus as well as in available supplies of this element. The total supplies of potassium are high but the availability is low to very low, so that they require potash fertilizers, the quantity depending on how much manure is used. Manure supplies about 10 pounds of potash a ton.

In the practical fertilization of crops on these sandy soils, it should be the rule to supply all the phosphorus needs from outside sources, as the natural supplies in the soil are so low that they should not be further drawn upon. It should be remembered, also, that some of the phosphorus applied in fertilizer will be fixed by the soil, and allowance for this should be made in the quantities applied. The quantities of potash that must be applied depend upon the crop and its ability to obtain this element from the soil. The deep-rooted legumes have greater ability in this respect than the cereals and the shallow-rooted legumes, like soybeans.

The droughty and leachy nature of these sandy soils also must be considered. These qualities limit the quantities of fertilizer that can be safely applied at one time. Manure is the safest fertilizer, and as much as possible should be made and applied, especially for corn and small grains. Top dressing on small grains, or disking into the surface, is favored on the more sandy and droughty soils. Corn, at best, is not well adapted to the droughty sandy soils and should never be expected to depend upon commercial fertilizer alone. It should have a legume sod to begin with and preferably manure also. Then, 150 pounds to the acre of fertilizer, as 0–12–12 or 0–10–20 if unmanured, may be expected to produce profitable returns.

Small grains should receive about 300 pounds an acre of 3–12–12 or 3–9–18 if seeded to legumes or grass-legume mixture or where alfalfa is to be seeded in disked stubble after the small-grain harvest. Winter wheat will generally respond profitably to a top dressing of 100 pounds of a nitrogen carrier such as ammonium nitrate, ammonium sulfate, cyanamide, or nitrate of soda. The best way to provide for the fertilizer needs of the soybeans grown in rotations is to fertilize the preceding crops more heavily. On land not previously heavily fertilized, soybeans should receive about 100 pounds of 0–9–27 placed on both sides of the row with a divider fertilizer attachment and twice as much plowed under in advance of planting.

Alfalfa should be grown more extensively on these droughty sandy soils and proper fertilization will pay well and lengthen the life of the stand. From 200 to 300 pounds of 0–9–27 should be applied at seeding time as soon as possible after the middle of July, after a rain, on fallow ground or on deeply disked small-grain stubble. To increase yields and lengthen the life of the stand, a top dressing of 200 pounds of 0–9–27 should be applied every spring.

Potatoes and horticultural crops should be specially fertilized as recommended by the Department of Horticulture of the Purdue University Agricultural Experiment Station.

DARK-COLORED SANDY SOILS

The group of dark-colored sandy soils includes the fine sandy loams of the Granby, Maumee, and Newton series; Maumee fine sandy loam, mucky phase; and Warsaw sandy loam. Together, they occupy 22,592 acres, or 7.6 percent of the county, with the Maumee soils greatly predominating.

DRAINAGE

Warsaw sandy loam is well to excessively drained and is more or less droughty, especially for corn. The Granby, Maumee, and Newton soils are naturally poorly drained, owing to their relatively low situations, and are in need of artificial drainage because of a too high water table, especially during the spring months. Most areas have been provided with drainage facilities. Where additional drainage is needed and outlets are available, it can be provided by open ditches or by large tile at relatively wide intervals, as water moves freely in the sandy subsoils.

LIMING

The Granby and Maumee soils are generally not in need of liming. Warsaw sandy loam is medium acid and needs liming at the rate of 2 to 3 tons of ground limestone an acre. Newton fine sandy loam is strongly to very strongly acid and should receive at least 3 or 4 tons of ground limestone, or its equivalent in marl or other forms of lime.

ORGANIC MATTER AND NITROGEN

The Newton and Maumee soils have fair to abundant supplies of organic matter and nitrogen. Granby fine sandy loam and Warsaw sandy loam, although classed as dark-colored soils, are relatively low in nitrogen and organic matter and require some attention to the maintenance, or even increase, of these constituents by more careful conservation and use of manure, crop residues, and green-manuring crops that could be seeded in corn where the land is to be plowed again the following spring.

CROP ROTATION

Newton fine sandy loam in its natural state will produce little in the way of desirable crops. It must be heavily limed and then well fertilized with phosphate and potash before anything worth while can be expected from it. With such treatment and more drainage where needed, this soil will produce corn, soybeans, small grain, and mixed hay and can be made profitably productive. The Maumee and Granby soils, after proper drainage, are naturally more productive and more versatile in crop adaptation. Besides the major field crops they are also well-adapted to vegetables. Livestock enterprises could be more generally emphasized. For such conditions good crop rotations are corn, small grain, mixed hay; corn, soybeans, small grain, mixed hay; and corn, corn, soybeans, small grain, mixed hay. Where more hay is required, part of the soybean crop can be used for this purpose. On the better drained areas alfalfa can be utilized for extra hay production. Warsaw sandy loam is well adapted to alfalfa after thorough liming and liberal applications of phosphate and potash, especially the latter.

FERTILIZATION

In fertilizing crops on these soils, the supplying of potash should be given the major emphasis. In cases where farmers have also lighter-colored soils most of the manure produced should be used on these areas. For the dark-colored soils more dependence must be placed on commercial fertilizers high in the mineral elements, as these soils are not so much in need of the organic matter and nitrogen supplied by manure.

As a general rule corn should receive about 100 pounds an acre of 0–10–20 or 0–9–27 applied on both sides of the hill at planting time. Where more fertilizer is needed it should be plowed under. Where soybeans are to follow corn, it is advisable to provide for their needs in advance by plowing under extra quantities of the fertilizer recommended for corn and thus avoid the necessity of fertilizing the soybeans directly, because they are sensitive to fertilizer injury from direct applications, especially if the soil is relatively dry during germination and early growth. Where direct fertilization of soybeans is needed, most of the fertilizer should be plowed under and not more than 150 pounds of 0–10–20 or 0–9–27 applied with a divider fertilizer attachment on both sides of the row.

Small grains should receive 200 to 300 pounds an acre of 0–10–20 or 0–9–27 drilled with seed, using the larger quantity if to be seeded to legumes or a legume-grass mixture. For alfalfa, where adapted, 200 to 300 pounds of 0–9–27 should be applied at seeding time, followed by spring top dressings of 200 pounds of similar fertilizer.

For potatoes, truck, and other horticultural crops, specific fertilizer recommendations for the particular conditions should be procured from the Department of Horticulture of the Purdue University Agricultural Experiment Station.

DARK-COLORED LOAMS AND HEAVIER SOILS OF THE UPLANDS AND TERRACES

The group of dark-colored loams and heavier soils of the uplands and terraces includes the silty clay loams of the Brookston and Clyde series; the silt loams of the Conover, Door, Pinola, Wallkill, and Washtenaw series; and the loams of the Brookston, Conover, Door, Granby, Lapaz, Maumee, Newton, and Warsaw series. Together, these soils occupy 59,072 acres, or 19.8 percent of the county, with the Brookston silty clay loam greatly predominating. The Wallkill and Washtenaw soils are included in this dark-colored group rather than in the light-colored group of the heavier soils because of their relatively high content of organic matter and nitrogen and the fact that the treatments they require are more nearly like those of the heavy black soils which they also resemble in total phosphorus content and in available phosphorus and potassium.

DRAINAGE

The Door and Warsaw soils are naturally well drained, with the more open-textured areas inclined to be excessively drained and droughty. The other soils of this group are naturally poorly to very poorly drained. Most cultivated areas have been sufficiently artificially drained for the production of the more common farm crops. Where more tile drainage is needed, the same general procedure should be followed as outlined in the more lengthy discussion of tile draining the light-colored heavy soils. Some kettle-hole areas of Pinola and Washtenaw silt loams are so deeply depressed that drainage is practically impossible.

LIMING

The Brookston, Clyde, most of the Maumee, and some areas of the Conover, Granby, and Lapaz soils are neutral to only slightly acid and not in need of liming. The lighter colored areas of Conover and Granby are medium acid and will respond to a little liming. Most of the Pinola, Wallkill, and Washtenaw soils also are medium acid and may be benefited by a little liming. The other soils of this group range from medium to strongly acid. The Newton and Door soils are especially in need of liming. Wherever there is doubt, soil acidity tests should be made.

ORGANIC MATTER AND NITROGEN

The Brookston, Clyde, Maumee, and Newton soils are generally well supplied with organic matter and nitrogen, and with reasonable care in their management no special provision for supplying these constituents will be necessary for a long time. The other soils of the group have only moderate supplies, which should be conserved as much as possible. The Warsaw and Door soils that are inclined to be droughty would be benefited by additions to the organic matter supply, as by seeding rye or sweetclover as an intercrop on cornland that is to be plowed the following spring.

CROP ROTATION

The heavier soils of this group are especially well suited to corn, and this may well be the major crop in general farming operations. Among the rotations that may be satisfactorily employed are the following: Corn, wheat or oats, and mixed hay; corn, soybeans, wheat or oats, and mixed hay; corn, corn, soybeans, wheat or oats, and mixed hay. The Warsaw soil is well adapted to alfalfa after thorough liming. The soybean may be satisfactorily utilized as a legume hay if for any reason alfalfa or clover cannot be grown or seedings fail.

FERTILIZATION

The soils of this group are naturally well or fairly well supplied with nitrogen, and if legumes are in the crop rotation the fertilizer need not contain nitrogen for the ordinary field crops, except wheat. On farms having both light- and dark-colored soils, the manure should be applied to the light-colored soils where organic matter and nitrogen are most needed. The available supplies of phosphorus and potassium are variable. Where there is doubt, availability tests should be made as a guide to the analysis and quantity of fertilizer required. Corn should generally receive about 100 pounds an acre of a phosphate-potash mixture, such as 0–12–12 or 0–10–20, placed on both sides of the hill or twice as much in the row.

The terrace soils are lower than the upland soils of this group in available phosphorus and potassium, particularly the latter. As a rule, wheat should be given 200 to 300 pounds an acre of a complete fertilizer, such as 3–12–12 or 3–9–18, at seeding time, especially where it follows corn or soybeans and is to be seeded to a legume or grass-legume hay mixture. Oats will seldom respond to nitrogen in fertilizer on these dark-colored soils, and where this is the small-grain crop a phosphate-potash mixture, such as recommended for corn, should be used and in sufficient quantity to provide for whatever hay mixture is seeded with the oats. The fertilizer for soybeans should be the same as for corn under similar conditions. Up to 150 pounds may be applied on both sides of the row with a divider fertilizer attachment at planting time. Where larger quantities of fertilizer are needed they should be plowed under, using 0–10–20 on the upland soils and 0–9–27 on the terrace soils, at twice the rate recommended for the row application.

MUCK SOILS

The group of muck soils includes the mucks of the Carlisle, Edwards, Houghton, and Kerston series. Together, these soils occupy 29,888 acres, or 10 percent of the county, with the Carlisle muck greatly predominating.

Profitable management of the muck soils involves careful drainage, where drainage is at all possible, the growing of suitable crops, and the application of large quantities of mineral fertilizer especially rich in potash.

The question is sometimes asked whether muck soils can be improved by burning. The answer is "No," and they may be seriously and permanently injured. Burning adds nothing and destroys much valuable organic matter and nitrogen. The mineral plant-nutrient elements concentrated in the ash remains are not to be considered gain. These elements are soon used up, and the land is left in a poorer condition than before burning because of the destruction of organic matter and the consequent lowering of the land level to such an extent, in many cases, as to make drainage more difficult.

DRAINAGE

In the improvement of muck soils the first requisite is proper drainage. A large proportion of the mucks in this county are already fairly well drained, largely by open ditches. As a general rule, the water table should be lowered to a depth of about 3 feet below the surface, but for meadows a depth of 2 feet may be enough for best results. Muck soils drain freely if the water has a chance to get away, and ordinarily the distance between tile lines or lateral ditches need not be less than 100 feet. Whether tile or open ditches should be used depends on local conditions. If the subsurface material is sufficiently firm to hold the tiles in place, tiling is preferable, as open ditches are always a nuisance. In extensive areas large open outlet ditches may be necessary. These, however, should not be deeper than necessary to keep the water table at a proper level.

Most muck areas receive considerable surface and seepage waters from the higher lands adjoining. The plan of drainage therefore should provide for the removal of such waters as well as the excess water that falls on the muck itself. The first thing to be done is to cut a ditch or lay a tile line along the edge of the muck area next to the higher land adjoining. This will catch the seepage and if a suitable outlet can be obtained it will make drainage of the rest of the area comparatively easy.

Muck soils should not be too deeply drained, because the crops grown on them may suffer from lack of moisture at critical times. Where tile drainage is employed, however, the tile lines must be placed deep enough for subsequent settling of the soil not to leave them too near the surface, as muck settles considerably during the first few years after drainage and the beginning of cultivation, and allowance for this should be made. The ultimate aim should be to have the water table about 3 feet below the surface. Great care should be taken to ensure an even grade for each tile line, so that the water will flow to the outlet with no interruption or slackening of the current. Fine materials, which wash in at the tile joints, settle easily and will soon clog the tile if the grade line is uneven. As a rule, nothing smaller than 5-inch tile should be used for muck soils. It is a good plan to cover the tile lines with a layer of straw or grass a few inches thick before filling the ditches, as this will keep out fine material while the ground is settling.

In some places, it may be desirable to raise the water table when the dry season approaches, especially for shallow-rooted crops. This can be done by temporarily damming the outlets of the ditches or blocking the tile outlets, thus holding the water table up until sufficient rains come again.

LIMING

As a rule these muck soils are not sufficiently acid to require liming for any of the crops commonly grown. Where a crop that is particularly in need of lime is to be grown, light liming especially for that crop should be practiced. If there is doubt about this, advice can be procured from the Department of Horticulture of Purdue University.

CROPS

Except for small grains, these soils, when properly drained and fertilized, can be satisfactorily used for most of the field and garden crops adapted to the climatic conditions of the region. Where markets and the necessary labor are available, more or less specialized truck farming is well suited to these soils, and such crops as onions, beets, carrots, parsnips, spinach, celery, lettuce, cabbage, cauliflower, and rutabagas, grow very well with proper drainage and fertilization. Sweet corn and potatoes also will do well. Details concerning production practices for any particular crop can be obtained from the Purdue University Agricultural Experiment Station.

For the general farmer, corn is the most popular and generally the best crop for muck soils, and with proper fertilization it can be grown most of the time. To escape early frosts, however, it is necessary to use early varieties. The small grains are the least suitable crops for these soils because they are apt to produce a rank growth of weak straw and to lodge readily. Liberal applications of potash will aid materially in producing stiffer straw. Soybeans, rye, and mixed timothy and alsike clover for meadow or pasture may be fitted into a crop rotation. Other extensive crops suited to muck soils are sorghum, mint, Sudan grass, and bluegrass for pasture.

MANAGEMENT

One of the difficulties in managing muck soils is that they are apt to be too loose on the surface. In preparing the seedbed, therefore, it is important to pack the ground thoroughly by the use of a heavy corrugated roller, going over the field more than once if necessary. Thorough compacting of the muck is not only better for crop growth but it also lessens the danger of early frost damage to immature crops.

The prevention of wind erosion of mucks during early dry periods and the blowing out of tender early planted crops, like onions, is an ever-present problem on these soils. The simplest practice is to plant a row of rye to every few rows of onions. Some muck farmers use willow hedges planted crosswise of the direction of the most damaging winds.

FERTILIZATION

In the fertilization of muck soils, potash is of first importance. Nitrogen is present in great abundance and need not be applied in fertilizer except for early planted crops that need quickly available nitrogen, especially in late seasons when nitrification, the bacterial action that makes nitrogen available, does not begin early enough.

In general farming, where corn is the principal crop, 0–9–27 and 0–10–20 are recommended fertilizers applied at the rate of 300 to 400 pounds an acre, plowing under two-thirds of it and applying one-third with a divider fertilizer attachment on both sides of the hill for corn and on both sides of the row for soybeans. When the cropping sequence is known in advance, enough fertilizer may be plowed under for the corn to provide for the needs of the other crops.

Most of the truck crops need special fertilization, details of which for each crop and local condition can be obtained from the Purdue University Agricultural Experiment Station. On areas of muck recently brought under cultivation, applications of partly rotted manure will be helpful in supplying beneficial bacteria, which are often lacking in newly cultivated mucks.

BOTTOM LANDS

The bottom lands of this county consist entirely of Griffin loam, which occupies all the land along streams that is subject to overflow during periods of high water. The elevation is variable. Some areas overflow several times a year, whereas others are high enough to escape flooding except in times of unusually high water. Many areas are too low for systematic cropping and are useful only for pasture. Bluegrass does well, as the soil is only slightly acid, and where not too wet is of fair to good fertility. On the more elevated areas, where the flood hazard is not too great, corn, soybeans, and other crops that can be grown under such conditions will do well. Usually some fertilizer of the kinds and quantities suitable for the light-colored soils of the uplands and terraces should be used.

NONARABLE LAND

The steep and badly eroded phases of the Argos, Bellefontaine, Coloma, Galena, Hillsdale, Lydick, Miami, and Tracy soils and areas of the Griffin, Pinola, and Washtenaw soils that cannot be satisfactorily drained are classed as nonarable and unfit for ordinary farming. Some of the areas unfit for tillage, however, may be successfully utilized for pasture if limed where needed, properly fertilized, and then seeded to adapted grass and legume mixtures. Many areas that are not suitable even for pasture should be reforested with adapted trees and given protection from livestock.

Areas mapped as Peat are mostly nonarable because decomposition of the vegetable matter of which they are composed has not advanced far enough to be satisfactory for farming. They are also very wet and so very acid that the cost of sufficient liming for farm crops is practically prohibitive.

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