

Soil Survey

Tama County Iowa

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Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
IOWA AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS REPORT with its accompanying map presents information primarily about the soils, crops, and agriculture of Tama County. It also deals briefly with certain related topics such as topography and cultural features. The report is designed to meet the needs of a wide variety of readers. Individual readers, however, will often find the information wanted without reading the whole report. For the convenience of various types of readers, the following paragraphs indicate those sections of interest especially to persons concerned with the entire county, to those concerned with specific tracts of land, and to students and teachers of soil science and related agricultural subjects.

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, areas for forest and wildlife management, and for recreation. The following sections are intended for such users: (1) Natural Geography of Tama County and Cultural Geography of Tama County, in which location and extent, physiography, relief, drainage, climate, water supply, vegetation, organization and population, industries, transportation, trading centers, churches, schools, and home conveniences are discussed; (2) Agriculture of Tama County, in which a brief history and the present status of the agriculture are described; and (3) Use, Management, and Productivity of the Soils of Tama County, in which the soils are grouped according to their relative physical suitability for agricultural use and their present management requirements and productivity are discussed.

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 of Tama County 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 section on Use, Management, and Productivity of the Soils of Tama County.

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 the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils of Tama County, 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 Purpose and Methods of Soil Surveys. Teachers of other subjects will find the sections on Natural Geography of Tama County; Cultural Geography of Tama County; Agriculture of Tama County; Use, Management, and Productivity of the Soils of Tama County; and the first part of the section on Soils of Tama County of particular value in determining the relations between their special subjects and the soils of the area.

This publication on the soil survey of Tama County, Iowa, is a cooperative contribution from the—

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SOIL SURVEY OF TAMA COUNTY, IOWA

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United States Department of Agriculture in cooperation with the Iowa Agricultural Experiment Station

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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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TAMA COUNTY was settled during the period 1850 to 1880, the most rapid increase following the completion of the railroad in 1862. The first settlements were along the Iowa River and the adjacent bluffs, where timber necessary for fuel and shelter was plentiful. The county is largely agricultural. Corn, the most important crop, is generally grown on more than 40 percent of the cropland. Soybeans are becoming an important crop. Recently, oats have been the chief small-grain crop, but barley, wheat, rye, and flax are grown to some extent. Clover and timothy, usually grown together, are the most important hay crops, although alfalfa is rapidly becoming important. Fruits and vegetables are grown for home use. Other industries furnishing employment to a number of people are a paper mill, creameries, a poultry-processing plant, a wood-preserving plant, and a cooperative cannery. To provide a basis for the best agricultural uses of the land a cooperative soil survey was begun in 1938 by the United States Department of Agriculture and the Iowa Agricultural Experiment Station. The report here presented may be briefly summarized as follows.

SUMMARY

Tama County covers an area of 713 square miles in east-central Iowa. The topography is undulating, rolling, or hilly, with only a few small undissected nearly level divides. Elevations above sea level range from 770 to 1,059 feet. Drainage is by several large streams and their tributaries, chief of which are the Iowa River and Wolf Creek.

The native vegetation consisted principally of tall grasses. Broad-leaf deciduous trees occurred on some of the more rolling areas and in some of the stream bottoms. Where grasses were present during the period of soil formation, the soils of the uplands are dark-colored; and where trees were present, the soils are light-colored.

The materials from which the soils have developed are loess (fine wind-blown material), which covers 60 percent of the county to depths ranging from a few inches to more than 20 feet; glacial deposits of sand, silt, clay, and gravel; limestone bedrock; and alluvium (stream deposits).

The soils are classified according to their internal and external characteristics, with special emphasis on the features that influence the use of the land for crop production. The more important classification units are series, type, phase, and complex. The series includes soils having essentially the same thickness, color, structure, and consistence of the soil layers; the type is a subdivision of the series and receives its name from the texture of the surface layer; a phase is a variation within the soil type, usually in slope, stoniness, or degree of accelerated erosion; and a complex is a unit of mapping that is used where soils of two or more series are so intricately associated that separate delineation on a map of the scale used is impractical. In order to bring out certain interrelations the soil series are placed in seven groups based on color of the soil profile, natural drainage conditions, and topography. Each series, type, phase, and complex is described in detail with regard to composition, distribution, and agricultural use.

The productivity of a particular soil depends upon a large number of factors, among which climate, soil characteristics, and management are important. Of these, management is the only variable that can be controlled. A system of management consists of many practices, and combinations of these may be made to constitute several systems of management. The farmer must select a combination of practices in order to perfect a system of management best suited to conditions on his farm. The soil pattern, formed by the association of different soils, differs in nearly every field and contributes to the individuality of farms. This influences the choice of management for each field. Crop rotations, maintenance of organic matter in the soil, liming, tillage, drainage, the use of commercial fertilizers, and supporting erosion-control practices, as grassed waterways, contour cultivation, strip cropping, terraces, and gully control are used. On the basis of those properties that affect their use and management and are reflected in their productive capacity, the soils of the county are classified in 13 groups.

The soils of Tama County are representative of seven great soil groups—Prairie, Gray-Brown Podzolic, Planosol, Wiesenboden, Alluvial, Dry Sands, and Lithosols. The county lies in the region of Prairie soils, but only about half the soils are Prairie soils; about a sixth are Gray-Brown Podzolic soils; and the rest are members of other groups.

NATURAL GEOGRAPHY OF TAMA COUNTY

Some of the important natural features of the landscape are briefly described in this section. Attention is given to physiography, topography, drainage, soil parent materials, climate, and native vegetation. Knowledge of these features will be helpful in understanding the subsequent discussion of soils.

LOCATION AND EXTENT

Tama County, in the east-central part of Iowa, is separated by four tiers of counties from Minnesota on the north, from the Mississippi River on the east, and from Missouri on the south (fig. 1). Toledo,

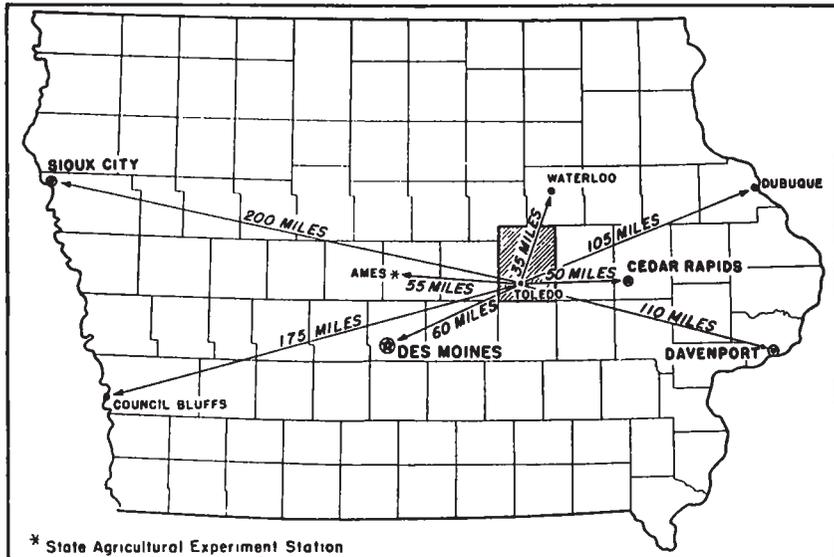


FIGURE 1.—Location of Tama County in Iowa.

the county seat, is 50 miles west of Cedar Rapids, 35 miles south by west of Waterloo, 60 miles northeast of Des Moines, and 110 miles northwest of Davenport. The county is 30 miles long and 24 miles wide, with a total area of 713 square miles, or 456,320 acres.

PHYSIOGRAPHY, TOPOGRAPHY, AND DRAINAGE

Tama County lies at the margin between the Dissected Till Plains and the Western Young Drift section of the Central Lowland (8).² Because of its geographic position with respect to these physiographic regions, the features of the county are not characteristic of either of them. Most of the county has topographic features similar to those found farther south in the Dissected Till Plains. The northeastern part of the county, however, has topographic features more like those of the Iowan Drift of the Western Young Drift section. The county

² Italic numbers in parentheses refer to Literature Cited, p. 108.

as a whole might be considered as a loess-mantled drift plain of low relief. Most of the uplands are undulating to rolling, but there are some hilly belts along the large valleys and a few level areas constituting divides between major drainage basins.

Elevations range from approximately 770 feet above sea level, where the Iowa River leaves the county, to 1,059 feet, at Lincoln near the northwest corner. The elevation at Gilman (near the southwest corner of Tama County but across the line) is 1,031 feet above sea level, and at Dysart, 968 feet. Dysart, Gilman, and Lincoln are on major broad divides, and their elevations indicate that the general slope of the land surface is to the east and southeast. Other elevations in the valleys of the Iowa River and larger creeks are as follows: Gladbrook, 950 feet; Traer, 916; Montour, 850; Elberon, 836; Tama, 816; and Chelsea, 789 (10).

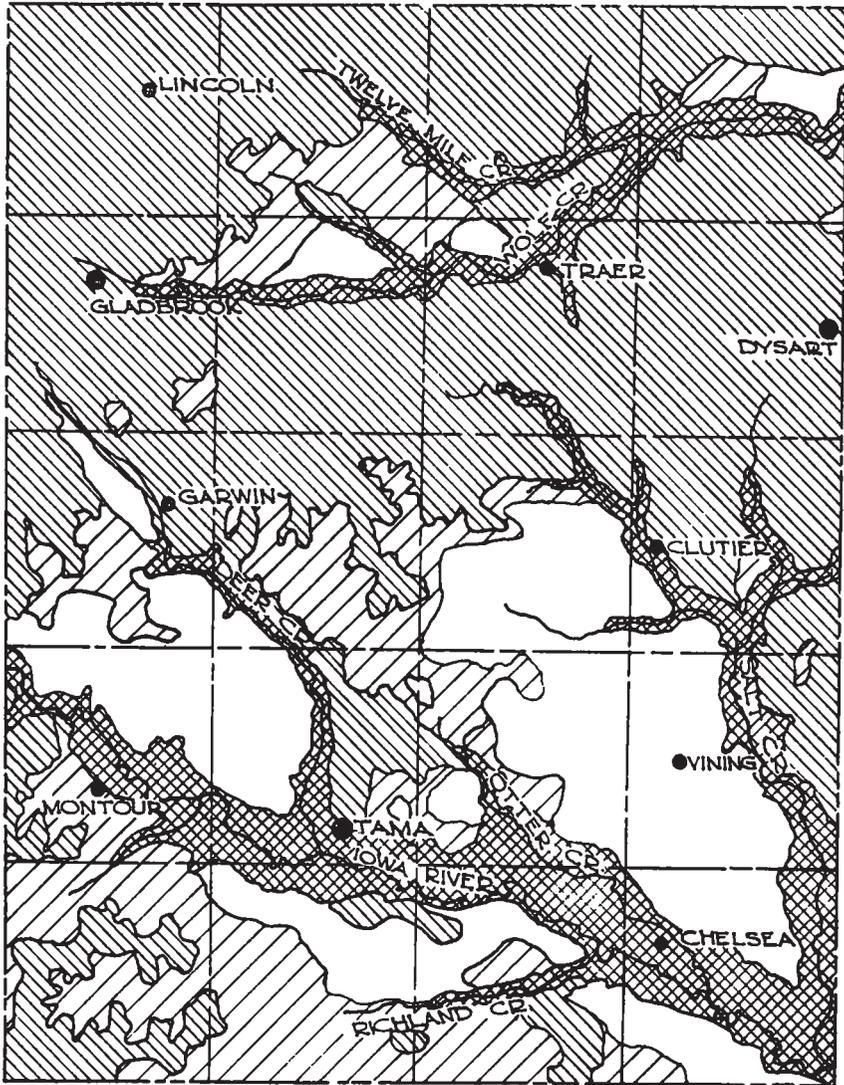
The topography of Tama County can be discussed more conveniently by reference to a sketch map showing four general soil areas (fig. 2), each so named as to indicate a few of the more important features. These areas are (1) undulating to level dark-colored soils of the uplands, (2) rolling to hilly dark-colored soils of the uplands, (3) light-colored soils of the uplands, and (4) soils of the flood plains.

The general area of undulating to level dark-colored soils of the uplands is predominantly undulating, with local differences^a in elevation ranging from 10 to 30 feet (pl. 1, A). The land surface includes a number of nearly level ridge crests or divides irregular in outline and commonly ranging up to one-fourth mile in width. Some of these, as the one between the Iowa River and Wolf Creek drainage basins, extend for many miles. The total acreage of these level divides, however, is less than that of the gentle slopes that form the sides of the ridges and even the ridge crests in more dissected areas. Slopes between the ridge tops and the upland drainageways usually range from 3 to 8 percent in gradient. These slopes comprise the major part of this general area.

The general area of rolling to hilly dark-colored soils of the uplands has a more dissected land surface, with stronger slopes and fewer level upland areas. The narrow ridge crests are usually rounded, though a few are nearly level, and the ridge slopes above the flood plains range from 8 to 20 percent in gradient. The steepest slopes usually occur near the heads of drainageways. Flood plains of the upland drainageways are narrow and ordinarily gently sloping in this part of the county. Local differences in elevation range from 60 to 120 feet.

The topography of the general area of light-colored soils of the uplands is more hilly than those of the other two upland areas. It might be called a hilly-level topography because it consists of narrow nearly flat ridge tops separated by much wider, hilly slopes (16 to 25 percent). In places, the ridge crests are rounded, but all lie at about the same elevation. The area as a whole has been highly dissected and has moderate relief, local differences in elevation ranging from 100 to 160 feet (pl. 1, B). As in the area of rolling to hilly dark-colored soils of the uplands, the steepest slopes are near the heads of the upland drainageways.

^aLocal, as used here, refers to common differences in elevation within a quarter section, or 160-acre tract.



-  Undulating to level dark-colored soils of the uplands (chiefly Tama and Muscatine)
-  Rolling to hilly dark-colored soils of the uplands (chiefly Tama, Carrington, and Downs)
-  Light-colored soils of the uplands (chiefly Fayette and Lindley)
-  Soils of the flood plains (chiefly Wabash)

FIGURE 2.—Distribution of the general soil areas of Tama County, Iowa.

The general area of soils of the flood plains includes not only the flood plains of the major streams but also some stream terraces. Most of the general area has a nearly level or flat topography. In some instances, as in the flood plain of the Iowa River, many old channels and small ox-bow lakes leave the surface undulating. The flood plains are generally wide for the size of the stream channel (pl. 1, *C*), the average widths being about 2 miles along the Iowa River and about 1 mile along Wolf and Salt Creeks. In a small area 3 miles north and northwest of Montour, outcrops of limestone along the Iowa River Valley have restricted the width of the flood plain to one-half mile.

Two major streams, the Iowa River and Wolf Creek, together with their tributaries drain all the county. The Iowa River, a slow meandering stream with a fall of slightly more than 2 feet per mile, enters Tama County about 4 miles northwest of Montour and flows southeast by east to leave the county just north of the southeastern corner. The larger tributaries of the Iowa River in the county, which include Deer, Otter, Richland, and Salt Creeks, have steeper gradients than the river. Rates of fall are as much as 5 to 10 feet a mile along the upper reaches of these creeks. The Iowa River and its tributaries drain approximately the southern two-thirds of the county. The remaining third is drained by Wolf Creek, which enters the county near its junction with Marshall and Grundy Counties and flows eastward through Gladbrook and Traer to leave the county about 6 miles north of Dysart. The average fall of the channel of Wolf Creek is nearly the same as that of the Iowa River. Smaller drainageways branch out from Wolf Creek as they do from the Iowa River and its tributaries to reach nearly all parts of the uplands.

SOIL PARENT MATERIALS

The nature of the soils of any locality depends upon the combined influences of several factors, one of which is the kind of material from which the soils have been formed. Three important kinds of parent materials have left their marks upon the types of soils—loess, glacial drift, and alluvium. Each is described briefly in subsequent paragraphs. A fourth kind of parent material, which is of limited extent and of little importance, is the limestone exposed along the Iowa River Valley north and northwest of Montour. The limestone outcrops on steep slopes, and soils with distinct profiles have not been formed from the limestone materials.

Loess deposits cover slightly more than four-fifths of the uplands. The loess, which consists of uniform, silty sediments laid down by wind, varies in thickness from place to place. On the level uplands in the northern part of the county the average thickness is approximately 10 feet, but on the level uplands in the southern part the loess is about 20 feet thick. In the more rolling areas, it ranges from a few inches to as much as 20 feet. Thickness of the loess on more level sites is greater in the western and northwestern than in the eastern parts.

Much of the loess is a light yellowish-brown slightly acid silt loam. Where the thickness exceeds 10 feet, the lower part of the loess is a light olive-gray to yellowish-gray silt loam, often mottled with weak and dark orange. The light yellowish-brown loess is usually leached free of carbonates, whereas the light olive-gray deeper sections are usually calcareous.

Glacial drift consists of the materials laid down by ice or by waters flowing out from the ice. Deposits of glacial till—glacial drift left in place by the melting of ice—are unsorted mixtures of clay, silt, sand, gravel, and boulders in variable proportions. Not all the sediments are present in every deposit. For example, in Tama County there are few boulders and only small quantities of gravel in the till. Glacial drift covers nearly all of the county, but it in turn has been largely covered by a mantle of loess. Drift is exposed at the surface or has contributed part of the material for the soil profile in approximately one-fifth of the uplands.

The exposures of glacial drift follow no definite pattern. In general, exposures are larger and more numerous in hilly sections, but some of the steeper slopes are completely covered by loess. Glacial drift is more often exposed on lower than on upper slopes, but it is possible to find drift near the top of a hill and loess on the lower part. Exposures of drift are largest and most common in the general areas of light-colored soils of the uplands and rolling to hilly dark-colored soils of the uplands.

Alluvium consists of sediments that have been moved and laid down by water. While being moved these sediments are sorted to some extent, and deposits of alluvium do not contain the wide range of particle sizes found in glacial drift. Alluvial deposits, however, are seldom as well sorted as loess. For example, alluvium may consist of silt and clay, silt and sand, or sand and gravel. In Tama County, the alluvium is derived from loess and glacial drift and therefore consists largely of a mixture of silts and clays. Where the sediments have accumulated at the foot of the slope on which they originated, the materials are referred to as colluvium or local alluvium. Alluvial sediments are parent materials for soils of flood plains, terraces, and upland drainageways.

CLIMATE

Tama County has a humid continental climate with warm summers, sometimes called "Corn Belt climate" because of its suitability for corn. The summers are long, hot, and humid, with a high absolute humidity resulting in many warm nights, which are excellent for corn growth. The winters are moderately cold but with alternating periods of subzero and mild temperatures.

The temperature varies greatly between summer and winter, the mean temperature for summer being 71.3° F., and for winter, only 21.5°. The difference between the mean temperatures of the hottest and the coldest months—July, 73.4° and January, 18.2°—is 55.2°. The highest and lowest temperatures on record are 109° (July 1901) and -31° (January 1912). The average frost-free season of 152 days extends from May 4 to October 3, but killing frosts have occurred as late as May 31 and as early as September 11. Severe damage to corn by frost rarely occurs, and, unless the summer is exceptionally cool, the frost-free season is adequate for the crop to mature. The grazing season is approximately 180 days, from about the middle of April to the middle of October, although there is some grazing during the rest of the year, depending on the condition of pastures and the snowfall.

The mean annual rainfall is 34.07 inches, most of which (21.48 inches, or about 63 percent) comes in the 5 months May to September. Only 3.36 inches, or 10 percent of the annual average, occurs during

the dry, cold months of December, January, and February. Most of the snowfall occurs during this period. The total rainfall varies from year to year, with extremes of 15.93 inches (1894) and 51.99 inches (1902). Although some wide variations exist in the yearly rainfall, it is usually within the range of 25 to 42 inches. Severe droughts rarely occur, but occasionally crop yields are decreased by short periods of dry weather associated with high temperatures. Many of the rains are slow and steady, but some are hard and occasionally accompanied by severe wind and thunderstorms.

The wind velocity is usually gentle, but in summer occasional windstorms damage crops to some extent. Tornadoes and hailstorms are rare and occur in localized areas. The prevailing wind direction is from the northwest in winter and from the south and southwest in summer. With the exception of the occasional summer storms, the wind velocity is greatest in spring.

Because of the relatively uniform elevation above sea level—less than 300 feet variation within the county—the climate is similar throughout all parts, although a few minor local variations do exist because of slope exposure and deep narrow valleys. The steep slopes with northern exposures generally are more humid and cooler, and the deep narrow valleys are protected to some extent from the influence of the winds. Such large local variations in climate as occur in mountainous regions, however, do not exist in this county.

The normal monthly, seasonal, and annual temperature and precipitation, as recorded by the United States Weather Bureau station at Toledo, Iowa, are given in table 1.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Toledo, Tama County, Iowa¹

[Elevation, 929 feet]

Month	Mean temperature	Precipitation		
		Mean	Total for the driest year	Total for the wettest year
	^{°F.}	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
December.....	24. 2	1. 15	0. 88	1. 40
January.....	18. 2	1. 08	. 72	1. 10
February.....	22. 1	1. 13	. 60	. 80
Winter.....	21. 5	3. 36	2. 20	3. 30
March.....	34. 8	1. 92	2. 53	1. 90
April.....	49. 6	2. 89	1. 86	1. 91
May.....	60. 6	4. 40	. 55	7. 30
Spring.....	48. 3	9. 21	4. 94	11. 11
June.....	69. 1	4. 81	2. 50	10. 50
July.....	73. 4	3. 83	. 05	8. 50
August.....	71. 3	3. 68	. 96	9. 35
Summer.....	71. 3	12. 32	3. 51	28. 35
September.....	64. 3	4. 76	2. 61	4. 50
October.....	52. 2	2. 53	1. 70	2. 16
November.....	37. 2	1. 89	. 97	2. 57
Fall.....	51. 2	9. 18	5. 28	9. 23
Year.....	48. 1	34. 07	² 15. 93	³ 51. 99

¹ From U. S. Weather Bureau records.

² In 1894.

³ In 1902.

VEGETATION

The native vegetation of Tama County included two main associations—that of tall grasses and that of oak-hickory forest. The association of tall grasses covered much of the upland, especially the general areas of undulating to level dark-colored soils of the uplands. Tall-grass vegetation also covered most of the area of rolling to hilly dark-colored soils of the uplands. The trees of the oak-hickory association occupied the general areas of light-colored soils of the uplands and of soils of the flood plains. From the nature and distribution of soil types, it appears that the forest invaded the grassland by following the major stream valleys and gradually spreading out from these valleys into the uplands.

PURPOSE AND METHODS OF SOIL SURVEYS (22)

The chief purpose of soil surveys is to provide accurate soil maps for use in classifying, interpreting, and applying data regarding agricultural production. In agronomic work, for example, it is not possible to conduct trials on each soil in every field in a State; trials can be made only on a limited number of soils and fields. Consequently, there must be some means whereby information obtained from trials in one locality can be extended to others. Such means exist when the different kinds of soils and their locations are known. Information obtained in experimental trials or by farmer experience can then be transferred from one area to others of the same or similar soils.

The degree of detail and precision needed in a soil map varies from one landscape to another. For example, a map of a county in the Corn Belt must show more and smaller soil differences than a map of a county in the range lands of the Great Plains. Smaller areas and smaller differences in soils are important to the success or failure of a farmer in the Corn Belt. Smaller areas must therefore be shown on the maps and finer distinctions made in the classification of soils. In both the Corn Belt and the Great Plains, however, the function of the soil map is the same—to aid in the classification and extension of information regarding the use suitability and management requirements of different soils.

Soil maps are prepared by means of soil surveys, the first part of which is the examination, classification, and mapping of soils in the field. Soil maps are commonly made for county areas, but occasionally parts of one or more counties may be selected, as for example irrigated areas in the West.

The first step in making a soil survey is to examine the soils in a number of places. Highway and railroad cuts are studied, pits dug, and borings made with a soil auger. Each excavation exposes a series of individual soil layers, or horizons, termed collectively the soil profile. Descriptions of the separate horizons in soil profiles are prepared, and samples are often collected for laboratory analyses. Each horizon of the profile as well as the underlying material is studied in detail by noting the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone. The reaction (degree of acidity) and the presence of lime or salts are

determined by simple tests. Other factors considered are the drainage, both internal (through the soil) and external (over the soil), the topography, or lay of the land, and the interrelations between soil and vegetation.

The soils are classified on the basis of observed characteristics, both internal and external, with special emphasis upon features that influence their adaptation for the production of crop plants, grasses, and trees. The principal three units in classification are (1) series, (2) type, and (3) phase. The types and phases constitute mapping units recognized in the survey. In addition to these two, certain areas have such intricate patterns of soil types or phases that they are mapped as complexes. Complexes are areas in which two or more of the above units of classification form such an involved pattern that the individual types or phases cannot be separated on the scale used. Another mapping unit is the miscellaneous land type that consists of areas where no true soil profiles have been formed (for example, Rough broken land).

The series is a group of soils having the same genetic horizons, which are alike in their important characteristics and arrangement in the profile, and overlie similar parent material. Thus, the series includes profiles having essentially the same arrangement of horizons and the same thickness, color, texture, structure, and consistence. Series are given geographic names selected in the localities where they were first identified. Tama, Fayette, and Wabash, are names of important series in Tama County.

Within a soil series there may be one or more types, defined according to the texture of the upper layers of the profile. Soil types are named by combining the name of the texture class of the upper layers with the name of the series. Wabash silt loam and Wabash sandy loam are soil types within the Wabash series. Except for the texture of the surface soil, the types within a series have substantially similar properties throughout the profile.

The phase is a subdivision of the soil type, separated because of some feature of practical significance. Features used for differentiating phases within a type are generally external, involving slope, stoniness, and degree of erosion. Fayette silt loam, for example, is divided into four phases because of differences in slope and erosion: (1) Fayette silt loam, level phase; (2) Fayette silt loam (the normal, or undulating, phase); (3) Fayette silt loam, eroded gently rolling phase; and (4) Fayette silt loam, eroded rolling phase. In each type subdivided into phases in this way, one phase is usually of more common occurrence than the others. This is regarded as the normal phase, and for it, the name of the type is used alone without phase designation. Thus, of the four phases of Fayette silt loam, the undulating phase is considered the normal phase, and it is designated on the map merely by the type name, Fayette silt loam. In comparing the named phases with the normal phase of a type, reference in the text is frequently made to the normal phase of the type.

After the soils of the county have been carefully studied, a legend is prepared. It consists of a list and description of the different soil types and phases to be shown in the field work. The next step is to obtain or prepare a suitable base map on which to delineate the soils in the field. Aerial photographs constitute the most satisfactory base maps for

field use and are used whenever available. The topographic maps prepared by the United States Geological Survey also are good base maps. For a few counties or parts of counties, however, no satisfactory base map is available, and the soil surveyor must prepare his own. These are usually prepared by road traverses with a plane table.

When both the legend and the base map are ready, the boundaries of the different soil types and phases can be located and indicated by symbols. In locating the boundaries of these mapping units, the surveyor traverses the area at intervals of one-quarter mile, one-half mile, or whatever interval will allow him to observe each boundary throughout its entire course. It is sometimes necessary to go out from the line of traverse to make sure of the location of a boundary, but it is seldom necessary to traverse a boundary through its entire course to see where it is located. After the field sheets for the map are completed they show the location of the soils with respect to roads, railroads, houses, streams, lakes, section and township lines, and other cultural and natural features of the landscape.

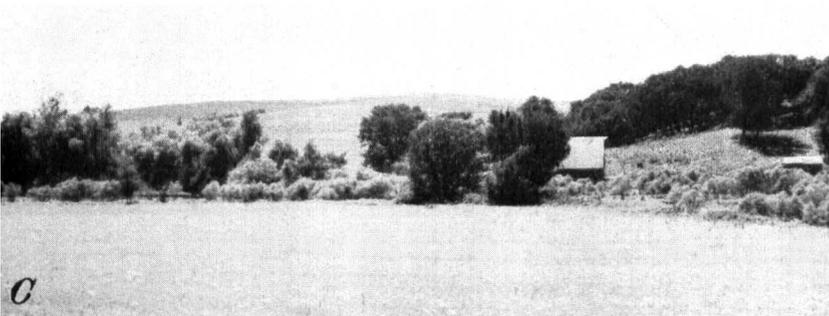
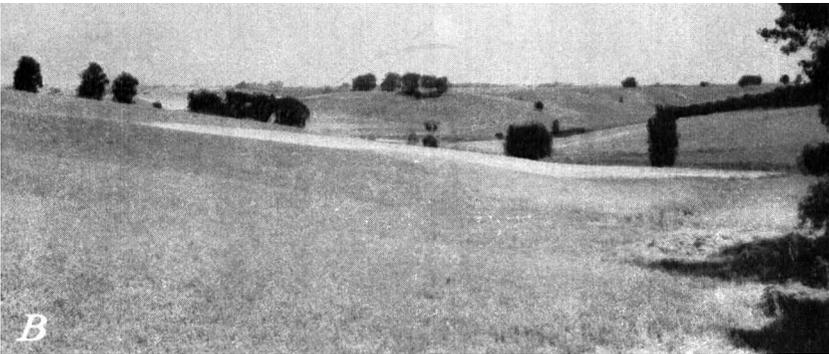
After the field work is completed for a county, a colored map on a suitable scale is compiled from the field sheets; a report is prepared to summarize information gained in the survey; and the text and the map are published together as a soil-survey report.

SOILS OF TAMA COUNTY

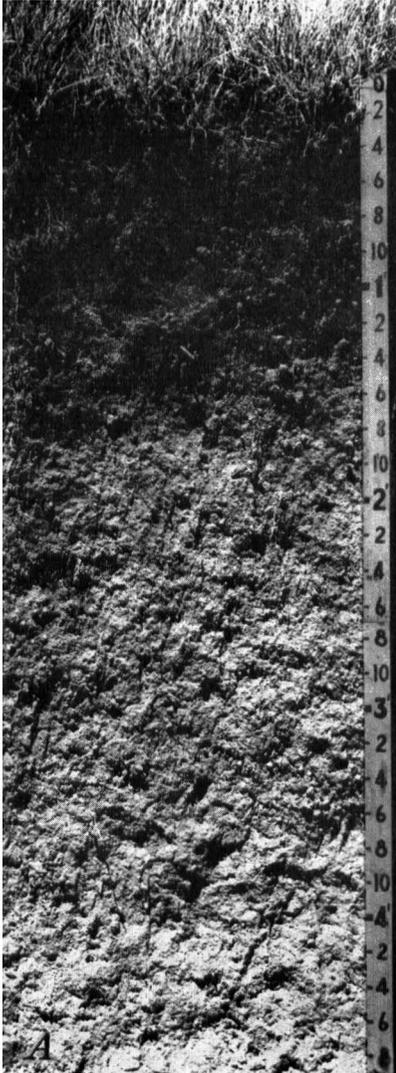
The soils of Tama County are discussed (1) in terms of their general relationships and (2) in terms of the characteristics of each type and phase. First is a general discussion of the formation and nature of soils. It includes a grouping of the soil series in seven classes and a brief discussion of each. The geographic location of the soils of the county with respect to those of Iowa as a whole is also indicated. In the second part of the discussion the individual soils, listed alphabetically by series, are described. These descriptions include information on the mode of occurrence, distribution, slope, drainage, erosion, productivity, present use, and special problems of use and management.

FORMATION AND NATURE OF SOILS

The formation of soil is a very slow process that goes on in three overlapping steps. First of all, parent material must accumulate, either by the break-down of bedrock in place or by the deposition of weathered rock by water, wind, or ice. After the parent material has accumulated, or sometimes while it is accumulating, simple forms of life, as bacteria and fungi, invade the mass of loose rock. As they grow, multiply, and die, their bodies decay slowly in the rock debris and thus organic matter begins to accumulate. The gradual accumulation of organic matter, the second step in the formation of soil, is due only in part to the activity of micro-organisms. It is due in large measure to higher forms of plants, as trees and grasses, which soon follow the lower forms in growing on weathered rock materials. These higher forms profoundly influence the soil-forming processes. As they continue to grow, the upper layers of the loose and broken mass of soil parent material are slowly changed and begin to differ



- A. An area of undulating to level dark-colored soils of the uplands; bluegrass pasture on Wabash silt loam in the foreground; corn and oats on Tama and Carrington soils in the background.
- B. An area of light-colored soils of the uplands; alfalfa on Fayette silt loam, eroded rolling phase, in foreground; permanent pasture on the rolling to hilly areas of Fayette and Lindley soils in the distance. Trees along fence lines and drainageways persist from the original forest cover even in rolling areas where most of the land is cleared.
- C. One of the more dissected parts of Tama County; Wabash silt loam in the small flood plain in the foreground; the partly wooded hills are on Lindley-Fayette silt loams, eroded phases



A, Profile of Tama silt loam, showing dark-colored A horizon, transitional layer (B horizon), and lighter colored (moderate yellowish brown) C horizon (parent material). The soil was formed from loess under a grass vegetation.

B, Profile of Fayette silt loam, developed from the same loess as Tama silt loam but under a forest vegetation. The profile shows a light-colored A horizon with a thin layer of darker material near the surface, a slightly darker colored heavier textured B horizon, and an underlying C horizon (parent material)

from the lower ones. This is the beginning of the development of the soil profile, the last step in the formation of soil.

A soil profile, which can be seen on the walls of a freshly dug pit or in a new road cut, consists of the succession of layers, or horizons, in a vertical section down through the soil. In most profiles these horizons grade into one another and are separated by transitional zones rather than by sharply defined boundaries. Some profiles do include horizons that are set apart by distinct boundaries, but such soils are not common in Iowa. In most of the upland soils of Iowa, the profile consists of a deep dark-colored surface horizon merging with a transitional lighter colored layer that separates it from the parent material beneath. The first, or uppermost, of these layers is the A horizon, commonly known as the surface soil; the second is the B horizon, sometimes called the subsoil; and the third is the C horizon, often called the parent material. All three horizons, the dark-colored, the transitional, and the upper part of the parent material, ordinarily occur within a depth of 5 feet.

The first step in soil formation, namely, the accumulation of parent material, is a geologic rather than a soil-forming process. The breaking down of rock and the transportation of the weathered material are forerunners of soil formation; such processes do not in themselves give rise to soils. Occasionally, the third step begins before the rock is fully broken down and soon gives rise to a very young soil. In an area as large as the State of Iowa, soils can be found in all the different stages of formation, ranging from sand bars recently laid down by the Mississippi River to

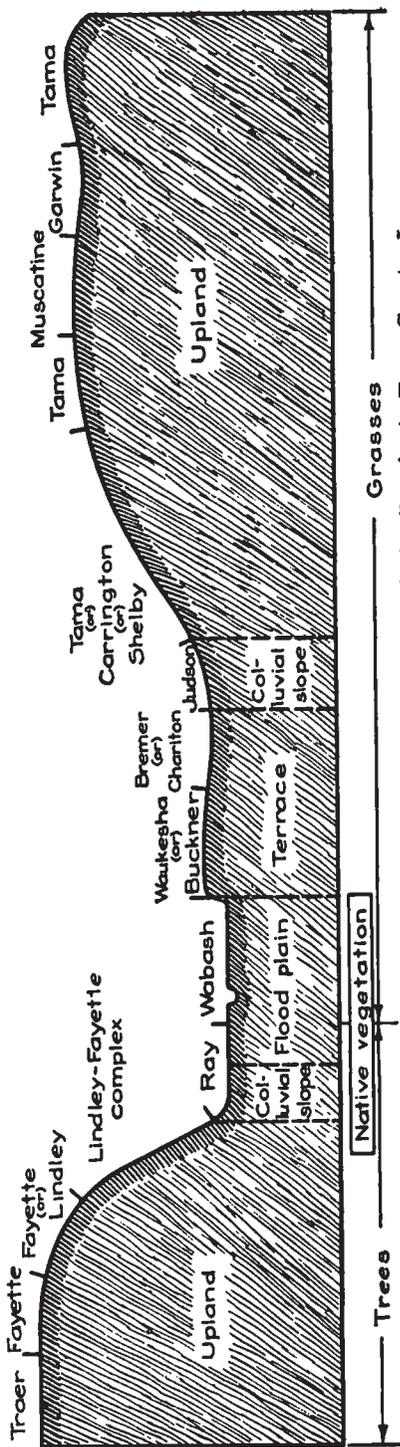


FIGURE 3.—Physiographic position and common slopes of the principal soil series in Tama County, Iowa.

soils with well-defined profiles. Most of the soils used for crops in Iowa have advanced beyond the stage of accumulation of soil parent materials and have reached the third step in soil formation—the development of the profile.

Although the same steps occur in the formation of every soil, the processes operating in each of the three steps differ from place to place. The deposition of soil parent material by wind leaves a well-sorted, fine-textured sediment, whereas the materials left by ice are unsorted and include particles that range in size from huge boulders to the finest clays. The soils formed from each of these two types of parent material differ in a number of important respects. Similarly, soils formed under different climatic conditions or under different types of native vegetation on identical parent materials will not be the same, once profile development has begun.

The nature of soils is determined by the combined influences of climate, native vegetation, parent material, topography, and age (the interval during which a soil has been developing). Regional differences in the nature of soils, as between those of Iowa and Maine, are caused by the effects of climate and native vegetation. Local differences, as those within a county, are more commonly due to parent material, topography, and age, but they may also be due to native vegetation, or in mountainous areas, to climate.

In Tama County, the differences among the soils are due to native vegetation, parent material, topography, and age. The effect of native vegetation is clearly shown by the differences between the Tama and Fayette soils (pl. 2). The Tama is a dark-colored soil developed under tall-grass vegetation, whereas the Fayette is a light-colored soil developed under oak-hickory forest. Yet both soils are derived from the same parent material, occur on the same kind of topography, and have developed under the same climate. The effect of parent material is indicated by the Tama and Carrington soils, which have been formed from loess and glacial drift, respectively. Both were formed under grass vegetation in areas with undulating to hilly topography. The effects of topography are demonstrated by comparing Muscatine soils in nearly level uplands with Tama soils in rolling uplands, both soils being underlain by loess and originally covered by tall-grass vegetation (fig. 3). The influence of age in soil formation is illustrated by the differences between the Waukesha and Wabash soils. Both are derived from alluvial sediments, but the Waukesha occupies stream terraces well above overflow, and the Wabash is occasionally flooded and receives additional sediments.

SOIL SERIES AND THEIR RELATIONS

For ease of discussion and to bring out certain interrelations, the soil series in Tama County are placed in seven groups, the grouping based chiefly on (1) colors of the soil profile, (2) natural drainage conditions, and (3) topography. In addition to the soil series, there is one land type, Rough broken land, that lacks an evident soil profile. The seven groups of series and the land type are discussed briefly in the following paragraphs. All groups are listed and the principal characteristics of the individual series and the land type are given in table 2.

TABLE 2.—Principal characteristics of the soil series of Tama County, Iowa

Soil groups, series, and land types	Parent material	Topographic position	Topography	Drainage		Subsoil consistence	Original vegetation
				Natural internal ¹	External		
Dark-colored well-drained soils:							
Tama	Loess	Uplands	Nearly level to hilly.	Good	Good to excessive.	Friable	Grassland.
Waukesha	Old alluvium ²	Terraces	Level to slightly undulating.	do	Slow to good	do	Do.
Carrington	Glacial drift	Uplands	Undulating to rolling.	do	Good to excessive.	do	Do.
Shelby	do	do	Gently rolling to hilly.	Imperfect to good	do	Moderately compact	Do.
Medium-colored well-drained soils:							
Downs	Loess	do	Level to rolling	Good	Good to rapid	Friable	Mixed forest and grassland.
Light-colored well-drained soils:							
Fayette	do	do	Nearly level to hilly.	do	Good to excessive.	Moderately compact	Forest.
Lindley	Glacial drift	do	Gently rolling to hilly.	do	do	do	Do.
Dark-colored imperfectly to poorly drained soils of uplands and terraces.							
Muscatine	Loess	do	Flat	Imperfect	Slow	Moderately friable	Grassland.
Garwin	Mixed loess and alluvium.	do	Slightly depressed	Poor	do	Plastic	Do.
Bremer	Old alluvium ²	Terraces	do	do	do	Moderately compact	Do.
Medium-colored poorly drained soils of uplands and terraces:							
Chariton	do	do	do	do	do	Compact	Do
Traer	Loess	Uplands	Flat	do	do	do	Forest.
Sandy soils							
Thurman	Wind-blown sand	do	Undulating to rolling.	Excessive	Good	Loose	Grassland.
Chelsea	do	do	do	do	do	do	Forest.
Buckner	Alluvial sand	Terraces	Undulating	do	do	do	Grassland.
Alluvial soils:							
Judson	Colluvium	Colluvial slopes	Level to undulating.	Fair to good	do	Friable	Do.
Wabash	Alluvium	Flood plains	Level	Imperfect to good	Slow	Moderately friable	Forest.
Ray	Alluvium and colluvium.	Flood plains and colluvial slopes.	Level to undulating.	do	do	do	Do.
Sawmill	Alluvium	Flood plains	Depressed	Poor	Very slow	Moderately compact	Do.
Miscellaneous land types:							
Rough broken land	Mixed loess and glacial drift over limestone.	Uplands	Hilly	Good	Excessive	Friable	Grassland and forest.
Wabash soils, undifferentiated. ³	Alluvium	Flood plains	Level	Imperfect to good	Slow	Variable	Forest.

TAMA COUNTY, IOWA

¹ Natural condition of drainage without tile or other artificial drainage.
² In many places the parent material is loess deposited on an old terrace. In the future these areas will be included with similar upland soils.

³ Subject to frequent overflow.

DARK-COLORED WELL-DRAINED SOILS

The group of dark-colored well-drained soils comprises the Tama, Carrington, Waukesha, and Shelby series. This group has the largest acreage of any of the seven. Among its four series, Tama soils are the most extensive and Shelby the least. Tama soils occur widely in the general areas of undulating to level dark-colored soils of the uplands and of rolling to hilly dark-colored soils of the uplands; the Carrington and Shelby occur mainly in the second of these two general areas; the Waukesha in the general area of soils of the flood plains.

The four series are members of the great group of Prairie soils. All have dusky-brown surface layers (horizons) grading through moderate yellowish-brown transitional layers into the light yellowish-brown parent material. All were formed under tall-grass vegetation with good natural drainage. The soils differ, however, because of the parent materials or the topography under which they were formed. The Tama soils were developed from loess in uplands; the Waukesha from alluvium in stream terraces. The Carrington soils differ from the Tama in having been formed from medium-textured glacial drift rather than loess. The Shelby soils also were formed from glacial drift, but of a finer texture and more deeply weathered.

MEDIUM-COLORED WELL-DRAINED SOILS

The medium-colored well-drained soils include only the Downs series. The series is not extensive. It occurs chiefly in the general area of rolling to hilly dark-colored soils of the uplands, although a few bodies are included in the area of light-colored soils of the uplands.

The Downs soils were formed from loess either under a mixed vegetation of trees and grasses or in places where forest long ago invaded and occupied Prairie soils. The profile is intermediate between those of the Tama and Fayette series. The surface layer is lighter colored than that of Tama soils but darker than in the Fayette. The subsoil layer, on the other hand, is more distinct than in the Tama profile but less distinct than in the Fayette.

LIGHT-COLORED WELL-DRAINED SOILS

The Fayette and Lindley series belong to the group of light-colored well-drained soils. The group as a whole occurs mainly in the southern half of the county in the general area of light-colored soils of the uplands. Of the two series, the Fayette is much the more extensive.

These series are members of the great group of Gray-Brown Podzolic soils, formed under deciduous forest vegetation. The profiles consist of light brownish-gray upper layers over a moderate-brown subsoil that merges with the parent material. The Fayette soils were developed from loess; the Lindley from glacial drift. Moreover, the Fayette soils are generally less rolling or hilly than the Lindley.

DARK-COLORED IMPERFECTLY TO POORLY DRAINED SOILS OF UPLANDS AND TERRACES

The group of dark-colored imperfectly to poorly drained soils of the uplands and terraces consists of the Muscatine, Garwin, and Bremer series, of which Muscatine is the most extensive and Bremer the least. The Muscatine and Garwin soils are commonly associated with Tama soils in the general area of undulating to level dark-colored soils of the uplands. Bremer soils, on the other hand, are restricted to the general area of soils of the flood plains.

The soils of this group were formed under grass vegetation in nearly level, flat, or slightly depressed positions. All have brownish-black to black surface layers overlying lighter colored layers that are frequently mottled. Colors of the deeper layers range from weak yellow to medium olive gray, and the mottlings vary from weak orange to strong brown. Generally, the deeper layers of the Muscatine profile have slightly brighter colors and better natural drainage than those of the other two.

MEDIUM-COLORED POORLY DRAINED SOILS OF UPLANDS AND TERRACES

The group of medium-colored poorly drained soils of the uplands and terraces are of the Chariton and Traer series, both of which occupy small total acreages. The Chariton soil occurs on old terraces within the general area of soils of the flood plains, whereas the Traer is in flat or slightly depressed upland sites in the general area of light-colored soils of the uplands.

These soils are Planosols and have a fine-textured, firm, and plastic subsoil. The Chariton was formed from silty alluvium under grass vegetation, and the Traer from loess under forest vegetation. The Chariton has the darker surface layer. Both have light-colored leached layers beneath the immediate surface layer, and both have evident claypans deeper in the profile.

SANDY SOILS

The group of sandy soils consists of the Chelsea, Thurman, and Buckner series. All three belong to the great soil group of Dry Sands. The Chelsea and Thurman series are upland soils developed from wind-borne sands and are distinguished on the basis of color of the surface layer, the Chelsea being light-colored in this layer, the Thurman dark-colored. The Buckner series closely resembles the Thurman in profile but was formed from alluvial sands in stream terraces. The Thurman and Chelsea soils occur principally in the uplands adjacent to the Iowa River flood plain.

ALLUVIAL SOILS

The group of Alluvial soils comprises the Wabash, Ray, Judson, and Sawmill series. These series are the principal ones in the general area of soils of the flood plains and extend into all other general soil areas along the upland drainageways. The aggregate acreage is slightly more than that of light-colored well-drained soils. The Wabash series is the most extensive of the group.

These soils were derived from alluvial sediments in flood plains and fans or from colluvial materials in toe slopes under a mixed vegetation of trees and grasses. The alluvial materials were deposited during recent geologic time and additional deposits are now being made, especially on the Wabash, Ray, and Sawmill soils. Most areas of the Judson soil now lie above overflow; the Sawmill soil occupies depressions in the flood plains and is marked by very poor natural drainage, which is indicated by the vegetation.

SOIL TYPES AND PHASES

In the following pages the soils are described in alphabetical order,⁴ their relation to agriculture indicated, and problems of their use and

⁴When a soil type has been subdivided into phases, that part of the type that bears no phase name will be referred to as the normal phase of the type.

management discussed. More complete discussions of use and handling are given in later sections. The location and distribution of each soil are shown on the accompanying soil map, and the acreage and proportion of each are given in table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Tama County, Iowa*

Soil type	Acres	Percent
Bremer silt loam.....	1, 792	0. 4
Bremer silty clay loam.....	192	(¹)
Buckner sandy loam.....	320	. 1
Carrington loam ²	384	. 1
Eroded gently rolling phase.....	1, 472	. 3
Carrington silt loam ²	11, 520	2. 5
Eroded gently rolling phase.....	9, 152	2. 0
Eroded rolling phase.....	4, 672	1. 0
Chariton silt loam.....	320	. 1
Chelsea loamy fine sand.....	512	. 1
Downs silt loam ²	4, 992	1. 1
Eroded gently rolling phase.....	2, 496	. 5
Eroded rolling phase.....	3, 264	. 7
Level phase.....	1, 856	. 4
Fayette-Chelsea complex.....	320	. 1
Eroded rolling phases.....	960	. 2
Fayette silt loam ²	14, 784	3. 2
Eroded gently rolling phase.....	5, 760	1. 3
Eroded rolling phase.....	11, 136	2. 4
Level phase.....	5, 376	1. 2
Garwin silty clay loam.....	5, 184	1. 1
Judson silt loam.....	8, 448	1. 9
Lindley-Fayette silt loams.....	11, 520	2. 5
Eroded phases.....	20, 352	4. 5
Lindley silt loam ²	3, 264	. 7
Gently rolling phase.....	896	. 2
Muscatine silt loam.....	8, 448	1. 9
Ray silt loam.....	9, 088	2. 0
Rough broken land.....	320	. 1
Sawmill silty clay loam.....	768	. 2
Shelby loam ²	1, 024	. 2
Eroded hilly phase.....	2, 112	. 5
Tama silt loam ²	35, 904	7. 9
Eroded phase.....	60, 672	13. 3
Eroded gently rolling phase.....	9, 216	2. 0
Eroded hilly phase.....	1, 152	. 3
Eroded rolling phase.....	4, 352	1. 0
Gently rolling phase.....	9, 856	2. 2
Level phase.....	64, 064	14. 0
Tama-Thurman complex.....	640	. 1
Eroded rolling phases.....	960	. 2
Thurman loamy fine sand.....	192	(¹)
Traer silt loam.....	64	(¹)
Wabash-Judson silt loams.....	28, 096	6. 2
Wabash sandy loam.....	192	(¹)
Wabash silt loam.....	50, 560	11. 1
Wabash silty clay loam.....	9, 344	2. 0
Wabash soils, undifferentiated.....	10, 176	2. 2
Waukesha loam.....	448	. 1
Waukesha silt loam.....	17, 728	3. 9
Total.....	456, 320	100. 0

¹ Less than 0.1 percent.

² The normal phase of the type.

Bremer silt loam.—This soil occupies slightly depressed areas in terraces along the Iowa River and larger creeks. In such positions it is associated with Waukesha silt loam. In a few places, however, the soil type occurs as a very low terrace that merges with the flood plain and is hard to distinguish from it. Individual areas are usually small, a few ranging up to 50 acres. The total area is 1,792 acres.

A profile description follows:

- 0 to 17 inches, black or brownish-black friable silt loam; medium to strongly acid.
- 17 to 28 inches, variegated weak-brown, weak-yellow, and yellowish-gray friable to firm silty clay loam; medium to strongly acid.
- 28 to 60 inches, mottled weak-yellow, light olive-gray, and dark-orange silty clay which is moderately plastic when wet and firm when dry; medium to strongly acid.

A few areas of Bremer silty clay loam and Chariton silt loam, too small to be mapped separately, are included with this soil.

Use and management.—Practically the entire acreage is used for crops. The yields in favorable years are equal to those obtained on soils with better natural drainage. A major problem in maintaining high productivity is providing adequate drainage. The soil is fertile, lies well, and is not subject to erosion. Soybeans and corn can be grown extensively after drainage is improved.

Bremer silty clay loam.—This soil occupies slightly depressed areas associated with Bremer silt loam and other soils on stream terraces. The total extent is small (192 acres). The soil is similar to the silt loam except that the texture is heavier throughout and the deeper layers are less friable. Because of the position and texture of the soil, natural drainage is poorer than in the silt loam and can be improved only with difficulty. The use and management of the two soils are closely alike, but yields are lower on this type, especially during wet years.

Buckner sandy loam.—This minor soil type covers only 320 acres. It occupies small knolls with slopes of less than 5 percent and generally occurs in association with Waukesha soils of the terraces.

A profile description follows:

- 0 to 6 inches, weak-brown nearly loose sandy loam, medium to strongly acid.
- 6 to 18 inches, dark yellowish-brown to brownish-gray loose loamy sand or sandy loam; medium to strongly acid.
- 18 to 48 inches, light to moderate yellowish-brown loose loamy sand or sand that occasionally contains some gravel; medium to strongly acid.

Use and management.—Most of Buckner sandy loam is cultivated. Yields are generally low, even in years with average rainfall, and they are extremely low in dry years. Although crops respond well to applications of manure and fertilizer, these materials will probably bring greater returns when applied to less sandy soils with higher levels of fertility. As a rule, available manure, fertilizer, and lime can be used to better advantage on other soils. When Buckner soil is cultivated, care must be exercised to keep down the danger of soil drifting. Where areas can be retired from cultivation and left in grass, the hazard of soil drifting will be reduced and long-time returns will be increased.

Carrington loam.—This, the normal phase of this type, is on undulating 3- to 8-percent slopes. It is a dark-colored soil formed from glacial till. In Tama County, Carrington soils usually occur on slopes

below loess-derived soils, especially the Tama and Downs soils. Drainage is good, but runoff is seldom rapid enough to cause serious erosion. The total acreage is 384 acres.

A profile description follows:

- 0 to 10 inches, weak to dusky-brown friable loam with medium strongly granular structure; strongly acid.
- 10 to 30 inches, moderate yellowish-brown friable sandy clay loam or light clay loam, sometimes gritty; strongly acid.
- 30 to 45 inches, light to moderate yellowish-brown moderately plastic light clay loam or heavy loam containing some gravel and rock fragments; medium to strongly acid.

Use and management.—Nearly all areas of Carrington loam are being cultivated. The exceptions are the occasional small isolated bodies associated with hilly soils. Corn is the most important crop, the average acre yields being about 45 bushels. Average acre yields of other crops are oats, 40 bushels; soybeans, 14 bushels; and clover-timothy hay, 1¼ tons. Fair to good yields of alfalfa also can be obtained when the soil is limed and fertilized.

Productivity can be readily maintained. Such maintenance requires the application of lime for legumes, especially for alfalfa, the addition of barnyard or green manure to replenish the supply of organic matter, and the choice of proper rotation. In the growing of intertilled crops, as soybeans or corn, it is desirable to use contour cultivation or strip cropping to reduce the rate of runoff. This will provide more moisture for the growing crop and cut down the possibility of harmful erosion.

Carrington loam, eroded gently rolling phase.—The eroded gently rolling phase is similar to the normal phase of the type in most characteristics but differs in degree of erosion and in slope. The thickness of the surface soil is somewhat less in the eroded phase, and there are more small severely eroded spots on the ends of the ridges or spurs. Slopes generally range from 8 to 12 percent, as compared with 3 to 8 percent for the normal phase. This phase covers only 1,472 acres.

Use and management.—Most of Carrington loam, eroded gently rolling phase, is cultivated, but the average yields of crops are about 20 percent less than on the normal phase. Management requirements are similar to those of the normal phase except that more emphasis should be placed on maintaining organic matter and more on the use of supplementary erosion-control practices. Because of its stronger slopes, this phase is not well adapted to the production of intertilled crops.

Carrington silt loam.—This, the normal phase of the type, is a Prairie soil formed from loess and glacial till in undulating uplands and occurs where the glacial drift is covered by a 6- to 24-inch layer of loess. (Where the average depth of the loess exceeds 24 inches, the soil is mapped as Tama silt loam.) The topography is undulating, the slopes ranging from 3 to 8 percent. Natural drainage is adequate, and runoff is not rapid enough to cause appreciable erosion.

This soil type is widely distributed throughout the county. Most areas lie on the lower slopes adjacent to the flood plains of streams, but a few occupy ridge crests. Occurrence is for the most part south and east of large streams, as Deer, Salt, and Wolf Creeks. The total area is 11,520 acres.

A profile description follows:

- 0 to 9 inches, dusky-brown very friable silt loam with medium moderately granular structure; varying in thickness from 6 to 12 inches; medium to strongly acid.
- 9 to 16 inches, moderate to dark-brown friable silt loam, containing some coarse sand and fine gravel; strongly acid.
- 16 to 30 inches, moderate to dark yellowish-brown firm light silty clay loam or light clay loam containing some grit and fine gravel; medium to strongly acid.
- 30 to 45 inches, moderate yellowish-brown moderately plastic clay loam, sandy clay loam, or heavy loam, faintly mottled with light olive gray and moderate brown; normally containing appreciable quantities of coarse sand and pebbles; medium acid.

Use and management.—Nearly all areas of Carrington silt loam are under cultivation. Corn is the most important crop, with average yields of 45 bushels an acre under good management. Other crops grown and yields obtained are: Oats, 40 bushels; clover and timothy hay, 1½ tons; and alfalfa, 2½ tons. Only a small part of the total acreage is used for pasture.

The yields of crops, especially corn, can be increased appreciably by improved management practices. These include the addition of organic matter, either as farm manure or as green manure, lime for legume crops, and phosphates for legumes and small grains. Supplementary measures, as contour tillage for the control of erosion, also would be helpful on the more sloping areas.

Carrington silt loam, eroded gently rolling phase.—This phase is similar to the normal phase except that the topography is more rolling and the surface soil thinner. Slopes generally range from 8 to 12 percent, but small areas more sloping than 12 percent are included. The average thickness of the surface soil is about that of the furrow slice, though it is occasionally deeper and in some places lacking. Most of this phase occurs in the general area of rolling to hilly dark-colored soils of the uplands. Total extent of the phase is 9,152 acres.

Use and management.—The use and management of the eroded gently rolling phase are generally similar to those of the normal phase. Most of this soil is cultivated with rotations that include less corn and more legumes and grasses. Average yields obtained are about 20 percent lower than on the normal phase. Problems of erosion control are greater, however, and more care needs to be exercised in management. Contour cultivation and strip cropping are desirable when the soil is used for intertilled crops.

Carrington silt loam, eroded rolling phase.—This phase differs from the normal phase of this type in topography and in thickness and texture of the surface soil. The topography is generally more sloping, and the surface soil is generally thinner. The texture of the surface soil is variable from a loam to a silty clay loam, although silt loam predominates. The loam occurs where small inclusions of Carrington loam are mapped. Silty clay loams are found in eroded spots on spurs or ends of small ridges.

Occurrence is largely in the general area of rolling to hilly dark-colored soils of the uplands. The small individual areas usually occupy the lower slopes beside drainageways and flood plains. The topography is rolling, the slopes commonly ranging from 12 to 16 percent or more. The soil is less extensive than other phases of the type (4,672 acres).

Use and management.—Carrington silt loam, eroded rolling phase, is used largely for pasture, with some areas in cultivation. Because of the steep slopes, the soil is not well adapted to intertilled crops, and yields of such crops are commonly low. It is better suited to permanent pasture or to long-time hay crops. Special attention needs to be given to the control of erosion when intertilled crops are grown. The use of grassed waterways and other supporting practices for erosion control are of special importance. Steps to improve organic matter and fertility levels and the structure of the soil will increase its productivity for pasture and crops.

Chariton silt loam.—The small individual areas of this soil occur on terraces along the larger streams. Many of the areas are slightly depressed or nearly level. This soil is associated with and similar to Bremer silt loam but differs in having the gray leached layer between depths of 10 and 16 inches. Chariton silt loam has a slowly permeable plastic claypan subsoil. It is of limited extent (320 acres).

A representative profile follows:

- 0 to 10 inches, weak-brown mellow silt loam with fine soft crumb structure; strongly acid.
- 10 to 16 inches, finely variegated light-gray and light olive-gray silt loam with medium weakly platy structure, the plates crushing easily to a light-gray floury mass; strongly acid.
- 16 to 36 inches, finely variegated medium olive-gray, light olive-gray, and weak orange silty clay, strongly plastic when wet, very firm when moist, and very hard when dry; strongly acid.
- 36 to 52 inches, mottled light-gray, medium olive-gray, and weak-orange silty clay, strongly plastic and very firm; medium to strongly acid.

A few small areas with a lighter colored surface horizon and a very slowly permeable subsoil are included with this type. These lighter colored soils are on terraces and commonly associated with the forested soils of the uplands. A few of the areas lie west of Salt Creek between the villages of Elberon and Vining.

Use and management.—Nearly all of Chariton silt loam is cultivated with the associated Waukesha and Bremer soils. Crop yields are much lower than on either, because of lower fertility and poorer drainage. Improvement of drainage is the principal management problem, although maintenance of fertility also requires attention. The impervious nature of the subsoil restricts the effectiveness of tile drainage, and therefore surface removal of excess water should be tried. Applications of lime are needed for good stands of alfalfa and for the satisfactory growth of other legumes.

Chelsea loamy fine sand.—This soil, occupying a total of 512 acres, is associated chiefly with the Fayette and Lindley soils, especially north of Chelsea, and normally occurs on ridge tops or east-facing slopes. Physiographic position in the uplands and location with reference to flood plains indicate that the sand has blown up from the stream bottoms.

The topography is undulating to rolling, with the exception of one small depression near a cemetery northeast of Chelsea. Runoff is very slight despite the rolling nature of the soil because of the rapid absorption of water. In times of prolonged heavy rain some erosion does occur, with deposition of sand on lower lying soils. These sandy deposits are generally harmful to the soils receiving them.

A profile description follows:

0 to 3 inches, light brownish-gray nearly loose loamy fine sand; strongly acid.
The thickness varies from 2 to 7 inches in uncultivated areas. In cultivated fields this layer has been mixed with the underlying one and has lost its identity.

3 to 17 inches, moderate yellowish-brown loose incoherent sand; medium to strongly acid.

17 to 29 inches, dusky-yellow loose sand; medium acid.

29 inches +, weak-yellow loose sand; medium acid.

Use and management.—Chelsea loamy fine sand is used principally for pasture, forest, and truck crops. In a few places corn and small grains are grown, but yields are light even in the better years. Rye is probably better adapted to the soil than any of the other field crops. Small patches are used successfully for watermelons and cantaloups. When it is cultivated, this soil drifts easily, especially during dry periods. Furthermore, it is very low in content of plant nutrients and in its capacity to retain moisture. Where the soil pattern permits the

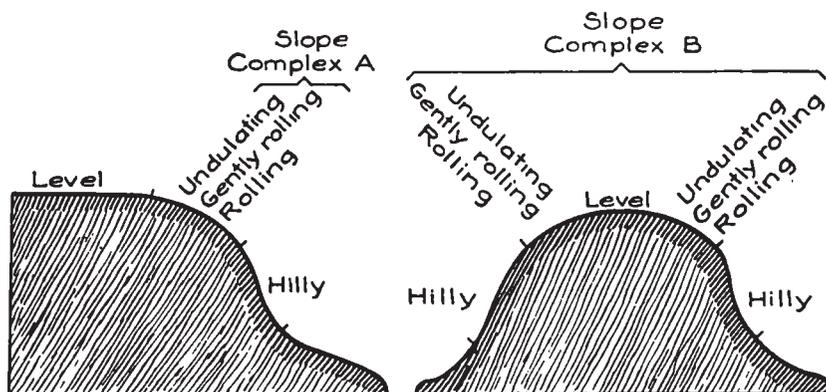


FIGURE 4.—Two slope complexes, A and B, shown on soil map as Fayette, Downs, and Tama silt loams.

retirement of Chelsea soils to pasture or forest, these uses are preferable because they involve lower production costs.

Downs silt loam.—This, the normal phase of the soil type, occupies undulating slopes of 3 to 8 percent. It formed from loess and is intermediate in characteristics between Tama and Fayette silt loams. The surface soil is darker than in Fayette but lighter than in Tama. There is also a tendency toward platy structure in the lower part of the surface soil (A_2 horizon). The subsoil (B horizon) has a medium moderately subangular structure somewhat like that in the corresponding horizon of the Fayette. The soil formed either under a mixed vegetation of trees and grasses or in areas that were grassed but have been invaded and taken over by trees.

The position occupied and the slope pattern differ much from area to area. In some places the soil lies below the level ridge crests and extends down to the edges of the flood plains. In others where it occurs on rounded ridge tops or on the upper shoulders of the ridges the slope pattern is complex. Two representative slope complexes are illustrated in figure 4.

Being transitional in character, this soil occurs in gradation zones between the light-colored and dark-colored soils of the uplands. Most of the areas lie in the southern half of the county, though there are a few in the northern part, especially northwest of Traer. The area is not extensive, covering 4,992 acres.

A profile description follows:

- 0 to 8 inches, weak to dusky-brown very friable silt loam with a tendency toward medium platy structure in the lower part; thickness variable, from 2 to 10 inches; medium acid.
- 8 to 16 inches, dark yellowish-brown friable heavy silt loam or light silty clay loam; strongly acid.
- 16 to 36 inches, moderate to dark yellowish-brown firm light silty clay loam with medium subangular blocky structure; strongly acid.
- 36 to 60 inches, finely variegated light-gray, pale-brown, and light yellowish-brown friable heavy silt loam or silt loam; medium to strongly acid. In places the silt loam is replaced by the gritty clay loam of the glacial till.

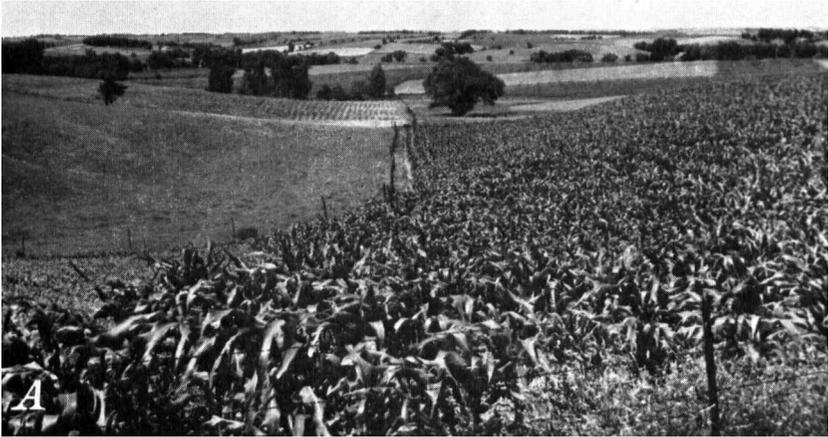
In addition to the range in characteristics of a profile approaching Fayette silt loam on the one hand and Tama silt loam on the other, some variations should be noted. Glacial drift is rarely exposed at the surface but in places it may occur at depths of $1\frac{1}{2}$ to 3 feet. The surface soil may be absent from the convex slopes on the ends of small ridges, and it reaches a maximum thickness of 10 inches in sheltered covelike spots. Where the type is associated with Tama-Thurman complex or Thurman loamy fine sand a number of sandy spots are included.

Use and management.—Practically all of Downs silt loam is used for crop production. The crops grown and the average yields are: Corn, 35 to 45 bushels an acre (pl. 3, A); oats, 40 bushels; and hay, $1\frac{1}{2}$ to 2 tons. Yields on the whole are somewhat less than those obtained on Tama silt loam. Areas not used for crops are mainly those intermingled with hilly soils where most of the land is in pasture or forest.

More work is required for the maintenance of productivity of this type than for Tama silt loam. Inclusion of a legume in the rotation at 3- or 4-year intervals and more frequent applications of barnyard manure and lime are needed. Contour tillage and the seeding of waterways to grass are helpful measures in preventing erosion.

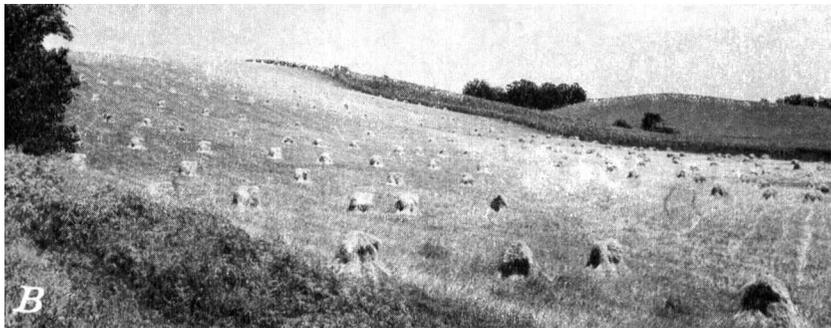
Downs silt loam, eroded gently rolling phase.—This phase differs from the normal phase in having steeper slopes and a thinner surface soil. It commonly occurs on slopes or the shoulders of ridges and does not have so many different slope patterns as the normal phase. Slope gradients commonly range from 8 to 12 percent (pl. 3, B). Because of its greater slope, this phase has suffered more erosion, so that small severely eroded spots are common. The average thickness of the surface soil is about equal to that of the plowed layer although it equals that of the normal phase in places. Occasional gullies, ranging from 6 to 18 inches in depth, occur where the soil has been used frequently for intertilled crops. Distribution within the county and association with other soils are essentially the same for this phase as for the normal type. The extent of this phase, which has a total area of 2,496 acres, is less than that of the normal phase of the type.

Use and management.—Most areas of this eroded gently rolling phase are cultivated, but the proportions of intertilled crops are lower



A, Landscape and cropping pattern on Downs soils. A field of corn and a blue-grass pasture are in the immediate foreground; hay fields, one recently cut, are just beyond; corn, hay, and oats (appearing as light-colored patches while ripening) are in the background.

B, Sweetclover pasture on Downs silt loam, eroded gently rolling phase. The rolling nature of the countryside is indicated by the slope of the ridge where Hereford cattle are grazing and by the landscape in the distance. The ungrazed and blooming sweetclover in the immediate foreground is along a fence row.



- A*, Farmstead in the area of light-colored soils of the uplands, the house largely hidden by trees. Oats in the foreground are on level and rolling phases of Fayette silt loam
- B*, Land use pattern in the rolling parts of the area of light-colored soils of the uplands. The bottom land, with oats in immediate foreground to right, is Ray silt loam; upland slopes in oats and corn are Fayette silt loam, eroded rolling phase; pasture in distance is on Lindley-Fayette silt loams, eroded phases.
- C*, Land use pattern in the areas of rolling to hilly Fayette and Lindley soils. The partly wooded slopes of these soils are used for pasture; corn is growing on Judson silt loam, and bluegrass pasture in the foreground is on Wabash silt loam

and of hay crops higher than for the normal soil. Crops grown are the same as for the normal phase, but yields are about 20 percent lower.

More careful management is necessary on this soil to maintain productivity and to prevent serious erosion. Less corn and more hay must be included in the crop rotation. The use of grassed waterways, contour cultivation, and strip cropping, desirable to prevent harmful erosion, can be followed on most areas.

Downs silt loam, eroded rolling phase.—This phase differs from the eroded gently rolling phase in having steeper topography and thinner surface soil. The distribution and the association with other soils are similar to those of the normal phase. The total acreage is about two-thirds that of the normal phase, or 3,264 acres.

A profile description follows:

- 0 to 5 inches, weak-brown very friable silt loam; thickness variable, from 0 to 8 inches; strongly acid.
- 5 to 14 inches, dark yellowish-brown friable light silty clay loam or heavy silt loam; strongly acid.
- 14 to 32 inches, moderate yellowish-brown firm light silty clay loam with medium weakly subangular structure; strongly acid.
- 32 to 55 inches, moderate yellowish-brown firm heavy silt loam to silt loam, faintly mottled with light gray and dark brown; strongly acid.

Several variations from the profile described are mapped with the eroded rolling phase. On convex slopes at the ends of ridges the surface soil is very thin or absent. In other places (the lower parts of slopes) the surface soil may be 8 inches thick. Local variations in thickness of the surface layer are common and widespread. Other less common variations are occasional outcrops of glacial drift, most often found in severely eroded spots.

Use and management.—Downs silt loam, eroded rolling phase, is used for crops and pasture. Though it is not well adapted to crop production, many areas have long been cultivated. Where the soil pattern permits and the soil is not urgently needed for crop production, its use for pasture is desirable and will generally provide greater returns. If the soil must be used for crops, careful management is necessary to maintain productivity and prevent harmful erosion. Rotations followed should include high proportions of hay and low proportions of intertilled crops. Addition of organic matter, either as farm manure or as green-manure crops, and the use of legumes are essential to maintain productivity. Lime also is needed for good stands of legumes. Contour cultivation, strip cropping, and the seeding down of waterways are generally needed for the control of erosion on cultivated areas.

Downs silt loam, level phase.—This differs from the normal phase in that it has a smoother topography and a somewhat deeper profile. The topography is level to very gently undulating with slopes ranging from 1 to 3 percent. This gradient is enough to provide adequate drainage without likelihood of harmful erosion.

Occurrence is principally on broad ridge crests in the transitional zones between Fayette and Tama soils. Occasionally areas lie within larger bodies of either light-colored or dark-colored soils. Areas are scattered throughout the southern half of the county and some lie along Four Mile Creek. The phase is less extensive than any of the others in the soil type, covering only 1,856 acres.

A profile description follows:

- 0 to 12 inches, weak to dusky-brown very friable silt loam with fine soft crumb structure in the upper part and weak medium platy structure in the lower part: strongly acid.
- 12 to 18 inches, dark yellowish-brown friable heavy silt loam or light silty clay loam; strongly acid.
- 18 to 38 inches, moderate to dark yellowish-brown firm silty clay loam or light silty clay loam with medium moderately subangular blocky structure; moderately plastic when wet and hard when dry; strongly acid.
- 38 to 60 inches, finely variegated light yellowish-brown, pale-brown, and light-gray firm to friable heavy silt loam to silt loam; medium acid.

Two inclusions are in Downs silt loam, level phase. On the broader ridge tops are occasional small spots of Traer silt loam. Glacial drift occasionally lies within 24 inches of the surface at the margins of the ridge crests.

Use and management.—Nearly all of Downs silt loam, level phase, is under cultivation to the common field crops. Good yields are obtained where the rotation followed includes a legume every 3 or 4 years. Under such management average acre yields for the different crops are: Corn, 45 to 50 bushels an acre; oats, 40 to 45 bushels; clover and timothy hay, 1¼ to 1¾ tons. Occasional small areas are used for pasture or woodland.

Maintenance of the soil at a high level of productivity is easily accomplished. Such maintenance requires addition of organic matter, use of lime for legumes, and inclusion of legumes in the crop rotation. Improvement of drainage and control of erosion are not problems on this soil.

Fayette-Chelsea complex.⁵—This complex consists of a mixture of the normal phases of Fayette silt loam and Chelsea loamy fine sand, with areas of the two soils intermingled in an intricate pattern. The complex occurs on a total area of only 320 acres, chiefly on ridge crests, and is undulating to gently rolling, the slopes ranging chiefly from 3 to 8 percent. The soil is associated with Fayette, Lindley, and Chelsea soils in the hills near the Iowa River north and northeast of Chelsea and west of Toledo.

A number of different profiles can be found within the areas mapped. On the average, 35 to 50 percent of an area consists of Fayette silt loam, 15 to 20 percent of Chelsea loamy fine sand, and the rest of profiles that are intermediate in their characteristics between the two. In some places the profile consists of a loamy sand surface layer over silty sediments, in others the silt is at the surface and rests on sand, and in still others the silt and sand has been mixed to a considerable degree.

Use and management.—The Fayette-Chelsea complex is used in much the same way as Fayette silt loam. Most areas are cultivated, chiefly because they are small and occur in association with soils that are suitable for tillage. Crop yields are much lower, however, than on the Fayette soil. Furthermore, yields are more variable from area to area and from year to year.

The chief problems of management are those of improving the level of fertility. Because of the favorable topography, erosion is not a serious problem, although some areas have a sufficiently high propor-

⁵ A complex is a mapping unit consisting of two or more soil types or phases so intermingled that they cannot be separated on the scale of mapping used.

tion of Chelsea loamy fine sand to drift occasionally. Management practices to improve fertility levels should include high proportions of legumes in the rotation, applications of organic matter and lime, and addition of phosphate for legume crops. In general it is not feasible to exclude the areas from cultivation and to use them for pasture or hay, but this is good practice where it can be done.

Fayette-Chelsea complex, eroded rolling phases.—These phases of the complex differ from the normal ones in having steeper slopes and thinner surface layers. Most areas occur on the shoulders of ridges rather than on the crests, and the common slope ranges are 8 to 16 percent. This complex is not extensive (960 acres), though it has a larger total acreage than the normal phases of the complex.

Use and management.—The use and management of Fayette-Chelsea complex, eroded rolling phases, are similar to those of Fayette silt loam, eroded rolling phase. Improvement of fertility is more important, however, and the maintenance of productivity is more difficult. Yields are appreciably lower than on Fayette silt loam, eroded rolling phase, and slightly lower than on the normal phases of the complex. Special precautions are necessary to maintain organic-matter levels where the land is cultivated. Some areas are used for cantaloups and watermelons.

Fayette silt loam.—This, the normal phase of the type, has been formed from loess under an oak-hickory forest. Slopes range from 3 to 8 percent. The soil is analogous to Tama silt loam but differs because it has been formed under forest rather than grass vegetation.

Most of this soil occurs in the general area of light-colored soils of the uplands. Individual bodies are commonly small and are widely distributed in this part of the county. The soil occurs chiefly in association with other phases of the type and with Lindley-Fayette silt loams. This phase is the most extensive of the type and covers a total area of 14,784 acres.

A profile description follows:

- 0 to 8 inches, light brownish-gray very friable silt loam with a fine weakly crumb structure in the upper part and a thin weakly platy structure in the lower part; thickness variable, from about 2 to 10 inches; strongly acid.
- 8 to 14 inches, moderate yellowish-brown friable light silty clay loam; strongly acid. This is a transitional layer in which the structure is changing from platy to blocky.
- 14 to 28 inches, moderate-brown firm silty clay loam or light silty clay loam, moderately plastic when wet; very strongly acid. This layer has a medium strongly subangular blocky structure.
- 28 to 42 inches, moderate-brown friable to firm light silty clay loam or heavy silt loam with a coarse weakly blocky structure and a faint mottling of weak orange and dark brown on the structural units; strongly acid.
- 42 inches +, finely variegated light-gray, weak-yellow, and moderate-brown very friable silt loam; medium to strongly acid.

The principal variations within areas of the soil are in the nature and pattern of slopes and in the thickness of the surface soil. Two different slope patterns are exhibited by the soil, depending upon the position occupied. Where it occurs as a transition from the level phase to the Lindley-Fayette complex, the slope pattern is that illustrated as slope complex A in figure 4. Where it covers the entire ridge or ridge crest, it has the slope pattern illustrated as slope complex B in figure 4. The latter slope pattern is common to narrow, undulating, and gently rolling areas.

Thickness of the surface soil is related to degree and shape of slope. Where the slopes are steeper and the land surface more rolling, the surface soil is thin and even absent from convex slopes. Where the slopes are gentle and slightly concave, thickness of the surface soil may reach 10 or 12 inches. Occasional gullies 12 to 24 inches deep may be noted, especially in drainageways.

An infrequent variation included consists of profiles in which glacial drift may occur within a depth of 30 inches. Exposures of glacial drift occur at the surface in a few places, especially on the sharper shoulders of ridges.

Use and management.—Most areas of Fayette silt loam are cultivated, although there are a number in pasture and a few in forest. The small areas closely associated with Lindley-Fayette silt loams are commonly left in forest or used for pasture. The crops grown and the average acre yields obtained are: Corn, 35 bushels; oats, 35 bushels; clover and timothy, 1½ tons; and alfalfa, 2½ tons.

More care is required for the maintenance of productivity than with Tama silt loam. This care is needed to improve and maintain the fertility and structure. Applications of manure and the use of long rotations with little corn are especially helpful in maintaining good tilth and fertility. An intertilled crop such as corn should be included only once every 4 or 5 years. Legumes like red clover and alfalfa help to improve the nitrogen level and structure of the soil, but applications of lime prior to planting are generally required. Favorable responses of legumes have been obtained from addition of phosphates. On many areas, especially those more rolling, contour tillage and strip cropping can be practiced to good advantage.

Fayette silt loam, eroded gently rolling phase.—This phase differs from the normal phase in having steeper topography, a simpler pattern of slope, and a somewhat shallower profile. The slopes commonly range from 8 to 12 percent and are less complex because they occupy only the shoulders of ridges. Severely eroded spots are less common than in the eroded rolling phase, and occasional shallow gullies occur in cultivated fields. All layers are somewhat thinner in the profile, but the surface soil is noticeably thinner than in the normal phase. This soil is associated with the same soils as the normal phase, but it is less widely distributed. The total area is 5,760 acres.

Use and management.—Fayette silt loam, eroded gently rolling phase, is used in the same way as the normal phase, but crop yields obtained are appreciably lower. Management problems are also generally similar, but much more care is needed for maintenance of yields and the control of erosion. Rotations should include very little corn and much hay. Heavier applications of organic matter are necessary, and most areas need lime for good stands and yields of legumes. Supplementary measures for erosion control, as contour cultivation and strip cropping, are generally applicable and useful on this phase.

Fayette silt loam, eroded rolling phase.—This phase differs from the normal phase in having steeper topography and a shallower profile. It is also steeper and shallower than the eroded gently rolling phase and includes a larger number of severely eroded spots. It occupies narrow strips generally parallel to drainageways or streams. The slope range is 10 to 16 percent. Individual bodies are small but numer-

ous in the general area of light-colored soils of the uplands (pl. 4, A). The total area is 11,136 acres.

A profile description follows:

- 0 to 5 inches, light brownish-gray very friable silt loam; thickness ranging from about 3 to 8 inches; strongly acid.
- 5 to 10 inches, moderate yellowish-brown friable light silty clay loam or heavy silt loam; strongly acid.
- 10 to 24 inches, moderate-brown firm light silty clay loam, slightly plastic when wet; very strongly acid. This layer has a subangular blocky structure less distinct than that of the normal phase.
- 24 to 36 inches, moderate-brown friable light silty clay loam or heavy silt loam with coarse weakly blocky structure; faintly mottled; strongly acid.
- 36 inches +, finely variegated light-gray, weak-yellow, and moderate-brown very friable silt loam; strongly acid.

Use and management.—The proportion of Fayette silt loam, eroded rolling phase, in cultivation is much lower than in the smoother phases. Some areas are being used for crop production, although the phase is better adapted to pasture or forest. Crop yields commonly obtained on cultivated areas are distinctly lower than on the other phases (pl. 4, B). Harmful erosion frequently occurs in areas used for crops, especially where corn is grown more than once in 8 or 10 years.

The soil is better adapted to pasture or forest than to cultivation (pl. 4, C), and such use is feasible on most farms. Where the soil is used for pasture, occasional applications of lime and fertilizer, reseedling with clovers, and controlled grazing are desirable to maintain a good sod.

If the soil must be used for crops, it should be cultivated no more often than necessary. A high level of management must be followed to maintain productivity and control erosion. This may include long rotations with little corn, additions of organic matter, lime, and phosphate, contour tillage, and strip cropping.

Fayette silt loam, level phase.—This phase differs from the normal phase in having smoother topography and a deeper profile. It occupies the smooth ridge crests but generally has enough slope (1 to 3 percent) to provide adequate drainage, and it occurs entirely in the general area of light-colored soils of the uplands. The individual bodies of the soil are small but are widely distributed. The total area of 5,376 acres is lowest among the phases of Fayette silt loam.

A profile description follows:

- 0 to 9 inches, light brownish-gray very friable silt loam with fine weakly crumb structure in the upper part and very thin weakly platy structure in the lower part; strongly acid.
- 9 to 16 inches, moderate yellowish-brown friable light silty clay loam; strongly acid. This is a transitional layer in which the structure is grading from platy to blocky.
- 16 to 30 inches, moderate-brown firm silty clay loam to light silty clay loam that is slightly plastic when wet; very strongly acid. The layer has a medium strongly subangular blocky structure.
- 30 to 45 inches, moderate-brown friable light silty clay loam to heavy silt loam with coarse weakly blocky structure; strongly acid. There is a faint mottling of weak orange and dark brown on the structural aggregates.
- 45 to 54 inches, finely variegated light-gray, weak-yellow, and moderate-brown friable silt loam; strongly acid.

Use and management.—Practically all Fayette silt loam, level phase, is cultivated. Occasional areas are used for pasture, and a very few are in forest. Crops grown and average acre yields obtained are: Corn,

40 to 50 bushels; oats, 35 bushels (pl. 5, A); clover and timothy hay, 1½ tons; and alfalfa, 2½ tons. Soybeans are grown to a limited extent, with average yields of about 15 bushels an acre.

The soil is easily farmed, has good drainage, and does not require special management for the control of erosion. It is less fertile, however, than Tama silt loam, level phase, and produces less under comparable management. It can be used successfully for crops with rotations having less corn and more hay. In general, corn should be included in the rotation only once in 4 years for maximum yields over a long period of time. Heavier applications of manure are desirable because of lower original soil content of organic matter. Since most areas are acid, applications of lime are necessary for successful stands of legumes. These crops are also benefited by applications of phosphate fertilizer.

Garwin silty clay loam.^a—This soil occurs on level or slightly depressed uplands. It formed from a mixture of loess and colluvium under grass vegetation. It is associated with Muscatine and Tama soils in the northern part of the county, especially south and east of Traer. Individual areas are like small bowls at the heads of drainage-ways. The soil type is not widely distributed in the county but has a total area of 5,184 acres.

A profile description follows:

- 0 to 5 inches, brownish-black to black friable silty clay loam with a coarse poorly blocky structure, crushing readily to medium moderately granular structure; medium acid.
- 5 to 14 inches, brownish-black silty clay loam to silty clay of medium weakly granular structure, moderately plastic when wet; medium acid.
- 14 to 30 inches, light brownish-gray to weak-yellow silty clay loam or silty clay faintly mottled with weak yellow and weak orange; moderately plastic when wet and hard when dry; slightly acid.
- 30 inches +, weak-yellow light silty clay loam to heavy silt loam mottled with weak orange and dark brown; moderately plastic when wet; slightly acid.

There are a few variations in the profile and one inclusion among the areas mapped. The principal variation is in the thickness of the surface layer, which ranges from 12 to 20 inches. The inclusion, one area of 40 acres on the boundary between sections 8 and 9 of Carlton Township is similar to soils of the Sperry series. The profile consists of a dark-gray smooth silt loam 10 inches thick, underlain by light-gray silt loam with medium weakly platy structure, below which there is a variegated weak-yellow, light-gray, and dark-brown heavy silty clay. This area is often covered with water and is much less productive.

Use and management.—Most Garwin silty clay loam is being used for crops, and good yields, especially of corn and soybeans, are obtained. Areas used for pasture provide excellent grazing, which is especially valuable in summer, when upland pastures produce little growth. For satisfactory cultivation the natural drainage must be improved, either by means of tile or open ditches. Most areas have been drained satisfactorily and do not now have difficult management problems.

Judson silt loam.—This dark Alluvial soil formed from a mixture of local alluvium and colluvium moved down from Prairie soils. It

^a Part of the more level and slightly depressed areas now included with Muscatine silt loam will be included with soils of the Garwin series in the future.

occurs in two kinds of positions. In one, it exists as long, narrow, irregular bands between the upland toe slopes and the flood plains; in the other, it occupies alluvial fans where small streams have deposited sediments on larger flood plains. The topography is mainly level to undulating, with slopes ranging from 2 to 5 percent. A few areas with slopes slightly above 5 percent are included, and in such places there is a noticeable tendency for gullies to be formed in the drainageways across the fans. Drainage is generally adequate, but occasional improvement of natural drainage is necessary on the lower parts of individual areas. The soil is widely distributed in the county and has a total area of 8,448 acres.

A profile description follows:

0 to 20 inches, brownish-black mellow very friable silt loam; black when wet; medium acid.

20 to 36 inches, dusky-brown friable silt loam; medium acid.

36 inches +, weak-brown to moderate yellowish-brown friable heavy silt loam or silty clay loam, very slightly plastic when wet; medium acid.

A few sandy areas included are indicated by symbols. These occur where sand has been washed from higher areas of Thurman or Chelsea soils.

Use and management.—Practically all of Judson silt loam is cultivated, with a few areas in pasture. The soil is one of the most productive in the county and commonly yields 60 bushels of corn an acre. It is well suited to cultivation, especially for intertilled crops, as corn and soybeans, and also produces excellent crops of hay. Yields of small grain are reduced in some years by lodging, especially if the growing season is wet. Keeping the soil highly productive is easier than for most other soils in the county.

Lindley-Fayette silt loams.—This complex consists of two hilly soils formed under forest vegetation, the one from a mixture of till and loess and the other from loess. The profiles of both soils are somewhat shallower and have less distinct horizons than where the topography is rolling or undulating. For descriptions of the profiles, see page 32 for Lindley silt loam, and page 27 for Fayette silt loam. In places where the mantle of loess is relatively thick and covers most of the upland, Fayette silt loam predominates. Where the loess is generally thin or absent Lindley silt loam predominates. All areas of the complex are hilly, the slopes ranging above 16 percent.

Lindley-Fayette silt loams are scattered through the general area of light-colored soils of the uplands (pl. 5, *B*), especially along flood plains of larger streams, where tributaries have cut many narrow valleys to reach the lower level of the larger stream. The complex has a total area of 11,520 acres.

Two other soils are included in places. One is Chelsea loamy fine sand, with hilly topography, which is indicated on the soil map by sand symbols; the second consists of small spots of the eroded phases of Lindley-Fayette silt loams too small to be shown separately.

Use and management.—Most of the total acreage of Lindley-Fayette silt loams is in forest, much of which is grazed (pl. 6, *A*). An appreciable part of the total acreage is in pasture not wooded, and a small part is cultivated. The complex is poorly suited to cultivation and best suited to pasture or forest. When cleared and cultivated the soil erodes badly, despite precautions that may be taken. With

moderate care many areas can be used successfully for pasture. Where the soil is so used, the composition and quality of the stand can be improved by the application of lime and phosphate, by reseeding with mixtures of grasses and legumes, and by controlled grazing.

Lindley-Fayette silt loams, eroded phases.—This complex differs from Lindley-Fayette silt loams in that it has been eroded. It is comparable with the normal complex in composition, in mode of occurrence, in its association with other soils, and in distribution. Severely eroded spots and shallow gullies are common on the eroded phases, whereas they are not common in areas of the normal complex. The topography is hilly, the slopes generally ranging from 16 to 25 percent. The complex is widely distributed in the general area of light-colored soils of the uplands. The total area is 20,352 acres, or about twice that of the normal phases.

Use and management.—Practically all areas of Lindley-Fayette silt loams, eroded phases, have been used for crops at some time in the past or are still being so used. The soils are poorly suited to cultivation and crop yields are very low. Because of the low productivity and the danger of erosion, many areas of the eroded phases are now being used for trees and pasture. Close-growing hay crops can be grown with fair success on this complex, as on Lindley-Fayette silt loams, but even such use tends to promote erosion. The eroded phases are better suited to pasture or forest than to cultivation (pl. 7, A). Moderate care should be exercised in pasture management if productivity is to be maintained.

Lindley silt loam.—This, the normal phase of the soil type, has been formed from a mixture of loess and till under forest vegetation in rolling uplands. The soil occurs where the mantle of loess is on the average less than 24 inches thick over glacial drift. The topography is generally rolling to strongly rolling, with slopes of 12 to 16 percent. The nature of the topography makes severely eroded spots common and results in gullies in a number of places. The total area of 3,264 acres is associated chiefly with Lindley-Fayette complex in hilly parts.

A profile description follows:

- 0 to 4 inches, light brownish-gray very friable silt loam with fine weakly crumb structure; strongly acid.
- 4 to 12 inches, moderate yellowish-brown friable to firm silty clay loam that may contain some detectable sand grains; strongly acid.
- 12 to 24 inches, moderate-brown firm silty clay loam or clay loam containing some gravel and coarse sand and usually having medium poorly sub-angular blocky structure; very strongly acid.
- 24 to 48 inches, light yellowish-brown firm gritty clay loam or clay, containing some coarse sand and numerous pebbles; often mottled with light gray and dark brown and usually moderately to strongly plastic when wet; strongly acid.

Variations from the normal profile are very common. Thickness of the different layers varies considerably from place to place, and the surface layer described may be entirely absent in severely eroded spots, especially on the convex ends of spurs or ridges. The texture of the surface soil is a loam rather than silt loam in places where the mantle of loess is very thin. Occasionally the subsoil consists of a moderate-to strong-brown clay that is extremely firm when moist and very strongly plastic when wet. This layer is commonly present at some depth and occasionally is exposed.



- A.** Corn and oats on Fayette silt loam, level phase, in the area of light-colored soils of the uplands. Where a good system of soil management is practiced, high yields of both corn and oats are obtained.
- B.** Hilly woodland pasture in the area of light-colored soils of the uplands. Lindley-Fayette silt loams on the steeper slopes, Fayette silt loam on the ridge crests, and Wabash silt loam in the flood plain along the creeks.



A, Area of stump, brush, and woodland pasture on Lindley-Fayette silt loams
B, Eroded condition that results when Lindley silt loam, gently rolling phase, is used for corn and other intertilled crops. This land is generally used for hay crops or pasture

Use and management.—Much of Lindley silt loam is used for pasture and forest, but some areas are under cultivation. The soil is generally better adapted to pasture or forest than to crops. Where it is cultivated, yields are low, with the average for corn being about 20 bushels an acre. Use for intertilled crops introduces a serious erosion hazard. The soil can be used with fair success for hay and small grains, but it is generally better practice to keep it in permanent pasture or in forest.

Lindley silt loam, gently rolling phase.—This phase differs from the normal phase in having smoother topography and a deeper profile. Its 896 acres are gently rolling, with slopes ranging chiefly from 8 to 12 percent. Few areas are steeper than 12 percent, but these for the most part are mapped as the normal type. The gently rolling phase usually occupies the shoulders of large ridges in the general area of light-colored soils of the uplands.

Of the several variations mapped the principal ones are those in texture and depth of the surface soil. Thickness of the surface layer ranges from 2 to 10 inches, with an average of about 7 inches. The texture is chiefly a silt loam but it is a loam where the loess and till have been mixed to some degree. Severely eroded spots without surface soil are common in cultivated fields, although they are less common on this phase than on the normal. Outcrops of moderate- to strong-brown clay, described as occurring in areas of the normal phase, occur also in areas of the gently rolling phase.

Use and management.—Slightly more than half the total acreage of Lindley silt loam, gently rolling phase, is being used for crops, with the rest in pasture or forest. The soil is better suited to pasture than to cultivation, and when cultivated it is better for hay than for corn. Yields of crops are about the same as those obtained on Fayette silt loam, eroded rolling phase. If the soil is cultivated, the rotation should include a low proportion of corn and a high proportion of legumes and grasses. Additions of lime for legumes, applications of manure, contour tillage, and strip cropping are helpful in maintaining fertility where the soil is used for crops (pl. 6, *B*). If the soil does not have to be used for crop production, it is better left in pasture (pl. 7, *B* and *C*). Moderate care is necessary in pasture management.

Muscatine silt loam.⁷—This type has been formed from loess under grass vegetation in nearly level uplands. It occupies 8,448 acres in broad level divides that separate the larger creek basins. The topography is nearly level to flat, with slopes ranging up to 3 percent. Natural drainage is imperfect to poor, but it has been improved by tile in most areas.

The soil is associated chiefly with Garwin and Tama soils. Most areas are in the northern half of the county, the larger ones being in Lincoln, in the southern part of Crystal, and in the northern part of Howard Townships. A few areas occur also in Highland Township in the southwestern corner of the county. Most individual bodies are irregular in shape and moderately large.

⁷ Part of the included soil, especially those areas occurring on broader flats that have naturally poor drainage, will be included with the Garwin soils in future mapping.

A profile description follows:

- 0 to 6 inches, brownish-black mellow friable silt loam with medium moderately granular structure; black when wet; strongly acid.
- 6 to 20 inches, dusky-brown friable heavy silt loam; slightly plastic and almost black when wet; becomes lighter in color and heavier in texture with increasing depth; strongly acid.
- 20 to 32 inches, medium olive-gray friable silty clay loam, faintly mottled with light olive gray, weak yellow, and moderate brown; slightly plastic when wet; medium acid.
- 32 to 48 inches, light-gray to light olive-gray friable light silty clay loam grading into silt loam mottled with dark gray, weak yellow, and dark brown and containing a few small dark-brown concretions, slightly plastic when wet; medium acid.

Variations in the profile cover a narrow range. On the one side the profile characteristics approach those of Tama silt loam, level phase, and on the other side, those of Garwin silty clay loam. This soil often borders one or the other of the two.

Use and management.—Muscatine silt loam is nearly all under cultivation (pl. 8, *A* and *B*). Crops grown and average acre yields obtained are 60 to 70 bushels of corn; 40 to 50 bushels of oats; 2 tons of clover hay; and 3½ tons of alfalfa hay. Crop yields are more frequently limited by moisture conditions in the form of either inadequate drainage or of limited rainfall than by any other factor.

Maintenance of high level of productivity is relatively easy. The soil is highly fertile. It has good structure but lacks adequate natural drainage, especially in the broad level areas where it resembles the Garwin soil. It is also slightly acid and requires applications of lime for sweetclover or alfalfa. It is not subject to harmful erosion and can be used frequently for intertilled crops.

Ray silt loam.—This is an Alluvial soil consisting of shallow light-colored sediments resting upon dark ones. It occurs chiefly in narrow flood plains but extends into the uplands along some of the drainage-ways. Positions occupied are like those of Wabash-Judson silt loams and Wabash silt loam. Most areas are associated with Fayette and Lindley soils. The individual bodies, usually narrow, irregular, and small, aggregate 9,088 acres.

A profile description follows:

- 0 to 16 inches, light brownish-gray very friable silt loam, frequently with a thin or medium moderately platy structure, apparently caused by stratification; medium acid.
- 16 to 36 inches, dusky-brown friable silt or silty clay loam; almost black when wet; medium acid.
- 36 inches +, dark-gray silty clay loam or silty clay, faintly mottled with moderate brown and weak yellow; medium acid.

The common variations in profile are chiefly those in thickness of the light brownish-gray surface layer, which ranges from about 6 to 36 inches but commonly falls between 10 and 20. Where the thickness exceeds 20 inches there is usually some mottling in the lower part. Another variation consists of slightly sandy areas below Thurman or Chelsea loamy fine sands.

Use and management.—Since most bodies of Ray silt loam are small, their use is generally determined by that of the associated soils. The areas occurring with Lindley-Fayette silt loams are commonly used for pasture or left in forest. The soil supports excellent stands of bluegrass and provides better pasture than the associated soils.

The larger bodies can be cultivated and are used chiefly for corn and other intertilled crops. As it is mapped in the county the soil is more productive than typical Ray silt loam. Normally, Ray soils are associated with more weathered ones. Average yields obtained are about 15 percent less than those from Wabash silt loam. Problems of drainage and flood control are somewhat similar for the Ray and Wabash silt loams.

Rough broken land.—This land type consists of hilly and stony uplands in which are outcrops of limestone. Except for small included spots, no soil profile has been formed from the limestone or from the thin layers of overlying loess and drift. Rough broken land is found principally along the valley of the Iowa River north and northwest of Montour, in a total of 320 acres. Most of it is in pasture or forest; local spots are the sites of quarries.

Sawmill silty clay loam.—This soil type is a minor one covering only 768 acres. It occupies depressed areas in the flood plains associated with the various types of Wabash soils. As mapped in this county, the soil is more poorly drained than typical Sawmill silty clay loam. Most areas are intermittent ponds covered by water during part of each year. The soil is covered by water long enough to prevent use of the land for crops but not to keep down a growth of coarse water grasses (pl. 9, A). These grasses are used for pasture and sometimes cut for hay. Production from the soil is low.

Shelby loam.—This, the normal or rolling phase, has been formed from medium- to fine-textured glacial till under grass vegetation in rolling uplands. It commonly occupies valley slopes (8 to 16 percent) along small streams and drainageways. This soil differs from the eroded gently rolling phase of Carrington loam in the finer texture and browner color of the deeper layers.

Individual bodies seldom exceed 20 acres. Most of them occur in the general area of rolling to hilly dark-colored soils of the uplands, chiefly south of the Iowa River. A few areas are north of the Iowa River in southern Howard Township. Most of the soil occurs in association with those of the Tama, Carrington, and Wabash series. Its total area is only 1,024 acres.

A profile description follows:

- 0 to 6 inches, dusky-brown friable loam; strongly acid.
- 6 to 20 inches, weak-brown to moderate yellowish-brown friable gritty light clay loam or clay loam; strongly acid.
- 20 to 34 inches, moderate- to strong-brown clay loam; very sticky and very strongly plastic when wet; strongly acid.
- 34 to 50 inches, moderate to light yellowish-brown gritty clay loam or clay, containing some gravel and coarse sand; medium to strongly acid.

Of the several variations, the chief ones are in the texture and thickness of the surface soil and in the nature of the subsoil. The surface soil commonly has a loam or silt loam texture with the loam predominating, but it usually is a clay loam in eroded spots. Thickness of the layer ranges from about 3 to 8 inches for the most part, though the surface soil may be absent from convex slopes. At depths ranging from 6 to 36 inches there is commonly a layer of strong-brown clay that is very strongly plastic and sticky. This layer is slowly permeable to water, permits some lateral movement of moisture over its surface, and most commonly occurs at the juncture of the loess and

Kansan till. Lateral movement of water over the clay seems to be responsible for the small earth slides or slips, the scars of which show on a number of hillsides.

Use and management.—Most of Shelby loam is under cultivation, with the rest largely in pasture. Yields obtained fall below those from the rolling Carrington soils.

Careful management is necessary to maintain productivity and prevent erosion. Rotations should include a high proportion of legumes and grasses and a low proportion of intertilled crops. Soybeans should not be grown generally, because they result in serious erosion. Additions of organic matter, applications of lime when necessary for legumes, contour cultivation, and strip cropping are all measures that will help to maintain production. Small grains, legumes, and grasses respond favorably to the application of phosphates.

Shelby loam, eroded hilly phase.—This differs from the normal phase in steeper slope and shallower profile. Slopes commonly range from 12 to 16 percent, but a few exceed 16 percent. On these steeper slopes the soil profile is distinctly shallower than on areas of the normal phase. All layers are less distinct, but the shallower surface soil is especially evident.

This phase occurs in the form of small scattered bodies, chiefly in the general area of rolling to hilly dark-covered soils of the uplands. Most of the 2,112 acres mapped is in the southwestern part of the county.

Use and management.—Most areas of Shelby loam, eroded hilly phase, are now in pasture, with a few small areas in cultivation. Though the soil is much better adapted to pasture than to crops, much of it has been used for crops with discouraging results. Occasional areas can be used to advantage for hay crops, as clover, timothy, or alfalfa. Applications of lime and phosphate are generally necessary for good stands and yields of legumes and grasses. If the soil is not badly needed for crops, better long-time returns will follow its use as permanent pasture. Where pastures are carefully managed, the carrying capacity is about one cow per 2½ or 3 acres during the grazing season.

Tama silt loam.—This, the normal phase, is a Prairie soil formed from loess under grass vegetation in undulating uplands. It occupies slopes ranging from 3 to 8 percent, mostly on slopes below 6 percent. The soil generally occurs on mild slopes lying between Tama silt loam, level phase, or Muscatine silt loam on the divides and Wabash-Judson silt loams or Wabash silt loam in the drainageways and flood plains (pl. 8, C).

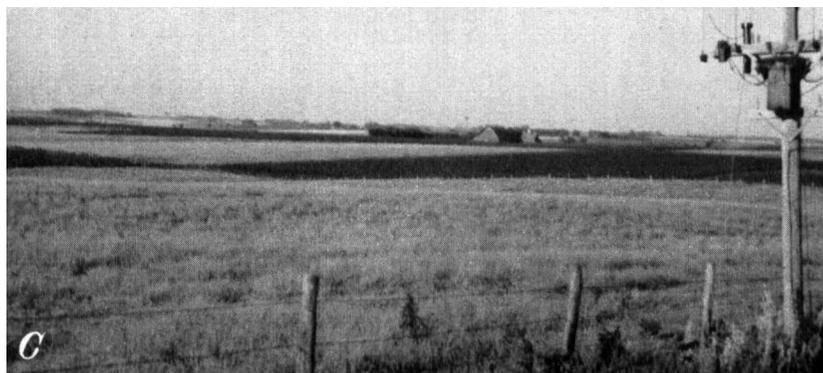
This soil is distributed throughout all areas of dark-colored soils of the uplands, but it occurs more widely in the northern half of the county. The total area is 35,904 acres.

A profile description follows:

- 0 to 12 inches, dusky-brown mellow very friable silt loam of fine moderately granular structure; medium to strongly acid.
- 12 to 18 inches, dark-brown to moderate yellowish-brown friable heavy silt loam or silty clay loam, becoming lighter in color and heavier in texture with increasing depth; strongly acid.
- 18 to 50 inches, moderate yellowish-brown friable light silty clay loam grading into silt loam; some dark-brown mottling; layer may give way to glacial drift at depths of 24 inches or more; medium to strongly acid.



- A*, Dissected region of Lindley and Fayette soils in which all the ridge tops are at or near the same elevation. The ridge tops, occupied by Fayette silt loam and its level phase, are used for crops, as also are moderate valley slopes and wider flood plains (Ray silt loam). Oats have been grown on Fayette silt loam, eroded rolling phase, in the field beyond the trees to the right. Steep slopes of Lindley-Fayette silt loams, eroded phases, in the foreground and in the background to the left are in permanent pasture.
- B*, Land use pattern of pasture, alfalfa hay, corn, and trees on Lindley silt loam, gently rolling phase. Ray silt loam occupies the narrow strip in the draw marked by the nearby trees at the right; bluegrass pasture in the immediate foreground; and corn to the left of the road. Beyond the draw to the right are two alfalfa fields. The graveled farm-to-market road (center) is common in many parts of the county.
- C*, Farmstead in the valley of the area of rolling to hilly dark-colored soils of the uplands. Timothy stubble and corn in foreground are on Judson silt loam, and pasture in the background is on Lindley-Fayette soils.



- A*, Farmstead in the area of undulating to level dark-colored soils of the uplands, oats on Muscatine silt loam in the foreground. Trees in background are one of the farm groves that include practically all trees found in this area.
- B*, Rotation pasture of sweetclover on Muscatine silt loam; corn and soybeans in the background.
- C*, Landscape in the smoother parts of the area of undulating to level dark-colored soils of the uplands, chiefly Tama silt loam with some Muscatine silt loam. The land use pattern, with almost all land under cultivation, includes rotation pasture (timothy and clover) in the foreground and corn, oats, and soybeans in the background.

Variations are mainly in thickness of the surface soil and in depth to glacial drift. The surface soil is often no thicker than 8 inches on convex slopes at the ends of spurs, and in a few such places it has been removed entirely. Maximum thickness of the surface soil is about 14 inches. The depth to glacial drift commonly ranges from 48 to 72 inches, but it may be only 24 inches, or as much as 100 to 250.

Use and management.—Nearly all of Tama silt loam is used for crops (pl. 10, *A*), and the soil is highly productive under cultivation. Crops grown and average acre yields obtained are: Corn, 50 to 55 bushels (pl. 10, *B*); oats, 40 to 45 bushels; clover and timothy hay, 1¾ to 2 tons; and alfalfa, 2 to 2¾ tons. Applications of lime are necessary for the successful production of legume crops (pl. 10, *C*).

Maintenance of a high level of productivity is not difficult. It requires measures for the addition of organic matter, the choice of suitable rotations, and applications of lime and phosphates for legumes. In general, intertilled crops should not be grown more often than 40 or 50 percent of the time. Waterways should be kept in grass, and contour tillage will be found helpful, especially on the more sloping areas.

Tama silt loam, eroded phase.—The eroded phase differs from the normal phase in having a shallower surface layer and more eroded spots. The slope ranges of 3 to 8 percent are the same, but a larger acreage of the eroded phase lies in the upper end of the range. In more level uplands the eroded and normal phases occupy the same kinds of positions. The eroded phase, however, also occurs extensively in the rolling to hilly parts of the county. Severely eroded spots are common, especially on the more sloping areas, and the average thickness of the surface soil is several inches less in areas of the eroded phase.

This phase is widely distributed in the general areas of rolling to hilly and undulating to level dark-colored soils of the uplands. It covers 60,672 acres and is second in extent among the soils of this type and of the county.

Use and management.—The use of Tama silt loam, eroded phase, is essentially the same as that of the normal phase. Crop yields obtained, however, are on the average about 20 percent lower. In farming the eroded phase, the same principles of management apply, but more emphasis should be placed on close-growing crops and such supporting erosion-control practices as contour cultivation.

Tama silt loam, eroded gently rolling phase.—This phase has more rolling topography, a shallower profile, and more eroded spots than the normal. The slopes commonly range from 8 to 12 percent.

The mode of occurrence, general distribution, and association with other soils are comparable with those of the gently rolling phase. This soil, however, is much less extensive (9,216 acres) than are the major phases of the soil type.

Use and management.—The eroded gently rolling phase of Tama silt loam is used in essentially the same way as the normal phase. Most areas are cultivated, a few remaining in pasture. Yields of crops are about 30 percent lower than those of the normal phase. This phase is well suited to hay crops and small grains (pl. 11, *A*) and less well suited to corn. Most areas are subject to harmful erosion if intertilled crops are grown too frequently in the rotation. Generally,

intertilled crops can make up 25 percent of the rotation and hay crops about 50 percent. Management methods to maintain fertility are like those necessary for the normal phase, but more emphasis should be placed on the control of erosion. General adoption of such practices as contour cultivation and strip cropping, with the use of terraces on the longer slopes, will make it possible to grow a much higher proportion of intertilled crops while controlling erosion and maintaining fertility levels.

Tama silt loam, eroded hilly phase.—This is the least extensive phase of Tama silt loam and covers only 1,152 acres. It is generally associated with the rolling phases of its type and with the rolling or hilly phases of Carrington and Shelby soils. It has much steeper topography, a shallower profile, and includes more eroded areas than the normal phase. Slopes commonly range from 16 to 25 percent.

A profile description follows:

0 to 5 inches, dark-brown very friable silt loam; medium acid.

5 to 14 inches, dark-brown to moderate yellowish-brown friable light silty clay loam, becoming lighter colored with increasing depth; medium acid.

14 to 42 inches, moderate yellowish-brown friable light silty clay loam grading to heavy silt loam at lower depth; may give way to glacial drift at depths of 24 inches or more; medium acid.

The variations in this phase are of the same kind as those of the eroded rolling phase. Badly eroded spots are common, especially on the rounded ends of ridges. Outcrops of glacial drift are present but not numerous.

A few small sandy areas, shown by sand symbols, are included with the eroded hilly phase in two localities. One of these is northeast of Toledo, and the other, south of the Iowa River in Richland Township. These sandy areas are essentially comparable to the Tama-Thurman complex.

Use and management.—Tama silt loam, eroded hilly phase, is used principally for pasture, with a small acreage in cultivation. Most of the soil has been cultivated in the past, and occasional areas are still cultivated from time to time. The soil is poorly suited to tillage, however, and usually erodes badly when used for corn or soybeans. It is better adapted to hay and small grains and, if cultivated, will produce better yields of these crops. Wherever use of the soil for pasture is feasible, however, the soil will provide greater long-time returns through grazing. Improvement of pasture stands by the use of lime and phosphate and by reseeding is generally desirable.

Tama silt loam, eroded rolling phase.—This phase differs from the normal phase in having more sloping topography, a generally shallower profile, and more eroded spots. The soil commonly occupies the shoulders of ridges, with slopes ranging from 12 to 16 percent. The profile is intermediate between those of the eroded gently rolling and eroded hilly phases. The individual layers are thinner than in the profile of the eroded gently rolling phase and thicker than in the eroded hilly phase.

The soil commonly occurs in areas of less than 20 acres. Most of these small individual bodies are in the general area of rolling to hilly dark-colored soils of the uplands, associated chiefly with Shelby, Carrington, and other Tama soils. Their total area is 4,352 acres.

Most variations included with this soil are of two kinds. In one kind there are occasional outcrops of glacial till, a few of which are shown

by map symbols, that are more eroded than the surrounding area. In these eroded areas the surface soil averages 6 inches thick and varies in the manner characteristic of soils occurring on both convex and concave slopes. The soil is thinnest on the convex slopes of the spurs. The other kind of inclusion is made up of a few small areas with slopes exceeding 16 percent.

Use and management.—All areas of Tama silt loam, eroded rolling phase, have been cultivated at some time in the past, but many are now in pasture. Because of rolling topography, the soil is not well adapted to intertilled crops. Corn yields under good management range from 30 to 35 bushels an acre. This phase is better suited to hay and small grains than to intertilled crops where it is to be cultivated. Many areas can be used to good advantage for pasture.

Much care needs to be exercised in the management of this phase for the maintenance of productivity and the control of erosion. Crop rotations should include little corn (20 percent) and much hay (60 percent). Emphasis should also be given to liberal applications of manure, to the use of lime and fertilizer, to the grassing of waterways, and to the adoption of contour cultivation and strip cropping. These latter practices are necessary for the control of erosion if intertilled crops are grown. On farms having soils better adapted to cultivation, this phase can be used for pasture with good results.

Tama silt loam, gently rolling phase.—This soil is somewhat more sloping than the normal phase and also has a shallower profile. It occurs either on the upper shoulders or on the lower slopes of ridges. The common gradient is from 8 to 12 percent, with a few slopes outside these limits. The phase, widely distributed in small individual bodies in many parts of the county, is associated with other phases of the type and with Carrington soils for the most part. The total area is 9,856 acres.

A profile description follows:

- 0 to 8 inches, dusky-brown friable silt loam with fine weakly crumb structure; medium acid.
- 8 to 18 inches, dark-brown to moderate yellowish-brown friable light silty clay loam with medium weakly granular structure, the color becoming lighter with increasing depth; medium to strongly acid.
- 18 to 50 inches, moderate yellowish-brown friable silty clay loam; medium acid.

The same variations in thickness of surface soil exist in areas of the gently rolling and eroded phases of this type. Thickness of the surface layer ranges from 4 to 10 inches, averaging somewhat less in the gently rolling phase because of the steeper topography. This topography is also reflected in the lesser depth of the entire profile. Occasional outcrops of glacial drift may be found, although depth to till ranges from 24 to 100 inches.

Use and management.—Most of Tama silt loam, gently rolling phase, is used for crops; the rest is in permanent pasture. The crops grown and the average acre yields obtained under good management are 40 bushels of corn, 40 bushels of oats, and 1½ tons of clover and timothy hay. Soybeans are grown to some extent, but the soil is not well adapted to the crop. To remain productive this phase needs better care than the normal phase. The greater slope makes the control of erosion somewhat more difficult. Crop rotations should include less corn (about 20 percent) and more mixed hay (about 60 percent). The

addition of lime and phosphate for legumes will improve the stands and yields of these crops. Additions of organic matter in the form of manure also are desirable to maintain nitrogen levels and good tilth. Waterways can be kept in grass to reduce the danger of gullying. Supporting practices, as contour cultivation and strip cropping, will aid greatly in the control of erosion when the soil is used for intertilled crops.

Tama silt loam, level phase.⁸—The level phase is smoother than the normal phase and has a deeper profile. It has been formed from loess under grass vegetation on the crests of broad irregular divides. The gentle slopes (1 to 3 percent) provide adequate natural drainage. Surface runoff after rains, however, is not rapid enough to cause an erosion problem.

The level phase is widely distributed, especially in the general area of undulating to level dark-colored soils of the uplands. Individual bodies vary greatly in size, and some of them extend for several miles along the crest of a divide. Most of the phase occurs in the northern half of the county, but a significant part lies in the southern part below the Iowa River. The total area of 64,064 acres makes this phase the most extensive among the soils of this type and of the county.

A profile description follows:

- 0 to 14 inches, brownish-black mellow and very friable silt loam with fine weakly granular structure; medium to strongly acid.
- 14 to 20 inches, dark-brown to moderate yellowish-brown friable heavy silt loam or silty clay loam, with medium moderately granular structure, the color in this transitional layer becoming lighter with increasing depth; strongly acid.
- 20 to 50 inches, moderate yellowish-brown friable light silty clay loam grading into silt loam at a lower depth; occasionally mottled with dark brown; medium acid.

Variations in the profile are uncommon, but they do occur in some places. In the more level areas, the profile has some of the characteristics of Muscatine silt loam. It is intermediate between the profile as described and that of the Muscatine soil. On narrow ridges in dominantly rolling to hilly landscapes the surface layer tends to be thinner and lighter colored. Where it is closely associated with members of the Carrington series, glacial till may be encountered at depths of less than 24 inches in some spots. In places calcareous loess may be encountered at depths of approximately 72 inches.

Use and management.—Practically all areas of Tama silt loam, level phase, are in cultivation, and good yields are obtained. The soil is considered one of the best in the county and is equaled by few others. Crops grown and average acre yields obtained under good management are 50 to 60 bushels of corn, 40 to 50 bushels of oats, 2 tons of clover and timothy hay, and 3½ tons of alfalfa. Soybeans also can be grown without danger of harmful erosion, and the average yields are 20 to 25 bushels. The soil can be easily kept at high levels of productivity. Additions of organic matter, as barnyard or green manure, the application of lime for alfalfa and clover, and the inclusion of a legume in the rotation are necessary practices for maintenance of productivity.

⁸ Parts of Tama silt loam, level phase, especially those areas on broad flats that have imperfect natural drainage, may be included with Muscatine silt loam in future mapping.



A, Coarse grass vegetation on Sawmill silty clay loam
B, Trees, weeds, and grasses are the common vegetation on Wabash soils, undifferentiated; the flood hazard ordinarily prohibits its use for crop production.



- A**, An area of undulating to level dark-colored soils of the uplands with a small flood plain of Wabash silt loam in the foreground. The undulating upland of Tama silt loam is being used for corn, oats, and hay.
- B**, Corn on Tama silt loam. The fence line to the left is an indication of the gentle slope of the land.
- C**, Alfalfa on Tama silt loam. To obtain good stands of alfalfa on most of the soils of Tama County, it is necessary to apply lime, preferably a year before the seed is sown.

Tama-Thurman complex.—This complex is a mixture of soils in which Tama silt loam and Thurman loamy fine sand predominate. As a rule, 40 to 50 percent of the total acreage is the Tama soil, 15 to 20 percent the Thurman, and the rest has profiles intermediate between the two. Actual proportions of the different soils vary from area to area. The profiles intermediate between the Tama and Thurman soils may have a surface layer of loamy sand, sandy loam, or loam resting on silt or sand. They may also consist of shallow layers of silt loam over sandier materials. The topography is generally undulating and provides moderate to rapid surface drainage.

The complex is of minor extent (640 acres). Most areas occur in the uplands along the flood plains of the Iowa River, especially near Toledo and Chelsea. It is associated chiefly with Tama, Thurman, and Chelsea soils.

Use and management.—Most areas of Tama-Thurman complex are cultivated with adjacent soils. The yields obtained are more variable from year to year, and the average is lower than for Tama silt loam. Except for sandy spots, droughty and of low productivity, the complex can be maintained at a fair level of productivity by following good rotations, by applying barnyard manure, and by adding lime as needed. Spreading strawy residues on the sandier spots helps to reduce the danger of soil blowing in spring.

Tama-Thurman complex, eroded rolling phases.—These phases have steeper topography, shallower surface soil, and more eroded spots than the normal complex and cover a slightly larger area (960 acres). The slope range falls largely between 8 and 16 percent, but a few steeper areas are included. Association with other soils, variations within individual bodies, and general distribution are the same as in the normal complex.

Use and management.—About 50 percent of the Tama-Thurman complex, eroded rolling phases, is under cultivation. The crops grown are the same as on Tama silt loam, eroded rolling phase, but the yields obtained are lower and more variable. Management problems are comparable with those of Tama silt loam, eroded rolling phase, except that some additional care is needed to prevent soil blowing on the sandier spots in spring.

Thurman loamy fine sand.—This minor type, covering only 192 acres, occurs on ridge crests or on east slopes below ridge tops among the hills near the flood plain of the Iowa River. It is commonly associated with Chelsea, hilly Tama, and Lindley-Fayette soils.

This type has been formed from uniform fine sand under grass vegetation in undulating to rolling uplands. The sand seems to have originated in the flood plains and then has been sorted, moved to the uplands, and laid down by wind. Local spots include glacial gravel and coarse sand in the lower part of the deposit. The soil differs from Chelsea loamy fine sand in having a dark-colored surface layer.

A profile description follows:

0 to 12 inches, dusky-brown slightly coherent loamy fine sand; medium acid.

12 to 20 inches, weak-brown loose loamy fine sand; medium acid.

20 inches +, weak-yellow to moderate yellowish-brown sand; medium acid.

Use and management.—Most areas of Thurman loamy fine sand are too small to be farmed by themselves and are therefore used with the adjacent soils. Most of them are cultivated, some with fair success

for watermelons and cantaloups, but a few are in pasture. The soil is of low productivity, though it is a little better than Chelsea loamy fine sand. Management problems of the two soils, however, are similar. In general, when the soil is cultivated care is needed to prevent blowing in spring. Except for this additional precaution, the soil can be managed in the same way as the adjacent soils. Where the pattern of soil types permits, it is desirable to use this soil for pasture or retire it to forest.

Traer silt loam.—Among the soils of Tama County this is the least extensive (64 acres). It occurs in small areas (3 to 10 acres) about $1\frac{1}{2}$ miles west of Vining, in northeastern Indian Village Township, and in northwest Toledo Township. It is usually associated with the level and normal phases of Fayette silt loam.

The soil has been formed from loess in level uplands, chiefly under forest vegetation. In some places there seem to have been mixed stands of forest and grass. Drainage is poor because of the level topography and fine-textured subsoil.

A profile description follows:

- 0 to 10 inches, light brownish-gray readily friable silt loam with a fine weakly platy structure in the lower part; strongly acid. This layer contains flecks and streaks of light-gray silt loam.
- 10 to 14 inches, finely variegated light-gray and light brownish-gray very friable silt loam with medium moderately platy structure; strongly acid.
- 14 to 22 inches, friable silt loam, moderate brown in place and becoming light brownish-gray when crushed; very strongly acid. This is a transitional layer.
- 22 to 33 inches, moderate olive-brown to moderate-brown silty clay mottled with weak orange and dusky brown; strongly plastic when wet and with medium moderately subangular blocky structure; very strongly acid.
- 33 inches +, light yellowish-brown mottled with weak-orange light silty clay loam grading into silt loam; medium to strongly acid.

Use and management.—Nearly all Traer silt loam is under cultivation, with a few small areas in forest. The crops grown and the average acre yields are 25 to 35 bushels of corn, 20 to 25 bushels of oats, and 1 ton of clover and timothy hay.

Management problems are chiefly those of improving natural drainage and fertility. Tile lines must be placed much closer together than is necessary in Muscatine silt loam. Tile drainage may prove effective on Traer silt loam, and surface drainage also may be needed. Applications of lime and phosphate are necessary for good stands of legumes. The use of manure and high proportions of legumes and grasses in the rotation will improve fertility. The control of erosion is not a problem.

Wabash-Judson silt loams.—This is a complex of dark-colored soils formed from local alluvium and colluvium along upland drainageways. Each individual area consists of two fairly distinct parts. One is the narrow flood plain along the channel, sometimes scarcely distinguishable, in which Wabash silt loam occurs. Along both sides of the flood plain are the narrow upland toe slopes covered by the dark colluvial material of Judson silt loam. Both kinds of positions are too narrow to be mapped separately. Most areas of the complex are gently sloping (2 to 4 percent) so that they have moderate external drainage. Internal drainage, however, is often imperfect or poor because of seepage from adjacent uplands.

Wabash-Judson silt loams are widely distributed as narrow, finger-like bodies that branch with the streams and reach into all parts

of the uplands. The complex occurs in all parts of the county but is associated chiefly with Tama, Carrington (pl. 11, *B*), and Downs soils. The total area of 28,096 acres makes the complex sixth in extent among the soils of the county.

Variations in the two profiles of the complex are rather common. In drainageways leading out from Garwin silty clay loam the texture of both soils is somewhat heavier than normal. The reverse is true where Wabash-Judson silt loams lie below areas of Thurman or Tama-Thurman soils. In such places, the surface layer is usually a loam or sandy loam. In regions where the soils of the uplands are light-colored, there is often a thin layer (3 to 6 inches) of light brownish-gray sediments over the surface of Wabash-Judson silt loams.

Use and management.—The use of Wabash-Judson silt loams is determined largely by that of the adjacent soils. Individual bodies are too small to be cultivated as separate fields. For this reason, some areas are cultivated, some are in pasture (pl. 12, *A*), and a few are in forest. Crops grown and average acre yields obtained are 50 to 60 bushels of corn an acre and 2 to 3 tons of clover and timothy hay (pl. 13, *A*). The complex is well adapted to pasture and supports excellent stands of bluegrass and clover (pl. 11, *C*).

Management problems center around the control of erosion in the channels and, in some areas, drainage improvement. Tile lines have been successfully used to carry off surplus water in many places. To control erosion in channels, the waterways should be grassed. Once a sod is established, the waterways should be kept permanently grassed, because runoff from adjacent uplands readily forms gullies in this complex. Where channels are not deep, grass waterways can be maintained with little difficulty. Practices needed for deep channels are discussed under Gully Control. Along upper drainageways where areas of this complex are too small to be shown on the map, the gullying also occurs and the methods of control also apply.

Wabash sandy loam.—Least extensive among the Alluvial soils, this dark-colored type covers only 192 acres. Most areas are slightly higher spots in the flood plain of the Iowa River. Natural drainage is better than in the silt loam with which this soil occurs.

A profile description follows:

- 0 to 10 inches, dusky-brown slightly coherent sandy loam; medium acid.
- 10 to 20 inches, dark-brown very friable fine sandy loam, grading to loam in the lower part; medium to slightly acid.
- 20 inches +, dark-brown to light brownish-gray silty clay loam; medium to slightly acid. Color and texture vary considerably, but the color generally becomes lighter and the texture heavier with increasing depth.

Use and management.—Because the individual bodies are small, nearly all Wabash sandy loam is used with the surrounding larger bodies of silt loam. The sandy loam is less productive for corn and hay and slightly more productive for small grains. Problems of controlling overflow are the same as for the silt loam. The sandy loam is a little easier to cultivate and can be tilled sooner after rains.

Wabash silt loam.—A dark-colored nearly level Alluvial soil formed from sediments washed down chiefly from Prairie soils of the uplands. External drainage is generally slow and internal drainage ranges from moderate to slow.

This is the most extensive member of the Alluvial soil group and its total area of 50,560 acres ranks third among the soils of the county.

The largest areas are in the flood plain of the Iowa River and smaller ones occur along smaller streams. Most of the soil is included in the general area of soils of the flood plain, but long narrow bodies extend along the smaller streams into many parts of the uplands. It is associated with other soils of the same series and with Sawmill silty clay loam in the flood plain of the Iowa River. Over much of the county it is associated with the Tama, Carrington, and other upland soils.

A profile description follows:

0 to 10 inches, brownish-black very friable silt loam; black when wet; medium acid.

10 to 26 inches, dusky-brown friable heavy silt loam; medium to slightly acid.

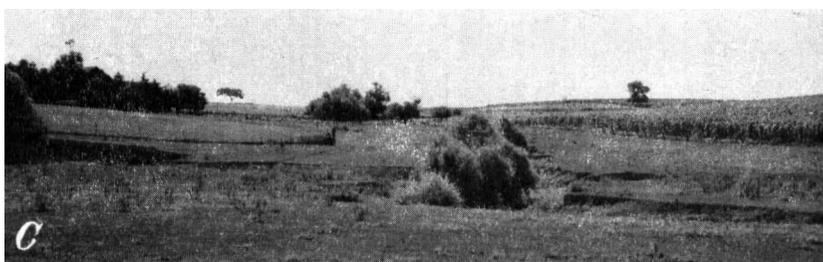
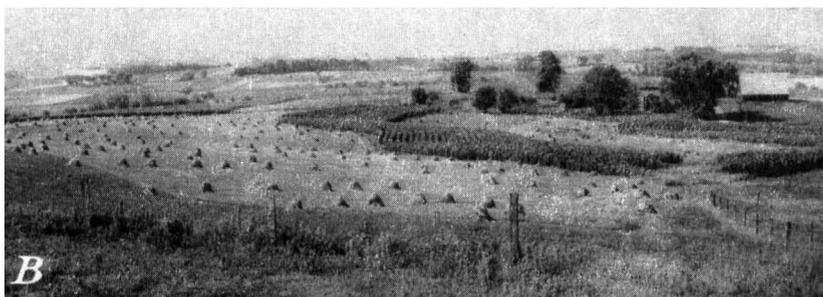
26 to 44 inches, dusky-brown friable to firm silty clay loam; slightly plastic when wet; medium to slightly acid.

44 inches +, dark-gray firm silty clay, somewhat mottled; slightly acid.

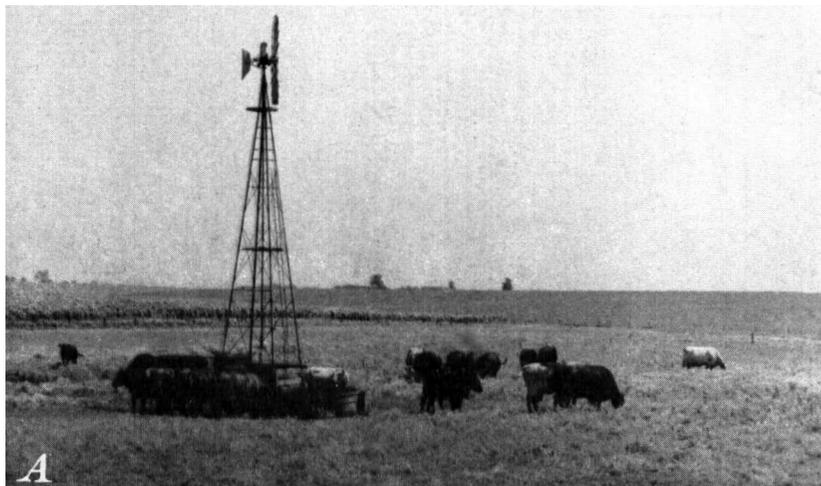
Variations are common within areas of this type, chiefly in color and texture. In flood plains through areas of light-colored upland soils, Wabash silt loam frequently carries an overwash of light brownish-gray silt loam less than 8 inches thick. Where this layer is more than 8 inches thick the soil is mapped as Ray silt loam. A less common variation also found in the same general regions is the presence of a light-gray layer in the profile comparable with that found at depths of 10 to 16 inches in the profile of Chariton silt loam. This variation is closely related to the Humeston series of southern Iowa. The profile differs from that of Chariton silt loam in that the deeper layers are not clay in texture. A third variation consists of soils with sandy profiles which, if larger, would have been mapped with Wabash sandy loam. The profile in such spots, however, is often sandier than that of the Wabash soil and it seems more nearly comparable with that of the Cass series. Most sandy areas are somewhat more acid than the Cass soils.

Use and management.—Slightly more than half the total acreage of Wabash silt loam is under cultivation, with the rest largely in permanent pasture. Proportions under cultivation differ from the flood plain of the Iowa River to the flood plains of the creeks and smaller streams. Approximately two-thirds of the soil in the Iowa River flood plain is under cultivation, but only about half that in other parts of the county. The uncultivated areas are almost entirely in bluegrass pasture (pl. 12, *B* and 13, *B*). Corn is the principal crop grown, and average yields are about 60 bushels an acre where the soil is protected from overflow. Excellent yields of soybeans also are obtained on protected areas (pl. 13, *C*). Yields of oats and other small grains (pl. 14) are good in dry years but tend to be low in wet years because of lodging. In uncultivated areas used for pasture, production is high, with a carrying capacity of about one cow per 1½ acres during the grazing season. Pastures are especially valuable when the vegetation on upland pastures stops growing in summer.

In common with all others of the flood plains, this soil is subject to overflow and flooding. The danger of overflow, however, varies from area to area and largely determines whether an individual area can be cultivated successfully. The frequently flooded areas are left in bluegrass pasture, whereas those that can be protected from overflow or those subject to infrequent flooding are cultivated. The difference in elevation between the flood plain and the stream channel and the extent



- A. Rolling phases of Tama silt loam. Oats in the foreground with hay and corn in the background. A farmstead is in the central background.
- B. Contour strip cropping on undulating Carrington silt loam. This is an important measure in erosion control on undulating to rolling slopes.
- C. Narrow pastured area of Wabash-Judson silt loams extending into the upland from a larger body of Wabash silt loam. Corn to the right and hay to the left are on undulating slopes of Carrington soils.



A, Bluegrass pasture on Wabash-Judson silt loams in the foreground; corn and hay on the gentle slopes of Tama silt loam in the background. The cattle are mainly Aberdeen Angus. Wells furnish water for livestock in many Wabash-Judson draws.

B, Permanent pasture along Bennett Creek in southwestern Tama County. The level land in the flood plain is Wabash silt loam and the upland slopes to the right and left in the background are Carrington silt loam, eroded rolling phase. Most of the cattle are of the Shorthorn breed.

of meandering materially influence the likelihood of overflow. Higher areas are less frequently flooded, and straight channels tend to overflow less often. The probability of flooding cannot be determined from the soil maps.

In some places farmers have erected small levees to reduce the danger of overflow, or the construction of roads and railway grades has reduced natural flood hazards. Though small levees may reduce flood frequency, on the whole little can be done about the danger of overflow.

Aside from the control of overflow there are few management problems in the farming of Wabash silt loam. The soil is fertile and is easily kept at a high level of productivity. It can be used often for corn, soybeans, and other intertilled crops.

Wabash silty clay loam.—This type has the same general profile appearance as the silt loam, but the texture ranges from silty clay loam to silty clay in all layers. The soil usually occupies slightly depressed sites, chiefly in the flood plain of the Iowa River, and many areas occupy former river channels that are now almost filled with sediments. As a rule individual bodies are small and irregular. The total area is 9,344 acres.

Use and management.—Approximately half of Wabash silty clay loam is cultivated, and the other half is in bluegrass pasture. Where adequate drainage is provided, the soil is used for corn and hay, with yields comparable with those on Wabash silt loam. Yields of small grains, however, are distinctly lower because of the tendency toward lodging. Areas that cannot be drained are used chiefly for pasture, although the vegetation is less desirable than that common on the silt loam. The silty clay loam carries coarser varieties of grasses and is usable for a smaller part of the grazing season.

The flood hazard on the silty clay loam is the same as that on the silt loam, but the damage from overflow is somewhat greater because of the more restricted drainage. In addition to problems of flood control, there is also one of proper tillage. The soil should be cultivated under favorable moisture conditions for the maintenance of satisfactory tilth.

Wabash soils, undifferentiated.—This mapping unit includes the several types of the Wabash series together with a few areas of Ray and Sawmill soils. It occurs in areas near the stream channel that have an irregular topography and are subject to frequent overflow. Most areas occur in the flood plains of the Iowa River and of Salt, Wolf, and Deer Creeks, usually 2 to 6 feet below the level of the smoother flood plains back from the channel. Furthermore, some areas include a number of ox-bow lakes and are crisscrossed by former channels. The total area is 10,176 acres, most of it near the channel of the Iowa River.

Use and management.—Most of Wabash soils, undifferentiated, are in woodland pasture, but a few areas are cultivated. Pasture vegetation consists of Kentucky bluegrass, various other grasses, weeds, and trees (pl. 9, B). Grasses are more common where the soils are less frequently flooded. In other places weeds and trees tend to predominate. The soils are not highly productive of pasture, chiefly because of the frequent overflow. Where cultivated the soils produce high yields of corn in years when the crop is not damaged by overflows. In gen-

eral, the risks involved in cultivation are too great to warrant use of the land for crop production.

Waukesha loam.—This soil type occurs with the silt loam of the same series on terraces along the Iowa River and larger creeks. The small individual bodies are usually higher than the surrounding larger areas of the silt loam. The topography is level to gently undulating. External drainage is slow, but internal drainage is moderate, so that the soil is well drained. It is of limited extent and covers only 448 acres.

A profile description follows:

- 0 to 14 inches, dusky-brown very friable loam; medium to strongly acid.
- 14 to 30 inches, moderate yellowish-brown silty clay loam or silt loam; medium to strongly acid.
- 30 to 60 inches, moderate yellowish-brown friable silty clay loam or heavy silt loam, often containing appreciable quantities of sand, pebbles, and coarse gravel; strongly acid.

Some small areas of Buckner sandy loam and some of Waukesha silt loam are included on the map. A few areas have undulating topography and somewhat excessive drainage.

Use and management.—Nearly all areas of Waukesha loam are cultivated, with a very few in pasture. Good crop yields are obtained under good management, though the averages are slightly lower than on the silt loam. The soil is easily cultivated and presents few management problems. Management for the maintenance of productivity is comparable with that of the silt loam, with some extra applications of organic matter.

Waukesha silt loam.—This Prairie soil formed from silty alluvium on terraces along the Iowa River and the larger creeks. These terraces commonly lie 5 to 10 feet above the flood plain, but a few are as much as 30 feet higher. The topography is level to gently undulating except along the margins of the terraces where they join the flood plains. These margins, seldom more than 2 or 3 rods wide, have slopes ranging from 4 to 12 percent. All areas are well drained.

The soil type is widely distributed, but occurs chiefly along the margins of the general area of soils of the flood plains. Individual bodies range from 5 to as much as 100 acres. The total area is 17,728 acres.

A profile description follows:

- 0 to 13 inches, brownish-black mellow very friable silt loam with medium weakly granular structure; medium to strongly acid.
- 13 to 20 inches, dusky-brown friable silty clay loam with medium moderately granular structure, weak brown to brownish gray when crushed; strongly acid.
- 20 to 40 inches, moderate yellowish-brown friable silty clay loam or heavy silt loam marked by occasional specks of light gray and dark brown; strongly to medium acid.
- 40 inches +, moderate yellowish-brown silty clay loam or heavy silt loam, slightly mottled with light gray and dark brown; medium acid.

There are few variations in the profile, but some areas of other soils are included. Occasional small spots of Waukesha loam and Buckner sandy loam were not separated, because of their small size. The margins of the terraces also are included, although they have shallower profiles and stronger slopes than is characteristic of the type. In some of these marginal areas between the terrace and the flood plain, gravel is common in the deeper layers. One such area lies north of

the town of Gladbrook. Crops growing on the soils with the gravelly substrata are subject to drought damage in drier seasons. In a few places where this soil is associated with the light-colored soils of the uplands the surface soil is lighter colored.

Use and management.—Nearly all areas of Waukesha silt loam are under cultivation, and very few are being used for pasture. Crop yields are comparable with those obtained on Tama silt loam, level phase. With its high yields and ease of management, this is among the best soils in the county. Management for the maintenance of productivity should include legumes in the rotation, the addition of lime and phosphate for legumes, and occasional applications of manure.

USE, MANAGEMENT, AND PRODUCTIVITY OF THE SOILS OF TAMA COUNTY

The use, management, and productivity of the soils of Tama County are discussed in three main parts. The first part is a general discussion of some practices and principles of soil management. Liming, crop-rotation, and contour-cultivation practices are described. In the second part the soils are grouped on the basis of those physical properties that have the greatest influence on management. Thirteen soil groups with similar management problems are listed, and the general nature of the problems of each described. The third part, dealing with the productivity of the soils, gives estimated yields that might be expected of the more important crops over many years under defined systems of management. The probable erosion hazard also is indicated. Three levels of management are usually defined for each soil. In addition, productivity ratings are given to indicate the relative capacities of the soils to produce crops as compared with other soils in the United States. It is suggested that those who live outside the county and are not familiar with its agriculture, first read the section on Agriculture of Tama County.

Farmers consider many factors in planning the organization and management of their farms. The more important of these factors are the price of the products that can be produced, the buildings, livestock, equipment, and machinery available, the cost of additional production materials and equipment, the likes and abilities of the farmer and his family, his financial resources and obligations, and the soil resources of the farm. These factors are not the same for every farm and farmer, and they also change with time on a given farm. Each farmer therefore must prepare the plans of organization and management of his farm for a set of conditions somewhat different from those of other farms. The farmer must decide what uses to make of his soil resources and what level of productivity is most practical in his circumstances. To make these decisions wisely, the farmer must know the various kinds of crops, grasses, and trees that may be grown on his farm, the productivity of his soils for these alternative crops under different systems of soil management, and the amount of labor, equipment, and other productive resources required by the different systems. He will also wish to plan a farming system that will make best use of his labor and resources throughout the year.

The productivity of a soil depends upon (1) its characteristics (including the climate it possesses) and (2) the management it receives.

The climate and the character of the soils on a farm ordinarily cannot be changed; they must be used as they are. Management, however, is largely controllable, and changes in the system of management can vary greatly the yield and quality of the crops produced. Changes can be made by varying one or more of many practices.

A system of soil management consists of a combination of many practices, as crop rotation, liming, contour strip cropping, and application of fertilizers. Each combination will produce different quantities and qualities of crops, but many combinations will produce similar results, all of which might be satisfactory from the standpoint of present and future production levels. Not all combinations, however, would be equally well adapted to the plan of organization of the individual farm unit. The farmer must select from alternative systems of soil management the one best suited to the set of conditions on his farm.

The effectiveness of any one management practice is dependent upon the other practices that are a part of the system. The response from an application of a commercial fertilizer in a system where no manure is applied or no legume grown, would be different from the response where such practices are followed. The degree to which serious erosion is prevented by contour cultivation depends partly upon the crop rotation followed. The value of any one crop in a rotation depends in part on its influence on the other crops in the rotation. The value of adding clover to a rotation with corn and oats is in part derived from the influence of the clover on the yields and quality of the corn and oats. It depends also on the total and seasonal needs for labor and other productive resources.

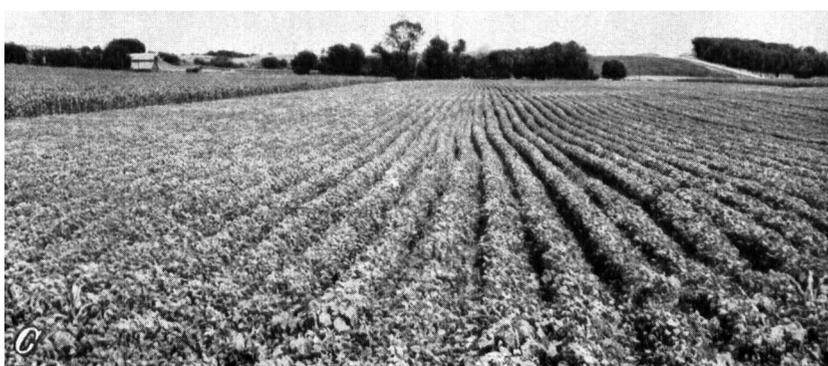
The soil pattern—a factor contributing much to the individuality of farms—is the particular combination and arrangement of different soils within the farm. This pattern is somewhat different in nearly every field. Most fields include more than one soil, and often these soils are significantly different from each other. Certain combinations of soils must be used and managed in one way, whereas other combinations can best be handled differently. The soil pattern should be considered in determining the size and shape of the fields into which a farm is to be divided, so as to adjust the cropping and pasture systems to the soils of the farm.

SOIL MANAGEMENT PRACTICES AND PRINCIPLES

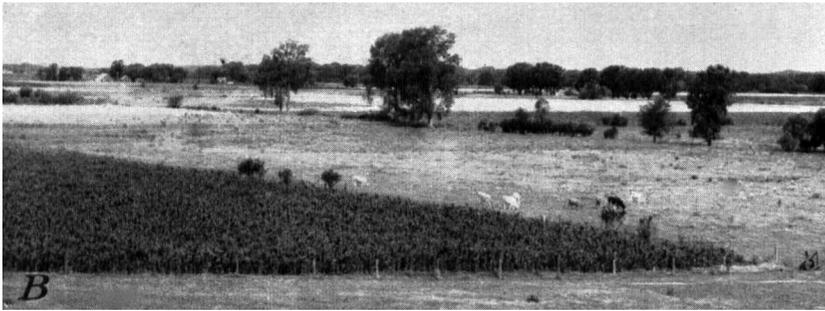
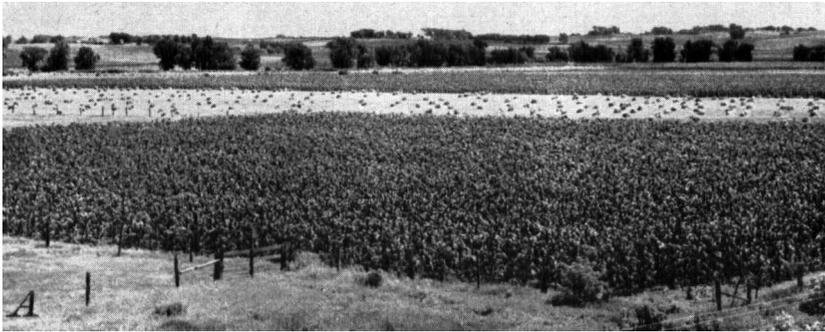
Every system of soil management is a combination of many practices. Some of the more important practices that can be the elements of a system and some of the important principles to be followed in choosing practices are discussed in this section.

CROP ROTATIONS

Crop rotation, the practice of alternating or rotating crops, is one important measure in maintaining yields and improving soil fertility. It has long been recognized, for example, that alternating crops of corn and oats yield better than either crop does when grown continuously. Moreover, the continued production of an intertilled crop, as corn, tends to lower the soil content of plant nutrients and organic matter and to bring about a gradual deterioration of soil structure.



1. Timothy and clover on Wabash-Judson silt loams and gently rolling Tama and Carrington soils. A mixture of timothy and clover is used more widely for hay in Tama County than any other crop.
- B. Landscape of gently rolling Carrington silt loam. The bluegrass pasture in the immediate foreground is on Wabash silt loam. A field of hay is in left background and one of corn in right background, both on Carrington soils.
- C. Soybeans and corn on Wabash silt loam. These level lands are better suited to growing intertilled crops, especially soybeans, than the gently rolling to rolling uplands, as Fayette silt loam, eroded gently rolling phase, which is along the highway in the distant background to the right.



- A**, Land use pattern of one of the better drained areas of Wabash silt loam that is being used for corn, oats, and pasture. The trees in the background along a stream are in a pastured area
- B**, Land use pattern of less well-drained Wabash silt loam in the flood plain of the Iowa River, with a greater acreage of pasture and smaller acreages of corn and oats.
- C**, Woodland pasture on a poorly drained area of Wabash silt loam near the edge of the flood plain of the Iowa River. Such areas are usually slightly lower, often because of the remnants of old channels and swales. Oats and corn in the background to the left are on a better drained site.

To offset these tendencies, it is necessary to grow crops other than corn and small grains in the rotation.

Legumes and grasses, both of which represent types of close-growing vegetation, are used in rotations with corn and small grains. These crops have beneficial effects on the soil. Organic matter is added, especially by the extensive root system; the structure of the soil is improved; and the content of certain plant nutrients, particularly nitrogen is increased. These improvements result in higher yields of corn and other crops and they must be considered in evaluating the part played by legumes and grasses in crop rotations.

The selection of rotations for a farm must be made on the basis of the nature and pattern of soil types and the organization of the farm unit. No one rotation is generally adaptable to all farms or soils. A rotation that would be feasible on a well-stocked, well-equipped farm would not be satisfactory on one having little livestock and less machinery. The rotations that could be followed on Wabash silt loam are not suitable for Chelsea loamy fine sand. The choice of suitable crop rotations must also take into account the fact that there will be considerable differences in the present productivity of soil types, such as Tama silt loam, because of differences in past management.

Crops used in rotations in this county are of three rather distinct groups, namely, grass and legumes, cultivated or intertilled crops, and small grains. The cultivated or intertilled crops are principally corn and soybeans. Oats is the principal small-grain crop, although there is a very small acreage in barley, wheat, and rye. The different kinds of grasses and legumes are more numerous, the principal ones being clover, timothy, alfalfa, sweetclover, and Kentucky bluegrass. An important function of the grain crop is to serve as companion crop when the grasses and legumes are seeded. More than one small-grain crop is seldom included in a rotation, but that one crop is nearly always included. The relative proportion of the cultivated crops to the grasses and legumes is the most important single characteristic of the crop rotation in this county. Generally, the greater the productivity of a soil and the fewer its problems of erosion control, the higher will be the proportion of cultivated crops that will give greatest returns.

Although crop rotations may appear to be rigid, considerable flexibility is permissible without materially changing the level of soil productivity or the degree to which serious erosion is prevented. Most of this flexibility is within the various crop groups. Substituting wheat or barley for oats, or sweetclover for some other clover, ordinarily will not have very great effects. Changes between groups, however, as a corn crop for clover may markedly influence productivity. Minor changes in the rotation are often necessary as the circumstances of the farm and the market shift. Specimen rotations by groups of soils are discussed in a later section and are illustrated in table 4.

MAINTAINING ORGANIC MATTER

The nature and quantity of organic matter in the soil are important for a number of reasons. Organic matter acts as a storehouse for the nitrogen needed by growing plants, and it also contains appreciable quantities of other plant-nutrient elements, particularly phosphorus. It serves as an energy source for micro-organisms, and some forms of

organic matter have a beneficial effect upon the physical condition (structure, permeability, etc.) of the soil. Because of the numerous ways in which organic matter may improve soil condition, the need for maintaining an adequate supply as part of a program for long-time high production is readily apparent.

Most of the soils of Tama County contained large quantities of organic matter when they were first brought under cultivation. The quantities were especially high in Wabash, Judson, and Muscatine silt loams, but low in Chelsea loamy fine sand. Poorly drained soils and soils of finer texture generally contain larger quantities of organic matter than those that are well drained or sandy.

Under the natural conditions prevailing before breaking the prairie or clearing the forest, a balance was established between the quantities of organic matter added by the native vegetation and that decomposed by micro-organisms. The quantities of organic matter and humus in the soil, therefore, tend to remain the same after the soil type has come into equilibrium with its climatic and vegetative environment. When the dark-colored soils of grasslands are brought under cultivation, the content of organic matter usually decreases for a number of years. Crops grow on the soils during a smaller part of the year than did the native vegetation, and part of each crop is removed from the land; furthermore, cultivation of the soil tends to promote more rapid decay of organic residues. Steps must therefore be taken to replenish the supply of organic matter and humus so as to maintain levels that will allow satisfactory crop production. These levels need not be the same, however, as those that prevailed in the virgin soils.

Organic matter may be added to the soil by plowing under crop residues, adding barnyard manure, using green-manure crops, and growing grass-legume mixtures for some period in each rotation. All may be found useful on a single farm, some perhaps more than others, depending on the nature of the soils and the organization of the farm.

Plowing under crop residues is perhaps the most common method. Although this will not maintain adequate quantities of organic matter in the soils of this county, the practice will be helpful. All crop residues, except those harboring diseases or insect pests, should be saved and used. Burning cornstalks, for example, is not desirable from the standpoint of soil fertility maintenance and should be avoided where possible. Addition of such types of organic matter as cornstalks is especially helpful in improving the physical condition of heavy-textured soils and in preventing erosion.

Barnyard manure is one of the most valuable forms in which organic matter can be added to soils. It supplies larger quantities of nitrogen than other kinds of organic matter generally available, and has other beneficial effects. Where considerable quantities of manure are available, as on a livestock farm, its conservation and proper use is an important step in maintaining an adequate supply of organic matter in the soil. It often happens, however, that manure is not well handled and thus loses much of its value before it is applied to the land. If maximum benefits are to be obtained, the use of large quantities of bedding to absorb the urine, storage of the manure where it will be kept moist but will not be exposed to leaching, and plowing it under as soon as possible after spreading are precautions that should be taken.

Sufficient quantities of manure to permit necessary applications on all fields are not always available, especially on grain farms, where fewer animals are kept. The growing of green-manure crops and the use of grasses and legumes in long rotations to supplement the organic matter supplied as barnyard manure and crop residues is therefore necessary on most farms. The best green-manure crops for general use are legumes, although other crops may be used in special cases. When well inoculated and thrifty, legumes obtain a large part of their nitrogen from the air, thus adding considerable quantities to the soil as they are plowed under. Growing such crops as sweet-clover also improves the physical condition of such soil types as Wabash silty clay loam. Good stands of legumes, as alfalfa and sweetclover, generally can be obtained in this county only after previous applications of lime.

Grasses and legumes, especially the former, with their fibrous root systems well distributed through the upper part of the soil mass, help to maintain the supply of organic matter in the soil. Grasses also seem to have beneficial effects upon the structure of the soil, making it more porous and providing better aeration and water absorption. More general use of grasses, especially in mixture with legumes, would be helpful in maintaining soil fertility in the county. Improved soil structure and increased organic matter are definite aids in preventing serious erosion.

LIMING

The principal crops of the county make their best growth on neutral or slightly acid soils. Some crops, as soybeans, are tolerant of moderately acid conditions, but others, as alfalfa and sweetclover, which are important for maintaining soil fertility, do not thrive on soils that are even moderately acid. Since many of the soils in humid regions are acid, it is generally necessary to neutralize this acidity before the best crops can be produced. The application of lime, commonly in the form of finely ground limestone, is the usual practice in correcting soil acidity. Lime should be used according to the degree of acidity of the soil, the nature of the crop to be grown, and the general needs of the farm as a whole. Heavier applications must be made on the more acid soils or when the crop to be grown is not tolerant of acid conditions.

Because of local variations in the degree of acidity and in lime requirement, it is desirable to determine, in advance of application, the quantities of lime needed on the different kinds of soil in a field. Samples to represent the soil conditions in various parts should be selected and the lime requirement of each determined. Samples of soil will be tested for their lime requirement by the county extension director, or they may be sent to the Soils Subsection of the Iowa Agricultural Experiment Station, at Ames. After the tests have been completed, limestone should be used in the quantities needed to neutralize soil acidity in the parts of the field where required. Tests of soil samples sometimes indicate that no lime is required on some parts of a field. Very few fields in this county contain soils that are not acid, however, and most of the soils will be more productive after they have been limed. This is particularly true where legumes are to be grown, but it also applies to other crops and to many of the permanent pastures.

The rate of application of lime is governed chiefly by the acidity of the surface layers of the soil, but consideration should be given to the lime requirements of the deeper layers also. Less lime needs to be added to a soil that is acid in the upper layers if the deeper ones are neutral or calcareous. If the soil is distinctly acid throughout its entire profile, enough lime must be added to the upper part to take care of the needs of the crop to be grown. Additional information on liming can be obtained from the Iowa State College (9).

TILLAGE

Proper tillage is one of the most important elements of crop and soil management. The primary purposes of tillage are to prepare a suitable seedbed, to destroy competing weeds, and to improve the physical condition of the soil. These purposes are closely related, and tillage operations generally achieve each to varying degrees. The principal factors that determine the time, quantity, and kind of cultivation are as follows: The crop grown or to be planted, the quantity and kind of weeds, other vegetation and crop residues, the prevalence of disease and insect pests, quantity and kind of rainfall, and soil types and phases. Only those elements of tillage closely related to the kind of soil will be considered in the subsequent discussion of soil management by soil groups. Serious erosion occurs principally on cultivated sloping lands, although some does occur on grassed or forested areas. These areas, however, are either overgrazed or for some other reason have an inadequate cover of grasses or trees. Tillage problems related to the prevention of erosion are considered in the following discussion on supporting practices for erosion control.

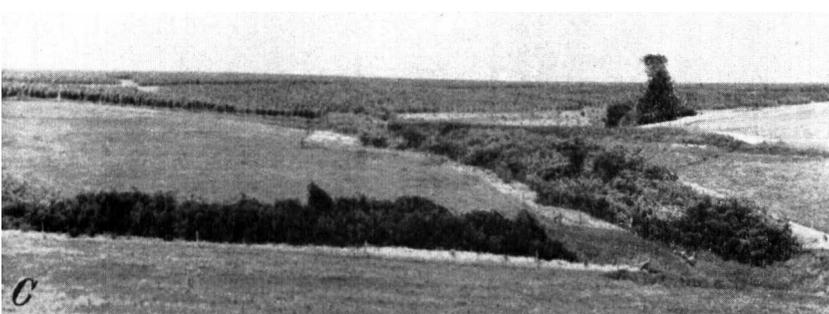
SUPPORTING PRACTICES FOR EROSION CONTROL

In this county, as in other parts of Iowa, the selection of proper rotations, the application of manure, the growing of green-manure crops, and the addition of lime to acid soils, all essential to the maintenance of soil fertility, are equally important in the control of erosion. Crops growing on fertile soils are more vigorous, and the soils themselves are more permeable to water and less susceptible to movement by water. Where the soils occur on slopes subject to accelerated erosion certain other practices, especially in the systems of planting crops and in tillage, are helpful in conjunction with programs of good soil management in controlling accelerated erosion.

Much of the landscape of the county is rolling, with a well-developed network of intermittent streams. In this type of rolling landscape, the seeding down of waterways, contour cultivation, and strip cropping are practices of considerable value in reducing erosion.

GRASSED WATERWAYS

The seeding down of waterways to grass and their maintenance in permanent vegetation are especially important in erosion control. Grassed waterways prevent the development of gullies in the channels of the intermittent upland streams. As they become larger, such gullies would interfere more and more with the farming of an entire field as one unit. Moreover, it is far simpler to maintain a grassed waterway than to control and reclaim a gully once it has reached a size



- A.** Grassed waterway along an upland draw. If these waterways are well managed they prevent the formation of deep gullies along the channels of small intermittent streams.
- B.** Corn planted on the contour with a buffer strip of timothy and clover. Contour cultivation, as practiced in this field, is an important engineering measure in the control of water on sloping lands and thus helps prevent serious erosion.
- C.** Control of a deep gully with a planting of locust trees. One method of controlling such gullies is to fence the area and plant trees; another method, also used on this gully, is to build a dam to keep water from rushing through after heavy rains. Gullies can be prevented by maintaining the swale or drainage-way in grass, as in the draw in the left background.

that interferes with farm operations (pl. 15, *A*). In seeding down a waterway, the grass should extend far enough up the slopes to prevent gullying along the upper edge of the grassed area. Where a small gully has already developed, it may be necessary to use sod checks (strips of sod placed across the gully) to help stabilize and control the gully until the seeding becomes established. Measures for the control and reclamation of established gullies are discussed under Gully Control. Additional information on grassed waterways can be obtained from the Iowa State College (15).

CONTOUR CULTIVATION

Contour cultivation is the practice of plowing, planting, and cultivating around the slope so as to stay at the same level (pl. 15, *B*). In order to cultivate around the slope, contour lines must first be established, and this can be done by rather simple methods. Contour lines are simply lines drawn through those points on a slope that lie at the same elevation. After these lines have been established, corn is planted along and parallel to them and cultivated in the same way. Changing field boundaries and relocating fences are desirable where contour cultivation is practiced. This practice helps to restrict water movement and thus aids in the control of accelerated erosion in rolling and gently rolling lands. Long, relatively unbroken slopes that are part of a system of distinct ridges and valleys lend themselves well to contour cultivation. Such slopes are found in the county, and more planting, especially of corn, on the contour is advisable. Additional information on contour cultivation can be obtained from the Iowa State College (24, 29).

STRIP CROPPING

Strip cropping, as the name suggests, is the planting of crops in strips. Alternate strips usually consist of a close-growing and an intertilled crop. For example, there may be a strip of hay and a strip of corn, another of hay and another of corn, and so on. Strips are usually laid out to follow the contour, although they are sometimes planted across the general slope of the field (pl. 11, *C*). Contour strips will be found more generally useful in this county; field strips are adapted to regions in which long and uniform slopes make up an entire field. Permanent narrow bands of grass along the contour at intervals across a field have been used widely instead of alternate strips of corn and hay, or corn and small grain. These buffer strips permit the operation of a field as a unit for corn, hay, or pasture, but they do not afford so great a degree of protection against washing during heavy storms as wider strips of close-growing vegetation. The proper width and arrangement of strips in a field depend upon the type of soil, its present condition with respect to fertility and tilth, the kind and degree of slope, and the kinds of crops to be grown. The strips of intertilled crops may be wider on the more permeable soils and on more gentle slopes, and they must be narrower, generally, as the degree of slope increases. Also, it appears that convex slopes require narrower strips than concave slopes, where the degree of slope is the same.

Strip cropping usually requires changing field boundaries and relocating fences. Frequently, the changing of farm boundaries by

selling or buying land or trading with adjoining farmers would in some places increase the ease with which these practices could be established and continued. In cases where such dealings are practical, the land that changes ownership would be more valuable to the new than to the previous owners. Also, when boundary changes are made, steep or badly eroded areas and land otherwise not suited to cultivation may be left out of the new fields and planted to trees or grasses. Additional information on strip cropping can be obtained from the Iowa State College (14).

TERRACES

Terraces are more expensive than contour cultivation and strip cropping and less adaptable to the more rolling land. On the long gentle slopes, terraces provide a more certain device for the control of erosion. Building and maintaining them is costly, however, and consideration should be given to the probable benefits compared to the expense of construction and upkeep. The kind of terrace commonly used consists of a broad, gently rounded ridge that follows the contour rather closely but has a slight grade downhill. A shallow channel along the upper side serves to carry runoff water around the slope to a protected or grassed waterway that transfers it to a lower level. Terraces in this county are apt to be most useful at the edge of large, level areas where they would prevent runoff to the sloping adjacent areas. Terraces should be used to supplement other practices, as good crop rotations and applications of organic matter, lime, and fertilizer. Additional information on terracing can be obtained from the United States Department of Agriculture and the Iowa State College (4, 12, 13).

GULLY CONTROL

Areas in this county that have been severely damaged by erosion commonly contain gullies. The gullies found in the uplands are generally shallow, ranging from a few inches to 1 or 2 feet deep. Occasional deeper gullies extend into the upland, and other deep gullies are the channels of some intermittent streams. The largest gullies, usually found in the stream valleys, may be as deep as 15 or 20 feet but are more commonly between 3 and 7 feet.

Various measures have been used to control gullies and reclaim gullied areas. Simple measures are usually adequate to provide control over gullies that are less than 1½ feet deep. Such small gullies often can be controlled by changing cultural practices or by plowing in and seeding them down as grassed waterways. Sod checks or temporary dams are sometimes necessary to establish a seeding of grass.

In the control of large gullies, temporary check dams are sometimes successful, but additional measures are commonly necessary. The deeper gullies that extend into the uplands and cannot be controlled by means of changes in cultural practices or by check dams may need to be planted to trees. Tree plantings to be successful must be fenced so that livestock cannot disturb or harm the young trees (pl. 15, C). Some of the large gullies, especially those in the channels of intermittent streams, may require permanent control structures. Permanent dams, whether of earth or of concrete, are expensive. Gullies should be controlled if possible by some other means at an earlier stage of development. A number of different types of dams

have been used for the control of large gullies. Additional information on gully control can be obtained from the United States Department of Agriculture and the Iowa State College (17, 25).

The presence of gullies in a field indicates that the system of soil management employed is inadequate to prevent harmful erosion. Any one or more of several things may need to be altered. Perhaps the crop rotation should be improved by increasing the proportion of grasses and legumes. The organic matter of the soil may need replenishing or the addition of such supporting erosion-control practices as contour cultivation or strip cropping may be desirable.

DRAINAGE

The removal of excess water from the soil is essential for the production of good crop yields. Excess water in and on the soil prevents adequate soil aeration and the development of plant roots. Also, good soil drainage is essential to provide the conditions necessary for the decomposition of organic materials by the soil organisms. Fortunately, only a very small acreage of the soils lacks adequate natural drainage.

Many measures helpful in the improvement of soil drainage are also those needed for good soil management generally. The rate of intake of water and the permeability of the surface soil are maintained and improved by growing grasses and making other additions of organic matter. Careful tillage helps preserve the soil structure. In addition to these practices, artificial means, as tile drainage and open ditches, provide more certain and immediate improvement of drainage. Tile drains are more effective on friable soils of medium texture than on impervious soils of heavier texture. Where the soil is heavier textured and more impervious to water movement the tile drains must be closer together. Open ditches are used principally to remove the surface water. Additional information on drainage can be obtained from the United States Department of Agriculture (18) and the Iowa State College, Ames, Iowa.

The likelihood of overflow of rivers and streams is somewhat related to the drainage problem. Where floods occur, it is important to provide as good surface drainage as possible so that the floodwaters will be quickly removed. Deepening and straightening stream channels and constructing small levees 2 to 6 feet high, have been undertaken advantageously. Before adopting any of these, consideration should be given to their possible effect on the flood hazards of lands farther down the stream.

PLANT NUTRIENTS AND THE USE OF COMMERCIAL FERTILIZERS

Nitrogen, phosphorus, and potassium, which are among the elements necessary for the growth of plants, are used rather heavily in crop production and often become deficient in the soils of humid regions. Deficiencies of nitrogen, phosphorus, and potassium adversely affect both the total yield and the quality of crops. These plant nutrients as well as those of lesser importance, are lost from the soil in several different ways.

Plant nutrients are removed from the soil by the crops, erosion, and leaching. Some of the plant nutrients also become unavailable to the plants by certain changes taking place in the soil. These changes

may be permanent or they may be only temporary. The quantity of plant nutrients removed by crops will depend upon the kinds of crops grown, how they are handled, and the yields obtained—the larger the yield, the larger the quantity of plant nutrients removed. Different crops differ in their needs for particular elements; for example, alfalfa needs more phosphorus than corn.

The quantity of plant nutrients lost by erosion varies with the kind of soil and the system of soil management. Some soils are not subject to losses by erosion, whereas others are, the extent of loss depending on their management.

The quantity of plant nutrients lost by the water passing through the soil is rather large on porous soils in humid regions. Nitrogen, potassium, and calcium are leached from the soil in rather large quantities, but only a very small quantity of phosphorus is lost. In Tama County removal of plant nutrients by leaching is not great.

Plant nutrients removed or leached from the soil can be replaced from one or more of several sources. One source of such replacement is the constant weathering and disintegration of minerals in the soil itself. Potassium, calcium, phosphorus, and magnesium are thereby released from soil minerals and may become available to plants.

Another important source of plant nutrients is manure, lime, and commercial fertilizers. Small quantities of many different nutrient elements are added in manure. Large quantities of calcium and some magnesium are added in lime. Many different plant nutrients, but more commonly potassium, phosphorus, and nitrogen, are added in commercial fertilizers.

A third source for the replacement of nutrient elements in the soil is the atmosphere. This is important only as a source of nitrogen. Limited quantities of nitrogen are fixed by lightning and then brought to the earth by rain or snow. Larger quantities are fixed by microorganisms either growing in the soil or on the roots of legumes.

All these various sources contribute to the supplies of plant nutrients in the soils of Tama County. The release of elements from minerals by weathering and the fixation of nitrogen from the air are much more important in this county than they are in some other sections of the country.

Nitrogen has more influence on the rate of plant growth than any of the other plant nutrients. As this element is one of the important ingredients in the proteins of the plants, its deficiency results in stunted growth and poor quality. Conversely, an excessive quantity of nitrogen in the soil—excessive in relation to other elements and factors of plant growth—results in too much vegetative growth and delayed maturity. Where nitrogen is deficient, the leaves of the plants generally are yellowish green to yellow (1). The yellowing and dying generally differ from symptoms of potash starvation, which occur at the tips or edges of leaves.

The nitrogen supply is generally maintained and increased by growing legumes, plowing under green-manure crops, and applying manure. These practices in this county usually provide a good supply of nitrogen, but further additions in the form of commercial fertilizers are made.

Phosphorus is one of the critical elements in plant growth, being necessary for the reproduction of plants and for other functions. Deficiencies of this element result in stunted growth, delayed maturity,

and low phosphorus content in the crops produced. The quality of grasses, hay, and other crops for livestock feed is influenced by the content of phosphorus. Considerable phosphorus is contained in farm manure. The addition of manure and crop residues, together with the phosphorus made available from the minerals in the soil through weathering, make this element adequate on some soils for the production of satisfactory yields of some crops. On a number of soils, however, further additions in the form of commercial fertilizers are practical, especially for hay and pasture crops.

Phosphorus can be applied to soils in a number of different fertilizers. Among those most commonly available are superphosphate, rock phosphate, and mixed fertilizers (mixtures containing more than one of the three common fertilizer elements and usually including superphosphate as the carrier of phosphorus). All these fertilizers have been tried in field experiments carried on by the Iowa Agricultural Experiment Station in various parts of the State.

The content of phosphorus in superphosphate is normally lower than in rock phosphate, but the form in superphosphate is more readily soluble and more generally available to plants. Definite superiority is indicated for the more soluble phosphate when it is applied in the hill or row, as with corn. Where rock phosphate is to be used, heavier applications are necessary. Furthermore, rock phosphate has given less satisfactory results in those sections of the State where the soils are predominantly neutral or alkaline than where they are acid.

Recently more phosphate fertilizers containing a higher content of phosphoric acid (P_2O_5) have been used because the transportation and other costs per unit of phosphorus are lower. Some of these more concentrated fertilizers are treble superphosphate and calcium metaphosphate. Treble superphosphate contains 40 to 50 percent phosphoric acid (P_2O_5), and calcium metaphosphate 62 to 64 percent, whereas ordinary superphosphate contains 16 to 20 percent.

Potassium is present in moderately large quantities and available forms in most soils of this county. General application of potassium fertilizers, more commonly known as potash fertilizers, does not seem necessary. Local applications on the sandy soils and for special crops would improve yields. In recent years chemical tests have been developed that determine whether or not adequate quantities of phosphorus and potash are available in a soil. Additional information on soil testing may be obtained from the county extension director or the Iowa State College.

SOIL GROUPS WITH SIMILAR MANAGEMENT PROBLEMS

For purposes of discussing the problems of soil management, the soils of the county are classified in 13 groups. The basis for classification were those properties of the soils that affect their use and management and are reflected in their productive capacity. Topography, texture, degree of erosion, natural drainage, and organic matter as indicated by the soil color were the most important factors considered. The 13 groups are as follows: (1) Level imperfectly to poorly drained dark-colored soils of uplands and terraces; (2) level poorly drained medium-colored soils of uplands and terraces; (3) level well-drained dark- to medium-colored soils; (4) undulating

dark-colored soils; (5) undulating dark- to medium-colored and gently rolling dark-colored soils; (6) gently rolling to rolling eroded dark- to medium-colored soils; (7) level well-drained light-colored soils; (8) undulating light-colored soils; (9) gently rolling to rolling eroded light-colored soils; (10) hilly soils; (11) sandy soils; (12) Alluvial soils with poor to moderate drainage; and (13) Alluvial soils with very poor drainage or serious flood hazard. In the discussion of each group, the soil types and phases in the group are listed, the present uses of the soils indicated, and the soil-management problems considered.

Table 4 summarizes the productivity, difficulty of preventing serious erosion, estimates of the proportion of grasses and legumes needed in the rotation to maintain a relatively high level of productivity and prevent serious erosion under a defined system of management, and the predominant soil characteristics affecting soil management for each soil in the respective groups.

Several sources of information were used in the preparation of table 4 and as a basis for discussions of soil use and management. One source was the data obtained by the experiment station in trials of different systems of soil management. Yields as obtained by farmers and reported in farm management records also were utilized. Agricultural workers familiar with conditions in Tama County were consulted for their judgments about yields under different systems of management. In addition to these sources, many observations on the use and management of the soils were made during the survey by the field party.

A major purpose of the information given in table 4 is to provide farmers with a rough guide to evaluate their systems of soil management. In other words, the purpose is to provide a basis for comparison of systems being used with those considered adequate for maintenance of productivity. These comparisons can be made by checking the management followed on a farm with that outlined in the table, especially that part in columns under the heading Crop Rotation. In the use of the table, however, it should be remembered that the required management levels have been estimated and that similar results could be achieved by any one of several systems of soil management. One system has been applied generally in table 4 so as to provide a comparison of the different soils.

GROUP 1. LEVEL IMPERFECTLY TO POORLY DRAINED DARK-COLORED SOILS OF UPLANDS AND TERRACES

The level imperfectly to poorly drained^o dark-colored soils of uplands and terraces are Muscatine and Bremer silt loams and Garwin and Bremer silty clay loams. These four soil types are not extensive or widely distributed in Tama County.

All soils in group 1 are suitable for cultivation when drained and most of them are being used for crops. A few areas are being used for pasture either where drainage has not been improved or where no other soils are available for pasture on a farm.

The improvement of natural drainage is the principal management problem for soils in group 1. This has been overcome by means of tile drains in most areas. Tile lines have to be laid close together in

^o Drainage characterizations refer to natural drainage conditions prior to installation of tile.

TABLE 4.—*Productivity, difficulty of preventing serious erosion, crop rotation, and predominant soil characteristics affecting the management of the soils of Tama County, Iowa, grouped according to similarities of management problems*

Soil groups with similar management problems and the soils of each	Productivity ¹	Prevention of serious erosion	Crop rotation ²						Predominant soil characteristics affecting soil management problems
			No supporting erosion-control practices			Contour strip cropping			
			Maximum inter-tilled crops	Minimum legumes and grasses	Sample rotation	Maximum inter-tilled crops	Minimum legumes and grasses	Sample rotation	
1. Level imperfectly to poorly drained dark-colored soils of uplands and terraces			<i>Percent</i>	<i>Percent</i>		<i>Percent (%)</i>	<i>Percent</i>		
Muscatine silt loam	Very high	No problem	50	25	CCOM	(?)		} Poor or inadequate natural drainage.	
Bremer silt loam	do	do	50	25	do				
Bremer silty clay loam	High	do	50	25	do				
Garwin silty clay loam	do	do	50	25	do				
2. Level poorly drained medium-colored soils of uplands and terraces:									
Chariton silt loam	Medium	do	40	40	CCOMM	(?)		} Poor natural drainage; low fertility.	
Traer silt loam	Fair to low	do	40	40	do				
3. Level well-drained dark- to medium-colored soils									
Tama silt loam, level phase	High to very high	do	50	25	CCOM	(?)		} None.	
Downs silt loam, level phase	Medium	do	50	25	do				
Waukesha silt loam	Very high	do	50	25	do				
Waukesha loam	Medium	do	50	25	do				
4. Undulating dark-colored soils									
Tama silt loam	High	Easy	40	40	CCOMM	50	25	} Undulating slopes (erosion problem).	
Eroded phase	High to medium	Fairly easy	33	50	CCOMMM	50	25		
Carrington silt loam	Medium	do	33	50	do	50	25		
Carrington loam	do	do	33	50	do	50	25		
5. Undulating dark- to medium-colored and gently rolling dark-colored soils:									
Tama-Thurman complex	Medium to fair	do	33	50	do	40	40	} Undulating to gently rolling slopes (moderate erosion problem); medium fertility.	
Downs silt loam	do	do	25	50	COMM	40	40		
Tama silt loam, gently rolling phase	do	Moderately difficult	25	50	do	40	40		

See footnotes at end of table.

TABLE 4.—*Productivity, difficulty of preventing serious erosion, crop rotation, and predominant soil characteristics affecting the management of the soils of Tama County, Iowa, grouped according to similarities of management problems—Continued*

Soil groups with similar management problems and the soils of each	Productivity ¹	Prevention of serious erosion	Crop rotation ²					Predominant soil characteristics affecting soil management problems	
			No supporting erosion-control practices			Contour strip cropping			
			Maximum intertilled crops	Minimum legumes and grasses	Sample rotation	Maximum intertilled crops	Minimum legumes and grasses		Sample rotation
6. Gently rolling to rolling eroded dark- to medium-colored soils:			<i>Percent</i>	<i>Percent</i>		<i>Percent</i>	<i>Percent</i>		
Tama silt loam:									
Eroded gently rolling phase.	Fair.....	Moderately difficult.	20	60	COMMM.....	33	50	CCOMMM...	Gently rolling to rolling slopes (serious erosion problem); medium fertility.
Eroded rolling phase.....	Fair to low.....	Difficult.....	15	70	COMMMMM.....	29	57	CCOMMMMM.	
Tama-Thurman complex, eroded rolling phases.	Low.....	do.....	15	70	do.....	25	50	COMM.....	
Downs silt loam:									
Eroded gently rolling phase.	Fair to low.....	Moderately difficult	15	70	do.....	25	50	do.....	
Eroded rolling phase.....	Low.....	Difficult.....	15	70	do.....	20	60	CCOMM.....	
Carrington silt loam.									
Eroded gently rolling phase.	Fair.....	Moderately difficult	20	60	COMMM.....	40	40	CCOMM.....	
Eroded rolling phase.....	Fair to low.....	Difficult.....	15	70	COMMMMM.....	20	60	COMMM.....	
Carrington loam, eroded gently rolling phase.	Fair.....	Moderately difficult.	20	60	COMMM.....	40	40	CCOMM.....	
Shelby loam.....	Low.....	Difficult.....	15	70	COMMMMM.....	20	50	COMMM.....	
7. Level well-drained light-colored soils:									
Fayette silt loam, level phase.	Fair.....	No problem.....	40	40	CCOMM.....	(?)			Low fertility and content of organic matter. Fair fertility and content of organic matter; undulating slopes (moderate erosion problem).
8. Undulating light-colored soils:									
Fayette silt loam.....	do.....	Easy.....	20	60	COMMM.....	40	40	CCOMM.....	
Fayette-Chelsea complex.....	Low.....	do.....	25	60	COMM.....	33	50	CCOMMM.....	

9. Gently rolling to rolling eroded light-colored soils:									
Fayette silt loam:									
Eroded gently rolling phase.....do.....	Moderately difficult.	15	70	COMMMMM.....	25	50	COMM.....	} Low fertility and content of organic matter, gently rolling to rolling slopes (serious erosion problem).	
Eroded rolling phase.....do.....	Difficult.....	11	78	COMMMMMMM.....	20	60	COMMM.....		
Fayette-Chelsea complex, eroded rolling phases.....do.....	Low to very low.....do.....	11	78	.....do.....	20	60	.....do.....
Lindley silt loam, gently rolling phase.....do.....	Moderately difficult.	15	70	COMMMMM.....	20	60	.....do.....	
Lindley silt loam.....do.....	Very low.....	11	78	COMMMMMMM.....	20	60	.....do.....	
10. Hilly soils:									
Lindley-Fayette silt loams.....do.....	Very difficult.....	0	100	Pasture.....	0	100	Pasture.....	} Hilly (very serious erosion problem); medium to low fertility and content of organic matter.	
Eroded phases.....do.....	.....do.....	0	100	.....do.....	0	100	.....do.....
Tama silt loam, eroded hilly phase.....do.....	Low to very low.....do.....	0	100	.....do.....	0	100	.....do.....
Shelby loam, eroded hilly phase.....do.....	Very low.....do.....	0	100	.....do.....	0	100	.....do.....
Rough broken land ⁴.....do.....do.....								
11. Sandy soils:									
Chelsea loamy fine sand.....do.....	Easy.....	17	67	COMMM.....	20	60	COMMM.....	} Droughty. Very low fertility and content of organic matter.	
Thurman loamy fine sand.....do.....	.....do.....	17	67	.....do.....	20	60	.....do.....
Buckner sandy loam.....do.....	.....do.....	16	67	.....do.....	20	60	.....do.....
12. Alluvial soils with poor to moderate drainage									
Wabash sandy loam.....do.....	High.....do ¹	50		CO (sweetclover) ⁴	(?)			} Inadequate natural drainage; subject to overflow.	
Wabash silt loam.....do.....	Very high.....do ¹	67		COO (sweetclover) ⁴					
Wabash silty clay loam.....do.....	High.....do ¹	67		.....do ¹				
Wabash-Judson silt loams.....do.....	Very high.....do ¹	67		.....do ¹				
Ray silt loam.....do.....	High.....do ¹	50		CO (sweetclover) ⁴					
Judson silt loam.....do.....	Very high.....do ¹	67		COO (sweetclover) ⁴					
3. Alluvial soils with very poor drainage or serious flood hazard. ²									
Wabash soils, undifferentiated.....do.....	Low (flood hazard).			Flood scarring.....				} Serious overflow hazard and very poor drainage.	
Sawmill silty clay loam.....do.....	Very low (poor drainage).			No problem.....					

¹ Productivity, as the term is used here, is the capacity of the soil to produce crops under a system of management commonly followed by farmers in the county. Although several different systems are used, depending upon the soil and other factors, 1 system is considered for all soils in this column so that a better comparison is possible. The system of management consists of a 4-year crop rotation of corn, corn, oats, and meadow, the application of lime when necessary, the application of 4 tons of manure every 4 years, the provision of adequate drainage where needed and feasible, and the adequate preparation of the seedbed.

² The columns under the heading "crop rotation" indicate estimates of the maximum proportion of intertilled crops and the minimum proportion of grasses and legumes in the rotation which, associated with the other parts of the system of soil management stated below, will maintain a relatively high level of productivity and prevent serious erosion for the soil in question. A sample rotation is also given. The other parts of the system include applications of 4 tons of manure every 4 years, liming when necessary,

tile drainage where needed and feasible, and a good seedbed preparation. Where contour strip cropping is practiced, it is assumed that no 2 strips of intertilled crops are adjacent to each other. The absolute levels of productivity are given in table 5 (p. 71) for different systems of management. It is not implied that the system or systems included here should be followed on an individual farm; 1 of the other alternative systems may be better suited to the conditions on the farm unit. In the column headed "Sample Rotation" C=corn, O=oats, and M=meadow.

³ Sheet erosion no problem.
⁴ Suitable only for pasture.
⁵ Some danger of flood scarring.
⁶ Sweetclover to be plowed under.
⁷ Gullies tend to form in drainageways.
⁸ Suitable only for pasture and timber.

the Bremer and Garwin silty clay loams, however, because of the slow movement of water through those soils. Additional aids in the improvement of drainage are growing grasses and legumes in the rotation and exercising care in tillage operations. Grasses and legumes improve the structure of the surface soil, which in turn improves the absorption and movement of water.

A less important problem in managing these soils is that of proper tillage. This problem applies especially to the Bremer and Garwin silty clay loams. The cultivation of these soils must be timed carefully if good structure is to be maintained. Cultivating soils either too wet or too dry results in a cloddy structure that makes preparation of a good seedbed difficult.

A high level of productivity in the soils of group 1 is easily maintained even when intertilled crops are frequently grown. The plowing under of crop residues, the application of manure or other forms of organic matter, and the use of a legume crop once in 4 or 5 years as illustrated in the type rotations given in table 4 will keep these soils productive. The application of lime to maintain a slightly acid to neutral reaction is necessary for the establishment of good stands of alfalfa and clover. The control of erosion is not a problem on these soils.

GROUP 2. LEVEL POORLY DRAINED MEDIUM-COLORED SOILS OF UPLANDS AND TERRACES

The level poorly drained medium-colored soils of uplands and terraces are the Chariton and Traer silt loams. These soils are very limited in extent but they are considered separately because they are much less permeable and much lower in productivity than the soils of group 1. Since the individual areas are small the soils are commonly used in conjunction with adjacent ones. Most areas are therefore being cultivated, though crop yields are commonly lower than those of adjoining soils.

Management problems on the whole are similar to those on the soils of group 1, but they are generally harder to overcome. Furthermore, the soils of group 2 are less productive under the same levels of management. The deeper horizons are less permeable, so that the soils are harder to drain satisfactorily. Tile lines must be laid very close together if they are to remove surplus water. More close-growing crops, as grasses and legumes, and less corn in the rotation are necessary if the levels of fertility are to be improved and maintained. With careful management the soils can be fairly productive, though they cannot approach those of group 1. Erosion control is not a problem with the soils of group 2.

GROUP 3. LEVEL WELL-DRAINED DARK- TO MEDIUM-COLORED SOILS

Waukesha silt loam, Waukesha loam, and the level phases of Tama and Downs silt loams comprise the level well-drained dark- to medium-colored soils. The total area of this group is slightly less than a fifth of Tama County. All these soils are well suited to cultivation and nearly all areas are used for crops.

These soils are easier to manage than those of any other group in the county. They are well drained and have level or nearly level topography. The slope is sufficient to provide for the removal of excess

water without danger of harmful soil washing. At the same time the topography is level enough to make farming operations easy. High crop yields are normal for these soils when good systems of management are followed. Crop rotations including 50 percent of intertilled crops and 25 percent of legumes and grasses are satisfactory for the maintenance of productivity. In such rotations it is necessary that crop residues be turned under and barnyard manure applied occasionally. Applications of lime are needed on these soils to maintain a reaction favorable for legumes. Higher yields of legumes have also been reported after applications of phosphate fertilizers. Yields obtained on Downs silt loam, level phase, and on Waukesha loam are slightly lower than those on the other two soils, but their acreages are also much lower.

GROUP 4. UNDULATING DARK-COLORED SOILS

The group of undulating dark-colored soils consists of Tama silt loam and its eroded phase, Carrington silt loam, and Carrington loam. This group is widely distributed and is the most extensive among the 13 groups of soils in Tama County. The soils are well suited to cultivation and are used chiefly for crops. Some areas are used for pasture, either where other soils are not available or where small bodies are intermingled with soils not well suited to cultivation.

The maintenance of productivity and the control of harmful erosion are the more important management problems for the soils of this group. They are well drained but sloping, so that some washing of soil does occur. Slopes are gentle, however, so that tillage operations are easily performed. On the whole, contour tillage is better than operations parallel to the rectangular boundaries of the fields. Contour tillage aids markedly in the control of erosion and is adaptable to most areas of these soils. Where contour tillage and strip cropping are not practiced, crop rotations can include a maximum of 40 percent intertilled and a minimum of 40 percent of close-growing crops. If contour tillage and strip cropping are used, the proportion of intertilled crops can be raised to 50 percent and that of close-growing crops reduced to 25 percent. Full use of crop residues and the addition of organic matter, as manure or in other forms, are necessary for maintenance of productivity. Lime should also be applied as needed to maintain a soil reaction favorable to legumes.

GROUP 5. UNDULATING DARK- TO MEDIUM-COLORED AND GENTLY ROLLING DARK-COLORED SOILS

Tama-Thurman complex, Downs silt loam, and Tama silt loam, gently rolling phase, comprise the undulating dark- to medium-colored and gently rolling dark-colored soils. The total acreage of this group is relatively small, though the soils themselves are widely scattered. These soils are used largely for crops, with somewhat lower proportions of intertilled crops and higher ones of hay than is common for group 4. A higher proportion of the total area is used for pasture than in group 4.

The management problems of this group are similar to those of group 4. In general, it is harder to maintain these soils at a high level of productivity, partly because of the lower inherent level of fertility and partly because of the steeper topography and greater

erosion hazard. Tama-Thurman complex and Downs silt loam are less fertile than the soils of group 4, whereas the gently rolling phase of Tama silt loam is more subject to erosion than the smoother phases. The greater difficulties in management can be overcome in any one of several ways. The proportion of grasses and legumes in the rotation can be increased, larger applications of manure can be made, more frequent use of green-manure crops can be adopted, or contour cultivation can be practiced with or without strip cropping.

GROUP 6. GENTLY ROLLING TO ROLLING ERODED DARK- TO MEDIUM-COLORED SOILS

The gently rolling to rolling eroded dark- to medium-colored soils consist of the eroded gently rolling phases and eroded rolling phases of Tama, Downs, and Carrington silt loams; Tama-Thurman complex, eroded rolling phases; Carrington loam, eroded gently rolling phase; and Shelby loam. These soils are widely distributed in Tama County. The acreage of this group ranks fourth among those in the county. These soils are used mainly for crops and to some extent for pasture. A large proportion of the acreage cultivated is used for hay crops consisting of legume-and-grass mixtures.

These soils are not well adapted to cultivation, because of the distinct erosion hazard. They are not well adapted to intertilled crops but are better suited to close-growing crops (hay) or to pasture. They can be used to better advantage for hay or pasture on farms that include a sufficient acreage of soils more suitable for cultivation. On such farms the problems of handling group 6 soils are those of pasture management. These are discussed under group 10, hilly soils (p. 67).

Several systems of management will maintain productivity and prevent excessive erosion for soils of this group. One of the simplest systems, though it will not work on some farms, is growing small grain and hay without production of intertilled crops. If the soils are cultivated in this way there is little danger of harmful erosion. In such a rotation, however, lime is usually necessary for good stands of legumes, and phosphate fertilizers will commonly improve the yields and quality of hay crops. The use of close-growing crops and small grains leaves the soil bare only a small part of the year. Moreover, growing legumes and grasses tends to improve the structure of the surface soil and to make it more absorptive of water.

On farms where soils of group 6 are needed for corn, the crop should be grown only in long rotations. It is doubtful whether the productivity of the soil can be maintained and serious erosion prevented without supplementary measures where the proportion of intertilled crops in the rotation exceeds 25 percent. If contour strip cropping (narrow strips) is practiced, the proportion of intertilled crops can be increased to 40 percent on the rolling phase and to 50 percent on the gently rolling phase except in local spots that have been severely eroded.

When the proportion of intertilled crops is high the general level of soil management must be high in all respects if production is to be maintained. The general application of manure or the use of green-manure crops is exceedingly important for the maintenance of fertility and structure. Growing soybeans as an intertilled crop is not desirable, because this leaves the surface layer loose and open so that severe

washing follows heavy spring rains. Applications of lime are generally needed to obtain good stands and yields of legumes. Widespread adoption of contour tillage would be helpful in the management of these soils. In places, the slope pattern may be unfavorable for contour tillage, but this can often be overcome by changing field boundaries.

Among the soils in group 6, Shelby loam is lower in fertility and more subject to erosion than the others. It has been included in the group, however, because of its very small acreage. Tama-Thurman complex, eroded rolling phases, and the two phases of Downs silt loam are less fertile than are the other soils of this group, excluding Shelby loam. Yields are consequently somewhat lower on these soils than on the Tama and Carrington.

GROUP 7. LEVEL WELL-DRAINED LIGHT-COLORED SOILS

The only soil of the level well-drained light-colored group is the level phase of Fayette silt loam. The total acreage of this soil is small, exceeding those of only two other soil groups, and the soil is not widely distributed. Nearly all areas are used for crop production, though the soil is only moderately fertile. It is generally better suited to crops, however, than the associated soils, which are commonly rolling to hilly.

Fayette silt loam, level phase, is easy to manage. It is not subject to erosion, because of its level to nearly level topography, but it has adequate drainage. Tillage operations can be performed easily on the mild slopes. Despite ease of management, the soil is less productive under similar levels of management than the soils of group 3. A lower proportion of corn with more grasses and legumes, more frequent or heavier applications of manure, and more general use of lime are all necessary for satisfactory production. Applications of phosphate fertilizer for grasses and legumes also have given favorable responses. These close-growing crops should be grown more frequently on Fayette silt loam, level phase, than on the soils of group 3 in order to maintain good tilth and adequate nitrogen levels.

GROUP 8. UNDULATING LIGHT-COLORED SOILS

The group of undulating light-colored soils consists of Fayette silt loam and Fayette-Chelsea complex. These soils are not widely distributed in the county, and their total acreage is rather small. Most areas are under cultivation, but some are used for pasture and others are left in forest. Individual areas that occupy crests of irregular ridges in hilly sections, or for some other reason are hard to cultivate, are commonly used for pasture or forest.

The more important management problems are the improvement and maintenance of nutrient supplies, organic matter, and good structure. These problems can be overcome in part by the use of long rotations with high proportions of legumes and grasses. Rotations with high proportions of legumes and grasses (60 percent) and low proportions of intertilled crops (20 percent) will provide for continued high yields. Additions of organic matter, as farm manure or in green-manure crops, also are required. Since the soils are commonly acid, the application of limestone to provide a favorable reaction for

legumes is generally necessary. The yield and quality of legumes also have been improved by the addition of phosphate fertilizers. These soils respond well to good management, but more care is needed for them than for the soils of group 3 because the latter are more fertile and have better structure.

The control of erosion is not a difficult problem on these soils but it deserves some attention. Where the management system provides for the maintenance of organic matter and good soil structure little further attention need be given to erosion control. Contour cultivation for intertilled crops is generally desirable, however, and can be adopted with little difficulty on most areas.

The small spots of Chelsea loamy fine sand included in the Fayette-Chelsea complex are droughty, less productive, and subject to some drifting. These spots are commonly too small for special handling, but extra applications of organic matter can be made to many of them to reduce the danger of soil blowing.

GROUP 9. GENTLY ROLLING TO ROLLING ERODED LIGHT-COLORED SOILS

The group of gently rolling to rolling eroded light-colored soils comprises the eroded gently rolling phase and eroded rolling phase of Fayette silt loam; Fayette-Chelsea complex, eroded rolling phases; Lindley silt loam; and Lindley silt loam, gently rolling phase. Soils of the group occur in many parts of Tama County, but their total acreage is not large. The group ranks sixth in size among those in the county. Many areas of these soils are used for crops, although they are not well adapted to cultivation. The main reason for their cultivation is that they occur on farms where soils well suited to crops are scarce.

The management problems of this group of soils are a combination of those common to groups 6 and 8. The problems are perhaps more closely related to those of group 8, though they are more difficult. In addition to the need for improving and maintaining fertility and structure, there is also the problem of controlling erosion on these more sloping soils.

The management problems are easily met, if the soils of group 9 need not be used for intertilled crops. The rotations can then consist of small grains and hay without intertilled crops, or the soils can be used for pasture. In either case, the soils are covered by vegetation most of the time and are not readily subject to erosion. Furthermore, close-growing crops aid in maintaining good structure and adequate nutrient levels. Because these soils are commonly acid, they require applications of limestone for good stands and yields of legumes. Additions of phosphate fertilizers also have improved the yield and quality of legume crops.

Intertilled crops should either be planted on the contour or used in extremely long rotations, if the soils of group 9 must be used for them. Where contour tillage and strip cropping are followed, intertilled crops can equal 20 to 25 percent of the rotation without harmful effect on productivity. These rotations should include legumes and grasses in high proportions (50 to 60 percent) for the maintenance of good tilth and adequate nitrogen levels. If supporting measures for erosion control are not adopted, corn should be grown not more than once in 8 or 10 years, even under high levels of management.

GROUP 10. HILLY SOILS

The group of hilly soils embraces the Lindley-Fayette silt loams; Lindley-Fayette silt loams, eroded phases; Tama silt loam, eroded hilly phase; Shelby loam, eroded hilly phase; and Rough broken land. This group has a fairly large total acreage and ranks fifth in size among those in Tama County. Areas of these soils are widely scattered. They are largely used for pasture, with occasional areas in cultivation and some in forest. Patches are cultivated on farms where the soils are dominantly hilly and no better land is available for crops. Forest is restricted to Lindley-Fayette silt loams and their eroded phases. In general, the soils of group 10 are poorly adapted to cultivation and will provide better returns if used for pasture or forest.

For most soils in the group, the principal management problems are those of improving and maintaining good pastures. In this connection three different conditions will be considered—(1) pastures with excellent stands of grasses and legumes, (2) pastures with fair stands of grasses, and (3) pastures with very poor stands of grass or cropland that is being put into pasture.

Management is simple where a pasture has an excellent stand of grasses and legumes. The pasture should be clipped from time to time for the control of weeds, and brush should be kept out. The control of grazing also is desirable. From time to time, usually at intervals of several years, it may be desirable to disk the pasture lightly and reseed with mixtures of clovers. Applications of lime and of phosphate fertilizer can also be made to advantage occasionally when the pasture is disked.

The importance of maintaining a mixture of legumes and grasses in the pasture sod needs to be emphasized. Mixed stands produce more feed economically than pure stands of grasses. They also provide a longer and better balanced grazing season. Retention of legumes in the pasture sod, however, requires occasional disking and reseeding, accompanied by applications of lime and phosphate.

If the pasture has a fair stand of grass without legumes, the latter can be introduced into the sod. Steps required for the introduction of legumes are addition of lime and phosphate, disking, and reseeding. Lime should be applied to different parts of the pasture in the quantities needed to make the soil reaction slightly acid to neutral. Phosphate applications should be in amounts of about 400 pounds of 20-percent superphosphate an acre. After the lime and phosphate have been applied, the pasture should be disked sufficiently to check temporarily the growth of grasses so that they will not compete too strongly with the young legumes. After disking, the legumes can be broadcast over the pasture. The time to seed legumes is early in spring. After reseeding, a pasture should not be grazed until the legumes have become well established in the sod, and then it is still desirable to practice controlled grazing.

If the pasture is poor or if a cultivated field is to be shifted to pasture, more work is necessary, although about the same things are done as with a fair pasture. Applications of lime and phosphate are generally needed in poor pastures or in fields. The addition of nitrogen either in manure or as commercial fertilizer also is desirable. Nitrogen will help the mixture of grasses and legumes to become established

more rapidly. After applications of lime, phosphate, and manure or other nitrogen carrier a good seedbed should be prepared before the grass-and-legume mixture is seeded early in spring. Seeding mixtures commonly include Kentucky bluegrass, white clover, and alsike, although a number of other mixtures are satisfactory. Bare and severely eroded spots in pastures should be given special treatment, as extra applications of manure or protection by fences, until vegetation has covered them. In the establishment of pastures or in the renovation of poor pastures, one of the most common errors is that of grazing the area too soon after seeding. Livestock should be kept out of the pasture until the sod has become well established. Additional information on pasture management can be obtained from the Iowa State College (3).

GROUP 11. SANDY SOILS

The group of sandy soils consists of Chelsea and Thurman loamy fine sands and Buckner sandy loam. These soils are limited both in extent and in distribution. The total acreage is almost as small as that of group 2, which is the lowest in the county. The soils of group 11 are cultivated, chiefly because the small individual areas are scattered among other soils that are more suitable for crop production.

Sandiness makes these soils of low productivity, as reflected in their low nutrient status and low water-holding capacity. The content of plant nutrients is lower in these soils than in those of any other group. Furthermore, although water is readily absorbed, not enough is retained. The yields are therefore low except during growing seasons when the rainfall distribution is exceptionally favorable.

Significant improvement of fertility levels and water-holding capacity is not generally feasible. Some improvement is possible through extra applications of organic matter, but limited supplies of organic matter on farms can be used to better advantage on more productive soils. Applications of straw or strawy manure aid in controlling a tendency toward drifting. Where areas of the soils can be operated as separate units, it is usually more desirable to have them in pasture or forest than in cultivation. Either pasture or forest requires lower expenditures and thus commonly provides somewhat better returns.

GROUP 12. ALLUVIAL SOILS WITH POOR TO MODERATE DRAINAGE

The group of Alluvial soils with poor to moderate drainage consists of Wabash, Ray, and Judson silt loams, Wabash sandy loam, Wabash silty clay loam, and Wabash-Judson silt loams. The soils of this group are widely distributed and extensive. The total acreage nearly equals that of group 4 and is slightly less than a fourth of the county. Soils of group 12 are used almost entirely for crop production or pasture. Nearly all areas of Judson silt loam, most areas of Wabash-Judson silt loams, and many of Wabash sandy loam and silt loam are under cultivation. A number of areas of Wabash-Judson silt loams and many of Wabash sandy loam, Wabash silt loam, and Ray silt loam are used for pasture either because of poor drainage or because of overflow hazards. The likelihood of overflow varies from one area to another, and the danger cannot be predicted from the soil map. Such information must be obtained from histories of flood frequencies.

The chief management problems are those of improving drainage and controlling overflow. The soils are level to very gently sloping, and many areas have adequate drainage for most crops. A number of areas, however, as the low-lying parts of Wabash-Judson silt loams, require artificial improvement of drainage for maximum production. Such improvement has been accomplished in many of the upland drainageways by means of tile laid along the channel. The control of overflow can be accomplished on some areas of Wabash and Ray soils by means of small dikes or by ditching a stream channel. These methods are not generally applicable by individual farmers. For the most part, areas frequently subject to overflow cannot be used successfully for crops. They provide greater returns when left in pasture. Soils of this group are especially valuable for pasture during summer seasons when vegetation grows slowly or stops growth on upland soils.

Less common problems in the use and management of soils of group 12 are those of controlling gullies in the stream channel and the maintenance of good tilth. Gullies are formed occasionally in the natural drainageways that flow through Wabash-Judson areas. Prevention of such gullies is relatively simple and can be accomplished by keeping the waterways in grass. Soils such as Wabash silty clay loam generally have poor drainage and tend to become cloddy when cultivated either too wet or too dry. Tillage operations on this soil and on Wabash silt loam should be timed carefully so as to avoid the difficulties of preparing a seedbed after the soil is cloddy.

The productivity of soils in this group suitable for cultivation can be maintained at high levels even when intertilled crops are grown as much as two-thirds of the time. Fields of these soils have been used for continuous corn over periods of 10 or 15 years, in some instances without appreciable decline in yields. On the whole, rotations that include some legume-grass mixture perhaps once in 10 years are desirable.

GROUP 13. ALLUVIAL SOILS WITH VERY POOR DRAINAGE OR SERIOUS FLOOD HAZARD

The Alluvial soils with very poor drainage or serious flood hazard are Sawmill silty clay loam and Wabash soils, undifferentiated. These soils occur chiefly along the larger streams, and their total acreage is small. Except for scattered areas they are used for pasture or left in trees. Neither of the soils is suitable for cultivation, the Sawmill being too poorly drained and the Wabash being subject to serious flood hazard. On the whole, it is better for a farmer to use these soils for pasture or trees than to attempt to make them suitable for cultivation.

PRODUCTIVITY OF THE SOILS

ESTIMATED AVERAGE YIELDS PER ACRE AND PROBABLE EROSION HAZARDS

The detailed problems of organization and management on any one farm are different from those on any other. To make wise decisions regarding these problems, a farmer needs to know the probable crop yields he may expect on his soils under alternative systems of management. Those who have been on the same farm for many years

know how their soils have responded to the systems of management employed. They are also familiar with some of the experiences of their neighbors. There are many systems, however, that they have not been able to try. Many who have just begun to farm, or who have moved to a new farm with different soils, have little previous experience with the soils they will now have to cultivate. To decide what crops should be grown and how the soils should be managed, the farmers must estimate the yields they may expect from the various systems of soil management that might be practiced. As an aid to such farmers, estimates of the average acre yields of the more important crops that may reasonably be expected on each soil in the county are given in table 5.

For most of the soils the estimates are given for three different systems of management. In addition there is given the probable erosion hazard that would exist on each soil when the different systems are practiced. The systems of management—usually three—are indicated by the letters A, B, and C. Where system A is practiced, the productivity is lower and on most soils the erosion hazard greater than under either systems B or C. Likewise, system C results in higher productivity and generally lower erosion hazard than system B. The systems of management indicated by the letter A are not the same for all soils; differences exist also between systems B and C. Although the productivity is highest and the erosion hazard lowest where system C is followed, it is not implied that system C would always be the most profitable on a given farm.

The systems of soil management—A, B, and C—are defined for each soil in table 5. These systems are the ones used as a basis for estimating average acre yields and probable erosion hazards. It is assumed that satisfactory tillage and other field operations are practiced, and that good seed is used, including hybrid corn.

Other systems than those given might be used to produce equally good results; that is, essentially the same results can be achieved in different ways. No one system is best for all farms, and the circumstances of each individual farm govern the choice of the most desirable system or systems. For example, on a grain farm where very little barnyard manure is available, the organic matter in the soil likely would be maintained by plowing under more green-manure crops.

The average acre yields estimated for soil management systems A and B provide a better basis for comparing the productivity of the different soils than those of system C. These two systems are similar for many soils, and therefore the yield estimates provide a fair basis for comparing the productivity of one soil with that of another. The soil management systems indicated as C vary greatly for the different soils. The yields obtained by using these systems (C) approach the maximum considered likely on the different soils over a period of years.

The probable erosion hazard of each soil under different systems of management is indicated in the last column of table 5. Five different categories of erosion hazard are used—none, slight, moderate, serious, and very serious. The first (none) indicates that there is no loss of surface soil because of erosion, but it does not mean that the soil cannot deteriorate under a poor system of management; the soil structure, for example, can be impaired. The second (slight) means

TABLE 5.—Estimated average yields per acre of important crops and probable erosion hazard on each soil in Tama County, Iowa, under different systems of soil management

Soil (type, phase, or land type) ¹	System of soil management ²						Estimated average yields per acre						Probable erosion hazard ¹⁰
	Symbol	Crop rotation ³	Applications of—			Other practices ⁷	Corn	Soy-beans ⁸	Oats	Clover and timothy	Alfalfa	Pasture ⁹	
			Lime ⁴	Fertilizer ⁵	Ma-nure ⁶								
				Pounds	Tons		Bushels	Bushels	Bushels	Tons	Tons	Cow-acre-days	
Bremer silt loam	A	CCO	No	0	0	Tile drained if necessary	55	24	40	(11)	(12)	150	None.
	B	CCOM	do	0	4	do	60	26	45	1.4	(12)	190	Do.
	C	CCOM	Yes	0	8	do	70	28	50	2.0	13 3.8	-----	Do.
Bremer silty clay loam	A	CCO	No	0	0	do	40	18	30	(11)	(12)	140	Do.
	B	CCOM	do	0	4	do	50	20	35	.8	(12)	170	Do.
	C	CCOM	Yes	0	8	do	60	22	40	1.2	13 2.0	-----	Do.
Buckner sandy loam	A	CCO	No	0	0	None	10	4	15	.2	(12)	20	Slight.
	B	CCOM	do	0	4	do	15	8	20	.4	(12)	40	Do.
	C	COMM	Yes	200	8	do	30	14	35	.6	8	-----	None.
Carrington loam	A	CCO	No	0	0	do	30	10	27	(11)	(12)	100	Serious.
	B	CCOM	do	0	4	do	45	14	40	1.2	(12)	170	Moderate.
	C	CCOMM	Yes	200	8	Contour cultivation	55	22	52	2.0	3.4	-----	Slight.
Eroded gently rolling phase	A	CCO	No	0	0	None	25	4	17	(11)	(12)	70	Very serious.
	B	CCOM	do	0	4	do	35	8	27	1.0	(12)	140	Serious.
	C	COMM	Yes	200	8	Contour strip cropping	50	16	40	1.7	3.0	-----	Slight.
Carrington silt loam	A	CCO	No	0	0	None	35	12	30	(11)	(12)	105	Serious.
	B	CCOM	do	0	4	do	45	16	40	1.4	(12)	180	Moderate.
	C	CCOMM	Yes	200	8	Contour cultivation	55	24	52	2.0	3.6	-----	Slight.
Eroded gently rolling phase	A	CCO	No	0	0	None	25	6	20	(11)	(12)	80	Very serious.
	B	CCOM	do	0	4	do	35	10	30	1.2	(12)	150	Serious.
	C	COMM	Yes	200	8	Contour strip cropping	50	18	45	1.8	3.2	-----	Slight.
Eroded rolling phase	A	CCO	No	0	0	None	20	2	15	(11)	(12)	60	Very serious.
	B	CCOM	do	0	4	do	30	6	25	.8	(12)	110	Do.
	C	COMM	Yes	200	8	Contour strip cropping	45	12	40	1.6	2.8	-----	Moderate.
Chariton silt loam	A	CCO	No	0	0	Drained if necessary	30	18	30	(11)	(12)	140	None.
	B	CCOM	do	0	4	do	40	20	35	1.0	(12)	180	Do.
	C	CCOM	Yes	200	8	do	50	24	40	1.4	13 2.2	-----	Do.

See footnotes at end of table.

TABLE 5.—Estimated average yields per acre of important crops and probable erosion hazard on each soil in Tama County, Iowa, under different systems of soil management—Continued

Soil (type, phase, or land type) ¹	System of soil management ²						Estimated average yields per acre						Probable erosion hazard ¹⁰
	Symbol	Crop rotation ³	Applications of—			Other practices ⁷	Corn	Soy-beans ⁸	Oats	Clover and timothy	Alfalfa	Pasture ⁹	
			Lime ⁴	Ferti-lizer ⁵	Ma-nure ⁶								
				Pounds	Tons		Bushels	Bushels	Bushels	Tons ⁽¹¹⁾	Tons ⁽¹²⁾	Cow-acre-days	
Chelsea loamy fine sand	A	CCO	No	0	0	None	5	2	7			10	Moderate. ¹⁰
	B	CCOM	do	0	4	do	7	4	10	.2		20	Slight. ¹⁰
	C	COMM	Yes	200	8	do	15	8	20	.4	.8		Do. ¹⁰
Downs silt loam, level phase	A	CCO	No	0	0	do	32	12	32	⁽¹¹⁾	⁽¹²⁾	100	None.
	B	CCOM	do	0	4	do	45	20	42	1.5	⁽¹²⁾	180	Do.
	C	COMM	Yes	0	8	do	55	26	55	2.0	3.6		Do.
Downs silt loam	A	CCO	No	0	0	do	25	10	25	⁽¹¹⁾	⁽¹²⁾	90	Serious
	B	CCOM	do	0	4	do	45	14	35	1.3	⁽¹²⁾	160	Moderate
	C	COM	Yes	200	8	Contour cultivation	55	22	50	2.0	3.4		Slight.
Eroded gently rolling phase	A	CCO	No	0	0	None	20	4	17	⁽¹¹⁾	⁽¹²⁾	70	Very serious
	B	CCOM	do	0	4	do	30	8	27	1.1	⁽¹²⁾	130	Serious
	C	COMM	Yes	200	8	Contour strip cropping	50	18	45	1.6	3.2		Slight.
Eroded rolling phase	A	CCO	No	0	0	None	15	2	12	⁽¹¹⁾	⁽¹²⁾	60	Very serious.
	B	CCOM	do	0	4	do	25	6	22	1.0	⁽¹²⁾	110	Serious.
	C	COMMMM	Yes	200	8	Contour strip cropping	45	14	40	¹⁴ 1.4	3.0		Slight.
Fayette-Chelsea complex	A	CCO	No	0	0	None	15	6	15	⁽¹¹⁾	⁽¹²⁾	60	Serious
	B	CCOM	do	0	4	do	25	10	25	.8	⁽¹²⁾	110	Moderate.
	C	COMM	Yes	200	8	Contour cultivation	50	18	45	1.6	2.8		Slight.
Eroded rolling phases	A	CCO	No	0	0	None	10	2	10	⁽¹¹⁾	⁽¹²⁾	40	Very serious.
	B	CCOM	do	0	4	do	20	6	17	.5	⁽¹²⁾	80	Serious.
	C	COMMM	Yes	200	8	Contour strip cropping	40	14	35	¹⁴ 1.2	2.4		Moderate.
Fayette silt loam, level phase	A	CCO	No	0	0	None	20	10	25	⁽¹¹⁾	⁽¹²⁾	80	None.
	B	CCOM	do	0	4	do	45	16	35	1.2	⁽¹²⁾	150	Do.
	C	COM	Yes	200	8	do	55	24	55	2.0	3.6		Do.
Fayette silt loam	A	CCO	No	0	0	do	17	8	20	⁽¹¹⁾	⁽¹²⁾	70	Serious.
	B	CCOM	do	0	4	do	35	12	30	1.0	⁽¹²⁾	140	Moderate.
	C	COMM	Yes	200	8	Contour cultivation	50	22	50	2.0	3.4		Slight.

Eroded gently rolling phase.	A	CCO	No	0	0	None	15	4	15	(11)	(12)	60	Very serious.
	B	CCOM	do	0	4	do	25	8	22	.8	(12)	120	Serious.
	C	COMMM	Yes	200	8	Contour strip cropping	45	18	45	14 1.8	3.2		Moderate.
Eroded rolling phase	A	CCO	No	0	0	None	10	2	10	(11)	(12)	50	Very serious.
	B	CCOMM	do	0	4	do	22	6	20	.6	(12)	100	Do.
	C	COMMMM	Yes	200	8	Contour strip cropping	40	14	40	14 1.6	2.8		Moderate.
Garwin silty clay loam	A	CCCC	No	0	0	Tile drained if necessary	35	20	(11)	(12)	140	None.	
	B	CCO	do	0	0	do	45	24	35	(11)	(12)	180	Do.
	C	CCOM	Yes	0	0	do	65	26	40	1.6	12 3.2		Do.
Judson silt loam	A	CCCC	No	0	0	do	45	26	(11)	(12)	160	Do.	
	B	CCO	do	0	0	do	55	28	45	(11)	(12)	200	Do.
	C	CCOM	Yes	0	0	do	70	30	50	2 2	12 4.0		Do.
Lindley-Fayette silt loams 16	A											50	Slight.
	B											100	Do.
Eroded phases	A	CCOM	No	0	4	None	10	2	10	.4	(12)	40	Very serious.
	B	OMMMM	Yes	200	0	Contour strip cropping	(11)	(11)	40	(11)	2 4	80	Moderate.
Lindley silt loam, gently rolling phase.	A	CCO	No	0	0	None	12	4	12	(11)	(12)	60	Very serious.
	B	CCOM	do	0	4	do	22	6	20	.7	(12)	110	Do.
	C	COMMM	Yes	200	8	Contour strip cropping	45	16	40	14 1.6	3 0		Moderate.
Lindley silt loam	A	CCO	No	0	0	None	10	2	10	(11)	(12)	50	Very serious.
	B	CCOMM	do	0	4	do	17	6	17	.6	(12)	100	Do.
	C	COMMMM	Yes	200	8	Contour strip cropping	45	12	35	14 1 4	2 6		Moderate.
Muscatine silt loam	A	CCO	No	0	0	Tile drained if necessary	45	22	40	(11)	(12)	130	None.
	B	CCOM	do	0	4	do	60	26	50	1.8	(12)	200	Do.
	C	CCOM	Yes	0	8	do	70	30	55	2 2	12 4.0		Do.
Ray silt loam 17	A	CCCC	No	0	0	Drained if necessary	30	18	(11)	(12)	140	Do.	
	B	CCO	do	0	0	do	45	20	35	(11)	(12)	190	Do.
	C	CCOM	Yes	200	0	do	60	26	45	2 0	12 3.4		Do.
Rough broken land	A											60	Slight.
	B											100	Do.
Sawmill silty clay loam	A											80	None.
Shelby loam	A	CCO	No	0	0	None	15	2	12	(11)	(12)	50	Very serious.
	B	CCOM	do	0	4	do	25	4	20	.6	(12)	100	Do.
	C	COMMM	Yes	200	8	Contour strip cropping	40	10	35	14 1 6	2 4		Moderate.
Eroded hilly phase	A	CCOM	No	0	4	None	15	2	12	.6	(12)	50	Very serious.
	B	OMMMM	Yes	200	0	Contour strip cropping	(11)	(11)	40	(11)	2 4	90	Moderate.
Tama silt loam, level phase	A	CCO	No	0	0	None	35	16	40	(11)	(12)	130	None.
	B	CCOM	do	0	4	do	55	24	50	1 8	(12)	200	Do.
	C	CCOM	Yes	0	8	do	70	28	60	2 2	12 4.0		Do.

See footnotes at end of table.

TABLE 5.—Estimated average yields per acre of important crops and probable erosion hazard on each soil in Tama County, Iowa, under different systems of soil management—Continued

Soil (type, phase, or land type) ¹	System of soil management ²						Estimated average yields per acre						Probable erosion hazard ¹⁰
	Symbol	Crop rotation ³	Applications of—			Other practices ⁷	Corn	Soy-beans ⁸	Oats	Clover and timothy	Alfalfa	Pasture ⁹	
			Lime ⁴	Fertilizer ⁵	Ma-nure ⁶								
Tama silt loam	A	CCO	No	Pounds 0	Tons 0	None	30	Bushels 14	Bushels 35	Tons (11) 1.7	Tons (12) 1.2	Cow-acre-days 120	Moderate. Slight. Do.
	B	CCOM	do	0	4	do	50	20	45	2.1	1.2	190	
	C	CCOMM	Yes	0	8	Contour cultivation	65	26	55	2.1	1.3	3 8	
Eroded phase	A	CCO	No	0	0	None	25	12	30	(11) 1.6	(12) 1.2	105	Serious. Moderate. Slight.
	B	CCOM	do	0	4	do	45	16	40	1.6	1.2	180	
	C	CCOMM	Yes	200	8	Contour cultivation	55	26	55	2.0	1.3	3 6	
Gently rolling phase	A	CCO	No	0	0	None	20	8	25	(11) 1.5	(12) 1.2	90	Very serious. Serious. Moderate.
	B	CCOM	do	0	4	do	40	12	35	1.5	1.2	160	
	C	COM	Yes	200	8	Contour strip cropping	55	20	50	1.9	1.3	3 4	
Eroded gently rolling phase	A	CCO	No	0	0	None	15	6	20	(11) 1.4	(12) 1.2	80	Very serious. Serious. Moderate.
	B	CCOM	do	0	4	do	35	10	30	1.4	1.2	140	
	C	COMM	Yes	200	8	Contour strip cropping	50	18	45	1.8	1.3	2	
Eroded rolling phase	A	CCO	No	0	0	None	15	4	15	(11) 1.2	(12) 1.2	70	Very serious. Serious. Moderate.
	B	CCOM	do	0	4	do	30	8	25	1.2	1.2	120	
	C	COMMM	Yes	200	8	Contour strip cropping	45	14	40	1.6	1.3	3 0	
Eroded hilly phase	A	CCOM	No	0	4	None	25		15	.8	(12) 2.6	60	Very serious. Moderate.
	B	OMMMM	Yes	200	0	Contour strip cropping	(11) 25	(11) 4	40	(11) .8	(12) 2.6	100	
Tama-Thurman complex	A	CCO	No	0	0	None	25	10	25	(11) 1.3	(12) 1.2	80	Serious. Moderate. Slight.
	B	CCOM	do	0	4	do	40	14	35	1.3	1.2	150	
	C	CCOMM	Yes	200	8	Contour cultivation	55	22	50	1.6	1.3	3 0	
Eroded rolling phases	A	CCO	No	0	0	None	20	4	15	(11) 1.1	(12) 1.2	60	Very serious. Serious. Moderate.
	B	CCOM	do	0	4	do	25	8	22	1.1	1.2	100	
	C	COMM	Yes	200	8	Contour strip cropping	45	14	40	1.4	1.2	2.6	
Thurman loamy fine sand	A	CCO	No	0	0	None	10	4	15	(11) .4	(12) .8	20	Do. Slight. ¹⁵ Do. ¹⁵
	B	CCOM	do	0	4	do	15	8	20	.4	.8	40	
	C	COMM	Yes	200	8	do	30	14	35	.6	.8		
Traer silt loam	A	CCO	No	0	0	Drained if necessary	20	8	20	(11) 1.0	(12) 1.2	70	None. Do. Do.
	B	CCOM	do	0	4	do	30	12	30	1.0	1.2	140	
	C	COM	Yes	200	8	do	50	20	50	1.8	1.3	3 2	

Wabash-Judson silt loams	A	CCCC	No	0	0	Drained if necessary	45	26	(11)	(11)	(12)	160	Do.
	B	CCO	do.	0	0	do.	55	28	45	(11)	(12)	200	Do.
	C	CCOM	Yes	0	0	do.	70	30	50	2.2	13 4.0		Do.
Wabash sandy loam ¹⁷	A	CCCC	No	0	0	do.	30	18	(11)	(11)	(12)	140	Do.
	B	CCO	do.	0	0	do.	40	22	30	(11)	(12)	170	Do.
	C	CCOM	Yes	0	0	do.	60	24	40	1.6	13 3.0		Do.
Wabash silt loam	A	CCCC	No	0	0	do.	45	24	(11)	(11)	(12)	160	Do.
	B	CCO	do.	0	0	do.	55	28	45	(11)	(12)	200	Do.
	C	CCOM	Yes	0	0	do.	70	30	50	2.2	13 4.0		Do.
Wabash silty clay loam	A	CCCC	No	0	0	do.	40	18	(11)	(11)	(12)	140	Do.
	B	CCO	do.	0	0	do.	50	20	30	(11)	(12)	170	Do.
	C	CCOM	Yes	0	0	do.	60	22	35	1.2	13 2.0		Do.
Wabash soils, undifferentiated	A										140	Do.	
Waukesha loam	A	CCO	No	0	0	None	30	14	30	(11)	(12)	110	Do.
	B	CCOM	do.	0	4	do.	45	18	40	1.4	(12)	170	Do.
	C	CCOMM	Yes	200	8	do.	55	26	55	1.8	3.4		Do.
Waukesha silt loam	A	CCO	No	0	0	do.	30	18	40	(11)	(12)	140	Do.
	B	CCOM	do.	0	4	do.	55	26	50	1.8	(12)	200	Do.
	C	CCOM	Yes	200	8	do.	70	30	60	2.2	13 4.0		Do.

¹ Soil types and land types are listed in alphabetical order; the phases of each soil type are listed in the order of increasing degree of slope or degree of erosion.

² Three systems of soil management defined for most of the soils and indicated by the letters A, B, and C are used as the basis for estimating the probable erosion hazard and the average acre yields of most of the crops. Pasture management is defined separately.

³ Crops included in the rotations are indicated by the letters C, O, and M. The letter "C" means corn, with one exception. When the average acre yield of soybeans is estimated, 1 crop of soybeans is substituted for 1 crop of corn in the rotation, except for continuous corn when it is considered that soybeans are raised every third year. The letter "O" indicates oats. The letter "M", meadow, is meant to include a mixture of timothy with red, white, and alsike clover, except when the yield of alfalfa is estimated or when there are 3 or more years of meadow in the rotation. For these 2 exceptions meadow is meant to be alfalfa.

⁴ When lime applications are included in the management system, they are made once during the rotation in quantities sufficient to neutralize the soil acidity. It is applied prior to the planting of the legumes.

⁵ Fertilizer application is 20-percent superphosphate (P₂O₅), and it is applied on the oats crop. This application is not to be considered the recommended one.

⁶ Manure applications are made once during the rotation on the first or second corn crop.

⁷ Grassed waterways are included with contour cultivation and contour strip cropping.

⁸ Soybeans are a relatively new crop in Tama County, and data on yields and soil adaptations are limited; consequently, the estimated average yields per acre are less accurate than for other crops.

⁹ Only 2 systems of management are defined for estimating the productivity of the soils for pasture—pasture management system A: (1) No application of lime or fertilizer is made, (2) vegetation consists principally of grasses, although no effort is made to improve the species or to add legumes, (3) weeds are not eradicated, (4) pastures are not overgrazed; system B, (1) enough lime is applied every 6 to 10 years to maintain neutrality of the soil, (2) a good stand of grasses and legumes is maintained, (3) phosphate fertilizer (400 pounds of 20-percent superphosphate) is applied at the time of seeding the legumes and every 5 years thereafter, (4) weeds are eradicated, (5) pastures are not overgrazed.

The term "cow-acre-days," used to express the carrying capacity of pasture land, is the product of the number of animal units carried per acre multiplied by the number of days that animals can be grazed without injury to pasture; for example, a soil that supports 1 animal unit per acre for 360 days rates 360; a soil supporting 1 animal unit on 2 acres for 180 days rates 90; and a soil supporting 1 animal unit on 4 acres for 100 days rates 25.

¹⁰ Except when the soil is used only for pasture, the probable erosion hazard is based on the system of soil management defined in this table.

¹¹ System of management does not include this crop in the rotation.

¹² Because alfalfa is very sensitive to acid conditions, no estimate of yield is given unless an application of lime is included.

¹³ Rotation is COMMM for estimating the average acre yield of alfalfa.

¹⁴ Rotation is COMM for estimating the average acre yield of clover and timothy.

¹⁵ These estimates apply to the undulating slope phase; on the gently rolling to rolling phases, the erosion hazard is greater.

¹⁶ When Lindley-Fayette silt loams is used for crop production, it soon becomes eroded and the estimated average yields per acre would be those of the eroded phase.

¹⁷ Floods do not interfere with crop production.

that the soil will erode, but under the system of management specified the degree of erosion would not result in deterioration of the soil. The third (moderate) indicates that under the system of management defined harmful erosion is possible but that the effect over a period of many years is not likely to decrease materially the productivity of the soil. The fourth (serious) means that there will be considerable erosion if the specified system of management is practiced. The fifth (very serious) indicates that the soil will deteriorate markedly because of the loss of surface soil if the system is followed. Thus, in this table the probable erosion hazard is a general indication of the extent to which harmful erosion is controlled by practicing the specified system of management.

Four important limitations should be kept in mind when using table 5. First, figures given in the table are estimates, or in a sense, predictions rather than proved facts. They are considered sufficiently reliable, however, to be of much value. Second, the figures are estimated averages of the various yields that may be expected over a period of many years; the yield in any one year may be considerably higher or lower than the average. Third, there are considerable variations within the areas of some soils, as Tama-Thurman complex, Fayette-Chelsea complex, and the steeper soils of the uplands. Fourth, past management of a soil will influence its response in the immediate future. Furthermore, development of new crop varieties and improved farm practices may affect the probable future yields.

Many sources of information were used in the preparation of table 5. The experiences of farmers with the soils of the county served as indications of crop yields under various systems of soil management. The Iowa Agricultural Experiment Station has conducted experiments, both in the field and laboratory, on a number of the soil types that occur in Tama County. Census data are available and helpful. The members of the survey party observed the growth of the different crops on the various soils during the seasons they were in the area. These samples of evidence, taken together, provide a fair basis for estimating probable crop yields. As additional evidence is gathered, the accuracy of estimates can be improved.

Past management has a very definite influence on the response of a soil in the immediate future to a specific system of management. After a period of years, however (varying with each soil), the effects of the previous system of management cease to be important. The rate of change in the productivity of a soil when the system of management is changed depends upon the soil type and phase, and also upon the nature of the change in the system of soil management. Such soils as Thurman loamy fine sand, which are unable to retain the benefits from applications of barnyard manure for a long time, may experience rapid changes in productivity. Other soils, as Muscatine silt loam, will change very slowly when the system of management is changed to a poorer one but will respond quickly to better management. Where a soil is used for pasture and the change in the system of management consists only of applications of phosphate fertilizers, the rate of increase in productivity is slow the first year, more rapid the second and third years, and then slower until it reaches a fairly stable higher level of productivity. The rate of change in productivity may be fast or slow, but eventually different areas of the same soil managed in the same way will attain the same level.

PRODUCTIVITY RATINGS

The soils are rated in table 6 according to their relative productivity for the various crops grown in the county. This table is used to supplement table 5, by showing how the yields given for Tama County soils compare with those on soils considered most productive for the crop in the United States as a whole.

TABLE 6.—Productivity ratings of the soils of Tama County, Iowa

Soil	Crop productivity index					
	Corn ¹ (100=50 bu.)	Oats ¹ (100=50 bu.)	Clover and tim- othy ¹ (100=2 tons)	Alfalfa ² (100=4 tons)	Soy- beans ¹ (100=2½ bu.)	Pasture ³ (100=100 cow-acre- days ⁴)
Muscatine silt loam.....	120	100	90	100	100	130
Bremer silt loam.....	120	90	70	95	105	150
Waukesha silt loam.....	110	100	90	100	105	140
Tama silt loam, level phase.....	110	100	90	100	95	130
Wabash silt loam.....	110	90	110	100	110	160
Wabash-Judson silt loams.....	110	90	110	100	110	160
Judson silt loam.....	110	90	110	100	95	160
Tama silt loam.....	100	90	85	95	80	120
Bremer silty clay loam.....	100	70	60	50	80	140
Wabash silty clay loam.....	100	60	60	50	80	140
Downs silt loam, level phase.....	90	85	75	90	80	100
Tama silt loam, eroded phase.....	90	80	80	90	65	105
Carrington silt loam.....	90	80	70	90	65	105
Carrington loam.....	90	80	60	85	55	100
Waukesha loam.....	90	80	70	85	70	110
Downs silt loam.....	90	70	65	85	55	90
Ray silt loam.....	90	70	100	85	80	140
Garwin silty clay loam.....	90	70	80	80	95	140
Fayette silt loam, level phase.....	90	70	60	90	65	80
Tama silt loam, gently rolling phase.....	80	70	75	85	50	90
Tama-Thurman complex.....	80	70	65	75	55	80
Chariton silt loam.....	80	70	50	45	80	140
Wabash sandy loam.....	80	60	80	75	90	140
Fayette silt loam.....	70	70	60	90	65	80
Tama silt loam, eroded gently rolling phase.....	70	60	70	80	40	80
Carrington silt loam, eroded gently rolling phase.....	70	60	60	80	40	80
Carrington loam, eroded gently rolling phase.....	70	55	50	75	30	70
Traer silt loam.....	60	60	50	80	50	70
Downs silt loam, eroded gently rolling phase.....	60	55	55	80	30	70
Tama silt loam, eroded rolling phase.....	60	50	60	75	30	70
Carrington silt loam, eroded rolling phase.....	60	50	40	70	25	60
Fayette-Chelsea complex.....	50	50	40	70	40	60
Fayette silt loam, eroded gently rolling phase.....	50	45	40	80	30	60
Tama-Thurman complex, eroded rolling phases.....	50	45	55	65	30	60
Downs silt loam, eroded rolling phase.....	50	45	50	75	25	60
Shelby loam.....	50	40	30	60	15	50
Lindley silt loam, gently rolling phase.....	45	40	35	75	25	60
Fayette silt loam, eroded rolling phase.....	45	40	30	70	25	50
Fayette-Chelsea complex, eroded rolling phases.....	40	35	25	60	25	40
Lindley silt loam.....	35	35	30	65	25	50
Buckner sandy loam.....	30	40	20	20	30	20
Thurman loamy fine sand.....	30	40	20	20	30	20
Chelsea loamy fine sand.....	15	20	10	20	15	10
Tama silt loam, eroded hilly phase.....	(⁵)	80	40	165	(⁶)	60
Shelby loam, eroded hilly phase.....	(⁵)	80	30	160	(⁶)	50
Lindley-Fayette silt loams, eroded phases.....	(⁵)	80	20	160	(⁶)	40
Wabash soils, undifferentiated.....						140
Sawmill silty clay loam.....						80
Rough broken land.....						60
Lindley-Fayette silt loams.....						50

¹ Except where noted, these indexes correspond to yields given in table 5, p. 71, for management system B.² Except where noted, these indexes correspond to yields given in table 5, p. 71, for management system C.³ These indexes correspond to carrying capacity for pasture management system A, defined in footnote 9, table 5, p. 75.⁴ See footnote 9, table 5, p. 75.⁵ These indexes correspond to yields under management system C (table 5, p. 71).⁶ Crop not included in management system B.⁷ These indexes correspond to yields under management system B for these soils.

The rating expresses the productivity of each of the soils for each crop as a percentage of a standard. The standard yield is given an index number of 100. It represents the average yield in a farming system, without the use of fertilizers and other mineral amendments, of the most productive group of soils of important extent in the United States where the crop is generally grown. An index of 75 indicates that the soil is about three-fourths as productive for the specified crop as the soil with the standard index. Soils given amendments, as lime or commercial fertilizers, or unusually productive soils of small extent may have productivity indexes of more than 100 for some crops.

The yield compared with the standard in table 6, except where noted, is that generally obtainable under management system B as defined for each soil in table 5. The crop rotation consists of corn, corn, oats, and meadow, except for soybeans and alfalfa. For soybeans it is corn, soybeans, oats, and meadow; for alfalfa it is corn, corn, oats, alfalfa, alfalfa, and alfalfa. Once during the rotation 4 tons of manure are applied. Adequate drainage is provided where necessary and practical. It is assumed that there is no damage from floods. Lime is applied only for alfalfa. In estimating the productivity of pasture, it is assumed that no applications of lime, commercial fertilizers, or manure are made.

The limitations that apply to the use of table 5 apply also to the use of table 6.

Productivity indexes cannot be interpreted into land values except in a very general way. Distance to market, relative prices of farm products, and other factors influence the value of land.

AGRICULTURE OF TAMA COUNTY

The more important characteristics of the agriculture of Tama County are discussed in this section, primarily for people not familiar with the county. Land use, types of farming, farm tenancy, farm investments and expenditures, crops, and livestock are described briefly. The relations of these characteristics of the agriculture to the soils of the county are indicated wherever possible.

The first settlers in Tama County built their cabins near the Iowa River and the adjacent bluffs where wood was plentiful. They practiced a subsistence agriculture in which wheat and corn were the staple crops (6). Some flax was grown for fiber and some animals (sheep and cattle) were kept for fiber and meat. There was little opportunity for the exchange of produce with other areas prior to the coming of the first railroad to the county in 1862 because the roads then existing did not provide adequate transportation for a commercial agriculture. During the three decades following completion of the railroad, however, agriculture shifted from the subsistence to the commercial type and developed rapidly.

At present nearly all the land area of the county is in farms and used principally for crop production. In 1940, according to the Federal census, the 2,724 farms occupied 96.1 percent of the county, or 442,605 acres, and had an average size of 162.5 acres. These constitute slight increases over 1930, when the number and average size of farms were 2,700 and 161.9 acres, respectively, and the area and proportion in farms, 436,999 acres and 94.8 percent. The uses made of farm

land in 1939 were as follows: Cropland harvested, 256,417 acres; crop failure (land from which no crop was harvested because of destruction from any cause or failure to harvest because of low prices or lack of labor), 973 acres; cropland lying idle or in summer fallow, 4,297 acres; plowable pasture, 95,550 acres; woodland, 15,889 acres; and all other land in farms, including pasture land other than plowable and woodland pasture, all wasteland, houseyards, barnyards, feed lots, lanes, and roads, 69,479 acres.

CROPS

Corn, the most important crop, has been grown consistently on more than 40 percent of the cropland, although in the last decade it has been replaced by soybeans on about 20,000 acres. The proportion of the farm land used for corn is highest in the area of undulating to level dark-colored soils of the uplands and lowest in that of light-colored soils of the uplands. The average corn yield of the county for the 10-year period 1930-39 was 45.7 bushels an acre (16). Most of the corn is fed on the farms where grown, although some is sold on the market.

Corn is usually planted before the middle of May and harvested during the last half of October and in November. Although a few fields are planted on the contour, most of the planting follows the common rectangular field pattern. Row-crop tractors are extensively used for cultivation, but some farmers use horses. Harvesting is done by hand or with corn pickers, which are becoming more numerous.

Oats have been the most important small-grain crop since 1889, occupying more than 60,000 acres during each census year, and in 1919 and 1929 more than 70,000 acres were sown. Yields range between 30 and 40 bushels an acre. The average yield for the period 1930-39 was 30.9 bushels. A higher proportion of the cropland is used for oats in the more rolling parts of the county than in the more level areas. The oat crop is grown primarily as a nurse crop for legumes and grasses. Most of it is fed on the farms where grown, but some is sold.

Oats are usually planted in April and harvested about the first of July. Most of the harvesting is with 8-foot grain binders, which were designed to be drawn by horses but now are pulled by tractors. There are a few combines, and as the grain binders wear out, the number of combines will likely increase, but there is also the possibility that they will be replaced by tractor binders.

Soybeans are becoming an important crop in the county and are grown for both hay and beans. Prior to 1929 the acreage was negligible, but during the decade 1929-39 it increased from 1,242 to 20,452 acres, about 73 percent of the 1939 acreage being harvested for beans principally for sale. Most of the soybeans are grown in the areas of undulating to level dark-colored soils of the uplands and soils of the flood plains, whereas the smallest acreage is in the area of light-colored soils of the uplands. The average yield for the period 1930-39 was 19.1 bushels an acre.

Soybeans are planted in May, after the corn has been planted, and are harvested late in October. Most of them are planted in rows in the same manner as corn, although some are drilled. When planted

in rows, they are cultivated with corn cultivators. Generally, the crop is harvested with a combine.

Other small-grain crops include barley, wheat, rye, and flax. Barley, most important of these, was grown on 5,155 acres in 1939, and the average yield during the 10-year period 1930-39 was 24.8 bushels an acre. Wheat is not so important in the agriculture of the county as it was in the days of the early settlers. In 1879 the census showed 77,950 acres of wheat, but this acreage decreased to 7,478 in 1889, partly as a result of the chinch bug plague in 1882 (6). Most of this decreased acreage was replaced by oats, but there also were increases in the acreages of barley and hay crops. In 1939 only 1,343 acres were used for wheat. Rye and flax were never important crops, and in 1939 the rye acreage was only 807 acres and the flax acreage 599. The planting and harvesting of these crops are very similar to those of oats, except the time when these operations are done. Winter wheat and rye are planted in the fall.

Clover and timothy, usually grown together, are the most important hay crops and in 1939 occupied 38,150 acres, rather well distributed throughout the county. Most of the clover and timothy hay is fed on the farms where it is grown.

Clover and timothy are planted in spring, usually with oats as a nurse crop. During the summer two crops of hay are generally harvested, the usual method being to cut the hay with an ordinary mower, windrow it with a side-delivery rake, and load onto a rack with a hay loader. From the hayrack it is placed usually in barns but often in stacks. Sometimes the hay is baled in the field directly from the windrows. The average yield is about 1.3 tons an acre.

Alfalfa is rapidly becoming an important hay crop. From 129 acres in 1919, its acreage increased to 2,351 in 1929 and to 7,735 in 1939. This acreage is distributed generally over the county except in the areas of alluvial soils, where it is very small. Nearly all of the alfalfa produced is consumed on the farms of the county. The average yield is about 2.75 tons. This crop remains on the land for several years, usually 3 to 5, and also it is sometimes seeded late in summer.

Other hay and forage crops include principally tame grasses, as millet, grains cut green, some wild grasses, and silage and forage crops. None of these are very important, their combined acreage in 1939 being only 5,513 acres.

Fruits and vegetables are not important commercially, but some are grown. Of the fruits, apple trees are the most numerous, with plum and cherry trees next. Since 1900 the number has gradually decreased. In addition to the fruit trees, some grapevines and a small acreage of strawberries, raspberries, and blackberries are grown, 5,306 grapevines and 35 acres of berries, mainly strawberries and raspberries, being reported in 1939. This is less than half those reported in 1929. Of the vegetables, potatoes are the most important, occupying 585 acres in 1939. This acreage, however, is considerably less than in previous years, especially 1909, when it was 3,625 acres. Some watermelons and cantaloups are raised commercially.

The acreages of the principal crops and the number of bearing fruit trees in the county are given in table 7 for stated years.

TABLE 7.—Acreages of the principal crops and number of bearing fruit trees in Tama County, Iowa, in stated years¹

Crop	1879	1889	1899	1909	1919	1929	1939
	<i>Acres</i>	Acres	Acres	Acres	Acres	Acres	Acres
Corn:							
For grain.....	107,904	106,804	128,780	121,210	115,016	122,478	109,800
For silage.....						3,246	1,640
Hogged, grazed, or cut for fodder.....					3,286	10,154	1,803
Oats:							
Threshed.....	18,367	62,956	60,364	63,901	75,266	73,380	60,554
Cut and fed unthreshed.....						308	1,406
Wheat.....	77,950	7,478	14,811	4,114	6,442	1,416	1,343
Barley.....	6,484	16,390	29,320	11,294	3,677	6,373	5,155
Rye.....	910	1,638	757	258	215	152	807
Flax threshed.....		1,321	60		13		599
Soybeans:							
For all purposes, except plowed under ²						1,242	20,452
For beans only.....							14,946
Hay, total.....	39,075	58,717	49,222	62,284	44,707	55,246	53,371
Clover or timothy, alone or mixed.....				58,220	36,845	39,202	38,150
Clover alone.....			1,319	1,313	6,194	12,447	498
Alfalfa.....				3	129	2,351	7,735
Annual legumes for hay (soybeans).....					32	198	5,250
Grains cut green.....			843	23	151	77	1,211
Other tame hay.....			38,791	94	95	176	318
Wild hay.....			8,269	2,631	1,261	795	209
Silage crops other than corn.....				4,316			154
Forage crops other than corn.....			1,576	1,216	42		178
Potatoes.....	9	2,336	2,174	3,625	1,210	965	585
Vegetables harvested for sale.....					410	988	393
Strawberries.....			23	38	40	35	18
Raspberries.....			5	20	25	23	14
Blackberries.....			20	19	11	3	3
	<i>Number</i>	Number	Number	Number	Number	Number	Number
Apples.....trees.....		32,697	56,312	48,293	26,198	19,353	8,205
Peaches.....do.....		9	239	1,891	179	1,021	700
Plums.....do.....		1,117	7,575	9,012	3,126	5,754	3,341
Cherries.....do.....		758	5,270	10,321	3,625	2,374	1,700
Grapes.....vines.....			5,714	16,181	12,073	12,328	5,306

¹ Fruit trees and grapevines are for the census years 1890 to 1940.

² Partly duplicated in annual legumes for hay.

³ Sweetclover only.

ROTATIONS, LIME, AND FERTILIZERS

A 4-year rotation, consisting of two crops of corn, one of small grain, usually oats, and one of clover and timothy, is commonly followed on the more nearly level and productive soils of the uplands. On the alluvial soils the rotations include less grasses and legumes and more intertilled crops, whereas on the less productive and more rolling soils the opposite is true. Also, more of this less productive land is used for permanent pasture and forest.

Considerable lime but only a small quantity of commercial fertilizers are used in this county. The Federal census in 1939 shows that 57 tons of commercial fertilizers were used on 33 farms, compared with 349 tons on 108 farms in 1929. The quantity of lime used in 1939 was 10,779 tons on 329 farms, most of it on land to be planted to alfalfa.

PERMANENT PASTURES

In 1939 (1940 census) a total of 95,550 acres was in plowable pasture. Considerable pasture is also included in the woodland acreage (15,889 acres) and in all other farm land except cropland (69,479 acres). The pasture acreage is distributed throughout the county but is about one-third larger in the area of light-colored soils of the uplands than in

that of undulating to level dark-colored soils of the uplands (fig. 2, p. 6). Most of the pastures in the latter area, except the small ones near the farmsteads, are on Wabash or Wabash-Judson soils.

The pasture vegetation is usually Kentucky bluegrass mixed with some clover. The carrying capacity of these bottom-land pastures is high. In the area of rolling to hilly dark-colored soils of the uplands, more of the pastures are on hilly slopes and less in the flood plains. Some of these hilly slopes are severely eroded and do not have a good plant cover. Some of the pastures in the area of light-colored soils of the uplands are woodland pastures, containing many trees and some brush. In the area of soils of the flood plains, most of the pastures are on Wabash soils, undifferentiated, and the vegetation consists of trees, grasses, and weeds.

LIVESTOCK

Horses are the principal work stock, although there are a few mules. Tractors, especially the row-crop type, have replaced many of the horses and mules, the number having decreased from a total of 20,394 in 1910 to 9,537 over 3 months old, April 1, 1940. Many of the farms at present have only a team, and some have none. Most of the horses are large and generally are of Percheron, Belgian, or Clydesdale breeds. Most of the replacements are raised on the farms.

Raising cattle has been a major enterprise for many decades, with beef production the more important, especially in the earlier periods. The number of cattle generally has exceeded 60,000, and on April 1, 1940, there were 67,856 over 3 months old. Slightly less than half of these were cows and heifers over 2 years old, January 1, 1940, of which 15,982 were kept for milk production and 16,089 for beef production. Most of the rest likely were beef cattle, with many being fattened for market. Cattle are uniformly distributed throughout the county with the exception of Lincoln and Spring Creek Townships where they are more numerous. Although there is no definite relationship between the number of cattle and the soils, there is a relationship between the quality of cattle and the soils. The better cattle are in the area of undulating to level dark-colored soils of the uplands. Hereford (pl. 16, *A*) is the principal breed of beef cattle, although many are of the Aberdeen Angus and Shorthorn breeds. Holstein-Friesian is the most important breed of dairy cattle (pl. 16, *B*). The markets for dairy products are mainly the local creameries, and for the beef cattle, such packing centers as Waterloo, Des Moines, Mason City, Ottumwa, and Chicago.

Hogs are not uniformly distributed throughout the county but are most numerous in those areas producing the most corn (pl. 16, *C*). On April 1, 1940, there were 72,256 hogs and pigs over 4 months old compared with 77,874 over 3 months old on April 1, 1930. The total number of all ages on the latter date was 141,622, or about 40 percent more than in 1920. The principal breeds are Hampshire, Duroc-Jersey, Berkshire, Poland China, and Chester White. Most of the hogs are shipped to markets in Waterloo, Des Moines, Cedar Rapids, Ottumwa, South Saint Paul, and Chicago.

Some sheep have been raised since pioneer days but have never been numerous on many farms. On April 1, 1940, 475 farms reported 10,649

sheep over 6 months old, the principal breed being Shropshire. Of the poultry, only chickens are very common, although some turkeys, ducks, geese, and guineas are raised. Nearly all of the farms have a few chickens, most of them having more than 100. A total of 371,983 chickens was reported by 2,562 farms in 1940. Beekeeping, an enterprise on a few farms (56 in 1940), is becoming less important, the number of hives decreasing from 1,604 in 1910 to 519 in 1940.

The numbers of different kinds of livestock on farms in the county in 1910, 1920, 1930, and 1940, as reported by the Federal census, are given in table 8.

TABLE 8.—*Number of livestock on farms in Tama County, Iowa, in stated years*

Livestock	1910	1920	1930	1940
Horses.....	20, 025	18, 347	13, 474	¹ 9, 102
Mules.....	369	716	915	¹ 435
Cattle.....	70, 443	67, 936	67, 924	¹ 67, 856
Swine.....	129, 818	100, 802	141, 622	² 72, 256
Sheep.....	13, 541	11, 713	16, 333	³ 10, 649
Chickens.....	} 341, 630	{ 366, 347	¹ 432, 805	² 371, 983
Other poultry.....					8, 602	(^{4})	^{2} 4, 748
Bees..... hives.....	1, 604	1, 280	747	519

¹ Over 3 months old, Apr. 1.
² Over 4 months old, Apr. 1.

³ Over 6 months old, Apr. 1.
⁴ Not available.

MAJOR SOURCES OF INCOME

Most of the income of the farmers in the county is from sale of livestock—mainly cattle and hogs. Some of the cereal crops, chiefly corn and oats, are sold for cash, but most of these crops are fed to livestock on the farm. Poultry and eggs, hay and forage, and dairy products are other important sources of income. Of the farm income 56.6 percent is derived from the sale or trade of livestock and livestock products, 35.3 from sale or trade of crops, and 8.1 percent through the use of farm products by the farm household. The values of specified agricultural products in 1939, as reported by the Federal census, are given in table 9.

A classification of farms by major source of income in 1939 shows that 1,382 received their major source of income from livestock; 927 from field crops; 74 from dairy products; 45 from poultry and poultry products and 2 from other livestock products; 10 from vegetables; 2 from horticultural specialties; and 1 from fruits and nuts. In addition to these, 214 were classified as subsistence farms, and 48 were unclassified.

SIZE OF FARMS

In addition to the types of farm classification based on the major source of income, the 1940 census also classified the farms by size. The number of farms in the different size groups is shown in figure 5. Although these data are for groups with a range in size, they represent largely the number of farms of a specific size. The size of farms usually varies by increments of 40 acres; the common sizes are 80,

TABLE 9.—*Value of specified agricultural products by classes in Tama County, Iowa, in 1929 and 1939*

Product ¹	1929	1939
Cereals.....	\$4, 817, 240	\$4, 327, 549
Other grains and seeds.....	91, 990	366, 801
Hay and forage.....	920, 608	664, 988
Vegetables for sale and farm households' use (excluding potatoes and sweetpotatoes).....	158, 765	102, 008
Potatoes and sweetpotatoes.....	137, 350	36, 407
Fruits and nuts.....	44, 925	14, 051
Horticultural specialties sold.....	12, 385	8, 625
All other crops.....	1, 137	2, 727
Forest produce sold.....	14, 528	2, 034
<i>Livestock products</i>		
Whole milk, cream, and butter sold.....	916, 852	474, 855
Whole milk.....	77, 080	57, 187
Cream ²	821, 958	414, 600
Butter.....	17, 814	3, 068
Animals sold or slaughtered.....	(³)	4, 330, 850
Cattle and calves.....	(³)	2, 169, 739
Hogs and pigs.....	(³)	2, 097, 695
Sheep and lambs.....	(³)	63, 416
Poultry raised and chicken eggs produced.....	1, 289, 553	665, 085
Wool shorn.....	20, 009	14, 563
Mohair and kid hair clipped.....	118	(³)
Honey produced.....	3, 390	425

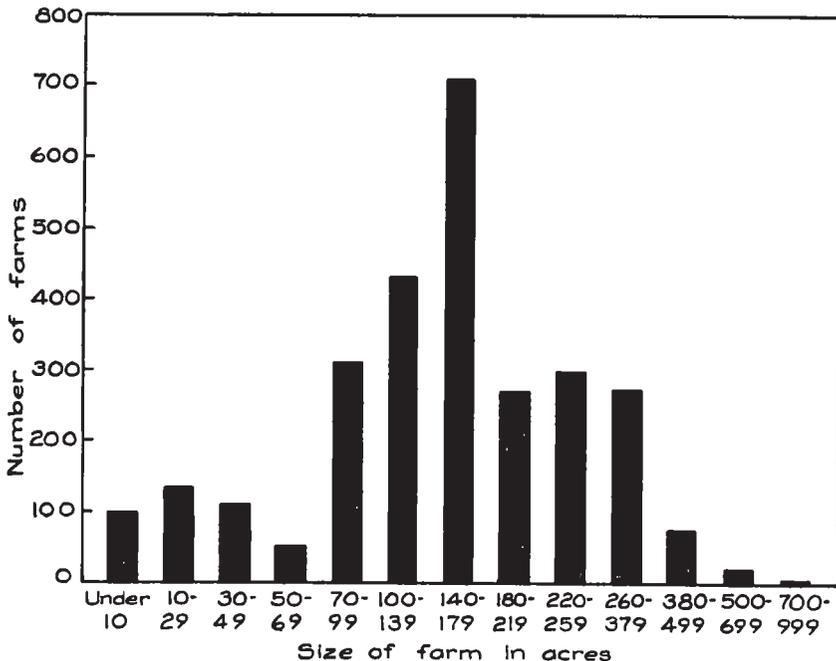
¹ Value of crops harvested.² Sweet cream and sour cream (butterfat).³ Not available.

FIGURE 5.—Number of farms in various size groups in 1940, Tama County, Iowa.



A. Hereford cattle in a sweetclover and brome grass pasture on rolling slopes of Tama and Carrington soils.
B. Dairy cattle on Wabash-Judson silt loams. Dairying is not so important as beef and hog production, but some milk cows are kept on most farms.
C. Hogs on permanent pasture. Hog production is an important livestock enterprise in Tama County.



A, One-room rural school, common throughout most of the county. In the area of undulating to level dark-colored soils of the uplands, many of these schools are brick.

B, Union Grove Lake provides some fishing and recreational facilities. Woods in the background are on Lindley-Fayette silt loams.

120, 160, 200, 240, and 280 acres. The size-group 140-179 acres, which includes the 160-acre farms, is the largest and includes about 26 percent of all farms. About 85 percent of the farms is within the range of 70 to 380 acres. The number of farms in each size group in 1940 was essentially the same as in 1930.

FARM TENANCY

The proportion of farm tenancy in Tama County has not changed significantly since 1920 but prior to that time the number of owners was continually decreasing and the number of tenants increasing. From 1880 to 1920 the percentage of farm owners decreased from 71.7 to 56.3 and in 1940 it was 55.8. The proportion of tenancy in 1940 was 43.4 percent, and of the 1,183 tenants, 542 were classed as cash tenants, 385 as share-cash tenants, 218 as share tenants and croppers, and 38 as other tenants. The cash rent usually ranges from \$4 to \$9 an acre. The share-cash tenants generally receive half the corn and hay and three-fifths of the oats. They pay cash for the use of the pasture and buildings, but the amount varies greatly and often involves a consideration of other factors not mentioned specifically. Livestock share, another type of tenure, is not listed separately by the census. Under this type the landlord and tenant generally share all income and expenses.

FARM INVESTMENTS AND EXPENDITURES

The average investment per farm in 1940 was \$18,272, according to the Federal census. More than four-fifths of this amount, or 82.6 percent, was in land and buildings; 7.1 percent in implements; and 10.3 percent in domestic animals, poultry, and bees. Buildings alone accounted for 24.2 percent.

During recent years there has been an increase in the quantity of machinery on farms, largely as a result of the development of the row-crop or general-purpose tractor. From 1930 to 1940 the number of tractors more than doubled, increasing from 904 to 1,963. The machinery commonly used on average or better farms is as follows: Row-crop tractor with cultivator and other attachments, grain binder, grain drill, disk, field cultivator, harrow, mower, side-delivery rake, hay loader, and manure spreader. In addition some farms have a combine or threshing machine and a corn picker.

The number of farmers buying feed increased from 25.9 percent in 1909 to 80.5 percent in 1939. For the latter year 2,192 farms reported a total expenditure of \$677,380 for feed, or an average of \$309.02 a farm.

The expenditure for commercial fertilizers has been very low, and in 1939 only 33 farmers bought a total of 57 tons at a cost of \$1,905. The expenditure for lime, however, has increased during recent years, and \$16,687 was paid for 10,779 tons by 329 farmers in 1939.

Additional labor is hired on about 50 to 60 percent of the farms, the cost usually averaging about \$300 a farm a year. In 1939, 1,606 farmers (59 percent) reported a total expenditure of \$455,526, or an average of \$283.64 a farm. Most of the farm laborers are natives of the county, and they are hired for cash, usually on a monthly basis.

CULTURAL GEOGRAPHY OF TAMA COUNTY

The cultural geography of Tama County relates to the people and their culture. Population, transportation and marketing facilities, schools, churches, and other cultural developments are discussed. Their relationship to the soils is indicated. Like the section on agriculture, this discussion is meant primarily for people not acquainted with the county.

ORGANIZATION AND POPULATION

Tama County (the name, Tama, is from Taomah, an Indian chief-tain of the Fox Tribe) in 1837 was part of the territory known as Benton County, created by the Wisconsin Territorial Legislature (28). On February 17, 1843, it was organized with its present boundaries and attached to Linn County for administrative purposes. An independent government organization was established in August 1852, and Toledo became the seat of government in 1853. Even at this time there were very few settlers in the county, the 1850 census listing only 8 whites.

The first settlement was made in 1848 by H. N. Atkinson, on the Iowa River just west of Tama (11). A year later Isaac Asher brought his family, and the three Wilkinson brothers with their mother and three sisters arrived from Ohio and settled in Richland Township. The early settlers came mainly from Illinois, Indiana, and Ohio, but there were also many immigrants from Europe. These early settlers were mainly of Scandinavian (principally Norwegian), German, Czech, and Scotch origin (5). The Scotch settled mainly in the northern part of the county, the first arrivals coming about the middle of the nineteenth century. "Tama Jim" Wilson, perhaps the most prominent of the group (he was later well known nationally as Secretary of Agriculture), arrived in 1855 after living 4 years in Connecticut (7). The Czechs, or Bohemians, came about 1870.

The settling of the county occurred mainly during the three decades 1850-80, with the most rapid increase in the second decade, following the completion of the railroad in 1862. In addition to lack of transportation facilities, trouble with Indians hindered settlement prior to that date. After 1880 there was very little increase in the total population, but there were fluctuations between urban and rural areas. Since 1920 the urban and rural populations have been rather stable.

Of the total population of 22,428 in 1940, 20,684 (92.2 percent) were native white; 1,247 (5.6 percent) foreign-born white, principally from Germany and Czechoslovakia; 17 Negroes (0.1 percent); and 480 Indians of the Sac and Fox Tribe (2.1 percent). The Indians live about 2 miles west of Tama on land owned by the tribe. The density of the rural population was 27.5 a square mile in 1940. There is no very definite relation between the nature of the land and the density of the rural population.

The population of the county as reported by the Federal census for the years 1880-1940 is given in table 10.

TABLE 10.—*Total urban and rural populations of Tama County, Iowa, in certain years*

Year	Total population	Urban		Rural	
		Total	Percent	Total	Percent
1880.....	21, 585			21, 585	100. 0
1890.....	21, 651			21, 651	100. 0
1900.....	24, 585	2, 649	10. 8	21, 936	89. 2
1910.....	22, 156			22, 156	100. 0
1920.....	21, 861	2, 601	11. 9	19, 260	88. 1
1930.....	21, 987	2, 626	11. 9	19, 361	88. 1
1940.....	22, 428	2, 832	12. 6	19, 596	87. 4

INDUSTRIES

Tama County is largely agricultural, but there are a few industries. According to the 1940 census, 4,078 of the 6,543 male workers were employed in agriculture. No other single industry employed more than about 350 people. Some of the principal industries furnishing employment are a paper mill, a creamery and poultry processing plant, and a wood-preserving plant at Tama; a cooperative cannery at Toledo; and a cooperative creamery at Traer. These industries provide a local market for some of the agricultural products.

TRANSPORTATION AND TRADING CENTERS

Tama County has good transportation and marketing facilities. Four railroad companies provide services within the county. A main east-west line of the Chicago and North Western System crosses the southern part, passing through Montour, Tama, and Chelsea. A main line of the Chicago, Milwaukee, St. Paul and Pacific Railroad also crosses the southern part through Tama, Vining, and Elberon. Gladbrook and Lincoln receive service from the Chicago Great Western Railway, which crosses the northwest corner; and the Chicago, Rock Island, and Pacific Railway passes through Dysart, Traer, and Dinsdale.

In addition to its railroad facilities, the county has an excellent system of roads. United States Highways Nos. 30 and 63 cross the county—the former in an east-west direction, through Montour and Tama, and the latter in a north-south direction through Tama, Toledo, and Traer. Several State and county highways and a system of hard-surfaced farm-to-market roads and graded roads also are well maintained and provide good outlets from nearly all farms. In 1940 the Federal census reported 224 farms on hard-surfaced roads; 1,756 on gravel, shell, and shale roads; 232 on improved dirt roads; and 438 on unimproved dirt roads.

Very few farms are more than a mile from a surfaced road that connects with one of the many markets and trading centers within the county. Toledo (population 2,073), the county seat, and Tama (2,832), the largest city, together with Traer (1,493), Dysart (986), and Gladbrook (945) are the principal markets and trading centers. Other smaller ones are Chelsea, Garwin, Montour, Elberon, Clutier, Lincoln, and Vining.

CHURCHES, SCHOOLS, AND HOME CONVENIENCES

Tama County has many churches and a good school system. Most of the churches are in the cities and small towns, although a few are rural. Nearly all are well built and rather large. Most of the schools are one-room rural elementary, and in the better sections there are nine in each township. A few of these are brick buildings, but most of them are built of wood (pl. 17, *A*). With the exception of the consolidated school in Geneseo Township, the high schools are located in the cities and small towns.

The farm dwellings, outbuildings, and general improvements vary somewhat in size, number, and quality with the quality of the soils. In the general areas of undulating to level dark-colored soils of the uplands and soils of the flood plains the farmsteads are generally good to excellent. The dwellings are well built and modern, and the outbuildings usually include a large barn or two, a large corn crib, machine shed, garage, and occasionally other small sheds. In the regions of rolling to hilly dark-colored soils of the uplands the farmsteads are more variable and often are located in the small valleys. Where the farms are large or include a considerable acreage of productive soils of the flood plains, the farmsteads are as good as those generally in the region of undulating to level dark-colored soils of the uplands. In the region of light-colored soils of the uplands the farmsteads are less well built and are generally located on the ridge divides. Modern rural home conveniences are less prevalent in this region.

Modern home conveniences are common on many farms. The 1940 census reported 1,279 farm dwellings lighted by electricity, which represents an increase of 586 since 1930. Of this number, 1,150 received current from power lines and 129 from home plants. Most of the farms have telephones, but the number decreased during the decade 1930-40 from 2,405 to 2,190. In addition to these conveniences it is estimated that about a fourth of the farms have running water systems and a third have furnaces. Most of the farmhouses not heated by furnaces are heated by a fuel-oil circulating-hot-air heater. Rural routes provide mail service to all parts of the country.

WATER SUPPLY

Wells and streams provide most of the water needed by the people and the livestock, but only well water generally is used for human consumption. Many of the wells are located in the drainageways, and the quality and quantity of the water is quite satisfactory throughout the county. Cherry Lake, at Tama, which furnishes water for the paper mill, is man-made and is supplied by a canal that joins the Iowa River about 3 miles northwest of Tama. This lake also furnishes some recreational facilities, but Union Grove Lake, about 4 miles south of Gladbrook, is much better for recreational purposes (pl. 17, *B*). It is an artificial lake covering about 120 acres. Fishing is also afforded by the larger streams.

MORPHOLOGY AND GENESIS OF SOILS

The discussion on morphology and genesis of soils presented in the following pages is technical and is intended primarily for soil scientists

and other specialists who want a more detailed discussion of the nature and origin of the soils of Tama County.

Relatively few morphological features are common to large numbers of soils in Tama County. The principal features that are common are chiefly due to climate, vegetation, or parent material. The effect of climate is shown in depth of the solum, which is fairly uniform in soils of undulating and rolling uplands. The effect of vegetation is expressed in a deep dark-colored A horizon in many profiles. The nature of the parent material is reflected in the silty character of the soils, most of which have formed from loess.

The soils with deep dark-colored A horizons are members of the Prairie and related great soil groups. Approximately half of Tama County consists of soils belonging to the Prairie group. Other soils with dark-colored A horizons, or surface layers, are the Wiesenboden and Alluvial groups. The Alluvial soils are extensive, covering about one-fifth of the county. The Gray-Brown Podzolic soils, covering about one-sixth of the county, lack the deep dark-colored A horizon so common in the general region of Prairie soils.

In the subsequent discussion, the morphological features of representative soils selected from the important great soil groups are outlined in some detail. One profile is given to represent each of the zonal and intrazonal groups. In addition to the descriptions of representative profiles, the influences of the several factors of soil formation are discussed briefly. Each of the important series is classified also in the appropriate great soil group and order. With the classification of the series, a few selected morphological features of each are given.

The soil series in this county are representatives of seven great soil groups, which are divided about evenly among the three soil orders—zonal, intrazonal, and azonal (\emptyset). The relation between series, great soil groups, and orders, in addition to some of the characteristics of each series, are given in table 11.

Zonal soils include those developed from parent materials of intermediate physical constitution and chemical composition on undulating to rolling sites with good drainage. They have been in place long enough to have a well-developed profile. These soils express the effect of the active factors of soil genesis, namely, climate and living organisms. Zonal soils are represented by Prairie and Gray-Brown Podzolic groups.

Prairie soils were formed in cool moderately humid climate under a vegetative covering of tall grasses dominated by bluestems ($\emptyset 7$). Their profiles consist of a dusky-brown to brownish-black A horizon, a dark yellowish-brown to moderate-brown B horizon, and a light yellowish-brown to weak-yellow, sometimes mottled, C horizon. The B horizon in most of the Prairie soils is marked by slightly higher concentrations of clay, as shown in figure 6. Prairie soils in Tama County are the Tama, Carrington, Waukesha, Muscatine, and Shelby. The Downs series also is included with the Prairie soils in this area, although it has certain characteristics normal to Gray-Brown Podzolic soils as well as some normal to Prairie soils.

Tama silt loam was formed from loess on level to hilly slopes. The depth of the soil profile varies with the degree of slope, being deepest on the level sites. On the hilly sites the profile is shallow and has

TABLE 11.—Classification and important characteristics of the soil series in Tama County, Iowa

ZONAL

Great soil group and soil series or land type	Parent material	Topographic position	Topography	Internal drainage	Color and texture		Consistence of B horizon or subsoil
					A horizon	B horizon or subsoil	
Prairie soils:							
Tama.....	Loess.....	Upland.....	Level to hilly.....	Good.....	Dusky-brown silt loam.	Moderate yellowish-brown silty clay loam.	Friable.
Muscatine.....	do.....	do.....	Flat to nearly level.....	Slow.....	Brownish-black silt loam.	Medium olive-gray medium silty clay loam, mottled.	Moderately friable.
Carrington.....	Glacial drift.....	do.....	Undulating to rolling.....	Good.....	Dusky-brown silt loam.	Moderate yellowish-brown gritty silty clay loam or light clay loam.	Friable.
Shelby.....	do.....	do.....	Gently rolling to hilly.....	Slow to good.....	Dusky-brown loam.....	Moderate yellowish-brown gritty silty clay loam to clay loam.	Very firm.
Waukesha.....	Old alluvium ¹	Terrace.....	Level to slightly undulating.....	Good.....	Brownish-black silt loam.	Dark yellow-brown light silty clay loam.	Friable.
Downs.....	Loess.....	Upland.....	Level to rolling.....	do.....	Weak-brown silt loam.....	Moderate yellowish-brown medium silty clay loam.	Do.
Gray-Brown Podzolic soils:							
Fayette.....	do.....	do.....	Nearly level to hilly.....	do.....	Light brownish-gray silt loam.	Moderate-brown medium silty clay loam	Firm.
Lindley.....	Glacial drift.....	do.....	Gently rolling to hilly.....	do.....	do.....	Moderate-brown gritty silty clay.	Do.

INTRAZONAL

Planosols:							
Traer.....	Loess.....	Upland.....	Flat.....	Very slow.....	Light brownish-gray silt loam. ¹	Moderate olive-brown silty clay, mottled.	Very firm
Chariton.....	Old alluvium ¹	Terrace.....	Slightly depressed.....	do.....	Weak-brown silt loam ² .	Medium and light olive-gray silty clay, mottled.	Do.
Wiesenboden:							
Garwin.....	Mixed loess and alluvium.....	Upland.....	do.....	do.....	Black silty clay loam.....	Weak-yellow silty clay loam to light silty clay, mottled. ³	Firm.
Bremer.....	Old alluvium ¹	Terrace.....	do.....	Slow.....	Brownish-black silt loam.	Moderate yellowish-brown silty clay loam, mottled.	Do.

AZONAL

Alluvial soils:							
Judson	Colluvium	Colluvial slope	Level to undulating	Slow to good	Brownish-black silt loam.	Dark-brown silt loam	Friable.
Wabash	Alluvium	Flood plain	Level	Slow	do	Dark-brown silty clay loam ¹	Do.
Ray	Alluvium and colluvium.	Flood plain and colluvial slope.	Level to undulating	do	Medium olive-gray silt loam.	do	Do.
Sawmill	Alluvium	Flood plain	Depression	do	Dark-brown silty clay loam, mottled.	Dark yellowish-brown plastic silty clay, mottled.	Firm.
Dry sands:⁴							
Thurman	Wind-blown sand	Upland	Undulating to rolling	Excessive	Dusky-brown loamy fine sand.	Light yellowish-brown loose sand.	Loose.
Chelsea	do	do	do	do	Moderate yellowish-brown loamy fine sand	Weak-yellow loose sand	Do.
Buckner	Alluvial sand	Terrace	Undulating	do	Weak-brown sandy loam.	Light yellowish-brown loose sand.	Do.
Lithosols:							
Rough broken land.	Mixed loess and glacial drift over limestone.	Upland	Hilly	Good	Weak-brown silt loam.	Moderate yellowish-brown gritty silty clay loam.	Friable.

¹ In many areas the parent material is loess deposited on an old terrace. In the future these areas will be included with similar upland soils.
² The lower part of this horizon, the A₂, is light-gray platy silt loam.

³ Soils have C or D horizon immediately below A horizon

⁴ The Thurman and Buckner series are now classified as Prairie soils, and the Chelsea series as a Gray-Brown Podzolic soil.

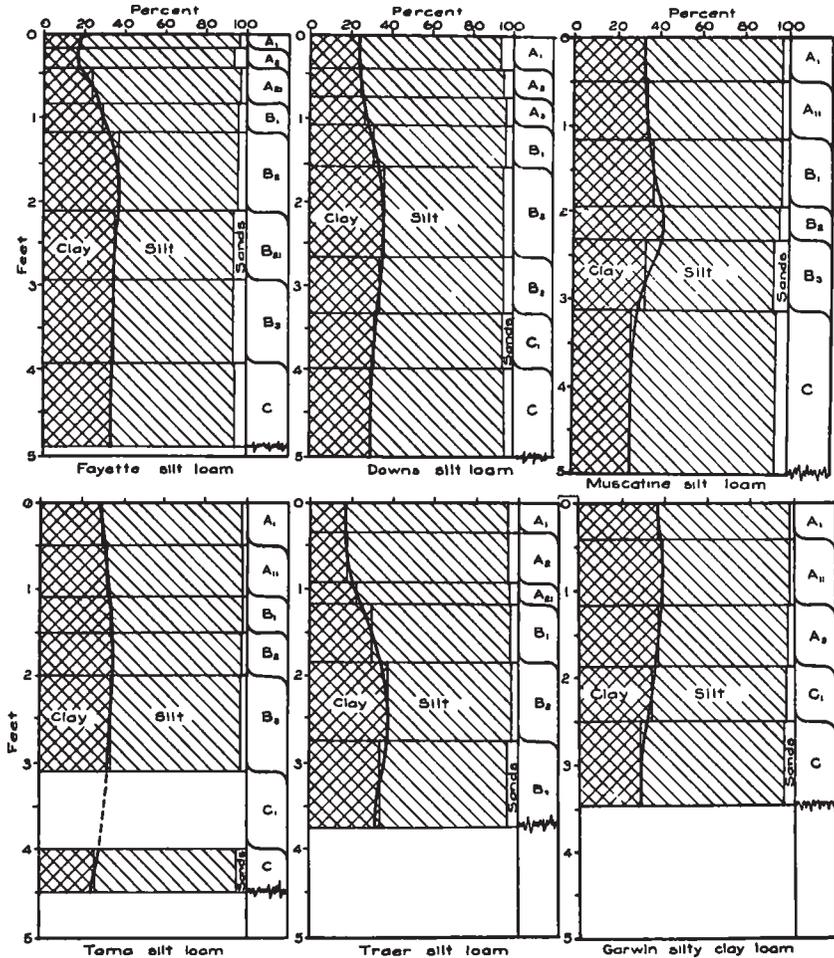


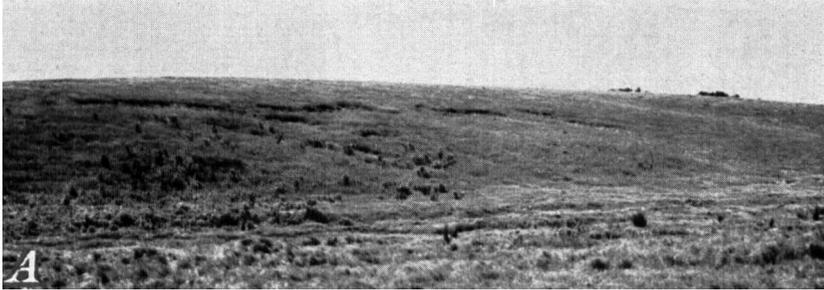
FIGURE 6.—Percentages of clay, silt, and sand in the principal horizons of Tama, Fayette, Muscatine, Downs, and Traer silt loams and Garwin silty clay loam in Tama County, Iowa.

characteristics that are to some extent similar to those of Lithosols. A description of a typical profile on an undulating site is as follows:

- A₁. 0 to 6 inches, the furrow slice, a mellow brownish-black silt loam with indistinct medium and fine-crumb structure.¹⁰ The soil mass is permeated by pinholes, and there are occasional worm holes (1 mm. in diameter). Plant roots are abundant.¹¹
- A₁₁. 6 to 13 inches, dusky-brown silt loam that digs out as poorly defined medium size blocky aggregates (1 to 2 cm.) which, in turn, are readily friable to indistinct fine crumbs. Some of the blocks in the lower

¹⁰ The nomenclature of soil structure used in this section is the one given by Nikiforoff (23). The various grades of structure are (1) very poorly defined or very indistinct, (2) poorly defined or indistinct, (3) moderately defined or fairly distinct, (4) well defined or distinct, and (5) very well defined or very distinct.

¹¹ The number of plant roots is described as either abundant, common, or scarce.



- A*, Row of severely eroded spots, or slips, along a hillside pasture where buried soil profiles have been exposed. These slips, common in the areas of Shelby and Lindley soils in the southern part of the county, mark the contact between the loess and the drift and tend to occur at approximately the same level along any one slope
- B*, Close-up view of one of the slips or severely eroded spots shown in *A*. The area in the foreground largely barren of vegetation is the exposure of the B horizon of the buried soil; these exposures are usually about a rod or two in width.
- C*, Pasture on Shelby loam, eroded hilly phase, with Wabash-Judson silt loams in the foreground. Two slips, or severely eroded spots, lying at about the same level, are in the upper left part.



A, Buried soil profile with vegetation growing both above and below it in a road-cut exposure. The soil profile at the surface is Fayette silt loam, and the buried soil also has been formed under forest vegetation.
B, Lindley-Fayette silt loams in which the buried soil profile *A* is located. Many of the exposures of buried soils in Tama County are in this kind of landscape.

- part carry weak-brown coatings, but when crushed the soil mass appears dark brown. Plant roots are slightly less numerous than in the horizon above. Pinholes are abundant and worm holes (2 to 3 mm.) are common.¹³ Horizon boundaries are diffuse.
- B₁. 13 to 18 inches, variegated dark-brown and dusky-brown light silty clay loam with fairly distinct medium-granular and fine-crumb structure. Individual aggregates are largely either one color or the other and thus give a variegated pattern in place. Plant roots are common but decreasing in number. Pinholes are abundant, and worm holes, passing vertically through the horizon, are common. Horizon boundaries are diffuse.
- B₂. 18 to 24 inches, dark yellowish-brown light silty clay loam with fairly distinct medium blocky structure. The aggregates are permeated by pinholes, penetrated by occasional small worm holes, and crush to fine granules if broken down carefully. The crushed soil mass is moderate yellowish brown. Within the horizon are a few krotovinas, some cylindrical and others spherical. Plant roots are common. Horizon boundaries are diffuse.
- B₃. 24 to 37 inches, moderate to light yellowish-brown light silty clay loam to heavy silt loam, digging out in very coarse blocks that break down readily to mixed distinct medium-granular and block structure. The aggregates are permeated by pinholes and when moist crush readily to indistinct fine crumbs. The crushed soil mass is light yellowish brown. Plant roots are present but not common. Horizon boundaries are diffuse.
- B₄. 37 to 48 inches, light yellowish-brown to dusky-yellow silt loam with numerous weak-orange mottlings of low contrast and with some dark-brown specks.¹⁴ The specks, most evident on cut faces, appear to be concretions. The horizon exhibits a poorly defined medium-prismatic structure in place, but the soil mass breaks down readily to distinct medium-blocky structure when removed. Blocks are readily friable to indistinct fine crumbs when moist. The natural faces of the prisms and larger blocks carry dark yellowish-brown coatings that become less distinct with depth. Plant roots are scarce, but pinholes are common. Horizon boundaries are diffuse.
- C. 48 to 60 inches. Weak-yellow silt loam with numerous weak-orange mottlings of medium contrast and with some dark-brown specks. The structure is like that of the B₄ horizon except that the prisms are less distinct and the blocks coarser. A few dark yellowish-brown coatings line the worm holes and root channels, and some dusky yellowish-brown threadlike stains mark the interior of structural units. Plant roots are scarce, but pinholes are common.

All Prairie soils in Tama County have the major profile characteristics indicated for Tama silt loam. Waukesha soils are similar to Tama silt loam, level phase, but were formed from old alluvium in stream terraces (fig. 3). Carrington and Shelby soils were formed either from shallow loess over glacial drift or from the glacial drift itself in undulating to hilly uplands. They differ from the Tama soils in containing sand, gravel, and some rock fragments in some or all horizons. The two series differ in that the Shelby profile is generally heavier textured and shows evidence of being more strongly weathered. Frequently a fine-textured layer interpreted as the B₁ horizon of a buried Planosol (26) (pls. 18 and 19) occurs within the Shelby profile. This old B₁ horizon is sometimes exposed at the surface, usually in narrow bands along the hillsides. Shelby loam, eroded hilly phase, has a shallow profile with many of the characteristics of Lithosols.

¹³ The number of pinholes and worm holes are described as abundant or numerous, common or frequent, scarce or present.

¹⁴ The grades of contrast of orange or reddish-brown mottlings are low, medium, and high.

The Downs series, one of the zonal soils of the county, occurs in the grassland-forest transitional belt and does not truly represent either the Prairie or Gray-Brown Podzolic groups. It was formed from loess as were the Tama and Fayette soils, and its properties are intermediate between those of the two series. It is included with the Prairie group in this discussion because it has more of the characteristics common to those soils.

Gray-Brown Podzolic soils were formed under deciduous forest vegetation (27). The larger regions of these soils in the United States lie east of Iowa, where the climate is more humid. Within Tama County, however, there is little room for differences in climate between the areas of Prairie and Gray-Brown Podzolic soils. The two groups are frequently intermingled and in places both great soil groups will be less than a mile apart along the same ridge crest. In Tama County, the Gray-Brown Podzolic soils were formed under an oak-hickory forest, which seems to have invaded the uplands by moving out from the larger streams.

The profile of Gray-Brown Podzolic soils under virgin conditions consists of thin A_{00} and A_0 horizons, a very thin weak brown A_1 horizon, a thicker light brownish-gray A_2 horizon, a moderate-brown heavier textured B horizon, and a light yellowish-brown to weak-yellow C horizon. These horizons are well expressed in the smooth to rolling phases of Fayette and Lindley soils in this county.

The Fayette soils were formed from loess on the level to hilly upland slopes. In the formation of this soil there was some movement of the fine clay from the A_1 horizon into the B_2 , as shown in figure 7. A description of a virgin profile of Fayette silt loam on an undulating site is as follows:

- A_{00} and A_0 . 1 to 0 inch, leaf litter and partly decomposed leaf residues. The layer is about equally divided between A_{00} and A_0 horizons, the later merging with the A_1 horizon.
- A_1 . 0 to 1½ inches, brownish-gray silt loam with indistinct fine-crumb structure, weak brown when crushed. Plant roots are especially numerous, and the lower boundary is fairly sharp but not abrupt.
- A_2 . 1½ to 4 inches, light brownish-gray to pale-brown silt loam with indistinct fine platy structure. The plates are sprinkled with light gray, have numerous vertical pinholes, and crush readily to a floury mass. Occasional cylindrical cores of darker colored material (5 to 10 mm.) extend downward through this horizon. Fine plant roots are common but much less numerous than in the A_1 horizon. The lower boundary is diffuse.
- A_{11} . 4 to 11 inches, finely variegated light brownish-gray and pale-brown silt loam with fairly distinct platy structure. Plates range from fine in the upper part to coarse in the lower, becoming less distinct with increasing size. Many carry an incomplete light-gray coating, apparent only when dry, and all have numerous vertical pinholes. The plates are brittle and crush readily to a very pale-brown floury mass (dry). Tree roots (5 to 10 mm.) are common and worm holes abundant. The lower boundary is fairly sharp.
- B. 11 to 16 inches, a transitional horizon of light to moderate yellowish-brown heavy silt loam to silty clay loam. In the upper part there is a gradation from an indistinct coarse platy structure to a fairly distinct medium subangular blocky structure, the latter becoming more evident with depth. The faces of the blocks are covered by dark coatings and carry a sprinkling of light-gray particles, apparent when the soil is dry. Pinholes are common, and there are a few worm holes. The lower boundary is diffuse.
- B_2 . 16 to 22 inches, moderate-brown medium silty clay loam with distinct fine subangular blocky structure. Blocky aggregates are firm. Af-

ter it is crushed, the soil has a moderate to light yellowish-brown color. The surface of the blocks is comparable with that in the B₁ horizon, pinholes are less numerous, and worm holes less common. The lower boundary is diffuse.

- B₁. 22 to 33 inches, moderate-brown light silty clay loam with very distinct fine to medium subangular blocky structure. The blocks are less easily crushed than those in the overlying horizon, are larger in the lower part, and have fewer pinholes and worm holes. They carry dark coatings on their faces and also have a sprinkling of light gray, apparent when the soil is dry. The soil material is moderate yellowish brown when crushed, only slightly lighter than the color of the natural faces of the aggregates. Occasional tree roots extend through this horizon, but few fine roots are present. The lower boundary is diffuse.
- B₂. 33 to 45 inches, a transitional horizon of finely variegated moderate and light yellowish-brown heavy silt loam with an indistinct coarse blocky structure. The surface of the blocky units is somewhat darker than the interior, which is also highly mottled with small dark-orange stains of low contrast. A number of dusky-brown concretions and many brownish-black threadlike stains are present in the soil mass. The blocky units are moderately friable and the soil is light yellowish brown when crushed. Pinholes are abundant, and occasional larger holes are present. The horizon boundaries are diffuse.
- C. 45 to 60 inches, finely variegated light yellowish-brown and weak-yellow silt loam with poorly defined coarse blocky structure. The blocky units are friable and crush under slight pressure to indistinct fine crumb aggregates. Dark-orange mottlings usually of low contrast and small size are numerous. Dark yellowish-brown coatings occasionally cover the faces of the blocky units and are common along cracks, root channels, and worm holes.

Gray-Brown Podzolic soils include only the Fayette and Lindley series in Tama County. The Lindley soils differ from the Fayette in having been formed either from shallow loess over glacial drift or from drift. Glacial material, as sand, gravel, and rock fragments, is present in some or all horizons within the Lindley profile. All horizons in the profiles of Lindley soils are generally thinner than those in Fayette soils because the topography is more rolling. The complex of Lindley and Fayette soils mapped in hilly uplands includes profiles that are shallow and have many characteristics of Lithosols.

Intrazonal soils are like the zonal in having well-defined horizons. The nature of these horizons, however, is determined more by topography or parent material than by climate and living organisms (2). All factors are important, but the influence of topography or parent material tends to be greater than that of climate and vegetation. Certain characteristics common to the zonal soils of a region are frequently found also in the profiles of intrazonal soils. Not all horizons, however, are the same in the two groups. In Tama County, the intrazonal soils are represented by two great soil groups, the Planosols and Wies-enboden, both of which occupy flat or depressed areas.

Planosols are distinguished by high concentrations of clay in the B₂ horizon and by a sharp, but not always abrupt, change from the A to the B horizon. The concentration of clay in the B₂ horizon is illustrated by the curve for Traer silt loam in figure 6. The B₂ horizon in this soil contains enough clay to restrict the free movement of water and penetration of plant roots. Planosols occupy level or slightly depressed sites having restricted natural drainage but water tables below the solum. They may be formed either under forest or grass vegetation and are represented in Tama County by the Chariton and Traer series.

The Chariton soil has been formed from old alluvium under grass vegetation in slightly depressed sites on stream terraces. A description of a typical profile of Chariton silt loam follows:

- A₁. 0 to 6 inches, the furrow slice, a weak-brown mellow very friable silt loam with indistinct fine-crumb structure. Within the layer are occasional egg-shaped accumulations of light brownish-gray material. Plant roots are common, and plant remains are recognizable throughout the layer.
- A₁. 6 to 9 inches, similar to the overlying material, except that there is a very indistinct and very coarse platy structure in this layer. The lower boundary is wavy but distinct.
- A₂. 9 to 12 inches, variegated brownish-gray and light brownish-gray silt loam with fairly distinct mixed medium and coarse platy structure. The upper and lower surfaces of the plates frequently carry dusky-yellow or weak-orange mottlings of low contrast. Vertical pinholes are common, and a few larger holes (1 mm.) also are present. Plant roots are common. The lower boundary is diffuse and wavy.
- A₂. 12 to 16 inches, finely variegated light-gray and light olive-gray silt loam with distinct medium platy structure. Plates are brittle and crush readily to a floury mass. Low-contrast mottlings of weak orange are present on the upper or lower faces of some plates, most of which have numerous vertical pinholes. Plant roots penetrate into this horizon, but few pass through it. The lower boundary is abrupt.
- B₁. 16 to 19 inches, coarsely variegated medium and light olive-gray silty clay loam with distinct medium to coarse blocky structure. The surface of the blocks is highly mottled with weak to dark orange of low contrast, and the mottlings extend into the aggregates. The blocks are firm and crush to distinct medium crumbs. Plant roots, pinholes, and worm holes are scarce. The lower boundary is diffuse.
- B₂. 19 to 25 inches, medium olive-gray to dusky-olive silty clay to clay containing numerous olive-black and light olive-gray flecks and many fine dark-orange mottlings of medium contrast. The pattern of colors is intricate, both on the surface of the distinct coarse blocky aggregates and within them. The blocks are hard to crush when dry, and the soil is strongly plastic when wet. The soil has a medium to light olive-gray color when crushed. Plant roots are scarce and pinholes common. The lower boundary is diffuse.
- B₃. 25 to 36 inches, medium to light olive-gray silty clay with distinct coarse blocky structure. Structural units are slightly less resistant to crushing than in the B₂ horizon, and the soil is light olive-gray when crushed. The layer is highly mottled with dark orange of medium to high contrast. Plant roots and fine gravel are scarce, but pinholes are common in the horizon. The lower boundary is diffuse.
- C. 36 to 55 inches, light olive-gray silty clay loam with many small dark-orange mottlings of high contrast. This horizon has an indistinct coarse blocky structure, the coarse blocky units crushing under moderate pressure to mixed fine blocky and crumb aggregates. It contains occasional dusky-brown or brownish-black concretions (1 to 3 mm.) and some sand and fine gravel. The material is less plastic when wet than that of the B₃ horizon.

The Traer soil, a Planosol formed under forest vegetation, resembles the Chariton series in some respects. It has the distinct light-gray platy A₂ horizon and a fine-textured B₂ horizon. It has a thinner and lighter colored A₁ horizon, however, and is noticeably lighter colored throughout the lower part of the solum. The Traer soil was formed from loess on upland flats in association with Gray-Brown Podzolic soils.

Muscatine silt loam has profile characteristics intermediate between those of Wiesenboden and Prairie soils. It is darker than typical Prairie soils but does not have the deep, dark A horizon and the light olive-

gray C₁ horizon that characterizes the Wiesenboden. The Muscatine developed from loess under a luxuriant grass vegetation on the upland flats in association with Tama soils. A description of a typical profile of Muscatine silt loam is as follows:

- A₁. 0 to 6 inches, the furrow slice, a brownish-black to black mellow heavy silt loam, with a mixed fine-crumb and fairly distinct fine granular structure. Plant roots are abundant. The lower boundary is distinct.
- A₁₁. 6 to 14 inches, brownish-black to dusky-brown heavy silt loam with an indistinct fine granular structure. The granules crush readily, and the crushed soil is dusky brown to weak brown. Occasional flecks of lighter colored material are present in the horizon, which becomes lighter in color with depth. Plant roots are abundant, pinholes are common, and a few worm holes (2 to 3 mm.) are present. The lower boundary is diffuse.
- B₁. 14 to 23 inches, dusky-brown to dark olive-brown silty clay loam with distinct coarse-granular structure. The surface of the granules is darker than the interior. Small, low-contrast mottlings of weak orange are present, and plant roots, worm holes, and pinholes are common. The lower boundary is diffuse.
- B₂. 23 to 28 inches, highly mottled, medium olive-gray silty clay loam with indistinct coarse blocky structure. Mottlings are weak orange, of low contrast, and small but numerous. In addition to the mottlings, a number of dark-brown or brownish-black stains are scattered through the soil mass. Cut faces of blocks often have a marbled pattern of colors. Natural faces of the blocks carry a darker colored coating which disappears when the blocks are crushed. The blocks crush readily to a mixture of light olive-gray distinct medium-granular and fine-crumb aggregates. Plant roots, pinholes, and worm holes are common in the layer. The lower boundary is diffuse.
- B₃. 28 to 37 inches, mottled, medium to light olive-gray silty clay loam with indistinct coarse blocky structure. The mottlings are of medium contrast, dark to weak orange and usually small, though there are some large dark-brown and dusky-yellow stains. Small dark-brown to black concretions are common. The blocks crush readily to indistinct medium-granular and fine-crumb structure. Plant roots and worm holes are scarce, but pinholes are common. The lower boundary is diffuse.
- C. 37 to 59 inches, mottled light olive-gray light silty clay loam to silt loam with very poorly defined and very coarse blocky structure. Mottlings are small and numerous in the upper part (coarser in the lower), of medium contrast, and chiefly dark orange. Moderate to light yellowish-brown splotches and some brownish-black concretions (3 to 5 mm.) are present. The coarse blocks in the upper part have a dark-colored coating, and numerous dark-brown threadlike stains are within the structural units. The coarse blocks crush under moderate pressure to smaller ones, finally to a mixture of medium- and fine-crumb aggregates. Plant roots and worm holes are scarce, but pinholes are common.

Wiesenboden, often called meadow, soils were formed under grass vegetation in slightly depressed sites. These sites are poorly drained and remain waterlogged for a considerable period each year. They also have a relatively high water table.

The profile consists of a black or brownish-black A horizon separated by a fairly sharp boundary from the mottled yellowish-gray or light olive-gray gleilike horizon. There is little evidence of concentration of clay within the profile, as indicated by the curve for Garwin silty clay loam in figure 6. The curve indicates also that in the Garwin profile the texture of the A horizon is finer than that of the deeper ones. This tendency is only one of the various possible ones within

profiles of Wiesenbodens. Textures of the several horizons in these soils generally depend more upon the sedimentation than upon textural differentiation during genesis. Weisenbodens are represented in Tama County by the Garwin and Bremer series, both of which are extremely limited in acreage.

Garwin silty clay loam developed in the slightly depressional areas at the head of or in the upper drainageways in association with Tama and Muscatine soils. A description of a typical profile is as follows:

- A₁. 0 to 5 inches, the furrow slice, a black silty clay loam, digging out in 2-inch clods that break down readily to fairly distinct medium-crumb structure. The large clods have a cheeselike consistence when moist, and the soil material is slightly plastic when worked between the fingers. The layer contains some recognizable plant remains and abundant plant roots.
- A₁₁. 5 to 14 inches, black to brownish-black silty clay loam with moderately defined medium-granular structure. Occasional aggregates have distinct faces. The soil material is slightly plastic when wet. Small accretions of light-colored soil material are scattered through the horizon, and plant roots are abundant. The lower boundary is fairly sharp.
- A₂. 14 to 22 inches, brownish-gray silty clay loam to light silty clay containing many small dark-orange flecks. It digs out in large pieces that break down to distinct medium-granular structure under careful handling. When moist the soil mass is moderately plastic and sticky. Pinholes are abundant and there are a few holes 1 to 2 millimeters in diameter. Plant roots are common. The lower boundary is distinct.
- C₁. 22 to 30 inches, yellowish-gray to light olive-gray silty clay loam to light silty clay, flecked with numerous strong yellowish-brown to weak-orange spots. Enough flecks appear on the natural faces to give the layer a speckled appearance, especially in the lower part. Krotovinas of darker colored material extend down the A₂ horizon and into but not through this layer. The soil digs out in large clods that can be crushed by moderate pressure to fairly distinct coarse-granular structure. The granules may be reduced to a plastic mass when moist. Pinholes and plant roots are common, and occasional vertical holes are 1 millimeter in diameter.
- C. 30 to 48 inches, yellowish-gray light silty clay loam to silt loam with many fine, medium-contrast mottlings of dark orange and occasional dusky-brown flecks. Mottlings become larger and more conspicuous and dusky-brown flecks disappear in the deeper part. The material digs out in large clods that feel slightly rubbery and can be crushed while moist to an indistinct coarse-granular structure. The soil mass is slightly plastic when wet. Plant roots and worm holes are scarce.

Azonal soils do not have well-developed profile characteristics, for one or more of several reasons (2). The soils may be young. The time interval that the parent material has been in place has been too short for the development of mature soil characteristics. The relief may be so steep that rapid geologic erosion allows no opportunity for horizon differentiation. The parent material may be of such character as to retard horizon differentiations, or the parent rock may weather so slowly that sufficient parent material is not available for the formation of well-developed soils. In this county the azonal soils consist of three great soil groups—Alluvial soils, Dry sands, and Lithosols.

Alluvial soils are young, and their profile characteristics are essentially those of the parent material. In this county most of them are dark-colored throughout the profile. The Judson, Wabash, Ray, and

Sawmill series are included in this great soil group. Judson soils occupy colluvial slopes that usually lie above flood levels, and the parent material has been derived from adjacent upland slopes. Wabash and Judson soils have similar profile characteristics, but the Wabash occupy flood plains and are subject to overflow. The profile of the Ray soil differs from those of Judson and Wabash in the presence of a light brownish-gray surface layer of varying depth. The Ray series occurs on colluvial slopes and in the flood plains in areas of light-colored upland soils. Unlike the other Alluvial soils, the Sawmill series occupies very poorly drained depressions in the flood plains; its profile is somewhat lighter colored and is mottled throughout.

Dry sands consist of accumulations of sand with very little horizon differentiation. Usually, however, a covering of tree or grass vegetation stabilizes the land surface. In this county this group consists of the Thurman, Chelsea, and Buckner series.

Thurman loamy fine sand is developed from the wind-blown sands of the upland under grass vegetation. A description of a typical profile is as follows:

- A₁. 0 to 11 inches, weak to dusky-brown loamy fine sand, slightly coherent when moist but crumbling readily to single grains when dry. Plant roots are numerous. The lower boundary is diffuse.
- A₂. 11 to 19 inches, brownish-gray loose loamy fine sand. Krotovinas in the form of tongues of darker colored material extend into this layer from the one above. Small pockets of light yellowish-brown sand similar to that of the C₁ horizon also are present. Plant roots are common. The lower boundary is diffuse.
- C₁. 19 to 34 inches, light yellowish-brown loose fine sand. A few plant roots extend into this horizon, but they are scarce.
- C. 34 to 60 inches, weak- to dusky-yellow loose fine sand in which individual grains are readily apparent to the naked eye.

Chelsea loamy fine sand is similar to Thurman loamy fine sand in texture but is lighter colored, having been formed under a forest vegetation. Buckner sandy loam resembles Thurman loamy fine sand more closely, but differs in that it occurs on terraces and has been formed from alluvial sands.

Lithosols have very little profile development and are commonly shallow. True Lithosols are represented in Tama County only by Rough broken land. This land type consists of areas in which there is a variable layer of mixed loess, glacial drift, and residuum over limestone. The topography is generally hilly to steep, and limestone outcrops are numerous. Except in local included spots, no soil profile has been formed from the thin regolith.

Some of the relations of the soil series with regard to parent material, drainage, and color are indicated in table 12. Some relations are catenary and some taxonomic. For example, certain soils that occur on a single horizontal line are members of one catena. Most of the catenae are incomplete, and not all the soils given in a single horizontal line belong to one catena. In the same way, certain soils in a single vertical column are members of one family. Not all soils are members of the same family, however, as is indicated in the column including Carrington, Tama, Waukesha, and Shelby series. The first three series in this group are members of a single family, whereas the Shelby series represents a second family of Prairie soils.

TABLE 12.—*Parent material, drainage, and color relations of the principal soil series in Tama County, Iowa*

Parent material	Excessively drained (internally)	Well drained			Slowly drained		Poorly drained	
		Light colored	Medium colored	Dark colored	Medium colored	Dark colored		
Loess.....		Fayette..	Downs..	Tama.....	Traer....	Muscatine..	Sawmill. Wabash soils, undifferentiated.	
Drift.....		Lindley..		{Carrington. Shelby. Waukesha..}				
Old alluvium.....					Chariton..	Bremer....		
Mixed loess and colluvium.						Garwin....		
Recent alluvium and colluvium.					Ray.....	{Wabash..... Judson.....}		
Wind-blown sand.	{Thurman..							
Alluvial sand....	{Chelsea...}							
	{Buckner..}							

One catena includes the Tama, Muscatine, and Garwin series. Some question may be raised in regard to the catenary relation of these three series. It can be considered that the parent material of Garwin soils is a mixture of loess and colluvium rather than loess alone, as are the Tama and Muscatine series. In this instance, however, the colluvium was derived exclusively from loess, so that the nature of the materials is essentially comparable for the three series.

The soils of this county, like those of any other area, are the products of the five main factors of soil formation—climate, living organisms (chiefly vegetation), topography, parent material, and age, some of which were more important than others. Climate and vegetation are the active forces that alter the parent material in various ways. The other three forces are passive, conditioning the influences of climate and living organisms. Topography affects the movement of water on the land. Where the land is hilly much of the water flows off rapidly and retards the development of the soil in two ways—by leaving less water available for the growth of plants and by promoting more rapid geologic erosion. Where the parent materials are extreme in physical constitution or chemical composition, these differences are retained by the soils and are often very significant. In places where the parent material has been in place for only a short time, from a pedological point of view, the properties of the soil are essentially those of the parent material. As the time interval increases, the soil becomes more like the zonal soil of the region, provided the topography is undulating.

Although climate is an active force in the formation of soils, it is commonly responsible for regional rather than local differences. It is possible that local variations of climate, or a form of microclimate, were among the contributing factors responsible for the presence of trees in some places and grasses in others.

Native vegetation was one of the most important factors causing differences in the soils of Tama County. Because there were trees in some places and grasses in others, some of the soils are light-colored and others dark-colored. The differences between the Gray-Brown

Podzolic soils and the Prairie soils are the result of this difference in vegetation. In places where the vegetation was a mixture of trees and grasses, the soils are intermediate in their characteristics.

Certain soil differences due to changes in slope are illustrated in figure 7. Differences between the Tama and Muscatine soils, on the one hand, and between the Muscatine and Garwin soils, on the other, are directly related to slope changes. Tama soils with their undulating to rolling slopes are well drained, whereas Muscatine soils with their nearly level slopes have imperfect drainage. This imperfect drainage has been reflected in a greater growth of the natural vegeta-

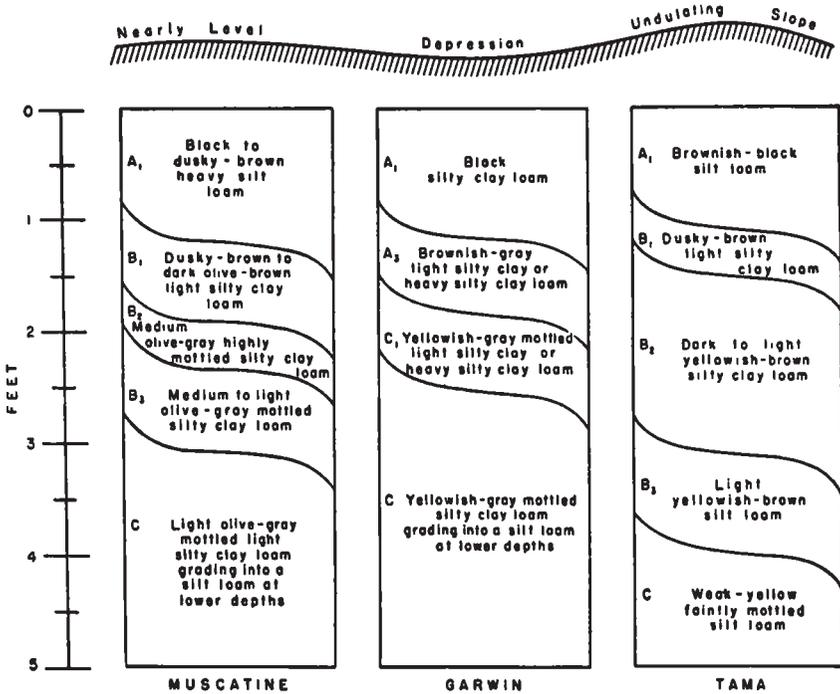


FIGURE 7.—Changes in profile with slope as illustrated by Tama, Muscatine, and Garwin soils formed from similar parent material under grass vegetation.

tion and slower decomposition of the organic matter left in the soil as plants died. The Garwin series differs from Muscatine in occupying slightly depressed positions with poor drainage. Decomposition of organic matter has been retarded to an even greater extent under such conditions, and the temporary waterlogging of the lower horizons has resulted in glei characteristics. Differences between the Waukesha and Bremer soils are comparable with those between the Tama and Garwin.

Differences in soils due to parent materials are less important generally in Tama County than those due to vegetation and topography. They do, however, have a certain significance in this area, and they have much more importance in others. For this reason, the surface

geology of the county is considered briefly in subsequent paragraphs. The general nature of the soil parent materials is closely related to the surface geology.

The present surface deposits of loess and glacial drift rest on bedrock consisting mainly of limestones of the Mississippian and Devonian systems (19). The bedrock is now buried under drift and loess more than 100 feet thick except where the limestone outcrops in the walls of deeper stream valleys in the west-central part of the county.

The glacial drift that forms a major part of the regolith was deposited by three different ice sheets (20, 21). The first of these was the Nebraskan glacier, which covered the entire county and left a deposit ranging from 100 to 150 feet thick. Little of this drift is widely exposed in the county, however, most of it being covered by drift left by the Kansan glacier. This second ice sheet also covered the entire county and left a deposit with an average thickness of about 50 feet. A third ice sheet, the Iowan Substage of the Wisconsin glacier, overran the northern part of the county and left a deposit of drift generally less than 10 feet thick.

During interglacial periods the natural processes of weathering and soil formation were impinged on the drift sheets. The intervals following the Nebraskan and Kansan glaciations were relatively long, whereas that following the Iowan prior to deposition of the loess was relatively short. Since the Nebraskan drift was covered completely by the Kansan drift and differs but little from it, subsequent discussions will deal with the Kansan only.

During the long interval following the retreat of the Kansan glacier, the land surface was well dissected by streams. The topography became generally rolling except for the flat divides that remained between the major drainage basins. As the dissection went forward, leaching and weathering of the glacial drift also progressed slowly. In the weathering of glacial drift, geologists recognize the formation of three major layers, all of which lie below the soil profile. The upper layer is that of leached and oxidized drift, the middle layer is that of oxidized but unleached drift, and the deepest layer is unoxidized and unleached. As the names suggest, the two upper layers were formed by the weathering and leaching of the deepest layer. In Tama County the upper two layers, especially the first one, constitute soil parent materials in the areas of glacial drift.

While the Kansan drift was being dissected and weathered, soils were also being formed on the land surface. Remnants of these persist in a formation known to geologists as gumbotil (19). These deposits are interesting in studies of soil genesis, although they have little importance as a source of parent material for soils in the present land surface. The gumbotil has recently been interpreted as the B horizon of a buried soil (26). The characteristic dark-gray gumbotil is found in very few places in Tama County. Instead of this, there is a strong or moderate-brown heavy clay, known to geologists as a feretto zone (19). Field observations and laboratory studies on buried soils in different parts of Iowa indicate that the dark-gray gumbotils represent B horizons of former grassland Planosols, whereas the feretto zone is the B horizon of a former Gray-Brown Podzolic soil. In a

number of places the old A horizon can be found immediately above and merging with the gumbotil or the feretto zone.

The approximate boundary and farthest advance of the Iowan glacier in Tama County corresponds roughly to the line separating the areas of the undulating to level and the rolling to hilly dark-colored soils of the uplands. The glacier moved into the county from the north and northeast and did not advance south over the line between these two soil areas. Much of the Iowan drift is covered by loess, but no buried soils have been found in this drift. The absence of such soils and of a distinct leached zone indicate that the interval between the retreat of the Iowan glacier and deposition of the loess was comparatively short. Where the drift is exposed it has usually been leached of carbonates to approximately the same depth as the Peorian loess. Differences that do occur indicate that depth of leaching is slightly less in the Iowan drift than in the Peorian loess.

The present drainage pattern seems to have been inherited largely from the land surface of the Kansan drift plain. There may have been certain changes in this pattern, especially in the area covered by the Iowan glacier, although these are not readily evident. The valleys of the major streams and most of the important tributaries seem to have persisted through the Iowan glaciation. Distribution of the loess with respect to the stream valleys is strong evidence that the drainage pattern was well developed before the loess was deposited. Deposition of the loess does not seem to have affected the topography to a noticeable extent. The deposition of the Iowan drift seems to have made the land surface appreciably less rolling in the northern part of Tama County.

The Peorian loess, covering more than 60 percent of the land surface in Tama County, is variable in thickness, ranging from a few inches to more than 20 feet. In most places the lime has been removed to a depth of more than 6 feet. The loess is thickest (more than 200 inches thick) on level uplands in the southwestern part of the county and in that part covered by the Kansan but not the Iowan glacier. These areas of deepest loess lie in (1) the rolling to hilly dark-colored soils of the uplands and (2) the light-colored soils of the uplands (see fig. 2, p. 6). On level upland sites in that part of the county covered by the Iowan glacier the loess ranges from 30 to 100 inches thick, thinning toward the eastern edge. The loess generally is absent on very steep slopes of spurs. In addition to the loess, the wind likely moved sands from the flood plains into the uplands. Most of the sandy areas border the flood plain of the Iowa River, and a few border the flood plains of Otter and Deer Creeks.

As indicated in this discussion on geology, loess and glacial till are the more important parent soil materials, but there is also some colluvium and much alluvium.

The fifth factor of soil formation—age—is responsible for some important soil differences. Most of the soils of the uplands and terraces have well-developed profiles. The Alluvial soils, however, are young and will continue to be young because new material is added from time to time. The characteristics of these young soils—Wabash,

Judson, Ray, and Sawmill—are essentially those inherited from their parent material.

Mechanical analyses of three soils are given in table 13.

TABLE 13.—*Mechanical analyses*¹ of samples of three soils from Tama County, Iowa

Soil type and sample No.	Depth	Material and diameter of particles (in millimeters)						
		Fine gravel (2.0-1.0)	Coarse sand (1.0-0.5)	Medium sand (0.50-0.25)	Fine sand (0.25-0.10)	Very fine sand (0.10-0.05)	Silt (0.050-0.002)	Clay (<0.002)
Fayette silt loam:		<i>Inches</i>	<i>Percent</i> (²)	Percent (^{2})	Percent (^{2})	Percent (^{2})	Percent (^{2})	Percent (^{2})
Ia-W-35-42	0-2							
Ia-W-35-43	2-4	0.1	0.1	0.1	0.4	2.3	79.1	17.9
Ia-W-35-44	4-7	0	0	0	0	0	79.4	16.4
Ia-W-35-45	7-12	0	0	0	0	0	74.3	23.6
Ia-W-35-46	12-16	0	0	0	0	0	69.2	28.4
Ia-W-35-47	16-27	0	0	0	0	0	61.8	35.7
Ia-W-35-48	27-36	0	0	0	0	0	62.4	34.2
Ia-W-35-49	36-48	0	0	0	0	0	62.6	34.3
Ia-W-35-50	48-60+	0	0	0	0	0	64.6	33.0
Muscataine silt loam:								
Ia-W-35-57	0-6	0	0	0	0	0	65.5	32.8
Ia-W-35-58	6-14	0	0	0	0	0	63.8	34.1
Ia-W-35-59	14-23	0	0	0	0	0	61.7	36.4
Ia-W-35-60	23-28	0	0	0	0	0	55.4	40.5
Ia-W-35-61	28-37	0	0	0	0	0	61.9	33.8
Ia-W-35-62	37-59	0	0	0	0	0	68.7	27.4
Tama silt loam:								
Ia-W-35-106	0-6	0	0	0	0	0	68.3	29.4
Ia-W-35-107	6-13	0	0	0	0	0	66.2	32.0
Ia-W-35-108	13-18	0	0	0	0	0	64.9	33.5
Ia-W-35-109	18-24	0	0	0	0	0	63.5	34.6
Ia-W-35-110	24-37	0	0	0	0	0	63.4	33.7

¹ Analyses made in laboratory of Bureau of Plant Industry, Soils, and Agricultural Engineering.

² Not available.

GLOSSARY

Aggregate. A single mass or cluster of soil consisting of many soil particles held together, as a clod, prism, crumb, or granule.

Agricultural land. Land in farms regularly used for crop or livestock production. The term includes also the farmstead, lanes, drainage and irrigation ditches, water courses, and grazing land of every kind in farms. It should not be considered synonymous with such terms as "land in farms," "cropland," "pasture land," "land suitable for crops," or "land suitable for farming." The term "nonagricultural land" is not used in the sense of land not suited to crops; such terms as "nonplowable," "nonarable," "land not in farms," and "land unsuited to crops," to suit the case, are preferable.

Alluvial soils. An azonal group of soils developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes. *See also* Alluvium, Azonal soils.

Alluvium. Fine material, as sand, mud, or other sediments deposited on land by streams.

Arable land. Land that, in its present condition, is physically capable, without further substantial improvement, of producing crops requiring tillage.

Association. A group of soils, with or without common characteristics, geographically associated in an individual pattern.

Azonal soils. Any group of soils without well-developed profile characteristics, owing to their youth or conditions of parent material or relief, that prevent the development of normal soil-profile characteristics. In Tama County, as in the United States generally, these groups include Alluvial soils, Lithosols, and some Dry sands. *See also* Alluvial soils, Dry sands, Lithosols, Profile.

Catena. A group of soils within one zonal region developed from similar parent material but differing in characteristics of the solum, owing to differences in relief or drainage. From

- the Latin for chain. (Plural, catenae.)
See also Parent material.
- Clay.** The small mineral soil grains, less than 0.002 mm. (.000079 inch) in diameter. (Formerly included the grains less than 0.005 mm. in diameter.)
- Claypan.** A dense and heavy soil horizon underlying the upper part of the soil; hard when dry and plastic or sticky when wet; presumably formed in part by the accumulation of clay brought in from the horizons above by downward moving water. Common in many of the Planosols. *See also* Clay, Horizon, Planosol.
- Colluvium.** Deposits of soil material accumulated at the base of slopes through the combined influences of water and gravity.
- Complex.** A soil association mapped as a unit because it is composed of two or more soil series, types, or phases occurring together in such an intricate pattern or in such small individual areas that they cannot be shown separately on maps of the scale used, as Wabash-Judson silt loams and Lindley-Fayette silt loams. *See also* Association, Series, Phase, Type.
- Consistence.** The degree of firmness of soil aggregates or of entire soil horizons due to the attraction of particles for one another and expressed in terms of resistance of soil to crushing, as loose; slightly, moderately, or very compact; mellow; friable; crumbly; plastic; soft; firm; hard; and cemented. (*See also* Friable.)
- Cove.** The area near the heads of drainageways having concave land surfaces.
- Cropland.** Land regularly used for crops, except forest crops. It includes rotation pasture, cultivated summer fallow, or other land ordinarily used for crops but temporarily idle.
- Crumb.** Generally soft, small, porous aggregates tending toward a spherical shape, as in the A₁ horizons of many soils. This variety is closely related to granular structure.
- Dry sands.** An azonal group of soils consisting of well-drained sandy deposits in which no clearly expressed soil characteristics have developed. (*See also* Azonal soils, Sand.)
- Fertility.** The quality that enables a soil to provide the proper compounds, in the proper quantities and in the proper balance, for the growth of specified plants when other factors, as light, temperature, and the physical condition of the soil, are favorable.
- Flood plain.** The nearly flat surface subject to overflow along stream courses.
- Forest.** Land not in farms and bearing a stand of trees of any age or stature, including seedlings (reproduction), but of species attaining a minimum average height of 6 feet at maturity, or land from which such a stand has been removed and is not now restocking, and on which no other use has been substituted. Forest on farms is called farm woodland or farm forest.
- Friable.** Easily crumbled in the fingers; nonplastic.
- Genesis.** Mode of origin of the soil, referring particularly to the processes responsible for the development of the solum from unconsolidated parent material.
- Glacial drift.** Rock and earth materials that have been transported through the action of ice (glaciers). The unsorted drift—sand, clay, silt, and boulders—left in place as the ice melts is called glacial till, the only form of drift outcropping in this county.
- Granular.** Consisting of roughly spherical aggregates, either hard or soft, and usually more firm than crumb and without the distinct faces of blocky, or nutlike, structure. Present in the A horizons, especially A₂, of Prairie soils.
- Gray-Brown Podzolic soils.** A zonal group of soils having a comparatively thin organic covering and organic-mineral layers over a grayish-brown leached horizon that rests on a moderate-brown finer textured horizon. They are developed under deciduous forest in a temperate moist climate. (*See also* Horizon, Leaching, Zonal soil.)
- Grazing land.** Land regularly used for grazing, except cropland and rotation pasture. It is not confined to land suitable only for grazing.
- Great soil group** (soil classification). A broad group of soils having common internal soil characteristics.
- Green-manure crop.** Any crop grown and plowed under for the purpose of improving the soil, especially by the addition of organic matter.
- Horizon.** A layer of soil approximately parallel to the land surface, with relatively well-defined characteristics that have been produced through the operation of soil-building processes.
- Intraazonal soil.** Any of the great soil groups having rather well-developed soil characteristics that reflect the

dominating influence of some local factor of relief, parent material, or age over the normal effect of the climate and vegetation. Each of these groups may be found associated with two or more of the zonal groups. (See also Planosol, Wiesenboden.)

Land. The total natural and cultural environment within which production must take place. Its attributes include climate, surface configuration, soil, water supply, and subsurface conditions, together with its location with respect to centers of commerce and population. It should not be used as synonymous with soil or in the sense of the surface of the earth only. (See also Agricultural land, Arable land, Cropland, Grazing land, Forest, Waste.)

Landscape (as used in soil geography). The sum total of the characteristics that distinguish a certain area on the surface of the earth from other areas. These characteristics are the result not only of natural forces but of human occupancy and use of the land. Included are such features as soil types, vegetation, rock formations, hills, valleys, streams, cultivated fields, roads, and buildings. All these features together give the area its distinguishing pattern.

Land uses, major rural. (1) Crop production (production of crops ordinarily harvested by man, except forest); (2) grazing; (3) forestry (production of repeated crops of forest products); (4) recreation, including observation for educational purposes; (5) wildlife preservation, propagation, or both; (6) mineral extraction; (7) protection (use of land to prevent injury to water supplies or to other more valuable land).

Land use pattern. The areal design or arrangement of land uses, major and minor, and of operation units.

Leaching. Removal of materials in solution.

Lithosol. An azonal group of soils having no clearly expressed morphology and consisting of very slightly altered parent material. Such soils, which may be either very stony or stone-free (loess), occur only on steep slopes in this county. (See also Azonal soils, Morphology, Parent material.)

Loess. A fine-textured, usually silty, deposit laid down by wind.

Massive. Characterized by large uniform masses of cohesive soil, sometimes with ill-defined and irregular breakage, as in some of the fine-textured Alluvial soils (structureless).

Morphology. The physical constitution of the soil expressed in the kinds of horizons, their thickness, the profile arrangement, and the texture, structure, consistence, porosity, and color of each horizon.

Mottled (mottling). Irregularly marked with spots of different colors.

Nutlike (blocky). Having aggregates with rather definite faces and approximately equal diameters in all directions, as in the B horizon of Fayette silt loam.

Nutrients, plant. The elements that may be taken in by the plant, essential to its growth, and used by it in the elaboration of its food and tissue. These include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps others obtained from the soil; and carbon, hydrogen, and oxygen obtained largely from air and water.

Parent material. The unconsolidated mass from which the soil profile develops. (See also Profile.)

Particle. A term usually used to refer to an individual grain of soil, regardless of shape, within a small-size group; as a clay, silt, or sand particle.

pH. A term to indicate weak acidity and alkalinity, as those existing in soils. A pH of 7.0 indicates precise neutrality; larger numbers (up to 14.0), alkalinity; and smaller ones (down to 0.0), acidity. The range of pH of the soils in Tama County is 4.5 to 8.0. (See also Reaction.)

Phase. A subdivision of a soil type differing appreciably in such characteristics as relief, accelerated erosion, or stoniness. Phase variations have practical importance, although they may or may not be reflected in profile characteristics. The normal phase is the form of the type expressed without these modifications.

Planosol. An intrazonal group of soils, with strongly leached surface horizons overlying finer textured compact or cemented B horizons, formed on flat uplands and terraces under either forest or grass vegetation in regions with humid or subhumid climates. (See also Horizon, Intrazonal soil.)

Platy. Having thin, horizontal plates, usually not well defined, as in the A₁ horizon of Fayette silt loam.

Prairie soils. A zonal group of soils in which there is a gradual gradation in color from the dusky-brown surface horizons through moderate yellowish-brown layers into the lighter

colored parent material. The soils are formed under tall grass vegetation in a region with a temperate relatively humid climate. They have no zone of calcium carbonate accumulation. (*See also* Horizon, Profile, Zonal soil.)

Productivity. The capability of a soil to produce a specified plant or sequence of plants under a specified system of management.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. (*See also* Horizon, Parent material.)

Reaction, soil. The degree of acidity or alkalinity of a soil mass expressed either in pH values or in words, as follows:

Extremely acid.....	Below 4.5
Very strongly acid.....	4.5-5.0
Strongly acid.....	5.1-5.5
Medium acid.....	5.6-6.0
Slightly acid.....	6.1-6.5
Neutral ¹⁴	6.6-7.3
Mildly alkaline.....	7.4-8.0
Strongly alkaline.....	8.1-9.0
Very strongly alkaline.....	9.1 and higher

Sand. Small rock or mineral fragments with diameters ranging between 0.05 mm. (0.002 in.) and 1.0 mm. (0.039 in.). The term sand is also applied to soils containing 90 percent or more of sand.

Series. A group of soils having genetic horizons similar as to differentiating characteristics and arrangement in the soil profile, except for the texture of the surface soil, and developed from a particular type of parent material. A series may include two or more soil types differing from one another in the texture of the surface soil. (*See also* Horizon, Parent material, Profile, Type.)

Silt. Small mineral soil grains ranging from 0.05 mm. (0.002 in.) to 0.002 mm. (0.000079 in.) in diameter.

Single grain. Each soil particle by itself, as in sand (structureless).

Soil. A natural body on the surface of the earth in which plants grow; composed of organic and mineral materials. (*See also* Aggregate, Association, Catena, Complex, Consistence, Fertility, Genesis, Horizon, Morphology, Phase, Productivity, Profile, Reaction, Series, Texture, Type.)

Soil class. A classification based on the relative proportion of soil sep-

arates. The principal classes, in increasing order of the content of the finer separates, are as follows: Sand, loamy sand, sandy loam, loam, silt loam, silty clay loam, clay loam, and clay.

Soil particle. *See* particle.

Soil pattern. The areal design or arrangement of soils.

Soil separates. The individual size groups of soil particles, as sand, silt, and clay.

Spur. The ends of ridges extending to or into level terraces or flood plains and having convex land surfaces.

Strip cropping. A practice of growing ordinary farm crops in long strips of variable width, across the line of slope, approximately on the contour, on which dense-growing crops are seeded in alternate strips with clean-tilled crops.

Structure. The morphological aggregates in which the individual soil particles are arranged. (The principal types of structure in the soils of this county are crumb, granular, massive, nutlike, platy, and single grain.) (*See also* Crumb, Granular, Massive, Nutlike, Platy, Single grain.)

Subsoil. That part of the soil profile commonly below plow depth and above the parent material.

Surface soil. The upper part of arable soils commonly stirred by tillage implements, or an equivalent depth (5 to 8 inches) in nonarable soils.

Terrace (for control of runoff or soil erosion, or both). A broad surface channel or embankment constructed across sloping lands, on or approximately on contour lines, at specific intervals. The terrace intercepts surplus runoff, to retard it for infiltration or to direct the flow to an outlet at nonerosive velocity.

Terrace (geological). A body of level or gently undulating land lying along a stream valley and intermediate in elevation between the flood plain and the upland. Terraces are seldom large and appear to be remnants of an earlier flood plain of the stream.

Texture. The relative proportion of the various size groups of individual soil grains. (*See also* Soil class, Soil separates.)

Till (glacial). *See* Glacial drift.

Topography. The elevations or inequalities of the land surface, the slope gradient, and the pattern of these.

¹⁴ Strict neutrality is precisely pH 7.0. Very few actual soil samples have this value, and those having pH values between 6.6 and 7.3 are considered neutral for all practical purposes. For more precise identification, those between 6.6 and 7.0 may be described as very slightly acid and those between 7.0 and 7.3 as very mildly alkaline.

Type. A group of soils having genetic horizons similar as to differentiating characteristics, including texture and arrangement in the soil profile, and developed from a particular kind of parent material. (See also Horizon, Parent material, Profile, Phase.)

Variiegated. Having a pattern of many colors of which none is dominant.

Waste. Land essentially incapable of producing materials or services of value. This term should not be used to describe idle farm or forest land.

Wiescnboden (Meadow soils). An intrazonal group of black to brownish-

black soils, high in organic matter, the color grading at a depth of 6 to 30 inches into light olive gray; developed under grasses and sedges, mostly in a humid or subhumid climate. (See also Intrazonal soil.)

Zonal soil. Any one of the great groups of soils having well-developed soil characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation. (See also Gray-Brown Podzolic soils, Prairie soils.)

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