

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey of Union County, Iowa

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Bureau of Chemistry and Soils

**In cooperation with the
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SOIL SURVEY

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By J. AMBROSE ELWELL, Iowa Agricultural Experiment Station, in Charge, and
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COUNTY SURVEYED

Union County is in the southwestern part of Iowa. (Fig. 1.) Creston, the county seat, is about 80 miles (in a direct line) east of Omaha, Nebr., and 55 miles southwest of Des Moines, the capital of Iowa. The total area of the county is 427 square miles, or 273,280 acres.

The gently rolling or rolling land surface of Union County has been carved from an almost level or very gently southward-sloping plain by a network of drainage ways which reach every quarter section of land in the county. The general trend of drainage is to the south and southeast, and this also is the trend of the divides between the separate drainage basins. The divides are narrow and in few places are distinctly flat. The shoulders of the slopes from the divides are rounded, not abrupt. In general the slopes at the heads of the drainage ways are gentle and those farther downstream and along the larger streams are of progressively greater slant. (Pl. 1, A and B.) The north and west slopes are generally steeper than the south and east slopes, owing to greater protection from the sun, from alternate freezing and thawing, and from other weathering forces.

The elevations above sea level at various points along the railroads of the county indicate the general slope of the upland divides and of the depth to which the main streams have cut. A divide extending from Spaulding through Creston to Arispe has a southward slope of about 4 feet to the mile, the elevations being 1,348 feet at Spaulding, 1,312 feet at Creston, and 1,267 feet at Arispe.¹ The divides to the east of this have about the same southward slope of 4 feet to the mile, but the elevations are about 120 feet lower, indicating an eastward descending slope of about 6 feet to the mile. The elevation at Talmage where the railroad crosses Grand River is 1,040 feet, indicating that the river valley is about 150 feet below the divide to the east and 200 feet below the divide to the west. Twelvemile Creek has not cut so deeply, the elevation at the railroad crossing being 1,116 feet, or 75 feet higher than the level to which Grand River has cut. The divide to the west of Twelvemile

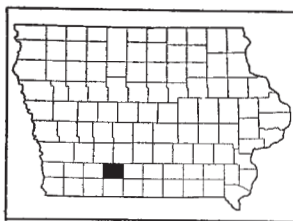


FIGURE 1.—Sketch map showing location of Union County, Iowa

¹ GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. (Fourth edition.) U. S. Geol. Survey Bul. 274, 1072 p. 1906.

Creek is 150 feet above the river valley and the one to the east is 80 feet above the valley. West Platte River is 100 feet and Middle Platte River 50 feet below the level of the adjacent uplands.

The width of the valley troughs varies almost directly with their depth and with the size of the stream. The Grand River Valley ranges from one-half to $1\frac{1}{2}$ miles in width. The Grand River bottoms lie at two levels, a first bottom along the stream channel and a second bottom, or terrace, from 5 to 75 feet above the first bottom. In many places the terraces are so eroded as to have lost their original form. Twelvemile Creek Valley ranges from one-eighth to one-half mile in width. Terraces become less numerous up the valley and are less elevated above the flood plain, until in Lincoln Township no terraces occur. The valleys of the other main tributaries to Grand River have similar characteristics. The valleys of West, Middle, and East Platte Rivers range from one-eighth to one-half mile in width and are at first-bottom levels, with the exception of a few very small low terraces.

Practically the whole county is in the watersheds of Platte and Grand Rivers. East Fork Nodaway River drains part of Spaulding Township and Clanton Creek part of New Hope Township. All the tributary drainage ways become dry at intervals. Even Grand River does not maintain a steady flow through dry seasons. Summit Lake and Lake McKinley are artificial lakes made by damming the streams. They are maintained for the water supply and as recreation resorts for the city of Creston. Many farms have small ponds held by dams for emergency use in watering livestock. The slope waters are quickly discharged into the main streams of the watersheds unless held back artificially. Practically all the slopes in the lower part of the watersheds are gullied more or less by erosion, every rain changing the character of the surface soil. Even the slopes at the head drainage ways are very slowly being washed by sheet erosion.

Union County was organized with its present boundaries in 1853. The population was then only 80 persons. The pioneers were largely natives of other States to the east. According to the Iowa census the rural population of Union County in 1925 was 6,351 and the population in the eight incorporated towns was 17,055. Of the total population 16.7 per cent were of foreign birth or parentage, principally German and Swedish. The density of the rural population exclusive of towns is 14.8 persons to the square mile. The rural population is evenly distributed throughout the county.

The industries of Union County are largely centered about the production of agricultural products, their handling and marketing. According to the 1925 Iowa census 2,164 persons were engaged in agriculture and 1,636 were engaged in trade and transportation pursuits. Creston, a railroad division point, contributes largely to the second group.

The 11 towns and shipping centers of the county are well distributed and furnish accessible local markets to practically all parts of the county. United States Highway No. 34 and State Highways Nos. 16 and 25 are graded and well maintained for travel, except in wet weather. The railroad facilities of the county provide ready

access to the main terminal markets. The main line of the Chicago, Burlington & Quincy Railroad provides direct shipment to Ottumwa, Iowa, and to Chicago and Omaha. Branch lines of the Chicago, Burlington & Quincy and of the Chicago Great Western Railroads lead directly to St. Joseph, Mo. The Des Moines and St. Louis markets are not so directly connected but are fairly accessible.

Eighty-four rural schools and four consolidated schools furnish good educational facilities for all parts of the county.

CLIMATE

The climatic conditions in Union County are healthful and are well suited to livestock raising and general farming. The mean annual precipitation is 34.05 inches, 28 per cent of which falls during May and June. Occasionally late spring rains interfere with planting. More than 60 per cent of the rainfall occurs during the corn growing season, which is between May 1 and October 1. The even distribution of moisture and the abundance of sunshine during the growing season, together with the dry weather in October and November, when the corn is maturing and being harvested, makes this an ideal climate for corn growing. Droughts are rare, and complete crop failures are unknown.

High temperatures and short periods of excessive heat are common in summer. The mean summer temperature is 74.1° F., and the mean for the winter is 24.3°, but the annual temperature ranges from an absolute maximum of 105° to an absolute minimum of -30°.

The average date of the last killing frost is April 25 and of the first is October 7. This gives a frost-free season of 165 days. However, records show a killing frost occurring as late as May 27 and as early as September 14. Considerable damage to growing crops is caused locally, at intervals, by hail and wind.

Table 1, compiled from records of the Weather Bureau station at Afton, gives the normal monthly, seasonal, and annual temperature and precipitation, which are fairly representative of climatic conditions throughout the county.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Afton, Iowa*

[Elevation, 1,212 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1873)	Total amount for the wettest year (1915)
December.....	°F. 26.2	°F. 55	°F. -21	<i>Inches</i> 1.19	<i>Inches</i> 2.15	<i>Inches</i> 0.25
January.....	21.1	56	-30	.86	.85	2.20
February.....	25.6	65	-23	1.17	.79	2.56
Winter.....	24.3	65	-30	3.22	3.79	5.01
March.....	36.5	84	-8	1.89	.60	2.05
April.....	50.2	91	19	3.50	3.10	2.61
May.....	61.4	91	24	4.77	3.55	13.21
Spring.....	49.4	91	-8	10.16	7.25	17.87
June.....	69.4	99	41	4.93	3.75	4.41
July.....	73.8	105	48	3.97	3.45	13.38
August.....	79.0	105	43	3.38	.60	1.80
Summer.....	74.1	105	41	12.28	7.80	19.59
September.....	65.1	104	27	4.38	2.95	5.83
October.....	53.3	86	14	2.58	1.25	.84
November.....	38.5	76	1	1.43	.80	1.47
Fall.....	52.3	104	1	8.39	4.50	8.14
Year.....	49.5	105	-30	34.05	23.34	50.61

AGRICULTURE

Before settlement Union County was a broad prairie with trees fringing the valleys of the main streams. Elm, cottonwood, hackberry, walnut, ash, linden, and sycamore were the principal hardwoods on the bottom lands, and those on the small area of timbered uplands were white oak, bur oak, and hickory. Cottonwood, elm, linden, and walnut were the principal trees cut for saw lumber in the early days. The walnut, hickory, and ash have been crowded out in the second growth by maple, elm, and boxelder. Small scattered thickets of bur oak, hazelnut, wild plum, wild cherry, and American crab apple encroached on the prairies. Most of these thickets have disappeared, and the only trees on the upland prairies are the planted groves and shelter belts about the farmsteads. These plantings commonly include cottonwood, maple, boxelder, willow, white and Scotch pines, red cedar, and mulberry. Osage-orange, maple, and willow were planted for hedges, but most of the hedges have been displaced by fences. In recent years plantings of hardy catalpa have been added to the wood lots.

From the first settlement of the county in 1851 until about 1870, agriculture was in a pioneer stage. Just prior to the Civil War an influx of new settlers started. After the war settlers arrived in increasing numbers, and the decade from 1870 to 1880 was marked by rapid expansion of agriculture. The main line of the Chicago, Burlington & Quincy Railroad was extended through the county in

1868, and by 1887 the present railroad routes of the county were in operation. Agriculture rapidly passed from the pioneer stage through the self-sustaining basis to the export basis of the present day. With this change there has been no marked change in the type of agriculture, but the relative importance of the various crops and of crops and livestock has changed. Even from the first, the agriculture of the county was a well-balanced general type combining livestock and grain production. Wheat and corn were the main market crops. The corn acreage in 1880 was almost equal to its present acreage, and the wheat acreage in 1880 was about six times that at present. The oats acreage doubled during the same period. Rye and barley have always been minor small-grain crops.

Cattle were grazed on the open range until the herd law was passed in 1887. This change brought about improvement of the native-grass pastures and hay lands. This section of the State was early recognized as especially adapted to bluegrass which maintains an excellent pasture stand, and at the present time large acreages are harvested for seed. In 1900 red clover was reported on 339 acres and alfalfa on 8 acres. A gradual shift to greater acreages of the leguminous-hay crops has taken place.

The numbers of livestock reported by the censuses show a steady increase in all branches of the industry. Hogs and cattle return the largest cash revenue to the farmers, and sheep and poultry net small additional incomes.

All livestock for market is shipped out of the county. The hogs and cattle are shipped to Ottumwa and Des Moines, Iowa, St. Louis and St. Joseph, Mo., Chicago, and Omaha; sheep are shipped almost exclusively to Ottumwa and St. Joseph; and poultry goes to Chicago or farther east. Horses and mules for work animals find only a small local sale within the county. Livestock products, such as butter and eggs, are marketed in Chicago and farther east; wool goes to the Boston wool pool; and honey is marketed locally in small quantities. Corn and small grains are shipped to the Chicago grain market; potatoes and timothy seed are marketed locally and to some extent on outside markets; bluegrass seed is sold on outside markets; and other crops, such as tame hay, clover seed, small fruits, and tree fruits, chiefly apples, are mainly consumed locally.

The fattened livestock is usually shipped direct to terminal markets by the individual farmer or by groups of farmers; grains and seeds are handled by local elevator dealers at the various shipping points of the county; local creameries handle most of the milk and cream sold; all the chickens and eggs are handled by local dealers; and wool is handled by local buyers and shipped to eastern markets.

Corn is by far the leading crop of the county. Three-fourths or more of the grain produced is fed on the farms. Of the total of 67,847 acres grown in 1924 and reported by the Federal census of 1925, 1,492 acres were cut for silage, 4,307 acres were cut for fodder, and 8,522 acres were hogged off. Corn is the most important feed crop, and by reason of the large production the quantities marketed are larger than of any other crop. The average yield for the county in 1926 as given by the Iowa Yearbook was 34.6 bushels to the acre. Yields of corn silage, according to the 1925 Federal census, average

8 or 9 tons to the acre. More corn is produced in the central and western parts of the county than in the other parts.

The 1925 Federal census reports 25,066 acres in oats in 1924. Most of the crop is fed on the farms, but a considerable quantity is marketed for a ready cash return. At usual market prices, oats are less profitable than wheat, barley, or rye, but in the quantities marketed oats return a gross income second to that from corn. Mixed home-grown seed is most commonly used. Early oats are by far the most popular, the chief varieties being Iowa 103 and Iowa 105. Oats are commonly a follow-up crop after corn.

Wheat was harvested on 2,759 acres in 1924. Except for 100 or 150 acres of spring wheat, the entire acreage is devoted to hard winter wheat. The average yield, according to the census, was 17 bushels to the acre. From one-half to three-fourths of the crop is marketed, the remainder being used for feed on the farm. The acreage grown varies with the prevailing market prices.

Rye is grown principally for grain, but it supplies some late fall and early spring pasturage. It is occasionally seeded as a cover crop to aid in checking erosion.

Barley is a substitute crop for oats, being seeded following corn. It is used mainly for feed on the farm, but probably one-fourth of the crop is marketed. It is ordinarily a more profitable market crop than oats. A mixture of oats and barley is occasionally grown for feed.

Mixed clover and timothy is the hay crop of largest acreage, being reported on 22,705 acres by the 1925 Federal census. The 1926 Iowa Yearbook reports the average yield in Union County as 1.01 tons to the acre. The crop is sown with small grain as a nurse crop, and makes sufficient growth after small-grain harvest to provide light pasturage in the fall and usually supplies two cuttings during the following year.

Timothy alone as a hay crop occupied 10,680 acres in 1924, according to the census. This is the second largest hay crop and ranks fourth among all crops in acreage. The average yield given by the Iowa Yearbook of 1926 was 0.88 ton to the acre. A considerable acreage is cut for seed for local marketing, and small surpluses are shipped out of the county.

According to the 1925 Federal census, red clover ranks third in acreage among the hay crops and fifth among all crops. It was reported on 2,772 acres in 1924. The 1926 Iowa Yearbook reported the average clover hay yield as 1.29 tons to the acre. Light pasturage is afforded on clover during the fall of the same year in which it is seeded, after the small-grain nurse crop is harvested. An occasional season is favorable for good seed production from the second cutting the following season. Only a small acreage is used for seed, however, the seed for local demand usually being purchased. Occasionally a stand of clover is plowed under for green manure. Mammoth clover and alsike clover are in rare cases used as substitutes for red clover.

Alfalfa occupied 145 acres in 1924. Most of the stands are less than 5 years old. Two or three cuttings of hay a season are obtained, depending on the age and the stand. It is never used for seed.

Sweetclover, once only a roadside weed, is now cultivated for hay and forage to some extent. The white biennial variety is grown. It is usually seeded in the spring with a nurse crop, and two or three cuttings of hay are obtained in a season. Small acreages are cut for seed to supply local demand. A new practice, but one little used, is that of sowing sweetclover in corn at the last cultivation.

Wild hay is cut from idle and waste acreages such as occur along poorly drained swales.

The census of 1925 reports a total of 96,356 acres of pasture land, of which 13,216 acres are woodland pasture and the remainder permanent pastures in various stages of improvement. Of these permanent pastures 57,573 acres are classed as plowable. Unplowable pasture land includes brush land, land cleared but not stumped, and land needing drainage improvement. Most of the pasture lands support an excellent bluegrass sod with improvement mixtures of white, alsike, and red clovers, sweetclover, timothy, and redtop. In the woodland and brush-land pastures, bluegrass is less well established, and in poorly drained areas bluegrass is entirely displaced by coarser water-loving grasses.

Orcharding receives little attention. A few orchards are operated on a small commercial scale, catering to near-by markets. Practically all farms have small orchards which supply fruit for the home and sometimes a small surplus for local markets. Apples are the most common orchard fruit. The main varieties are the Oldenburg (Duchess of Oldenburg), Wealthy, Ben Davis, Sweet June, Wolf River, Yellow Transparent, and Fameuse (Snow). Grapes rank next to apples in popularity. The Concord, Moore Early, and Worden are the varieties grown. Strawberries, blackberries, and raspberries are grown on small acreages.

Potatoes are grown mainly to supply the home demand. About 15 per cent of the crop is marketed locally, and small surpluses are shipped.

The livestock enterprises engaged in, rank in importance as follows: Fattening hogs and cattle for market, dairying, raising sheep for mutton and wool, poultry production, and colt production for local supply of work animals.

The 1925 Federal census reports the total number of cattle as 34,563, of which 14,882 were cows more than 2 years old, and of these 12,437 were classed as beef cows. Beef production is mainly from native farm-raised cattle. About 50 farmers, or about 3 per cent of the farmers of the county, purchase feeder stock from the Omaha and St. Joseph markets for fattening during fall and winter. Most of the beef cattle are grade Herefords, Aberdeen Angus, and Shorthorns. Only a few farmers are specializing in purebred cattle, but the average herd is slowly being bred up to a higher standard.

In 1925 the total number of hogs in the county was 49,571, of which 8,509 were brood sows. It is estimated that 30 or 35 per cent of the herds are purebred. The most popular breeds are Duroc-Jersey, big-type Poland China, Chester White, Spotted Poland China, and Hampshire. Hog cholera causes occasional losses.

Dairying is a side-line enterprise on most of the farms, being engaged in only on a scale sufficient to supply farm needs and a small surplus for local markets. The census of 1925 reports the total

number of cows milked as 7,112, of which 2,239 are of dairy type. More dairy products are produced in the western tier of townships than in the rest of the county, except in two centers near Lorimor and Afton. Only about 15 per cent of the dairy cattle are purebred. The Holstein breed is the most popular, particularly in the western part of the county; Jerseys rank second; Guernseys, third; and there are also a few Ayrshires. The 1925 report of the Iowa State dairy commissioner states that the four creameries of the county received 6,531,029 pounds of cream during the year. A large part of this was shipped in from outside the county, however. Practically the only dairy product marketed is cream, the skim milk being fed on the farm.

In 1925 sheep raising was engaged in on 255 farms. The total number of sheep was 7,404, of which 81 per cent were shorn for wool, producing 45,949 pounds. Some of the sheep are fattened for market. A large number of feeder sheep are bought at the Omaha and St. Joseph markets and after a feeding period, from August to December, are marketed.

Poultry is kept on most farms of the county. A few flocks of turkeys, geese, and ducks are kept in addition to the 210,467 chickens enumerated by the 1925 Federal census. The 1924 Iowa census reports 117,537 fowls and 202,292 dozen eggs sold to local dealers for shipment.

The work animals of the county are a medium-draft type of horses or mules. The sires are mostly purebred and the mares, grades. Percheron and Belgian are the most popular breeds of horses, but there are only a few breeders of purebred horses in the county. The colt production supplies local demands and a small surplus for outside markets. The total number of horses and mules was 9,564 in 1925.

No soil type in the county has a special adaptation to any one crop. Differences in productiveness on certain soils are recognized, however. For instance, the Clinton, Lindley, Jackson, and Calhoun soils are more productive of small grains than of corn, and these soils do not stand continuous cropping to corn and small grains as well as do the dark-colored soils. Conversely, certain dark-colored soils, such as the heavier Wabash soils and the Bremer and Grundy silt loams are known to be better corn soils than small-grain soils because of the tendency of the small grains to lodge. The farmers speak of these soils as being too rich for small grains, consequently more continuous cropping to corn is practiced.

Very little commercial fertilizer is used, and the supply of manure is insufficient for systematically maintaining the soil fertility of the whole farm. It is therefore used only on the thinner soil spots, or, too often, it is spread on the fields near the barnyard to the neglect of more distant fields in need of fertilization. Green manuring is rarely practiced. Commercial fertilizers are used on very small acreages devoted to special crops or garden crops. In 1926 and 1927, as reported by the county agent, 1,445 tons of ground limestone, 75 tons of quicklime, and 3 tons of superphosphate were shipped into the county. According to the 1925 Federal census, 25 farms of the county reported a total expenditure of \$2,031 for fertilizers in 1924.

The average building improvements of the farms consist of a dwelling, a combined cattle and horse barn with haymow, a chicken house, a grain crib, a hog house, and a combined tool shed and separator room. Each farm has a windmill or engine pump. On a few farms there are separate cattle, horse, and sheep barns. The 1925 Federal census reports 83 silos, a few farms having 2 silos each. Most of the fields are fenced with barbed wire or woven wire.

The implements of common use in the farm work are owned individually. The more expensive machinery or implements of only occasional use for special work, such as corn binders, silage cutters, corn shellers, threshing machines, hay balers, and corn pickers, are usually owned cooperatively by a group of farmers or are rented. The 1925 Iowa census reports 135 tractors and 84 autotrucks in operation on the farms of the county.

Most of the farm labor is done by the family, additional help being hired only during small-grain harvest, haying, and corn picking. According to the 1925 Iowa census, 50.4 per cent of the farms reported an average expenditure for labor of \$178.26 to the farm. Day labor is paid from \$2.50 to \$3.50, corn pickers are paid 5 or 6 cents a bushel, and monthly wages range from \$35 to \$45 in summer and are \$25 in winter. Married men are paid from \$50 to \$60 a month, and single men from \$35 to \$45 a month on a yearly basis. Most of the labor is supplied locally, and some transient labor is hired for shocking, threshing, or corn harvesting. Where a particular operation, such as threshing and silo filling, calls for a crew of labor, a group of farmers exchange help.

Farm tenancy has shown a slow steady increase. The 1925 Federal census reports 45 per cent of the farms operated by tenants. Under tenant operation, the farm is more continually cropped to grain than when operated by the owner. Usually less livestock is kept by the tenant, and a greater proportion of the grain produced is sold for cash. Landlords are beginning to realize the benefit of keeping a certain amount of control over the cropping system, in order that the fertility of the land may not be impaired. About one-half the renting is on a cash basis, one-fourth on a share basis, and one-fourth on a combination cash and share basis. Cash rents range from \$4 to \$6 an acre. Share rent is usually one-half the corn and oats when the owner furnishes the seed, and one-half the crop and livestock when the owner furnishes one-half the animals. Under a combined cash and share rent, the pasture and hay land is usually rented for cash, and the remaining crops are produced on shares.

According to the 1925 Federal census, the average size of farms is 157 acres. The market value of the land varies widely with access to local county market points, state of improvement of the farms, and the character of the soil. Well-improved farms of Muscatine, Tama, and Grundy soils command the higher prices. Where the Shelby soil occurs on eroded slopes, the market price is lowered as a rule. The Lindley, Clinton, Jackson, Calhoun, and Chariton soils have a similar depression on the market value. Bremer and Wabash soils usually do not greatly lower the market price except where they are suitable only for pasture and constitute a rather large proportion of the farm acreage. The range in land prices, based on some 50 recent transfers (in 1926 and 1927), is from \$32 to \$225 an acre.

Methods for improving the productivity of the various soils are rather well known to the farmers. Under tenant operation, many practices recognized as beneficial, if not needful, can not be systematically carried out. The greatest soil problem at present in Union County and throughout most of southern Iowa is that of erosion. Many farms will soon be abandoned unless the eroded, gullied slopes are reclaimed. Terracing and other means of checking the slope waters seem at the outset prohibitively expensive, but this expense does not compare with the great loss of abandoned lands and the consequent spread of erosion up the watersheds to the better lands. If not met now, this problem will have to be met later at even greater expense. The problem of erosion is not limited to those slopes now gullied to the point of abandonment. Control measures such as damming and filling up gullies, contour plowing, cover cropping, or seeding down should be employed to maintain the fields in tillable shape.

A systematic 3 or 4 year crop rotation which includes a legume-hay crop is the basis for maintaining the fertility of the soil. On the farm with little livestock it is important to supplement the scant supply of manure by utilizing all crop residues and by green manuring. The use of the cheaper commercial fertilizers is often profitable, but the higher-priced fertilizers are not thought economical under the present conditions and the type of farming practiced in the county. Lime and superphosphate (acid phosphate) are the only fertilizing materials bought and applied on the land at present.

SOIL SERIES AND TYPES

In this survey, soils having essentially the same color and structure from the surface downward, and developed on parent material having the same manner of deposition, are grouped into series and are given a name, such as Wabash. Within a soil series, a difference in the texture of the surface soil, that is, in the proportionate content of sand, silt, and clay, may occur. On the basis of texture the soil series is divided into soil types. Thus in Union County the Wabash series is mapped in four different types—silty clay loam, silt loam, loam, and fine sandy loam. Minor differences within a soil type are shown as phases. For instance, soil phases based on differences in topographic features are designated as rolling phases or flat phases as the case may be.

Soils of the Grundy series have almost black surface soils, lighter-colored subsurface soils, and mottled gray and yellow plastic compact heavy-textured subsoils. They occupy level or gently rolling uplands. The Grundy soils have weathered from silty materials overlying the older glacial drift deposits in Missouri, Iowa, and Nebraska.

Soils of the Muscatine series are characterized by almost black surface soils, lighter-colored subsurface soils, and mottled heavy-textured subsoils which are plastic but comparatively friable. Their less compact subsoils and less mottled subsurface soils serve to distinguish the Muscatine from the Grundy soils. The Muscatine soils occupy undulating or gently rolling uplands. Natural drainage is generally very slightly better than in the Grundy soils and poorer than in the Tama soils.

Soils of the Tama series have very dark-brown or black surface soils, brown subsurface soils, and yellowish-brown subsoils. The subsoils are a trifle heavier than the surface soils and the substratum, but are more friable than the subsoils of the Muscatine and Grundy soils which they closely resemble. The Tama soils are similar to soils of the Grundy series, and like them show no content of lime in the subsoils. They occur on gently rolling or rolling uplands having good natural drainage.

The soils of the Shelby series have dark-brown or black surface soils, brown subsurface soils, and yellowish-brown heavier-textured, somewhat compact subsoils containing sand and gravel. Boulders occur on the surface and embedded in the soil, and these, together with the slightly lighter-colored and shallower surface soils, serve to distinguish the Shelby from the Tama soils. The Shelby soils occur on rolling uplands of good or, in places, of excessive natural drainage. In Union County their common occurrence is on slopes below crests of the Tama, Muscatine, or Grundy soils.

The four soils series described above include upland soils which have dark-colored surface soils, and which originally supported a prairie-grass vegetation. In contrast to them the Clinton and Lindley soils have light-colored surface soils and now support or formerly supported trees principally of hardwood species. The subsoils of the Clinton soils are yellowish brown, somewhat silty, friable, but rather compact, and they contain no lime. They are heavier textured than the surface soils. The Lindley subsoils are more clayey, less friable, and more plastic than the Clinton subsoils and contain sand, pebbles and a few boulders, and, in a few places, some lime. The soils of these two series occur on rolling uplands having good or in many places excessive surface drainage. Except in their light-colored surface soils and subsoils the Clinton soils resemble the Tama soils, and with the same exception the Lindley soils resemble the Shelby soils.

Soils occurring on terraces adjacent to stream bottoms differ from the upland soils in origin. The terrace soils have been formed from older alluvium, and the soil of the stream bottoms is annually being altered by depositions from overflows. No lime is found in any of the terrace soils of Union County.

The soils of the Waukesha series have black surface soils, brown subsurface soils, and yellowish-brown subsoils. The subsoils are heavier textured than the surface soils but are comparatively friable. The Waukesha soils closely resemble the upland Tama soils. They occur on well-drained terraces.

The Bremer soils have black surface soils, slightly lighter-colored subsurface soils, and gray and yellow mottled heavy-textured plastic subsoils. Soils of the Bremer series resemble those of the Grundy series on the uplands. They occur on terraces, and natural drainage ranges from fair to poor.

The soils of the Chariton series have black surface soils, ash-gray subsurface soils, and mottled yellow and gray subsoils which are heavy-textured, plastic, and of tougher, more impervious structure than the Bremer subsoils. They occur on terraces having from fair to poor natural drainage.

The soils of the Calhoun series have grayish-brown surface soils, and their subsurface soils and subsoils are similar to those of the Chariton soils. In Union County the Calhoun soils have better natural drainage than the Chariton soils.

The soils of the Jackson series resemble closely those of the Clinton series. The color, texture, and structure of the soils are practically the same from the surface downward. The subsoils of the Jackson soils are usually a little more compact and impervious, approaching the character of the Calhoun subsoils. The Jackson soils do not have the ash-gray subsurface soil of the Calhoun soils. They occupy terraces having good natural drainage.

The Wabash soils occur on first-bottom flood plains of streams. The surface soils are very dark brown or black, and the subsoils are of slightly lighter color somewhat mottled with gray and yellow. The subsoils contain no lime. In many places drainage is well established, but the frequency of overflow governs the practicability of cropping these soils.

In the following pages of this report the soils of Union County are described in detail and their agricultural importance is discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 2.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in Union County, Iowa*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Muscatine silt loam.....	66, 560	24.3	Bremer silt loam.....	3, 648	1.3
Grundy silt loam.....	24, 064	11.3	Chariton silt loam.....	1, 472	.5
Shallow phase.....	6, 848		Calhoun silt loam.....	2, 368	.9
Tama silt loam.....	8, 000	4.3	Jackson silt loam.....	3, 136	1.1
Shallow phase.....	3, 968		Wabash silt loam.....	13, 632	5.4
Clinton silt loam.....	3, 200	1.2	Gray-subsoil phase.....	1, 088	
Shelby loam.....	121, 856	44.6	Wabash loam.....	8, 448	3.1
Lindley loam.....	3, 584	1.3	Wabash fine sandy loam.....	64	.1
Lindley silt loam.....	64	.1	Wabash silty clay loam.....	448	.2
Waukesha silt loam.....	832	.3	Total.....	273, 280	

MUSCATINE SILT LOAM

The surface soil of Muscatine silt loam is dark grayish-brown or black mellow silt loam, in most places about 12 or 14 inches deep. Below this and continuing to an average depth of 36 inches is dark-brown heavy silt loam or silty clay loam. When moist this layer is comparatively friable, when wet it is moderately plastic, but when thoroughly dry it is hard and brittle. Below this layer is yellowish-brown heavy silt loam which is more friable and less plastic than the layer above. Rust-brown and black iron stains occur in this layer of the soil. Below a depth of 5 feet the soil is similar to that above except that it has a more grayish-brown color.

The surface soil is slightly acid in reaction. To a depth of 5 or more feet there is no evidence of lime, and according to field tests the soil is acid. As a rule no stones or gravel occur above a depth of 5 feet. However, over a considerable part of this soil, railroad and roadside cuts show a stone and gravel bearing drift substratum

at a depth of 25 or 30 feet. A substratum of this character contains white spots and streaks of lime in many places, whereas the loess-like clay above contains no pebbles or streaks of lime.

In many respects Muscatine silt loam is intermediate in characteristics between the Tama and Grundy soils, but more closely resembles the Tama. In most places boundaries between these soils are arbitrarily drawn. Muscatine silt loam has a less friable and more plastic subsoil than that of the Tama soils but more friable and less plastic and impermeable than the subsoil of the Grundy soils. Muscatine silt loam in Union County is intermediate in occurrence between the Tama soils to the north and the Grundy soils to the south and east.

Areas of Muscatine silt loam are gently rolling. Where stream dissection is of such depth and the slopes of such gradient as to cause slope washing and exposure of the underlying drift material well up on the slopes, this soil occupies only the narrow divides having undulating or almost flat surfaces. Where stream dissection is not so deep and the slopes are not so eroded as to expose the drift, the soil occurs on gentle slopes and crests, usually giving place to the Grundy soil, however, on flat divides having an area of 160 or more acres. The largest areas of Muscatine silt loam are in the western tier of townships, where the soil occupies many of the slopes below the divides.

In the more rolling sections, where the soil occupies rather narrow winding ridge crests, the surface soil is of lighter color than typical and is not more than 8 or 10 inches deep. In many places the subsoil shows greater compactness than in the typical soil. These areas of lighter-colored thinner surface soil and more compact subsoil as a rule occur adjacent to areas of Clinton soils and approach the characteristics of these soils. Most of the narrower ridges on either side of the Grand River Valley include soils of this kind. On eroded slopes of valleys small areas of Muscatine silt loam occur within areas of Shelby and Grundy soils. These are not of sufficient size, however, to indicate on the soil map.

The natural surface drainage of Muscatine silt loam is in most places well developed, and rain water is readily absorbed by the silty surface soil. In some places, where surface run-off is sluggish, the harder rains so saturate the soil that field work is retarded. The subsoil is permeable, but not so porous as to make the soil droughty. Under average moisture conditions Muscatine silt loam maintains desirable moisture content for good crop growth.

Muscatine silt loam has a total area, in this county, of 104 square miles, about three-fourths of which is in the western half of the county. Practically all the land is improved farm land and is regularly cropped. Most of the farms on this soil include other soils on slope areas or bottom lands which are utilized for pasture, and the Muscatine soil is kept almost entirely in grain or used as temporary hay and pasture meadows.

Owing to its mellow surface soil and well-regulated drainage, Muscatine silt loam is not difficult to maintain in good tilth. Seed beds can be prepared for planting in time for favorable crop growth and maturity. Except under extremely dry or wet seasonal conditions, crops on Muscatine silt loam outyield those on other soils of the county.

Yields of corn average about 45 bushels to the acre, and yields as high as 75 bushels are frequently reported. Oats and barley each average between 35 and 40 bushels, wheat between 20 and 25 bushels, and rye about 25 bushels. Timothy produces from three-fourths to 1 ton of hay to the acre, clover and timothy mixed about 1 ton, red clover from 1 to 1 $\frac{1}{4}$ tons, and alfalfa about 2 $\frac{1}{2}$ tons.

The productivity of Muscatine silt loam varies considerably with the method of handling and cropping. Although the soil is naturally well supplied with organic matter and nitrogen, the use of manure generally increases crop growth. The response to manure is, however, not so great as on soils of lower organic-matter content, such as the Clinton and Lindley soils. Grain crops on Muscatine silt loam usually produce better following legumes, such as red clover, sweetclover, and alfalfa. The legume-hay stubble or short late fall growth is plowed under ordinarily, but green manuring is seldom practiced. Lime is used occasionally in preparing the soil for alfalfa. No commercial fertilizers are used for field crops.

GRUNDY SILT LOAM

The surface soil of Grundy silt loam to a depth of 16 or 18 inches is black friable silt loam high in organic matter. Below this the material gradually becomes heavier and less friable, until at a depth of about 24 inches it is heavy silty clay. In its usual moist condition this layer is rather plastic, but under certain moisture conditions not too wet or too dry, it is somewhat friable and crumbles into a mass of very small clods. This layer is darkened by organic matter, and is mottled with rust brown, yellow, and gray. Soft iron concretions cause rust-brown and black spots. At a depth of about 30 inches the soil is heavier-textured silty clay which is usually less moist than the layer above, is tougher, and is more compact. The color is dark brown or dark grayish brown, with an increased mottling of rust brown, yellow, and gray. At a depth of about 40 inches the soil becomes lighter textured, approaching heavy silt loam which is less plastic and not nearly so tough as the layer above. The texture becomes less heavy with depth, until at a depth of about 5 feet the soil loses its compactness and plasticity. At this depth in many places there is also a change in color, the material above being yellowish brown and that below, grayish brown. Rust-brown and black iron stains occur throughout the layers below a depth of 40 inches but are usually less pronounced in the grayish-brown layer. Grundy silt loam is free of stones or pebbles as far as the deeper drift substratum which occurs at a depth of 15 or more feet.

The soil is acid in reaction to a depth of 5 or more feet. The degree of acidity ranges from slight to strong, averaging about medium, but in general the acidity decreases with depth. Below a depth of 5 feet the soil is neutral or slightly alkaline.

Grundy silt loam, together with its shallow phase, comprises a total area of 48.3 square miles. This soil occupies the highest and broadest divides of the upland. The largest areas are on the divide extending through Creston and Arispe in Highland and Sand Creek Townships. Smaller areas are scattered throughout the county.

In the eastern and southern parts of the county the soil occurs on flat-topped narrow divides and extends down the slopes to the

Shelby soils. In other parts of the county, these narrow divides are in most places occupied by Muscatine silt loam, or where the Grundy soil occurs on the flat top of the divide the Muscatine soil occupies the slopes and rounded crests. The Grundy soil on the more sloping surfaces of these narrow divides is generally thinner than typical, and approaches the character of the Muscatine soil in places. A narrow divide between Sand Creek and Twelvemile Creek in the southeastern part of the county is of this character. Boundaries between the two soils were arbitrarily drawn in many places.

On the broader flats near Creston and Arispe newly plowed fields in the saucerlike depressions show a gray color on drying which seems to be coincident with poor drainage.

Except in the depressions the natural drainage of Grundy silt loam is normally sufficient to prevent damage by standing water. In wet seasons, however, crop yields, particularly of corn, are reduced on the flatter areas. Comparatively little tiling has been done. It seems reasonable to suppose that tiling of the flats would be profitable, although on some of the more poorly drained tracts a very close spacing of tile has failed to effect the desired improvement, the heavy subsoil here evidently being of an exceptionally impervious character through which tile would not satisfactorily drain the water.

Grundy silt loam is nearly all in cultivation, being cropped to corn and small grains. In seasons of well-distributed rainfall yields of grain are as high as or higher than those on any other soil in the county. Corn averages between 40 and 45 bushels to the acre, yielding as high as 75 or 80 bushels in some places. Oats average between 30 and 35 bushels, and wheat averages about 20 bushels. Red clover and timothy, grown separately or mixed, yield about $1\frac{1}{2}$ tons to the acre, and, provided drainage conditions are not too poor, alfalfa hay yields as well as or better than on any of the other upland soils of the county, averaging between $2\frac{1}{2}$ and 3 tons to the acre.

Although Grundy silt loam contains a large amount of organic matter in its surface soil, applications of manure increase crop yields. The increase is not so great as on the Clinton and other soils, which are deficient in organic matter, but is fully as great as on the Muscatine and Tama soils. Crop rotations including legumes should be more generally practiced. Cultivated crops following a legume hay crop usually show an increase in yield.

This soil has a tendency to bake and crack, in some places so severely as to cause damage from drought, but when the cracking is controlled by thorough cultivation the soil is very drought resistant. Grundy silt loam holds moisture for longer periods after rains than the other soils, and this sometimes delays seed-bed preparation and planting in the spring a week or two longer than on the better-drained soils. If rains persist and are immediately followed by unusually dry hot spells, the control of cracking is very difficult.

Liming is necessary in order to obtain a good stand of alfalfa. For red clover, also, it would undoubtedly prove beneficial.

Grundy silt loam, shallow phase.—The shallow phase of Grundy silt loam is in most respects similar to the typical soil except that, by reason of its occurrence on slopes, it has a shallower surface soil. The heavy clay subsoil is exposed in places. Soil of the phase is more intractable than the typical soil.

This shallow soil occurs on gentle slopes around the heads of drainage ways which cut back into the broader flat divides, and on some narrow divides in Pleasant Township. Most of it occurs in Sand Creek and Highland Townships, adjoining areas of typical Grundy silt loam. The areas in Sand Creek Township have a slightly greater degree of slope than those in Highland Township.

As the shallow phase generally occurs in the same fields as the typical soil, the two are cultivated together.

TAMA SILT LOAM

The surface soil of Tama silt loam, to a depth ranging from 12 to 18 inches, is mellow dark-colored silt loam, high in organic matter. Below this and extending to a depth of about 36 inches is dark-brown or dark yellowish-brown rather friable heavy silt loam or silty clay loam. This layer is less plastic than the corresponding layer in the Muscatine soil, and it is principally on this difference and the more yellow color of the subsoil that the two soils have been separated, as in practically all other characteristics they are very much alike.

Below a depth of 36 inches the soil is similar to the Muscatine soil but is slightly less plastic, a little lighter in texture, and, in a moist or wet condition, is a trifle more open and porous. A change in color from yellowish brown to gray generally occurs at an average depth of 5 feet in Tama silt loam as it does in Muscatine silt loam.

The surface soil averages medium acid in reaction, being slightly acid in some places and strongly acid in others. The acidity generally decreases with depth, but in places it increases to a depth of 40 inches and then decreases to a neutral state at a depth of 5 feet. However, lime is not present in sufficient amounts to make the soil alkaline until the drift substratum is reached, which in many places is 25 or more feet below the surface.

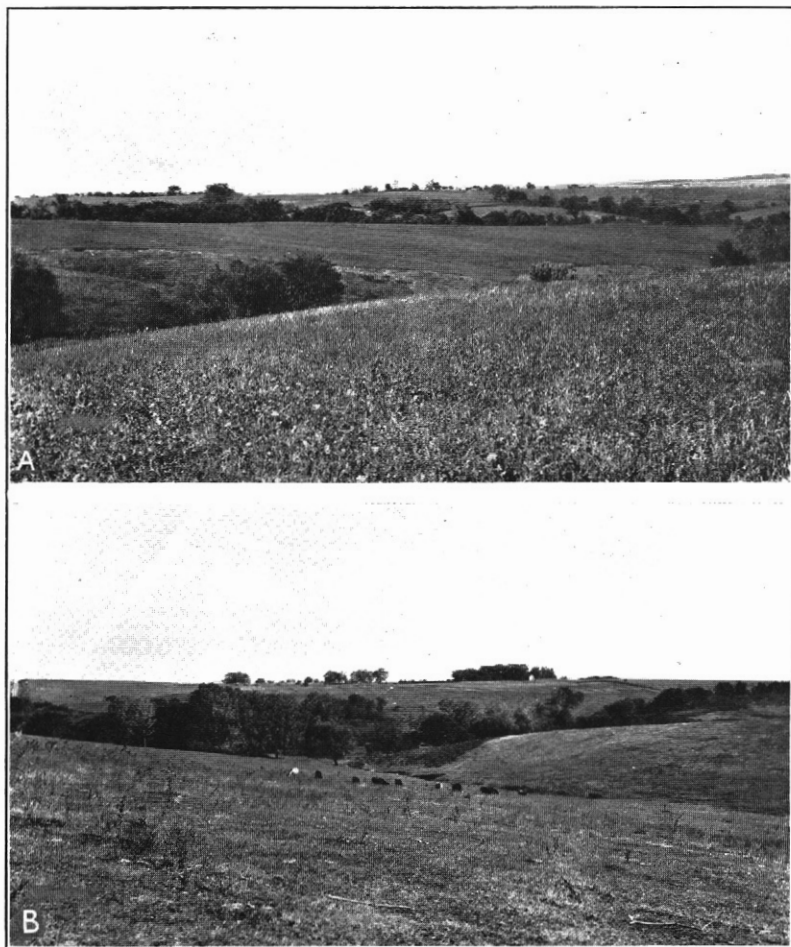
Like Muscatine silt loam, Tama silt loam occupies the tops of the upland divides. As a rule the Tama soil occupies ridges having more thorough drainage and never occurs on flat divides. However, many areas of Tama and Muscatine soils occur in positions of similar relief and drainage.

Tama silt loam, as mapped, includes a few areas in which the surface soil is lighter in color and approaches the Clinton soil in appearance. These areas occur on the narrower crests in the more rolling sections of the county.

Tama silt loam differs little from Muscatine silt loam in productivity, cropping methods, and soil management.

Tama silt loam, shallow phase.—The shallow phase of Tama silt loam is similar to typical Tama silt loam to a depth of about 30 inches, below which the subsoil differs widely from place to place. This deep subsoil layer partakes of the character and appearance of the various substrata found in this region. In most places it is a pebbly sandy clay similar to the subsoil of the Shelby soil, which is developed on drift material. In a few areas a dense "blue clay" occurs, in some places at a depth of 30 inches but generally at a greater depth.

Soil of this phase occurs on rather gently sloping areas below ridges of Tama silt loam in the northwestern part of the county. In small



A. General relief and characteristic vegetal covering of Union County, Iowa, showing curved slopes to upland divides; B. relief showing well-rounded slope shoulders and crests and natural tree growth occurring only along the drainage ways

areas on the shoulders of slopes the surface soil is entirely removed in places, and the pebbly sandy clay layer is exposed. At the base of the slopes a silt loam soil as deep as or deeper than the typical soil has been washed down from the land above.

The shallow phase of Tama silt loam has good natural drainage. The descending waters have a tendency to cause gullyng, particularly when the soil is under cultivation. Soil of the shallow phase generally occurs in the same fields as typical Tama silt loam and is cultivated with that soil. The total area of the shallow phase is 6.2 square miles.

CLINTON SILT LOAM

The surface soil of Clinton silt loam is light grayish-brown or yellowish-brown mellow silt loam about 10 or 12 inches deep. Below this is a 4-inch layer of darker gray and more granular soil. Below a depth of 18 inches and extending downward to a depth of about 30 inches is light-brown heavy silt loam which is friable when moist, slightly plastic when wet, but somewhat compact when dry. The soil in this layer breaks into a fine crumbly mass. The material becomes more cloddy with depth and becomes lighter in color with rather prominent splotches of rust brown, yellow, and gray. Between depths of 4 and 5 feet the soil material is noticeably less compact, being very friable silt loam, and the color is light grayish yellow or light yellowish brown mottled with gray and with rust-brown, black, and yellow iron stains.

This soil ranges from medium to strongly acid in reaction to a depth ranging from 4 to 5 feet. It is generally more deficient in lime than the Tama, Muscatine, and Grundy soils.

Clinton silt loam occupies the narrower ridge crests in the more rolling sections of the county, most of the areas lying close to the Grand River Valley. In only a few places does the soil extend a great distance down the slopes, most of which are occupied by either the Lindley or the Shelby soils.

Where bordered by the Grundy soil, the areas of Clinton silt loam have a heavier-textured, more plastic subsoil and a darker surface soil than typical.

Clinton silt loam is well drained. The tops of the divides in places are rather rounded and are subject to erosion by run-off water.

This soil covers a total area of 5 square miles in Union County. About one-fourth of the area is in woodland pasture which has not been cleared of the native hardwood growth. Clinton silt loam is not regarded so highly as the dark-colored upland soils. It is deficient in organic matter, as is indicated by the light-colored surface soil. It ordinarily receives more manure than the dark-colored soils and is not cropped so heavily to corn and oats. More of the rainfall is lost through run-off than on the less rolling soils, and crops suffer more during dry periods. With crop rotation, proper fertilization with manure, and the application of lime where needed, crop yields are very satisfactory. Under the practices prevalent on the average farm, however, this soil does not produce as large yields as the Tama, Muscatine, or Grundy soils. Yields of corn average about 35 bushels to the acre; of oats, between 25 and 30 bushels; and of

winter wheat, about 15 bushels. As a rule, stands of tame hay are more difficult to obtain and maintain on this soil than on the dark-colored upland soils.

SHELBY LOAM

The surface soil of Shelby loam is dark-brown or black granular loam to an average depth of 10 inches. It is underlain by dark-brown or brown coarse granular heavier clay loam which extends to an average depth of 21 inches below the surface, at which depth it is underlain by a layer of heavy clay loam or sandy clay containing embedded pebbles and gravel. This layer is yellowish brown and is spotted with gray and stained with rust-brown or black iron colorations. It is more plastic when wet than is the layer above. At an average depth of 35 inches this layer is underlain by a more plastic, more sticky, and heavier material averaging sandy clay in texture. Gray and black iron spots are more numerous than in the layer above.

The surface soil ranges from medium to strongly acid in reaction. Below a depth of 3 or 4 feet the soil is only slightly acid or almost neutral, and at a depth ranging from 5 to 6 feet spots or streaks of white concretionary lime occur in many places. The lime in the substratum of the Shelby soil occurs at less depth than in the other upland soils, with the possible exception of the Lindley soils. A few boulders occur on the surface.

Because Shelby loam occurs on slopes which are constantly being washed, areas of this soil as mapped include numerous variations. In places the surface soil has been largely washed off, and lower down the slope a deeper black surface soil has resulted. Narrow strips of very heavy land known as "push soil" commonly occur on slopes occupied by Shelby loam but are too small to map separately. In general the more rolling areas of Shelby loam along the main streams are more spotted and variable than the gently rolling areas nearer the upland divides. An area of this soil in sections 30 and 31 of Platte Township, along the east side of Platte River, has a fine sandy loam surface soil and a light sandy clay loam subsoil. If this area had been of sufficient size it would have been separately mapped as Shelby fine sandy loam.

Shelby loam is the most extensive soil in Union County, covering a total area of 190.4 square miles. It occurs on practically all the farms of the county. Under cultivation it presents to most farmers the problem of control of slope washing. Little effort is made to prevent gullying until the condition of the slope is such that further cultivation must be discontinued. If the farmer then desires to seed the land, terracing becomes necessary in many places. Most of the Shelby soil in the western tier of townships is not seriously eroded and is still in a good state of cultivation. On the steeper slopes along the main stream valleys throughout the eastern part of the county erosion presents a serious menace, however, and will make waste acreages of former tillable fields unless effective control measures are adopted.

Except for small seeped spots on the slopes, the surface drainage of Shelby loam is excessive, and crops on many of the slopes suffer during dry spells.

Only about one-third of this soil is cultivated, the remainder being in permanent pasture, some of which is woodland. The principal crops are corn, oats, and clover and timothy mixed. The yields obtained are generally lower than on the Tama, Muscatine, and Grundy soils, corn averaging about 35 bushels, oats between 25 and 30 bushels, and clover and timothy hay three-fourths of a ton to the acre.

Thin spots of Shelby loam, if close to the barn, usually receive a greater supply of manure than the other soils of the farm. Lime is added to a few fields of this soil when an alfalfa seed bed is being prepared.

On much of this soil further cropping should be discouraged until a system of terracing or other effective means are employed to prevent and control erosion. Until that is done, pasturing is the most feasible use of the land.

LINDLEY LOAM

The surface soil of Lindley loam to an average depth of 4 inches is gray very friable and somewhat floury loam or very fine sandy loam. When moist the surface soil is more brown or yellowish brown than gray. Below this and extending to an average depth of about 12 inches is friable grayish-yellow or yellowish-brown heavy loam or silt loam. This is underlain by dark yellowish-brown silty clay loam which is moderately plastic when wet. Below a depth of about 20 inches the soil is yellowish-brown heavy plastic gritty silty clay spotted with gray and with rust-brown and black iron stains. Below a depth of about 40 inches the iron stains become more prominent and the soil becomes slightly more friable with increased depth, otherwise the material in this layer is similar to that in the layer above.

In reaction the surface soil and subsoil of Lindley loam ranges from slightly to strongly acid, the subsoil generally being less acid than the surface soil. At a depth of about 4 feet, white specks and streaks of lime commonly occur, but above that depth the subsoil has a low content of lime.

Stones and a few boulders are on the surface and embedded in the soil. The areas of Lindley loam have the same variations in the texture of the surface soil and subsoil as the Shelby loam areas. On bare slopes the surface soil is inclined to wash, and spots of exposed subsoil appear.

Areas of Lindley loam are rolling or broken, and eroded slopes are characteristic of this soil in Union County. The principal areas are on the south bluffs of Threemile Creek Valley in Lincoln Township, along Grand River near Monette and Talmage, and in sections 12 and 13 of Pleasant Township. The greater part of this soil is in woodland which is utilized for pasture. Under cropping Lindley loam is considered similar to Clinton silt loam in productiveness, but owing to the difficulty of preventing gullying, a smaller proportion of the Lindley soil is cultivated.

LINDLEY SILT LOAM

Lindley silt loam is essentially similar to Lindley loam except that it has a more floury, mellow silt loam surface soil. Only one small area on the Ringgold County line in section 36 of Pleasant Township is mapped.

WAUKESHA SILT LOAM

The surface soil of Waukesha silt loam to a depth of 4 inches is very dark grayish-brown slightly gritty mellow silt loam. Below this the color is almost black to a depth of 16 inches and dark brown between 16 and 25 inches, but the texture remains rather uniform. Between depths of 25 and 30 inches the color is yellowish brown and the texture is heavy silt loam. At a depth of about 30 inches the somewhat compact yellowish-brown heavy silt loam subsoil proper occurs. At a depth of 40 inches a greater sand content gives the soil rather loose friability, and the yellowish-brown color is varied by gray stains. The soil contains no lime to a depth ranging from 4 to 5 feet, in most places testing from slightly to medium acid. Below that depth lime may occur at variable depths and in different amounts.

Most of the areas of Waukesha silt loam in Union County differ from typical Waukesha silt loam as mapped in other Iowa counties. Here it has a shallower dark-colored mellow surface soil and a thicker yellowish-brown subsoil. Areas of this soil in Union County include areas of Judson silt loam which are too small to map separately. In section 3 of Pleasant Township a high terrace area having a subsoil similar in compactness to that of the Jackson soil was mapped with Waukesha silt loam because of the dark surface soil.

Small areas of Waukesha silt loam occur along Grand River and along Threemile and Twelvemile Creeks. The areas occupy three different positions, some being on low foot slopes above the bottom land, others on low benchlike lands 5 or 10 feet above the bottoms, and others 20 or more feet above the bottoms. The higher terrace lands have the best natural drainage, but all the soil is well drained.

Waukesha silt loam is productive and is practically all under cultivation. In cropping practices and in yields the soil is similar to the upland Tama and Muscatine soils.

BREMER SILT LOAM

The surface soil of Bremer silt loam is almost black rather heavy silt loam which, when wet, is not so mellow and friable for plowing as desirable, but when dry or moist easily pulverizes to form an excellent seed bed. Between depths of 8 and 17 inches the soil is heavier and less friable than the surface soil, becoming moderately plastic in the deeper part when wet, and the color changes to dark gray. Between depths of 17 and 25 inches the soil is plastic heavy silty clay loam which becomes somewhat tough and compact when dry. The dark-gray color is faintly stained with rust-colored iron spots. The soil between depths of 25 and 40 inches is stiff plastic heavy silty clay or clay which, on drying, cracks into tough soil masses and is very hard to break. The color is dark gray with numerous spots of lighter gray and bluish gray as well as rust-brown and black iron spots. Below a 40-inch depth the color is a mottled mass of these stainings. The texture of this layer shows a change from clay to silty clay loam, and the soil is not so stiffly plastic, being much more friable when dry than the heavy layer above. No noticeable quantities of lime are present in the soil above a depth of 4 or 5 feet. The soil usually tests from slightly to medium acid.

Bremer silt loam is similar to the Grundy upland soils. Small areas of the Chariton soils having distinctly gray subsurface layers and subsoils even more tough and compact when dry and more waxy when wet than the Bremer subsoils are included with Bremer silt loam on the soil map because of their small size.

Bremer silt loam is the main terrace soil in the county, covering a total area of 5.7 square miles. It generally occurs on sloping or benchlike terraces from 5 to 10 feet above the bottom lands. The larger areas are along Grand River and Twelvemile Creek in Pleasant Township and in sections 30 and 31 of New Hope Township. An area having an exceptional location for Bremer silt loam occurs on a high terrace in sections 25 and 26 of Pleasant Township. Here the soil is very similar to Grundy silt loam areas occurring at lower elevations.

The natural drainage of Bremer silt loam ranges from fair to poor. Water does not readily percolate downward through the soil. On the gradually sloping areas drainage is fairly good, on flat terraces it is slow, and in basinlike depressions receiving water from higher lands it is deficient.

Perhaps two-thirds of the area of Bremer silt loam in Union County is in cultivated crops, and the remainder is in pasture and hay lands. The soil is better suited to corn than to small grains, because of the tendency to rank growth and lodging of the small grains. This soil is often cropped to corn or to corn and small grains for a number of successive years. Manuring the land and rotations including a legume hay crop are beneficial, even though the soil is naturally fertile. Tiling is the first improvement necessary in areas where natural drainage is poor. Even where well drained, Bremer silt loam tends to hold moisture longer than desirable in wet seasons. A proper tilth can be obtained only when the land is plowed under the most favorable state of moisture. If plowed when too wet a cloddy surface soil results, and if the soil is too dry a baked crust is formed which is hard to pulverize. After a crust has formed, numerous deep surface cracks develop which in some places cause so great a loss of soil moisture that crops are damaged in dry spells.

Under proper management and good seasonal moisture conditions, Bremer silt loam produces as high crop yields as are obtained on any other soil in the county. On the other hand, under poor management and poor seasonal growing conditions, crop yields will be lower on this soil than on the better-drained, less fertile soils. The average crop yields obtained are slightly lower than on Grundy silt loam.

CHARITON SILT LOAM

Chariton silt loam to a depth of 10 inches is very dark grayish-brown or almost black smooth and mellow silt loam which becomes slightly more gray when dry. This layer is underlain to a depth of 16 or 18 inches by distinctly gray very floury silt loam faintly mottled with black organic-matter stains and a few rust-colored iron stains. Below this and extending to a depth of 32 inches is very compact impervious silty clay or clay which is sticky and waxy when wet. This layer is dark grayish brown, becoming more yellowish brown with depth. In the lower part gray and yellow mottles and rust-brown iron stains occur, and the soil is somewhat less sticky. Below

a depth of 32 inches there is a slight change toward softly plastic, moderately friable and more pervious silty clay loam or silt loam. A somewhat gray color displaces the yellowish-brown color in places in the substratum, and the stains fade out, then reappear.

To a depth of 4 or 5 feet the soil is medium acid in reaction, and no lime is present.

Chariton silt loam occurs on terraces, closely associated with Calhoun silt loam and Bremer silt loam, and in places it merges gradually into these soils. With the exception of a small terrace area in section 1 of Platte Township, this soil occurs only on terraces along Grand River and Twelvemile and Threemile Creeks in Pleasant, Jones, Union, and Sand Creek Townships. Most of the areas are small narrow strips lying only 18 or 20 feet above the bottoms.

Surface drainage is in most places fair or good. The gray subsurface layer absorbs moisture slowly, and in many spots the subsoil is so impervious as to resemble a hardpan layer. Where tiling is required for drainage improvement the impervious subsoil necessitates closer spacing of the tile than in the Bremer soil.

Chariton silt loam is cropped similarly to Bremer silt loam but is recognized as less fertile because of its lower organic-matter supply. About half the area of this soil is in cultivated crops, and the other half is in hay and pasture fields. Crop yields average lower than on Bremer silt loam and higher than on Jackson silt loam and Calhoun silt loam.

CALHOUN SILT LOAM

The surface soil of Calhoun silt loam to a depth of 7 inches is grayish-brown floury mellow silt loam. It is underlain to a depth of about 19 inches by light-gray floury silt loam which is rather compact in place. A layer of brown silty clay or silty loam stained with gray in the upper part and with rust brown in the lower part occurs between depths of 19 and 32 inches. This is the heaviest, most plastic, and most impervious layer. When dry or moist, the material of this layer shatters into firm, tough, sharp-edged particles. Below a depth of 32 inches the soil is dark yellowish-brown heavy silty clay loam more stained with rust-brown and black iron colorations. When wet this layer is not so stiffly plastic or waxy as the layer above. Below a depth of 40 inches the soil is still less plastic, and moist soil can be easily broken into a somewhat friable, crumbly mass. When dry, however, the soil mass is hard to break or shatter. The silt content increases with depth, and the texture becomes that of heavy silt loam at a depth ranging from about 4 to 5 feet.

In nearly all places the soil is medium or strongly acid in reaction to a depth ranging from 2 to 3 feet and slightly or medium acid to a depth of 5 feet. No appreciable amount of lime occurs in the substratum below a depth of 5 feet.

More than half the Calhoun silt loam mapped in Union County is in Pleasant Township, and practically all the rest is along Grand River and Twelvemile and Threemile Creeks in Union and Jones Townships. A small area occurs along East Platte River in section 26 of Platte Township.

Most of the terraces occupied by Calhoun silt loam are 20 or 25 feet above the bottom lands. The surface is level or gently sloping. Surface drainage is good but internal drainage is slow, owing to the

heavy impervious subsoil, and small depressions need tiling. Calhoun silt loam occurs in association with the Jackson and Chariton soils and includes small spots of these two soils.

Practically all the land is under cultivation with the exception of a few areas which are in woodland pasture. Originally all the land was woodland. This soil is low in organic matter and is less productive than the dark-colored terrace soils. It is better suited to small grains than to corn. Crop yields average about the same as or a little lower than on the Clinton and Jackson soils. Crops on this soil show marked benefit from manuring. Farmers seldom crop this soil as heavily as the Bremer soil, but in their crop rotations a larger place for legumes should be made. In most areas liming will be necessary for a good stand of alfalfa or sweetclover.

JACKSON SILT LOAM

The surface soil of Jackson silt loam to a depth of about 8 inches is mellow slightly gritty silt loam, which is grayish brown or dark grayish brown when moist but almost gray when dry. Below this layer the soil material to a depth of about 20 inches is heavy silt loam a shade lighter in color and less mellow than the surface soil. Between depths of 20 and 34 inches the material is light-brown or yellowish-brown rather gritty compact heavy silt loam which is slightly or moderately plastic when wet. Between depths of 34 and 52 inches is a layer of yellowish-brown silt loam or silty clay loam containing rust-brown iron stains and some gray spots. Below a depth of 52 inches the soil is yellowish-brown or light grayish-brown friable silt loam with numerous rust-brown iron stains and streaks and spots of gray. There are no noticeable amounts of lime in the soil to a depth of 6 feet. The compact layer and the soil above are medium or strongly acid in reaction.

In most respects Jackson silt loam resembles Clinton silt loam of the uplands. In most places the subsoil of Jackson silt loam is not so compact as that of the Clinton soil, and it is much less compact than the subsoil of Calhoun silt loam which in many places occurs on the same terraces as the Jackson soil. Jackson silt loam lacks the distinctly gray subsurface layer present in the Calhoun soil, although in places it does show a slight development of gray color. On the more sloping positions below the uplands this soil includes spots having fine loamy surface soil washed from the uplands. Jackson silt loam is generally less floury, more gritty, and not so pure a silt loam as Clinton silt loam.

This soil occurs on small terraces well elevated above the bottom lands of Grand River and Twelvemile and Threemile Creeks. The larger areas are along the lower courses of these streams in Jones and Pleasant Townships. A few of the higher areas have been so eroded as to have lost all resemblance to benchlike terraces. The larger of such areas occur in section 29 of Jones Township and section 14 of Pleasant Township.

Jackson silt loam is naturally well drained. In a few places the run-off is excessive. The soil absorbs moisture readily but does not hold it so long as does Waukesha silt loam or other black soils which are high in organic matter. Prolonged dry spells usually cause damage to crops on Jackson silt loam sooner than on Waukesha silt loam.

Applications of manure on the Jackson soil will, as a rule, prevent such damage to crops. This soil is not so droughty as soils with sandy or gravelly subsoils.

The natural vegetation consisted of hardwood trees. About one-third of the total area is now cleared and in cultivation, another third is in hay and pasture grasses, and the remainder is in woodland pasture. Under cultivation the same cropping and soil-management practices are in use as on the Clinton soils. Jackson silt loam is less productive than the Waukesha terrace soils or the dark-colored upland soils of the Tama, Muscatine, and Grundy series. Applications of manure greatly benefit crops and show this soil to be more dependent on regular fertilization and crop rotation than the more productive soils. Yields on the Jackson soil are about the same as on the Clinton soil.

The main steps to be taken in improving the productiveness of Jackson silt loam are (1) to increase its moisture-storing capacity by deep plowing, thorough cultivation, and plowing under all stubble and organic matter possible, (2) to increase the organic-matter supply by manuring, green manuring, and rotating with leguminous crops such as alfalfa and sweetclover, and (3) to correct any acidity present by applications of lime.

WABASH SILT LOAM

The surface soil of Wabash silt loam is black mellow rather gritty silt loam about 14 inches thick. It is underlain by black heavy silt loam or silty clay loam which is moderately plastic when wet. At a depth of 24 inches the color is somewhat gray, and below this becomes dark brown slightly mottled with gray and yellowish brown and a few rust-brown iron stains. The texture is a heavier silty clay loam or silty clay which is plastic when wet but moderately friable when dry. Both surface soil and subsoil are lacking in lime.

In small areas the surface soil varies from sandy loam or loam to heavy silty clay loam, and, as a rule, the subsoil is correspondingly light or heavy textured. The small narrow bottom lands are more varied in soil texture than the larger wider flood plains, owing to wash from the uplands as well as to sediment left by overflow waters.

The bottom lands of the Platte River system are composed almost entirely of this soil. In the Grand River system, Wabash silt loam occurs mainly along the lower courses of Twelvemile Creek and Grand River.

Areas of Wabash silt loam are level, and the surface waters are largely taken care of by downward percolation through the soil. The soil is of sufficient porosity to absorb the rains during the growing season if overflow waters from the stream channel do not remain for a long period of time. The position of Wabash silt loam with respect to overflows governs the success of cropping the land. A considerable part of the land can, in normal seasons, be cropped without overflow damage.

Areas of Wabash silt loam are largely in pasture, but the wider bottom lands are ordinarily cultivated to a considerable extent. The soil is highly productive. It is particularly well suited to corn and pasture and hay grasses, and a little less suited to small grains because of frequent damage from lodging. Stands of red clover are

much better, as a rule, than on the upland soils. Alfalfa does well if the field is not subject to overflow and is well drained. Yields of corn and hay are about the same as or a little higher than those on the Tama and Muscatine upland soils. The mellowness of the soil makes for ease of cultivation, and good surface mulch can be maintained with greater ease than on the dark-colored upland soils.

Because of occasional overflows, cropping plans are seldom made in advance of the growing season. Corn is commonly planted if conditions are favorable and is grown for two or three years, sometimes longer, without change to small grains and clover. In a wet season often only a short-season catch crop, such as millet, Sudan grass, or rape, can be grown.

Wabash silt loam is not usually manured. However, crops on this soil respond well to applications of manure, and it will be necessary, if the productiveness of the soil is to be maintained, to employ this method of fertilization.

According to tests made over various areas of Wabash silt loam, the soil seems to be somewhat less acid in reaction than the upland soils. The lime requirement of the particular field should be ascertained in preparing a seed bed for alfalfa or sweetclover.

Wabash silt loam, gray-subsoil phase.—The gray-subsoil phase of Wabash silt loam is similar to typical Wabash silt loam except that the layer between average depths of 12 and 24 inches is more gray and is somewhat compact in place. In some places this gray layer approaches the floury character of the similar layer in the Chariton and Calhoun soils. In most places the gray color is sprinkled, stained, or coated over the surfaces of the soil granules which, when broken, show a dark-brown or black color. The subsoil below a depth of 28 or 30 inches is silty clay loam mottled with gray and rust-brown iron stains. When dry the soil in this layer becomes slightly tough and compact, but this compactness is not nearly so great as that shown in the subsoils of the Chariton or Calhoun soils.

The gray-subsoil phase of Wabash silt loam occurs on the better-drained parts of the first bottoms and appears to be slowly developing into a soil resembling the Chariton terrace soil. Most of the small areas occur on the first bottoms of Grand River and Twelve-mile Creek. These areas are generally well protected from overflow, and consequently more of this soil than of typical Wabash silt loam is cultivated. Cropping practices and yields are similar to those on Wabash silt loam.

WABASH LOAM

Wabash loam has a black mellow loam surface soil to a depth of 8 or 10 inches, below which the soil is more silty, less loamy and friable, and slightly less black. At a depth of about 25 inches the subsoil is dark-brown heavier-textured silty clay loam which is generally much more loamy and open structured than the subsoil of Wabash silt loam. Faint mottles occur in a few places in this layer. Both surface soil and subsoil are lacking in lime. The soil is only slightly acid, as a rule, and in some places is of neutral reaction, indicating no need of lime.

The textures of the surface soil and subsoil of Wabash loam vary greatly. In spots the surface soil may be fine sandy loam and the

subsoil rather sandy and porous. In some small areas the surface soil and subsoil are both loams showing little difference in mellowness and openness of structure, but the color of the subsoil changes to dark brown.

Wabash loam covers an area of 13.2 square miles in Union County. Most of the areas are on the bottom lands of Grand River and Twelvemile and Threemile Creeks.

This soil is well drained except where subject to frequent overflow. Most of the land is in pasture, some of which is woodland.

Under cultivation, corn is the crop most commonly grown. Yields are about the same as on Wabash silt loam. This soil is similar to Wabash silt loam in crop adaptation and response to such soil improvement practices as manuring, crop rotation, and liming.

WABASH FINE SANDY LOAM

Wabash fine sandy loam has a loose very friable fine sandy loam surface soil which is dark colored but not so intensely black as the surface soil of Wabash silt loam. The only changes with depth are toward lighter color and heavier texture. In general the subsoil is dark-brown loam, but in places below a depth of 3 or 4 feet it is more sandy, approaching the loose sandy character of the subsoils of the Cass soils. No appreciable amounts of lime occur either in the surface soil or subsoil.

The only area of Wabash fine sandy loam mapped in Union County is on the north county line along Grand River, adjoining an area of this soil in Madison County. Small strips occur in several places along the channel of Grand River and other main streams, but they are so narrow and of such variable texture that they are included with Wabash loam or Wabash silt loam in mapping.

Practically no attempt is made to cultivate this soil. It is utilized for pasture, much of it being in woodland pasture.

WABASH SILTY CLAY LOAM

The surface soil of Wabash silty clay loam is intensely black heavy silty clay loam which is moderately plastic when wet but friable when moist. Below a depth of 10 inches the material is heavier-textured silty clay not so intensely black as the surface soil and mottled with gray and rust-brown iron spots. When wet the soil is plastic and when dry it is very tough and difficult to pulverize. Below a depth of 20 inches the mottling is more intense. Both surface soil and subsoil are lacking in lime.

Most of the Wabash silty clay loam occurs in the bottom along Grand River. The largest area is in section 2 of Dodge Township. Small areas are along Platte River in section 30 of Douglas Township and in sections 3 and 33 of Platte Township, and along Twelvemile Creek in section 34 of Union Township and in section 17 of Pleasant Township. Parts of these areas are under cultivation. Owing to the heavy surface soil, a good surface mulch is difficult to maintain on a cultivated field. If the land is plowed when too wet, a cloddy surface soil will result. With this exception, Wabash silty clay loam has as high agricultural value as Wabash silt loam. In most places, however, its productiveness is dependent on protection from overflow and on tile drainage.

SOILS AND THEIR INTERPRETATION

The most noticeable soil characteristic and one common to all but a few of the soils of Union County is the dark color of the surface soil. In its virgin state the land was treeless, except on small areas adjacent to the stream valleys. Prairie grasses grew abundantly on the great treeless expanses and formed a considerable part of the undergrowth in the small wooded tracts. The dark color of the surface soil is due to the decay of grass roots in the soil and the incorporation of the resulting finely divided organic matter with the mineral constituents of the soil. The condition of moisture and temperature, which to a great extent regulate the activity of the soil-forming agencies, have evidently been optimum for the formation of black organic matter and for its preservation in the soil.

A second soil characteristic which is common to all the soils of Union County is the absence of lime carbonate to a depth of 4 or more feet. In some places it is not present above a depth of 25 feet below the surface. The parent materials were originally calcareous and the absence of lime carbonate in the upper weathered soil is undoubtedly due to leaching. As evidence of this it lies at the lower depths in many places segregated in concretionary spots or streaks which are thought to have been carried down from the surface soil and added to the lime of the parent material.

A third characteristic common to all the soils of Union County except the alluvial soils of the Wabash series and some alluvial terrace soils is the well-defined and almost perfect granulation. The granules range from fine to coarse in size and from fragile to firm in consistence. The granular structure continues to a depth ranging from 24 to 30 inches. The depth as well as the degree of perfection and definition are variable but this structure is a characteristic feature of the surface soils and heavy upper subsoil layers of the upland and terrace soils of this county.

The activity of the soil-forming agencies has varied in degree. The relief and the surface and internal drainage, which control the moisture supply in the soil, are factors which largely determine the degree of soil development. The difference in the degree to which soil formation has proceeded gives rise to the main differences between the soil series. The present soils owe their differences more to the alteration wrought by the agencies of soil weathering than to the influence of the original differences in the parent material on which these agencies have acted.

Prior to dissection of any kind, the original surface of Union County and surrounding territory consisted of a flat plain having a very gentle slope to the southeast. At that time the surface covering was in all probability the less-weathered loess which now occurs at a depth ranging from 15 to 20 feet beneath the Muscatine, Grundy, and Tama soils. Except for possible incorporation of organic matter at the surface, little alteration was wrought by the soil-forming agencies prior to the dissection of the surface by drainage, when small watercourses began to cut into the least resistant soils of the plain.

The development of the efficient drainage system of the present day has occurred in recent times and, geologically speaking, during a comparatively short period of time. As the drainage ways cut

deeper and farther back into the level plain, new surfaces were exposed to weathering, and the alteration of the surface soil and development of different soils by the soil-forming processes took place rapidly.

Of the three upland soils which developed over loess (Tama, Muscatine, and Grundy), the Tama soils have the regional profile, that is, the soil-forming processes as determined by climatic conditions have acted on the parent material unhindered by other conditions. In this county, however, the parent loess is rather thin and is underlain by glacial drift at such slight depth that typical Tama soils have not developed. In the Grundy soils, a flat surface and a heavy substratum have restricted water movement, and these soils have the characteristics of soils developed under conditions of excessive moisture. The Muscatine soils have developed under conditions of moderately slow drainage and are intermediate in characteristics between the soils of the other two series.

Muscatine silt loam is well drained and is one of the most extensive soils in Union County. To give a more exact idea of the average thickness of the soil layers and to add to the general description given, certain details peculiar to this soil are shown in the following profile description. This profile, observed on the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 27, T. 78 N., R. 31 W., was selected for study as a typical profile of Muscatine silt loam in Union County.

To a depth of $1\frac{1}{2}$ inches the material consists of a grass-root mat containing small amounts of humus. Even in the root mat proper there is little organic matter which is not thoroughly decayed and incorporated with the soil.

Between depths of $1\frac{1}{2}$ and 4 inches the soil is mellow silt loam, tightly matted together with grass roots. The material is perfectly granular. The granules are very fine, about one-sixteenth inch in diameter, and are soft and fragile. The larger of the granules are clustered close to the grass roots and are shaken from them with some difficulty, as the roots are wrapped about or penetrate them. When shaken out, most of the granules shatter, and the soil-mass is about 75 per cent dust. The granules appear black owing to the incorporated organic matter, but the color formula of the air-dried soil sample was found to be 78 per cent black, 7 per cent white, 7 per cent red, and 8 per cent yellow, and the soil is classed as very dark grayish-brown. The texture is silt loam containing more silt than the average loessial silt loam. When dry the soil has a slightly gritty feel.

Between depths of 4 and 10 inches the soil material is very friable mellow silt loam. As in the layer above, the granulation is most definite close to the embedded roots. The root system of this layer is not so matted as in the layer above, the arrangement being one of fine taproots with short fibrous branches. This root system reaches into every part of the soil layer. The granules are more firm than those of the surface layer, and when shaken from the roots only a few of them shatter into single-grained soil particles. Lamination is very well developed, and the flat structure particles or laminae are moderately firm. This layer is the layer of maximum darkness of color, each single-grained soil particle as well as the granules being well coated by the black organic matter. This layer contains

as large a proportion of silt as the average loessial silt loam. When dry the soil has a slightly gritty feel.

The layer between depths of 10 and 18 inches is the one of maximum granulation, or, perhaps better stated, the layer in which the granules are firmest and most resistant to crushing. The granules, however, are comparatively friable. They range from one-eighth to one-fourth inch in diameter, are irregular in shape, and have sharp or slightly rounded edges. The material of this soil layer very readily falls apart into a perfectly granular mass with practically no dust particles. Organic matter has coated the granules and the broken faces of the soil mass, causing a dark grayish-brown color. A cross section shows a distinctly dark-brown color on the inside of the granule. The texture of this soil layer is heavy silt loam which is mellow and friable but very slightly sticky and plastic when wet.

Between depths of 18 and 32 inches is a layer of silty clay loam which breaks into irregular soft fragile columns which, in turn, break less readily into irregular structure particles a trifle larger than the granules of the layer above. These smaller structure particles are moderately firm and are distinctly angular and sharp edged. Toward the lower part of the layer, the particles are less distinct and the larger structure columns are correspondingly more definite. The distinctly dark organic matter occurs not as a coating on the soil particles but apparently as impregnations, from the soil layers above, which have penetrated this layer along vertical cleavage lines. The surface color of the structure particles is dark brown of a lighter shade than in the layer above. Yellow and rust-brown iron stains make their first appearance, dimly defined, in this layer. The color of the crushed mass is dark yellowish brown or dark olive gray. This layer is heavier textured than the layer above but is only a little less friable, and when wet it is practically no more plastic or sticky. However, where undisturbed it is more compact than the overlying granular layer.

The soil between depths of 32 and 54 inches is silty clay loam. The most distinct cleavage lines are those between the soil columns. The columnar structure is best developed in this layer but is still irregular and fragile, the columns being crossed by breakage lines at intervals of not more than 5 inches. The secondary breaking of the columns results in a mass of soft soil particles of very irregular sizes and shapes. These soil particles are of larger average size than those in the layer above but are not so sharp edged and are less firmly formed. The columns of this layer, on the other hand, are more firmly formed than in the overlying layer. The soil of this layer shows little or no dark color from the organic matter of the surface soil. The basic color is light grayish brown or grayish yellow with gray and yellow mottlings and many rust-brown and black spots of concretionary iron. The iron-stained spots are much softer and more friable than the rest of the soil. The mottling is sharply defined, and even when pulverized, the soil still retains a variegated color. The soil material of this layer is as friable as is the one above, and the compactness in place is perhaps a little greater. When wet the soil is stiffly adherent almost to the point of being plastic.

Between depths of 54 and 72 inches the soil is silt loam containing a considerable proportion of very fine sand. The irregularly vertical

cleavage lines and soil columns of the layer above are absent in this layer. The material breaks up into large soft clods having no definite shape. The layer is honeycombed with minute vertical pores, which also occur in the layers above but are less noticeable. The body color of this layer is light olive gray which appears almost white when the soil is dry. Sharply defined mottlings, principally rust-brown and black concretionary spots of iron, are abundant. The iron-stained spots are much larger than in the layer above and have the same friable soft structure in contrast to the firmer soil around them. The color of the air-dry soil is light grayish yellow. In its usual moist condition the material of this layer is more friable than that of the two layers next above.

Below a depth of 72 inches the material is practically the same as in the layer above, except that rust-brown iron stains are less numerous. In places, exposures of the substratum below a depth of 6 feet show pockets of distinctly laminated very fine sandy clay which is somewhat plastic when wet, but brittle, breaking into flaky laminae, when dry. In other places pockets of looser-textured very fine sandy loam occur. These differences are undoubtedly owing to differences in the parent material and not to weathering.

Table 3 gives the pH determinations by the quinhydrone method of samples of Grundy silt loam and Muscatine silt loam.

TABLE 3.—*pH determinations of Muscatine silt loam and Grundy silt loam in Union County, Iowa*

Soil type	Horizon	Depth in inches	pH value	Soil type	Horizon	Depth in inches	pH value
Muscatine silt loam. ¹	Grass-root mat.	0 - 1½	-----	Grundy silt loam—Con.	A ₂ -----	17 - 23	5.68
	A ₁ -----	1½ - 4	5.84		B ₁ -----	23 - 29	6.48
	A ₂ -----	4 - 10	5.76		B ₂ -----	29 - 41	6.71
	A ₃ -----	10 - 18	5.73		B ₃ -----	41 - 50	7.20
	B ₁ -----	18 - 32	5.56		B ₄ -----	50 - 58	7.27
	B ₂ -----	32 - 54	6.47		C ₁ -----	58 - 68	7.63
	C ₁ -----	54 - 72	7.00		C ₂ -----	68 - 80	7.76
					C ₃ -----	80 - 98	8.20
Grundy silt loam. ²	Grass-root mat.	0 - 2	-----		C ₄ -----	98 - 104	8.13
	A ₁ -----	2 - 7	5.71				
	A ₂ -----	7 - 17	5.61				

¹ Soil sample taken on NE. ¼ NE. ¼ sec. 27, T. 73 N., R. 31 W.

² Soil sample taken on NW. ¼ NW. ¼ sec. 27, T. 73 N., R. 28 W.

Sweetclover, a plant requiring lime, commonly grows on railroad and roadside cuts in areas of loess soils to within about 3 feet of the top of the cut. This is an indication that the lower part of the subsoil and the substratum are practically neutral or basic in reaction.

The loess of Union County is typically from 20 to 25 feet thick over the Kansan drift. In many places, however, the loess soil mantle is much thinner, and on most of the upland drainage-way slopes it has been entirely removed, the soil in such places belonging to the Shelby and Lindley series. Many roadside and railroad cuts and eroded slopes show an extremely heavy layer below the friable loess and in the upper parts of the Kansan and Nebraskan till sheets. Observations and notes descriptive of this material ap-

pear in the geological reports published by the Iowa Geological Survey.² The term "gumbotil" has been applied to this material. It is regarded as the weathered surface material of the underlying drift sheet. This gumbotil has influenced the soil where it appears near the surface on slopes or on thinly capped loess crests. The farmer knows it as "push soil", because of its intractable physical condition.³ In the soil surveys of other counties in this section of Iowa, no areas of these so-called push soils are of sufficient size to map as a separate soil type or phase.

The Tama silt loam mapped in Union County is heavier textured and is less friable in the subsoil and substratum than typical for this soil. In Adair County Tama silt loam has the granular, friable, silty-textured subsoil typical of the Tama soils. The color of the subsoil in Union County can not be considered typical as it has a more gray or olive cast than the typical yellowish-brown subsoil characteristic of Tama soils in eastern Iowa.

Grundy silt loam occurs on the flat interstream divides. The mellow silty surface layers are not greatly different from the corresponding layers of Muscatine silt loam. The color is almost black, being slightly darker than the Muscatine soil. Below a depth of 17 inches the influence of poor drainage can be seen. The broken surface of the very granular soil mass is dark, but when a clod is sliced the dark color is found to be caused by a coating over the brown or rust-brown inner material of the granules. The sliced surface has a highly mottled appearance, and the material when powdered is grayish brown. The texture of this layer is heavier than that of the layer above, being silty clay loam or silty clay. This layer is denser and more impervious than the corresponding layers in the Tama soils. Below this layer the color, in general, becomes lighter as the organic coating becomes thinner, and yellow and brown predominate in the sliced surface. The layer between depths of 30 and 42 inches is the toughest and most compact of the profile. The material is grayish brown with dark-colored streaks and tongues of organic matter penetrating downward from the surface layers. Iron stains and concretions also occur. Below this layer the material does not change greatly in color but becomes lighter in texture and more friable. It is similar in appearance to the lower layers of Muscatine silt loam.

On most of the eroded slopes in Union County the surface soil of Shelby loam is dark and is underlain by a layer of dark-brown granular soil. These layers are similar in most respects to the corresponding layers of the Tama and Muscatine soils. The upper subsoil layer, however, is gritty, pebbly, variable-textured soil, mainly sandy clay. Shelby loam has developed from Kansan drift material which has been exposed as the loess mantle has been cut through by drainage ways. The lower part of the subsoil, between average depths of 3 and 5 feet, is much heavier textured than layers at the same depth in the Tama and Muscatine soils. When wet a considerable degree of plasticity exists. No definite columnar structure

²KAY, G. F., and AFFEL, E. T. THE PRE-ILLINOIAN PLEISTOCENE GEOLOGY OF IOWA. Iowa Geol. Survey. 34: 9-304, illus. 1929.

³FORMAN, L. W. RECLAIMING IOWA'S "PUSH" SOILS. Iowa Agr. Expt. Sta. Bul. 191, p. 161-176, illus. 1919.

has developed as in the lower part of the heavy layer of Muscatine silt loam. Below this layer the texture and composition of the material varies with that of the parent drift.

Another soil series of the group having well-drained dark-colored surface soils is the Waukesha series. The silt loam only is mapped in Union County. This soil is developed from old alluvial deposits on terraces lying above the stream flood plains. The soil-forming agencies have accomplished much the same results with this alluvium as with the loess on the uplands, and the resulting soil is essentially similar to the Tama soils. The structure profile of the Waukesha silt loam is, however, not so well differentiated as that of the Tama soil, and granulation is not so nearly perfect.

The Bremer soils belong to the group of soils which have weathered under poor drainage. In most places the dark color of the surface soil continues to greater depths than in the Grundy soils. The heavy layer of the Bremer soils is not so highly mottled, and the breakage surfaces are darker gray than in the Grundy soils, but in texture and structure this layer is essentially like that of the Grundy soils. No carbonates occur in the soil profile. The reaction varies from slightly to strongly acid, the third layer being generally the most acid. The acidity in the lower layer is very slight or lacking. The Bremer soils occur on second bottoms above the normal flood stage of the streams. They are formed from water-laid deposits of silts and clays which were laid down at stages of very sluggish flow. The surface soils are black and are thicker than those of the upland soils. The subsoils are gray or mottled and show the influence of excessive moisture.

The Chariton soils belong to the group of dark-colored soils. The surface soil is very dark grayish brown or black and is underlain at a depth ranging from 6 to 10 inches by light-gray floury silt loam. Below this is very tenacious plastic clay which becomes tough and impenetrable when dry. The Chariton soils occupy terraces similar to those on which the Bremer soils occur. Surface drainage is about the same as that of the Bremer soils but internal drainage is poorer because of the more impenetrable layer in the subsoil. The gray soil layer seems to be developing under a condition of excessive moisture at that particular depth in the soil. Small depressed spots in areas of Chariton soils commonly show this distinct gray color in the surface soil. The association of the gray color with small spots which are water-logged or on which standing water occurs is of common knowledge to the farmer. The local term for the depressions is "buffalo wallows."

The Wabash series includes the dark-colored alluvial soils of most recent deposition occurring on the flood plains of the main streams. Much of the alluvium as first laid down was composed of sediments from the already darkened surface soils of the watershed areas. Some additional incorporation of organic matter has no doubt taken place at the surface, but this has been insufficient to account for the dark color to the depth to which it occurs in the Wabash soils. The structure profile of the Wabash soils is poorly defined, the soil being granular to a considerable depth in places, but the granules as a rule are not well formed. The typical soil is friable throughout. Layers of distinct compaction occur only where layers of various textures have been deposited by the streams.

The second major group of soils includes soils of the Clinton, Lindley, Jackson, and Calhoun series. These soils are differentiated from the soils already described by the light color of their surface soils. All except the Calhoun soils have weathered under good drainage which has favored rather thorough aeration and leaching. The light color of the surface soils, or rather the absence of a dark color, is a result of the influence of the forest vegetation under which soil development has taken place. The light-colored soil areas formerly supported or still support a hardwood timber growth with only a scant grass growth on the forest floor. The roots penetrating the upper soil layer have been largely of a woody character, more resistant to decay and yielding much less black organic matter than grass roots.

A profile of Clinton silt loam observed in the SE. $\frac{1}{4}$ sec. 20, T. 72 N., R. 28 W. is described in the following paragraph.

The first layer consists of about a 2-inch layer of dark grayish-brown silt loam held together by grass roots and containing partly decomposed leaves, leaf mold, and raw humus. The second layer, occurring between depths of 2 and 10 inches, consists of rather dark grayish-brown or yellowish-brown mellow silt loam. A few dark-brown or dark grayish-brown stains or streaks occur in this layer owing to impregnations of organic matter from the surface. The soil material has a fragile and very fine granular structure and is easily shattered into single-grain soil particles. Thin laminae appear very faintly defined in the structure mass. The soil of the third layer, which occurs between depths of 10 and 16 inches, is grayish-brown granular friable silt loam. The granules are of various sizes, ranging from very fine to medium, and they are moderately firm. The surfaces of some of the granules are thinly coated with gray, but the interiors are grayish brown or light yellowish brown. The fourth layer, between depths of 16 and 31 inches, is heavy silt loam. The material breaks up into fine or coarse structure particles which are irregular in shape but have a slight tendency toward cubical blocks with angular edges. On drying, they are rather firm and resistant to breaking. The soil mass when wet is very slightly plastic. The fifth layer, occurring between depths of 31 and 62 inches, is heavy silt loam or silty clay loam having a distinctly columnar structure. The columns are rather easily broken along distinct horizontal cleavage lines. This material when dry is rather hard and is more compact than that of the other layers. When wet it is moderately friable and only slightly plastic. Below a depth of 62 inches the material is very friable structureless silt loam which is soft when wet. The color is light yellowish brown stained with gray, rust-brown, and black iron stains. The black stains are large and are more numerous than in the layer above. With depth the less-weathered soil shows only slight changes in texture and color. The texture, which is that of the loess deposits from which the overlying material has developed, ranges from silt loam to very fine sandy loam. The weathered soil material contains no lime. The Clinton soils are usually more acid than the Tama soils, but the soils of both series are less acid in the lower soil layers than in the second, third, and fourth layers.

The differences between the soil profiles of the Jackson and the Clinton soils are practically the same as the differences between the soil profiles of the Waukesha and the Tama soils. In the granular structure horizon of the Jackson soils the granules are less firmly formed than in the same horizon of the Clinton soils, and the layer below the granular horizon in the Jackson soils lacks the degree of compactness and the perfection of columnar structure present in the same layer of the Clinton soils. The Jackson soils have developed over terrace materials under good drainage and under the influence of a forest vegetation.

The soil profile of the Lindley soils differs from that of the Clinton soils in the same essential respects that the profile of the Shelby soils differs from that of the Tama soils in the dark-colored well-drained soil group. Between average depths of 3 and 5 feet the Lindley soils are more variable but of heavier average texture than the Clinton soils. When wet the Lindley soils are more plastic than the Clinton soils. When dry the structure masses into which the soil material breaks apart are of irregular shape rather than columnar as in the Clinton soils and are much tougher and more resistant to breakage. The less weathered substratum of the Lindley soils consists of the variable-textured Kansan drift, whereas that of the Clinton soils is a uniform-textured loess. In Union County this loess occurs on practically all upland divides. The Lindley soils occur only on slopes where the underlying drift has been exposed by erosion. The Lindley soils contain no lime to a depth ranging from 4 to 6 feet. Below this depth large white spots and streaks of lime such as occur in the Shelby soil substratum are common. The weathered soil ranges from slightly acid to strongly acid. The third, fourth, and fifth layers are generally the most strongly acid, and the two lower layers are but slightly acid.

The soils of the Calhoun series have light-colored surface layers but have been weathered under poor drainage. The features of the soil profiles of the Calhoun soils are very similar to those of the Chariton soils except that the Chariton soils have dark-colored surface soils. The gray subsurface soil layer is characteristic of soils of both series and denotes that each soil has been weathered under conditions of permanent water-logging at the depth of the gray layer. The light-colored surface soils of the Calhoun soils have developed under a native growth of hardwood timber, whereas the prairie vegetation on the Chariton soils has produced darker-colored surface soils.

The above grouping of soils on the basis of dark or light surface soils and on the basis of characteristics produced by good or poor drainage is a grouping relative to the features of the soil profile without any reference to the origin or parent material. On the basis of origin the parent materials of these soils can be placed in four groups: Kansan drift, loess, old alluvium, and recent alluvium. The Lindley and Shelby soils are weathered from Kansas drift; the Tama, Muscatine, Grundy, and Clinton soils from loess; the Chariton, Calhoun, Jackson, Waukesha, and Bremer soils from old alluvium; and the Wabash soils are of recent alluvial deposition.

SUMMARY

Union County is in the southwestern part of Iowa. This section of the State is well developed agriculturally and has good transportation facilities and excellent markets to handle the staple farm products. The land is gently rolling or rolling. Small patches or strips of timber occur along the main stream valleys, but the great expanse of the county is a prairie dotted with planted groves about the farmsteads.

The county is drained by Grand and Platte Rivers and their tributaries. All but the main stream channels have periodic flow.

From the time of first settlement agriculture has been the main industry of the county. General farming of a type combining grain and livestock production is practiced.

The average frost-free season is 165 days. The mean annual rainfall is 34.05 inches, and this is usually well distributed during the growing season. The mean summer temperature is 74.1° F. and the mean winter temperature 24.3°.

Corn and oats are the main grain crops grown. When market prices are favorable, wheat and barley are grown on a considerable acreage. Little rye is planted. The hay lands are practically all in tame-hay grasses, principally clover and timothy mixed or alone. Small but steadily increasing acreages of alfalfa and sweetclover are grown. The most important livestock industry is the fattening of hogs and cattle for market. Dairying is a side line on most farms. Mutton and wool production is engaged in on about one-fourth of the farms. Practically every farm has a small steady income from poultry products. Colt production is sufficient to keep a good type of work animals on the farms.

The soils of the county may be grouped into two large groups, one group having dark-colored and the other light-colored surface soils. Each of these groups may be further subdivided into well-drained soils and fair or poorly drained soils. Of the dark-colored soils the Tama, Shelby, and Waukesha soils have good drainage, the Muscatine soils have slow drainage, and the Grundy, Bremer, Chariton, and Wabash soils have poor or deficient drainage. Of the light-colored soils the Clinton, Lindley, and Jackson soils have good drainage, and the Calhoun soils have fair or poor drainage.

The dark-colored soils are recognized as more productive than the light-colored soils.

Manure is practically the only material used to maintain soil fertility. The soils are prevailing acid and need liming for such crops as alfalfa and sweetclover.



[Public Resolution—No. 9]

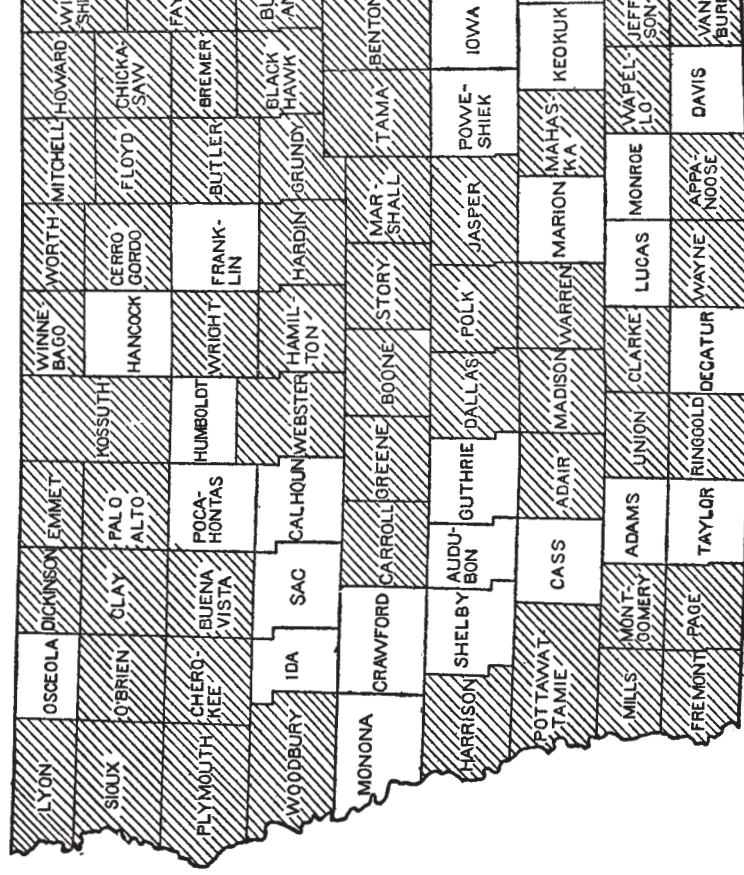
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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

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

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Iowa, shown by shading

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