

SOIL SURVEY OF ANDREW COUNTY, MISSOURI.

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DESCRIPTION OF THE AREA.

Andrew County is situated in northwest Missouri. The southern boundary is approximately 4 miles north of St. Joseph and 50 miles north of Kansas City. For a short distance the southwestern part of the county borders on the Missouri River, which forms the State boundary. The main channel of the river, which at present (1921) is east of the area known as Cat Island, formerly was west of the island.

The county has a length from north to south of 21 miles and a maximum width of 24 miles. It has an area of 435 square miles, or 278,400 acres.¹

Andrew County has two topographic divisions, a thoroughly but not deeply dissected upland, which constitutes the principal part, and numerous but not very broad stream flood plains.

The uplands range from nearly level to undulating, rolling, and hilly. Only a very small part would be classed as rough or broken. The most nearly level part, known as Empire Prairie, extends from near the northeast corner southward almost to the county line. The southern part of this, however, is more or less dissected by Muddy Creek and its small tributaries. The divide between the Platte and One Hundred and Two Rivers is a smaller upland area of more rolling topography, which is widest and best developed in the northern part around Rea, and in the southern part is somewhat dissected by Long Branch and its tributaries. A third undulating region lies between the One Hundred and Two and Nodaway Rivers. This upland, a part of which is known as North Prairie, extends from the county line a few miles west of Bolckow southward nearly to Savannah, one part reaching southwest to Fillmore. The rest of the upland is rolling and hilly. Extending back from the Missouri and lower Nodaway River Valleys is a belt of distinctly hilly country 3 to 5 miles wide. In general, there is a gradation in topography from the nearly level northeastern to the hilly southwestern part of the county.

In the northern and southeastern parts the uplands in many places merge into the flood plains of the larger streams by long, very gentle slopes, so that the boundary between upland and lowland is indistinct. The best examples of this are along the Platte River west of Cawood



Fig. 29.—Sketch map showing the location of the Andrew County area, Missouri.

¹The areas given in this report are approximate, being based on planimeter measurements.

and the One Hundred and Two River near Bolckow. Through the central part of the county from east to west the valleys are narrow and the adjacent slopes much steeper. The small streams of these upland regions usually occupy narrow V-shaped gullies, which are bordered by broad, shallow valleys or valleylike depressions. In general the larger streams occupy fairly deep, well-defined valleys, usually bordered by a steep slope on one side and by a much more gradual one on the opposite side. Along east or west flowing streams the steep slope is in most places on the south side of the stream, facing north. The upland in most places is undulating or gently rolling away from the streams but becomes more hilly as the steeper slopes of the larger streams are reached. Few of these slopes are too steep for cultivation, although in places rock outcrops and ledges prevent their use for cultivated crops.

The Missouri River flood plain is bordered by a very steep bluff, 100 to over 150 feet in height, and marked by rock outcrops in many places. The adjacent upland is thoroughly dissected with numerous small, deep valleys and steep, rounded, loess-covered hills.

The general slope of the country, as indicated by the drainage, is toward the south. The elevation of the Burlington depot at Amazonia, on the higher part of the Missouri River flood plain, is 832 feet above sea level. The Burlington depot at Savannah, situated near the crest of the divide between the One Hundred and Two and Missouri Rivers, is 1,087 feet. Rea and Helena, both on higher parts of the upland, have elevations of 1,069 and 1,054 feet, respectively. The streams have a maximum fall of about 250 feet within the limits of the county. The greater part of the fall is in the small streams within distances of a few miles; the larger streams have almost reached base level, that is, the level of the Missouri River flood plain, as indicated by their broad valleys and wide-swinging meanders.

The entire drainage of the county is into the Missouri River, principally through the Platte and One Hundred and Two Rivers, which flow entirely across the county, and the Nodaway River, which forms the western boundary. Only a few of the larger tributaries flow throughout the year. Drainage ways reach into every part of the county, and all sections of the upland have good surface drainage or can easily be provided with outlets for the drainage waters.

The three largest streams meander through broad, nearly level flood plains, which they frequently overflow. Recently, however, the Nodaway River has been diverted into a new and much more direct channel made by dredging, and the valley lands, especially in the upper part of its course, given considerable protection. Drainage districts have also been organized covering parts of the valleys of the One Hundred and Two and Platte Rivers.

Some water power has been developed at Rochester, on the Platte River, and at Rosendale, on the One Hundred and Two River.

Andrew County is a part of the Platte Purchase, arranged by the Federal Government with the Indians in 1836. It was organized as a county in 1841. The early settlers came largely from the older settled parts of Missouri, from Kentucky, Virginia, Tennessee, and from the Carolinas. There were also some settlers from the northern and eastern States and from Germany. A small colony of Swiss settled near Amazonia.

The population in 1920 was 14,075, all of which is classed as rural, there being no towns of 2,500 or more inhabitants. Approximately 4,000 live in towns and villages. Of the population actually living on farms, there is approximately one person for each 27 acres, or, considering the entire population, there is one person for each 19 acres. The farming population is most dense in the southern and southwestern parts of the county and least dense in the northern and northeastern parts. The population of the county as a whole is over 3,000 less than in 1900 and over 2,000 less than in 1880.

Savannah, the largest town and county seat, had a population of 1,831 in 1920. Helena, Bolckow, Cosby, Amazonia, Rosendale, and Rea are small but important railroad towns. Fillmore and Whitesville are prosperous inland towns, the centers of good farming communities.

Andrew County is well supplied with railroads. The main line of the Chicago, Burlington & Quincy from Kansas City to Omaha and branches of this system, and the Chicago Great Western give direct access to all the principal markets of the Central States. A branch of the first-named system extends north and south near the center of the county, connecting with the main lines leading to Chicago, Omaha, St. Joseph, Kansas City, and St. Louis. An electric inter-urban links Savannah and St. Joseph, with connections to Kansas City.

Andrew County has no hard-surfaced roads, but has a good system of earth roads. The majority of these are well graded and kept in good condition by dragging. Telephone lines and rural free delivery of mail reach practically every homestead.

St. Joseph, 4 miles south of the southern boundary of the county, is the principal market for all farm products. Hogs, sheep, and cattle in large numbers are hauled there in trucks. Some livestock is loaded at railroad points in the northern part of the county and shipped by rail to St. Joseph, Kansas City, St. Louis, and Chicago. Cattle for feeding are bought principally on the Omaha, St. Joseph, and Kansas City markets. St. Joseph is the principal market for garden truck, small fruit, and apples. Poultry and poultry products are handled largely through the local merchants and shipped to various markets. Cream is handled in the same way and shipped to Omaha, St. Joseph, or Des Moines. Alfalfa hay is shipped principally to Kansas City. Watermelons and potatoes are sold chiefly in the local towns. Wheat is marketed through the local elevators and mills. Corn for feeding cattle is shipped into the county from other parts of northwest Missouri and from Iowa.

CLIMATE.

The climate of Andrew County, like that of all northwestern Missouri, is temperate and well suited to general farming and livestock raising. Serious injury to crops or stock from extremes of climate is of rare occurrence.

There is no Weather Bureau station in Andrew County, but the records of the station at St. Joseph are believed to be representative. The mean annual precipitation at St. Joseph, according to records covering a period of over 40 years, is 32.7 inches. This is well distributed throughout the year. The heaviest precipitation occurs

during the months of May, June, and July, when most needed. Some injury to crops in the spring occasionally results from excessive rains followed by a few weeks of very dry weather, and periods of drought during July and August sometimes cause diminished yields. Injury from both causes may to some extent be avoided by proper drainage and the conservation of soil moisture by means of deep plowing followed by thorough cultivation. Serious injury or total loss of crops in the larger stream bottoms through overflow has been common.

The average date of the last killing frost in the spring, as recorded at St. Joseph, is April 15, and that of the first in the fall is October 13. The latest killing frost recorded in the spring occurred on May 1, and the earliest in the fall, September 26. The average growing season is 181 days. This is ample for maturing all ordinary farm crops and permits the growing of a crop of cowpeas or soybeans following a crop of wheat or early potatoes. Alfalfa is cut three and occasionally four times during the season. Bluegrass often affords excellent pasturage until late in November. Fruit is sometimes injured by a heavy frost following warm weather early in the spring, but the crop is rarely a total failure from this cause. Losses are more often due to lack of proper care than to unfavorable climatic conditions. Corn is at times injured by hot dry winds during July and August, and young clover frequently suffers from drought after the wheat, with which it has been sown, is cut.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation as recorded at the Weather Bureau station at St. Joseph:

Normal monthly, seasonal, and annual temperature and precipitation at St. Joseph, Buchanan County.

(Elevation, 967 feet.)

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1901).	Total amount for the wettest year (1877).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December	29.9	66	-13	1.11	1.37	2.36	4.2
January	28.1	63	-24	1.11	.88	.55	4.3
February	29.8	71	-16	1.34	1.19	1.11	9.1
Winter	28.6	71	-24	3.56	2.94	4.02	17.6
March	42.3	89	-4	2.01	3.30	3.99	5.4
April	53.8	93	24	2.87	3.68	5.00	.2
May	61.5	96	35	4.34	1.31	7.50	T.
Spring	53.5	96	-4	9.22	8.29	16.49	5.6
June	73.9	104	46	4.68	1.03	12.35	.0
July	79.2	106	53	3.88	1.18	4.32	.0
August	77.4	109	46	3.66	1.73	6.32	.0
Summer	76.8	109	46	12.22	3.94	22.99	.0
September	68.7	102	32	3.35	2.16	5.47	.0
October	56.3	89	20	2.60	2.05	5.99	T.
November	44.4	82	5	1.75	1.15	2.17	.3
Fall	56.5	102	5	7.70	5.36	13.63	.3
Year	53.9	109	-24	32.70	20.53	57.13	23.5

AGRICULTURE.

Since the early settlement there have been no very striking changes in the principal agricultural products of this region. The leading crops then, as at present, were corn, wheat, oats, and grasses of various kinds for hay and pasturage. The raising and feeding of livestock has always been an important part of the agriculture.

Numerous minor changes have, however, taken place. Before the Civil War tobacco and hemp were important crops. Hemp was grown for home use and tobacco for home use and for the market. The growing of tobacco on a commercial scale was revived for a short time between 1909 and 1912, but has since been almost entirely abandoned, and hemp is not grown at all. Immediately after the Civil War cotton was grown to a very small extent for home use. Barley and rye were formerly more important crops than at present. Clover was grown to only a small extent by the early settlers, but for many years has been one of the more important crops of the county. Apple growing, especially in the southwestern part of the county, has gradually become a considerable industry.

The agriculture of Andrew County as a whole now consists largely of stock raising and grain farming, in which nearly all grain except wheat is marketed in the form of livestock or livestock products. Some attention is given to dairying, poultry raising, and the growing of apples, small fruits, truck crops, alfalfa, potatoes, and a few minor crops. Corn is the most important crop in all parts of the county and it is especially important in the northeastern part of the county where stock raising dominates. In the central part a larger acreage is devoted to wheat and other staple crops. In the southwestern part fruits, berries, garden truck, alfalfa, and melons are important products. Among the more notable recent changes in the agricultural system, are the introduction and rapidly increasing acreage of alfalfa, the extension of the dairy business into all parts of the county, the development of the small-fruit industry in the southwestern part, and the very great increase in poultry raising.

The table below shows the acreage and production of the leading crops in the county, as reported by the Federal census:

Acreage and production of leading crops in 1879, 1889, 1899, 1909, and 1919.

Year.	Corn.		Wheat.		Oats.		Hay.	
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Tons.</i>
1879.....	64,779	2,723,745	29,603	291,717	9,888	254,728	13,189	17,449
1889.....	70,624	2,975,362	13,176	237,029	12,490	375,709	29,460	49,206
1899.....	88,402	3,083,710	4,321	45,060	8,543	211,960	30,113	56,208
1909.....	80,726	2,413,559	9,004	160,079	7,782	188,174	28,347	49,296
1919.....	61,904	2,062,128	34,912	525,603	6,587	135,231	26,145	49,201

From this table it will be seen that corn has steadily occupied the largest acreage. In 1919 it was grown on about 22 per cent of the area of the county and on nearly 29 per cent of the improved land in farms. The average yields of corn in Andrew County for the 10 years from 1911 to 1920, inclusive, as reported in the Missouri Farm Review for 1920, have ranged from 16 bushels to 39 bushels per acre, the average for the 10-year period being 29.4 bushels.

The acreage of wheat has been much more variable than that of corn. The change from corn to wheat in 1919 was due to war demands; since then the trend has been back to corn. The average yields of wheat for the 10 years from 1911 to 1920, inclusive, according to the Missouri Farm Review for 1920, have ranged from 15 to 25 bushels, the average yield for the 10-year period being 19.1 bushels per acre.

The acreage of oats has been fairly constant. As reported by the Missouri Farm Review for 1920, the yields of oats for the 10 years from 1911 to 1920, inclusive, have ranged from 23 to 47 bushels per acre, the average yield for the 10-year period being 30.1 bushels.

The hay crop in 1919 was made up as follows: Timothy alone, 4,184 acres, 7,719 tons; clover alone, 4,777 acres, 9,873 tons; timothy and clover mixed, 7,857 acres, 13,555 tons; alfalfa, 6,187 acres, 13,835 tons; other tame grasses, 445 acres, 725 tons; wild grasses, 442 acres, 657 tons; small grains cut for hay, 2,226 acres, 2,802 tons; annual legumes, 27 acres, 35 tons. In addition to the hay crop, there were 826 acres of silage crops reported for 1919, and 6,236 acres of coarse forage, principally corn. Alfalfa has shown the most striking increase in acreage of any farm crop; it occupied 16 acres in 1899, 878 acres in 1909, and 6,187 acres in 1919, and the plantings have been enlarged in more recent years.

Of the minor field crops, rye was grown on 522 acres in 1919, yielding 4,556 bushels; barley, 294 acres, 4,197 bushels; potatoes, 1,037 acres, 43,146 bushels; sweet potatoes, 97 acres, 12,708 bushels; and sorgo, 252 acres, yielding 14,571 gallons of sirup.

The production of fruits in 1919 was reported as follows: Apples, 66,824 trees of bearing age, yielding 102,597 bushels; peaches, 15,600 trees, 299 bushels; pears, 6,759 trees, 12,378 bushels; plums, 4,950 trees, 1,902 bushels; cherries, 7,871 trees, 5,100 bushels; grapes, 129,828 vines, 801,820 pounds; strawberries, 43 acres, 66,056 quarts; blackberries and dewberries, 20 acres, 20,039 quarts.

The value of the agricultural products for 1919, as reported by the census of 1920, follows: Cereals, \$4,350,988; other grain and seeds, \$19,092; hay and forage, \$1,301,754; vegetables, \$331,236; fruits and nuts, \$363,338; all other crops, \$19,396; dairy products, excluding home use, \$453,570; poultry and eggs, \$667,010; wool and goat hair, \$35,601. The value of domestic animals sold or slaughtered, which was not reported by the census, amounted to a large sum.

During the progress of the soil-survey work information was collected from 25 farms well distributed over the county and representing a total of nearly 5,000 acres. According to this information an average farm of 160 acres would have $37\frac{1}{2}$ acres in corn, 26 acres in wheat, $16\frac{1}{2}$ acres in oats, 60 acres in pasture, 13 acres in clover, 5 acres in alfalfa, one-third acre in potatoes, and 1 acre in orchard. Each 160-acre farm would also have 5 head of horses or mules, 7 milk cows, 14 other cattle, 89 hogs, 10 sheep, and 190 chickens. Corn is an important crop on all of these farms. Clover is grown on over 90 per cent of them, wheat on 80 per cent, oats on 80 per cent, and alfalfa on over 60 per cent. Work animals, milk cows, other cattle, hogs, and poultry are raised on every farm, but sheep on only a few.

The estimated yields of crops on these 25 farms for the last five years or more is corn 38 bushels, wheat 20, oats 33, and potatoes 88 bushels per acre. Soybeans are or have been grown on only 6 of

these farms, and lime is used on none of them. About half of these farmers believe their soils are more productive than they were 20 years ago. The rest report that their productiveness is about stationary or has decreased.

The most common rotation used is corn, oats, wheat, clover. This, or a variation of it, is used on practically all farms. The most common variation consists in extending the corn period to 2, 3, or 4 years, usually 2 years. Sometimes it is varied by omitting either the wheat or oats, wheat being omitted more often than oats. Another variation consists in mixing timothy with clover.

Reid Yellow Dent corn is grown on nearly 80 per cent of the farms; Iowa Silvermine, Boone County White, and St. Charles White are grown on a few. Texas Red oats are grown to a greater extent than any other variety.

In this region there is a rather close relation between topography and soil and therefore between topography and crops. Considering the county as a whole, the more hilly parts are used for diversified farming, the more level parts largely for corn and grass, and those parts having an intermediate topography also have intermediate cropping systems. The same relation, but less marked, prevails locally and even on individual farms. The smoother uplands, which have the stronger soils, are used most extensively for corn. The more broken areas, in which the soils are less productive, are used to a larger extent for pasture and grassland. The residual limestone soils, however, even on steep slopes, on account of their higher lime content, grow clover, sweet clover, and alfalfa better than do some of the more nearly level soils.

The soils commonly recognized as being best suited for corn are the deep, dark-brown or black, upland soils, and the recently deposited soils of the stream bottoms. The latter include the entire bottoms of the small streams and the lighter textured soils of the larger valleys. The soils commonly recognized as being the best wheat soils are light-brown upland soils near the Missouri River and the darker brown forest soils of the central part of the county. These are also best for clover and alfalfa. The heavy or "gumbo" bottom soils are also better for wheat than corn, as are the terrace soils having a gray subsurface layer and heavy subsoil. The light-brown upland soils are recognized as being the best for apples, small fruit, and truck crops. The more nearly level dark-colored upland soils with heavy subsoil and the heavy first-bottom soils are poorly suited to alfalfa, and on them clover does not reach its best development. The soils of light texture in the first bottoms are well suited to alfalfa, melons, and garden truck.

Land is usually plowed to a depth of 5 to 7 inches for corn and to a somewhat shallower depth for wheat. Three-horse or four-horse plows are used in breaking, and the seed bed is prepared with disk harrows. Tractors are used to some extent in plowing and preparing the ground, but are not in general use.

Probably more than three-fourths of the corn is listed or "double listed." Listed corn receives one or more cultivations with a small wheelless disk cultivator called a "go-devil." Later cultivations are with the ordinary 2-horse disk or shovel cultivator. Corn planted on level ground is frequently check-rowed and cultivated both ways.

Corn receives 3 to 5 cultivations, and many farmers cut the weeds out by hand after the last cultivation.

Small grains are cut with a self-binder and usually threshed from the shock, though, when the acreage is small, stacking is often necessary. Hay for home use is stored in large barns. Alfalfa for the market is baled, principally in the fields as cut, and stored or hauled directly to market.

The typical farm in Andrew County is well improved and equipped. Well-constructed, woven-wire fences and cross fences are common. The houses are modern, with surrounding lawns and shade trees. There is usually a home orchard and carefully kept garden. Other farm improvements include one or more large well-painted barns, hog houses, poultry houses, a garage, and other outbuildings. Many farms have one or more silos. The character of farm improvements seen throughout a large part of the county is shown in Plate XXV, Figures 1 and 2.

Clover, manure, and pasturing with livestock are relied on almost entirely for keeping up the productiveness of the soil. According to the census report for 1920, commercial fertilizer was used on less than 1 per cent of the farms, and the total expenditure was only \$4,526. It is used largely on wheat and on small fruit and truck crops.

Farm labor is largely American. Farm wages range from \$35 to \$40 per month with board. Day laborers receive \$1.50 to \$2 per day, with higher wages during harvest and corn gathering. Many farms are operated without the use of hired labor, except during harvesting.

Farms range in size from a few acres to several hundred acres, although there are not many large farms. The most common size is 160 acres. The average size of farms for the entire county, as reported by the census, was 111 acres in 1920, and the average assessed value of the land was \$155.46 an acre.

Of the 2,334 farms enumerated by the census in 1920, 34 per cent were operated by tenants. The share system is used principally, the ordinary rent being one-half the crop delivered on the farm or at a marketing point.

The range in land prices in Andrew County in 1914-15 and in 1920-21, is shown by the records of land sales on the books of the recorder's office at Savannah. In the fiscal year 1914-15, 31 tracts of land, ranging in size from 40 to 136 acres, well distributed over the county and representing a total of 2,284 acres, were sold at prices ranging from \$40 to \$234 an acre. Of this acreage, 36½ per cent sold for less than \$100 an acre, 48 per cent sold for \$100 to \$200 an acre, and only 15½ per cent for over \$200 an acre. In 1920-21, 32 tracts, ranging in size from 40 to 160 acres, representing a total of 2,249 acres, were sold at prices ranging from \$50 to \$400 an acre. Of this acreage only 13 per cent sold for less than \$100 an acre, 27 per cent sold for \$100 to \$200, 37 per cent sold for \$200 to \$300, and 23 per cent at prices ranging from \$300 to \$400 an acre. Prices have declined considerably since 1921.

This represents land used strictly for agricultural purposes, but much of it with excellent improvements. The very wide range in prices is due to character of improvements, convenience to roads and

markets, and the character of the land itself. Some of the lower priced land is rather rough, some is not very productive, and some is subject to frequent overflow.

SOILS.²

The soils of Andrew County are predominantly dark in color, silt loams or loams in texture, and of high agricultural value. They form a part of an extensive region of dark soils in northwestern Missouri which is included in the Corn Belt.

These soils may be divided into two broad classes: (1) Upland soils and (2) lowland or stream-bottom soils. The upland soils may be further divided according to differences in color profile, and to some extent in the material from which they have been developed; the stream-bottom soils are separated mainly on the basis of color, drainage, and material, having existed too brief a period as soils to show profile characteristics, what zonation does appear being due to deposition and not to changes taking place since deposition.

An examination of the profile (vertical section to a depth of 3 feet) will in this region show three principal variations: (1) A profile of three well-defined layers or horizons; (2) a deep but not sharply zoned profile; (3) a shallow not sharply zoned profile. Each of these is dependent upon differences in the action of weathering and is closely related to the existing topography. Soils of the first class may be considered mature to old in the cycle of soil development, those of the second class as in an intermediate stage, and those of the third class young.

Soils which have remained for a long time in a level or nearly level position tend to develop a profile of three clearly defined layers. The upper layer consists of friable granular soil. Beneath this is a heavier, more compact layer (the subsoil), ordinarily more or less mottled. Below this is material of lighter, more friable texture, usually distinctly mottled. In this region the soil immediately overlying the subsoil is slightly lighter in color and less granular than the surface soil. On the flat prairies of northeast Missouri this layer has a distinct light-gray color and ashy structure. In this soil section the upper layer has been changed in two ways—first, percolating soil water has mechanically carried down and away from it some of the finer material; second, it has dissolved some of the soluble salts and minerals and carried these downward into the subsoil. Thus the upper soil layer has by weathering lost material both chemically and mechanically, the underlying subsoil has received material, and the third layer has remained practically unchanged, being incompletely decomposed parent soil material. Soils having this well-developed profile predominate in the northeastern part of the county. They may be identified in many deep roadside cuts. They also occur on long, gradual slopes adjacent to stream valleys and in places in small areas around the heads of streams.

² Andrew County adjoins Nodaway County on the north, Dekalb County on the east, and Buchanan County on the south. In certain cases the maps of these counties do not appear to agree along the boundaries. This is due mainly to changes in correlation resulting from a fuller knowledge of the soils of the State. The most important of these changes is that a part of the Marshall silt loam as mapped in Dekalb County is now classed with the Pettis silt loam. The Carrington silt loam as mapped in Nodaway County, on account of its small area in Andrew County, is included with the Shelby loam.

It is believed that prairies owe their origin to the development of this profile, which is not favorable for the movement of moisture either upward or downward. Here forest growth could maintain itself during seasons of normal or excessive rainfall, but during seasons of unusual drought it would die out. The difficulty trees had in establishing themselves was also doubtless increased by fires. Although soils having this profile do in places support a forest growth, it is usually where conditions for collecting moisture are more favorable. Such places occur in this region in small areas, and where forested they usually support scrubby oaks, which are able to survive under adverse conditions.

In areas of undulating to rolling topography the movement of soil water is not only downward but also lateral. The subsoil layer is developed, but usually at somewhat greater depth. It is also less compact and ordinarily not mottled. No indication of a gray layer is found overlying it. The soil is well drained and thoroughly oxidized. Large areas of soil of this kind lie south and southwest of the soils having the well-developed profile.

On very steep slopes and where the underlying material is hard, so that the soil erodes as fast or nearly as fast as formed, the heavy subsoil layer is not distinctly developed. Its upper surface is rarely sharp, and in places the overlying soil is shallow. Soils having a profile of this kind are found on the steep slopes bordering the larger streams within the county. Here the shale or limestone comes very near the surface, and the soil is formed at about the same rate at which it is being eroded. The same process is going on in the gray-brown or buff soils of the river hills, but is there less noticeable because the parent loess material and the soil formed from it are so nearly identical.

In color the soils of Andrew County may be divided into dark-colored soils and light-colored soils. The dark-colored soils may be further divided into very dark brown to black and brown to dark brown.

The dark color in soils is related to the content of decaying organic matter; soils which have supported a heavy growth of grass for long periods of time are commonly high in this constituent and consequently dark in color. This is well illustrated by the prairie soils of this region, all of which are very dark brown to black.

Soils which have supported an open hardwood forest which has not inhibited a growth of grass, though less luxuriant than on the open prairies, tend to be dark brown. Soils of this color predominate through the central part of Andrew County.

Where soils have been heavily forested they are in general light in color. Light color also may be due to rapid erosion of the surface, in which case the soil has no opportunity to accumulate organic matter. Soils of this kind are found adjacent to the streams where the slopes are steep and on the hills adjacent to the Missouri River Valley.

The soils of Andrew County have been formed by the action of soil-forming agencies on materials of three different kinds or from three different sources. These are residual, glacial, and loessial.

Residual soils are formed by the weathering of the native rock beds that underlie the county. The rock beds nearest the surface

in this region consist of shale and limestone, with some sandstone. The shale is usually light brown, drab, bluish or greenish gray in color, but in some places it has a pink or purplish tinge. Upon exposure to the weather it breaks down very quickly, thus forming a soil that covers the rock from which it has been formed, so that the shale itself is seen only in gullies and recently cut stream or roadside banks.

In places thin beds of light-brown to gray, fine-grained, soft sandstone are closely associated with the shale. These are not uniform in thickness, but occur in beds or broad lenses which are a few feet thick in places but thin out or are entirely wanting in others. Like the shale, the sandstone breaks down into soil very readily and is rarely seen except in cuts or on very steep slopes.

Closely associated with the shale and sandstone are beds of limestone of varying thickness. The greater part of this rock is light gray to light brown, rather fine grained, and fossiliferous. In the northwestern part of the county and in the extensive stone quarries near Amazonia more massive beds are exposed. Owing to the resistance of the hard limestone to weathering, it is found either as rock fragments or as outcrops and ledges on nearly all the steeper slopes occupied by residual soils.

These various rock beds are nearly horizontal, dipping or tilting very slightly to the northwest. Before they were eroded into their present form they were continuous, the beds now found in one hill slope being a continuation of those found on the opposite slope. Geologically they are a part of the Upper Coal Measures. The areas of residual soil in this region are not extensive. They are confined principally to the steep slopes bordering the large valleys.

All of Andrew County has been glaciated. The ice brought in an immense mass of foreign boulders, pebbles, gravel, and finer material and this was thoroughly mixed with material derived from the local rock formations. This heterogeneous till now varies in thickness from zero to 60 feet or more, and is apparently thickest in the southeastern part of the county, thinning out toward the north.

Soils of glacial origin are developed in nearly all parts of the county. They occupy the slopes between the prairie soils or the silty soils of the divides on the one hand and the stream-bottom or residual soils on the other. They are readily recognized by their sandy or loamy texture and by the foreign material which they carry.

The hills adjacent to the Missouri River valley are covered by a deposit of grayish-brown or buff silty material known as loess. Where cut into by streams and roads the loess stands up in vertical banks, resisting erosion to a remarkable degree; but where gullies are allowed to start they erode rapidly, soon becoming deep V-shaped gashes. The loess in Andrew County, which is not so deep as in some of the other river counties to the north and south, varies in depth from only a few inches to several feet. In general, it is deepest on the river bluffs and thins out toward the east and north, or away from the river. At the stone quarry near Amazonia it has a depth of about 18 feet. Erosion has had much to do with the present thickness of the loess. In many places the deposit has been almost or entirely removed, exposing at the surface the glacial or residual materials. There are, however, few soils in the area that have not

been influenced and improved by it. It is this deposit over the southwestern part of the county which gives the topography its billowy, rounded appearance.

The higher parts of the uplands and stream divides farther from the river also have a thin layer of silty material above the glacial till, which may or may not be of loessial origin.

In many places it is difficult to determine whether certain soil materials are of residual or of some other origin. This is especially the case on undulating, well-drained slopes which occur at the same level as steep rocky slopes that are clearly residual. In many places the soil of the gentle, deeply weathered slope is almost identical with the soils of the upland overlying glacial till and therefore not of residual origin. However, the origin of the material in this case is not important, as the classification of soils depends primarily on the soil character.

On the basis of the essential differences already discussed, the soils of the region are grouped into soil series. Each soil series consists of a number of soil types that are closely related but differ from each other in the texture or relative coarseness or fineness of the surface soil. The type is the unit of soil mapping.

The Grundy soils are relatively old and have a well-defined profile. The surface soil is dark, being prairie land. The lower part of the soil is slightly gray and the subsoil is heavy and mottled. The series has been developed from loess or loesslike material of the uplands. Only one type, the silt loam, has been mapped in Andrew County.

Corresponding in stage of development to the Grundy soils is a light-gray forest soil with a well-defined heavy subsoil layer. It is of glacial and possibly partly of loessial origin and is classed as the Lindley silt loam. Closely related to this but lacking the profile development is the Lindley loam.

The Marshall soils have been developed both on prairie and on areas of open forest. They range in color from brown through very dark brown to black. They are deep and thoroughly oxidized. The upper subsoil is well but not sharply defined and the mottling is much less pronounced than in the Grundy series. Only one type, the silt loam, is mapped, but this has been divided into the typical Marshall silt loam, which is the dark prairie soil, the brown phase, which developed under open forest conditions, and the shallow phase, which developed under open forest conditions and has been more or less eroded. The Marshall soils are believed to have come largely from material of loessial origin.

Corresponding closely to the brown phase of the Marshall silt loam, but differing from it in origin, is the Pettis silt loam. This is largely derived from shale, or from shale and thin beds of argillaceous limestone.

The Shelby soils, which are of glacial origin, correspond to the soils of this group, since they have the brown color, rolling topography, and not sharply defined upper subsoil layer. The loam and the clay loam are mapped in Andrew County.

On the colluvial slopes is the Judson silt loam, which to a depth of nearly 3 feet resembles the surface soil of the Marshall silt loam.

Of the young soils, the most important is the Knox silt loam, the grayish-brown or buff loess soil of the hills adjacent to the river. On account of the similarity between this soil and the underlying soil material, it is difficult to appreciate its constant formation and erosion. The Knox silt loam is the only type of the Knox series mapped here.

The Mandeville soils are gray, shallow, young soils derived from shale and limestone. There are two types. The silt loam comes largely from shale, but includes some material from thin limestone and sandstone. The stony loam is largely from limestone. Both have been modified by the addition of loess.

Alluvial soils derived largely from material eroded from the dark-colored Marshall and Grundy soils are dark gray to black in color and belong to the Wabash series, represented in this area by the Wabash silt loam, silty clay loam, and clay. Soils of this derivation and color but occurring on a second bottom or terrace belong to the Bremer series, of which the silt loam has been mapped. The brown soils of the terraces belong to the Waukesha series, the silt loam being the only type in this area.

Alluvial soils derived largely from wash from the Knox silt loam and from the residual slopes are light brown to gray in color and belong to the Ray series. The Ray silt loam has been mapped.

In the Missouri River flood plain the soil materials have been brought long distances and from many sources. These deposits usually begin as sand bars which are gradually built higher from additional deposits and become thickly seeded with willows. These divert the currents so that later deposits, being from still or slowly moving water, consist largely of very fine sand, silt, and clay. The soil thus formed has a heavy surface soil and a light silt loam or fine sandy loam subsoil. Such soils are dark brown or light brown at the surface and light brown to gray in the subsoil. They belong to the Sarpy series, represented in this area by the very fine sandy loam, silt loam, and silty clay.

The distribution of the different soils is shown on the soil map accompanying this report. The table below gives the actual and relative extent of each soil type mapped:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	55,296	31.3	Sarpy silt loam	2,688	1.0
Shallow phase	17,600		Sarpy silty clay	2,112	.7
Brown phase	14,208		Waukesha silt loam	1,856	.7
Wabash silt loam	41,984	15.1	Riverwash	1,728	.6
Shelby loam	36,096	13.0	Wabash clay	1,664	.6
Grundy silt loam	33,152	11.9	Lindley silt loam	1,472	.5
Pettis silt loam	24,448	8.9	Shelby clay loam	1,024	.4
Knox silt loam	12,928	4.6	Sarpy very fine sandy loam	1,024	.4
Mandeville silt loam	10,944	3.9	Lindley loam	704	.2
Mandeville stony loam	6,656	2.4	Judson silt loam	704	.2
Wabash silty clay loam	3,584	1.3			
Bremer silt loam	3,328	1.2			
Ray silt loam	3,200	1.1			
			Total	278,400

GRUNDY SILT LOAM.

The surface soil of the Grundy silt loam is a dark-brown to black, loose, friable silt loam which becomes slightly heavier with increasing depth. At a depth of 15 to 18 inches the subsoil is a grayish-brown clay loam slightly mottled. This extends to a depth of 24 inches, where the material becomes a distinctly mottled, gray, rather plastic clay. In places the lower part of the 3-foot section has some mottling of light brown, is slightly more friable, and may contain some glacial sand and gravel at the bottom of the section. In most places the gray occurs as mottlings and not as a distinct layer.

Practically all of this type is rolling enough to give good surface drainage. Some of it would be classed as a rolling phase of the type as mapped in Dekalb County.

This type includes two variations. In broad, shallow depressions around the heads of small tributary streams and on long slopes immediately above and often including a part of the small stream valleys, the dark surface soil passes rather abruptly, at a depth of about 15 inches, into a mottled yellow and brown, compact, heavy clay subsoil, locally containing iron concretions. Below 2 feet the subsoil becomes lighter and more friable and in places gray in color. Such areas really belong to the Carrington series as mapped in Nodaway County, but are included with this type because of their small extent. East and southeast of Whitesville an included area has a dark-gray to black surface soil, underlain at about 15 inches by a layer of light-gray silt loam which gives way at about 20 inches to a tenacious somewhat mottled silty clay. The surface is nearly level, resembling in places a high terrace, and part of the area is covered with forest.

Practically all the Grundy silt loam lies east of the Platte River extending from near the northeast corner of the county southward to near Bethel Church east of Cosby. It is the dominant soil in this part of the county. It occurs also in a few small areas on the long slopes bordering the Platte and One Hundred and Two Rivers. It occupies nearly level, undulating, and rolling areas, being most typically developed in the more level parts.

The surface drainage of the greater part of the type is good or may easily be made so by opening ditches and furrows. Owing to the compact clay subsoil the underdrainage is not good, and the type is less drought resistant than the Knox or Marshall soils.

This is an important type agriculturally. All of it is under cultivation, and some of the best improved and best kept farms in the county are on this type. It was originally nearly all in prairie, the principal part of it being known as Empire Prairie.

Corn is the most important crop. Large areas are in bluegrass pasture. Wheat and oats are grown to some extent. Clover is grown occasionally, although much of the type is not very well suited to clover, and it is not the best alfalfa land.

On account of its fitness for large farming operations, this soil is held principally in farms of good size, 100 acres or more, well improved, and used for general farming and stock raising. Corn yields 30 to 50 bushels per acre. Wheat is not as important as on the Marshall

or the Knox soils, but the yield is often almost as large, 15 to 25 bushels per acre. Well-improved and well-located farms sell at about \$200 an acre.

The first steps in improvement of this soil are to increase the nitrogen supply and to correct the acidity. Lime is especially necessary if clovers are to be grown. It should be applied at the rate of 1 to 2 tons per acre once every 4 to 8 years. Much of this land is also in need of phosphates, especially for wheat and clover.

In a number of places, especially along the breaks adjacent to the larger streams that extend into the region covered by this type, there are small areas that are considerably eroded. Here the surface soil is lighter gray than in the typical soil, and the heavy subsoil comes nearer the surface, being reached at a depth of 8 to 15 inches. The lower subsoil is more distinctly mottled with dark brown, and glacial till is more commonly encountered in the deep subsoils. The topography is also more broken and hilly. The principal areas of this occur along the upland on the south side of Hickory Creek, but small areas are found in other places. It is less productive than the main type and much of it is used for permanent pasture.

MARSHALL SILT LOAM.

The surface soil of the Marshall silt loam is a very dark brown to almost black, loose, friable silt loam, which becomes slightly heavier with increasing depth. At about 15 inches it grades into a dark-brown heavy silt loam. At 24 inches this grades into a light-brown very heavy silt loam to silty clay loam, marked with a few splotches of light gray. The color becomes slightly lighter with increasing depth and below 30 inches is mottled with dark brown and gray, and is quite friable. Where exposed to the weather in road cuts and ditch banks, the heavier part of the section from 15 to 24 inches shows upon drying a somewhat columnar structure, which is also noticeable to a less marked degree in the lower subsoil. This structure is shown in Plate XXVI, Figure 1.

This soil has its best and deepest development on the higher parts of the broad, gently sloping divides. Near the large streams and also along the slopes and around the heads of the smaller streams it tends to become shallower, heavier in texture, and usually lighter in color. This variation appears throughout the type.

In the north-central part of the county, around the headwaters of Arapahoe Creek, and in the northeastern part near Hickory Creek, areas of rather rolling topography, in which the soil is dark in color but lacks the depth and productiveness of the better part of the type, have been included.

The Marshall silt loam is the most extensive type in Andrew County. The largest body extends from a point a few miles south of Savannah north to the county line and west to the valley of the Nodaway River or to the rougher region adjacent to the larger streams which empty into it. Another area occupies the larger part of the main upland between the Platte and One Hundred and Two Rivers, being almost continuous across the county from north to south. A third but smaller body occupies the upland east of the Platte River, east and south from Cosby.

The type is undulating to rolling, but none of it is too steep for cultivation, and it is not gullied to any serious extent. Surface drainage is good and underdrainage is also good except where the heavy glacial till comes too near the surface. In such situations poor drainage is indicated by mottling in the soil, and in places seepage water comes to the surface along the slopes.

On account of its extent and productiveness this is the most important type in the county. It was originally covered by a dense growth of prairie grasses. At present it is all under cultivation or in bluegrass pasture. The principal crops grown are wheat, corn, clover, timothy, oats, and alfalfa. A typical wheat field is shown in Plate XXVI, Figure 2. Much of the type is used for bluegrass pasture, for which it is especially well suited. The type as a whole is well improved and used for general farming and stock raising. The revenues come from hogs which are usually raised and fattened on the farm, from cattle which are fed on the farm but may be bought on the market, from cream, poultry, and eggs sold locally, and from wheat. To this may be added the sale of corn from one farm to be fed on an adjacent one, clover seed, wool, potatoes, and a few other minor products. Crop yields on this type range from 35 to over 50 bushels for corn, 16 to 25 for wheat, 30 to 40 for oats, and $1\frac{1}{2}$ to $2\frac{1}{2}$ tons for clover. Alfalfa is not grown to as great an extent as on the brown phase. A little fertilizer is used, principally on wheat.

Three things are needed for the improvement of this soil—an increase in the supply of organic matter and nitrogen, sweetening of the soil by the use of lime, and the checking of erosion. The first can be accomplished by adopting a crop rotation in which corn is grown for not more than 2 years in succession, except on old pasture land, and for only 1 year where the soil is thin; by growing and plowing under more clover and supplementing this by growing soybeans planted in the corn or alone; and by keeping as much livestock as possible and using the manure judiciously.

Examination of samples of this soil show that from 1 to $2\frac{1}{2}$ tons of ground limestone would be necessary to sweeten it and put it in the best condition for clover. Beds of limestone of sufficient purity for agricultural purposes are well distributed through the county and may be found wherever the Mandeville stony loam type is shown on the soil map. The use of ground limestone has in many regions proved valuable, not only in growing the legumes but also in production of other crops.

Control of erosion is the most serious problem on this type. It has a heavier subsoil than the Knox silt loam and is underlain at a shallower depth by glacial till. The heavy subsoil does not take up moisture as well as the Knox subsoil, so that the run-off is greater. As soon as the silty surface soil is removed erosion becomes more rapid, and when the glacial till with its sand and gravel is reached, erosion proceeds at a very rapid rate and soon forms deep gullies. Thousands of small streams have their source in this type. At the head and along the side slopes of each of these streams the change from deep to shallow loessial soil and from shallow loessial to glacial soil is taking place. Each year shows a slight decrease in the area of the Marshall silt loam and a corresponding increase in the area of the less productive glacial or residual soils that underlie it. In some places the soil that is being uncovered is of low crop value.

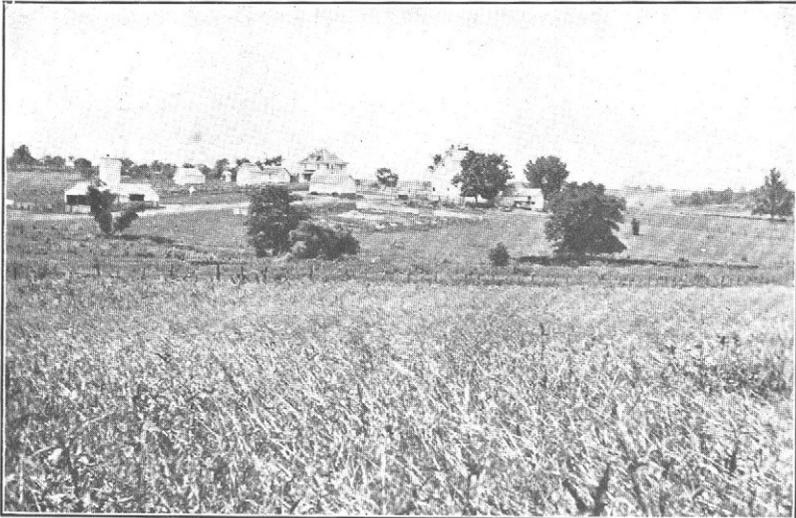


FIG. 1.—GENERAL VIEW OF A FARM IN ANDREW COUNTY.

S. 11065

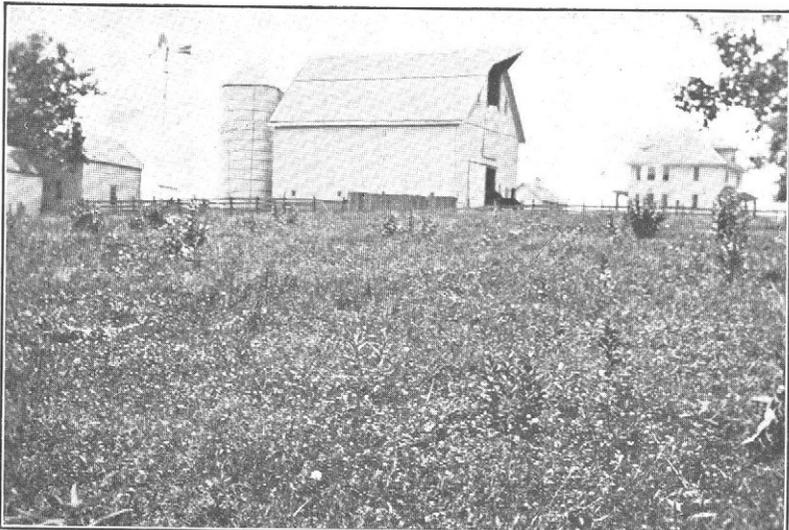
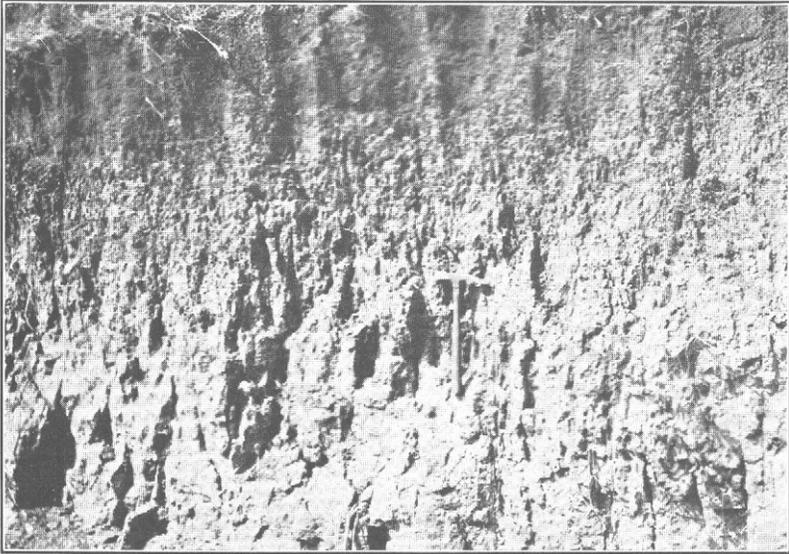


FIG. 2.—TYPICAL BARN AND SILO.

S. 11069



S. 11234

FIG. 1.—COLUMNAR STRUCTURE OF SUBSOIL OF THE MARSHALL SILT LOAM.

The middle of the hammer handle is 3 feet below the surface.



S. 11066

FIG. 2.—WHEAT ON THE MARSHALL SILT LOAM.



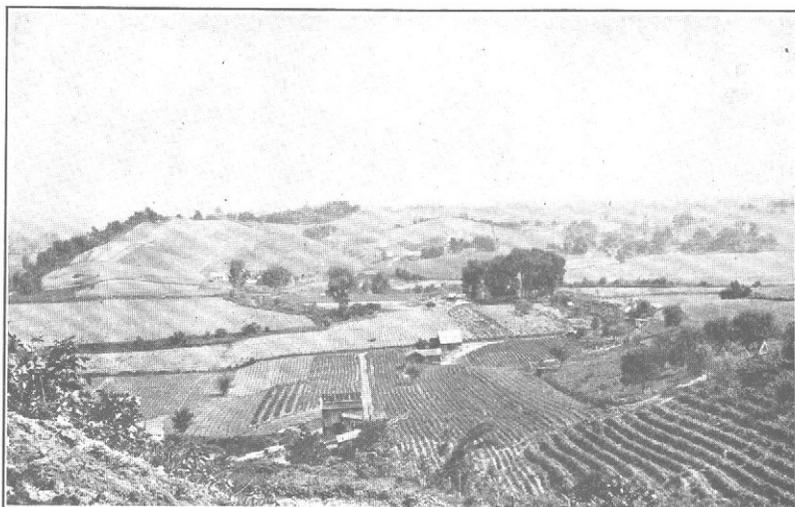
S. 11672

FIG. 1.—OPEN FOREST GROWTH ON THE MARSHALL SILT LOAM, BROWN PHASE.

The trees are mainly walnut, elm, white oak, and bur oak.



FIG. 2.—ALFALFA ON THE MARSHALL SILT LOAM, BROWN PHASE, IN OCTOBER AFTER THIRD CUTTING.



S. 11075

FIG. 1.—CHARACTERISTIC TOPOGRAPHY AND CROPS ON THE KNOX SILT LOAM.

Raspberries in the foreground. Corn, wheat, and other crops in distance.



S. 11074

FIG. 2.—VINEYARD ON THE KNOX SILT LOAM.

Erosion can be retarded by deep cultivation, which enables the soil to readily take up and hold more moisture and thus to decrease or prevent the run-off. The moisture-holding capacity of the soil can be further increased by keeping it well supplied with organic matter from manure and clover or other green-manure crops. Plowing, cultivation, and especially the listing of corn up and down the slopes is aiding erosion more than any other one cause. In each furrow thus placed some of the best soil from the ridges is carried to lower levels by every rain. Level planting and cultivation is less injurious, but the use of the contour method would be even better. By this method the rows are laid off so that they run across the slope at the same or nearly the same elevation. The use of the Mangum terrace is also widely applicable to this soil.

Cover crops of rye and wheat, to be used for winter and spring pasture and then plowed under, check erosion by their root growth and also by the organic matter which their decay adds to the soil. Gullies, as soon as started, should be filled with straw or brush fastened down, partly covered with soil, and seeded to redtop, timothy, and bluegrass. Many large gullies can be entirely filled by the use of concrete dams, but the process is expensive and comparatively slow. Much can be done to check the larger gullies by thickly seeding the bottom and sides with black locust.

Marshall silt loam, brown phase.—The surface soil of the Marshall silt loam, brown phase, is a brown to dark-brown loose, friable silt loam which becomes slightly heavier with increasing depth. At about 15 inches it grades into a slightly lighter brown heavy silt loam to silty clay loam, which has faint markings of gray but no distinct mottlings. Below 25 inches it grades into a light-brown friable silt loam which has a few specks and faint markings of dark brown, but no distinct mottling, and resembles the subsoil of the Knox silt loam. The phase is really transitional soil between the Knox and Marshall.

Four important areas of this phase have been mapped. One extends from Fillmore to a point 1 mile northeast of North Star School; the second and largest is the principal soil on the divide west of Savannah between the streams flowing north into Lincoln Creek and those flowing south into the Missouri River; a third lies along the interurban electric line in the south-central part of the county; and a fourth occurs in the southwestern part of the county, extending from the Washington School south to Dillon Creek. Small areas are to be found in other places, but they are too small to show on the map, and they have been included with the typical Marshall silt loam.

The topography is slightly more rolling than that of the typical soil. The drainage is good. The land was formerly covered with an open forest growth of large elm, basswood, walnut, and hard maple, like that shown in Plate XXVII, Figure 1. At present it is all under cultivation and is generally recognized as one of the best soils in the county for general farming. It produces good crops of clover, alfalfa, corn, and wheat and is excellent bluegrass land. Alfalfa on this soil is shown in Plate XXVII, Figure 2. In crop yields, improvements, and land values it corresponds closely to the best grade of the typical soil.

Marshall silt loam, shallow phase.—The shallow phase of the Marshall silt loam consists of a light-brown to yellowish-brown friable silt

loam, which becomes slightly heavier with increasing depth. Below 15 inches it grades into a slightly lighter brown heavy silt loam to silty clay loam and at 22 to 25 inches into a light-brown friable silty clay loam mottled to some extent with gray and dark brown. This phase is rather variable in color of the surface soil, which ranges from dark brown to light grayish brown. The subsoil as a whole is heavier and more compact than in the typical soil or in the brown phase.

The shallow phase has resulted from erosion of the typical soil and of the brown phase of the type. In a few places where the surface is nearly level and the subsoil heavy and compact, there is a faint suggestion of a gray layer immediately above the heavy layer at a depth of 12 or 15 inches. Small areas of this kind are found in several places on points and the ends of ridges near the large stream valleys. The shallow phase is fairly extensive; it occupies numerous rather small areas throughout the greater part of the region covered by the typical soil. In many places it occurs as narrow strips separating the typical soil from the adjacent glacial soils. In other places it covers the entire surface of ridges, which are prevailing narrow. The topography is slightly more rolling than that of the silt loam. Surface drainage is excessive, but on account of the heavy subsoil the under-drainage is inadequate.

The greater part of the shallow phase is used for the general farm crops. A good deal of it is in bluegrass pasture. It was formerly in forest consisting of bur and red oak, hickory, walnut, and some other varieties. Much of the phase is a very good soil and produces fair yields, but as a whole it is less productive than the Marshall silt loam or the brown phase. The recommendations made for the improvement of the silt loam apply to this phase. It erodes even more readily and every effort should be made to prevent the washing of the fields.

KNOX SILT LOAM.

The Knox silt loam is a light yellowish brown or buff, smooth, friable velvety silt loam. The surface in dry, cultivated fields has a light-gray tint, especially in areas that are flat or lie on ridges that have been subjected to erosion. Where well filled with organic matter, as in forest land or where it has produced a growth of grass for several years, it has a darker color to a depth of 2 or 3 inches. The soil becomes very slightly heavier with increasing depth to about 15 or 16 inches, where it becomes distinctly heavier, being a heavy silt loam to silty clay loam of friable structure. Below 20 to 24 inches the subsoil is slightly lighter and more friable. The color remains nearly uniform throughout the soil and subsoil. Small iron pipes and thin, reddish-brown, slightly cemented bands are occasionally found at depths of 3 to 5 feet. Lime-carbonate concretions are found in places at depths of 5 to 10 feet, but the soil does not effervesce with acid.

Where exposed to erosion the loessial material washes very rapidly, deep cuts or gullies with perpendicular walls forming quickly. The loess deposit in Andrew County is not so thick as in Buchanan and Platte Counties to the south, and the soil as a whole corresponds more nearly to the heavy-subsoil phase of the type mapped in Buchanan County.

The Knox silt loam is the predominating type in a strip extending approximately 3 miles back from the Missouri River bluff line. It is best developed in an area a few square miles in extent, northwest of Amazonia and in a narrow strip extending from Amazonia southward to the Buchanan County line. In these areas it covers hill crest and slope. Farther back from the river and in the region north of Nodaway it is developed principally on the tops of the ridges and in many places is surrounded by areas of residual soil from which the loess has been eroded away. It has a hilly topography with many slopes as steep as can be cultivated with light machinery. It is drained by numerous branching small streams; consequently it is divided into many small fields unsuited for general farming. The topography of this type, the great variety of crops, and the small size of the fields are shown in Plate XXVIII, Figure 1.

Although the hilly topography would seem to favor very rapid erosion, the tendency to erode is counteracted to a considerable degree by the readiness with which the soil takes up moisture, thus checking or entirely preventing run-off, except following very heavy rainfall or after the soil has become saturated from long-continued rains. Nevertheless, erosion is a serious problem on many of the slopes.

On account of its limited extent this type is not as important in Andrew County as in some of the adjacent counties or as the Marshall silt loam. Because of its wide crop adaptation, however, and its value especially for orchards, vineyards, small fruits, garden truck, and alfalfa, it is one of the important soils of the county. A vineyard on this type is shown in Plate XXVIII, Figure 2. The value of the soil is due to its being well supplied with the essential plant-food elements, with enough lime for the successful growing of leguminous crops; to its uniform silty texture and ease of cultivation; and to readiness with which it takes up and holds moisture. The type was formerly covered with open forest of elm, walnut, large bur and white oak, linden, and some other trees. Pawpaw bushes are found wherever the type occurs.

The Knox silt loam is used for wheat, corn, clover, alfalfa, fruits, and all the special crops grown in the area. It is an excellent tobacco soil, although in this county very little of it is used for this crop. Wheat yields 18 to 25 bushels, with occasional larger yields. Corn yields 35 to 45 bushels, clover $1\frac{1}{2}$ to $2\frac{1}{2}$ tons, and alfalfa 2 to $3\frac{1}{2}$ tons per acre.

Small quantities of fertilizer high in phosphates are sometimes used on wheat, and fertilizers of various grades and in varying quantities are applied in growing some of the special crops. Clover and manure are depended upon almost entirely to keep up the fertility of the soil.

Land of this type is held principally in small tracts, and although the improvements as a whole are not so good as on the Marshall soils, the farms bring about the same price per acre.

The natural productiveness of this soil, its great depth, and the fact that the subsoil when brought to the surface soon becomes productive, has led to the conclusion that it can not be worn out and will remain productive under any system of farming. This is a serious error that has in places led to the abuse of the soil and reduction of its productiveness. The nitrogen supply should be kept up by proper rotations, by the more general use of green manures, and the

use of all available animal manure. Erosion should be controlled, as far as practicable, by stopping the gullies as soon as they begin to form, by protecting the fields during the winter with wheat or rye or other cover crop, and by cultivating across instead of up and down the slope. Terracing may be used to good advantage where the slopes are not too steep.

SHELBY LOAM.

The surface soil of the Shelby loam is a brown to dark-brown loose, friable loam, which varies in texture from a silt loam on the one hand to a fine or very fine sandy loam on the other. At 8 to 12 inches the color becomes a lighter brown and the soil a friable sandy clay. This may extend to a considerable depth, but usually at 12 to 16 inches it grades into a heavy, tenacious, yellow to drab sandy clay. Scattered over the surface and through soil and subsoil in varying quantities are small waterworn gravel and pebbles, sand, and in places masses of granite, quartzite, and many other kinds of rocks of foreign origin.

The till from which the Shelby loam is formed by weathering is variable in character. In places it carries a very high percentage of sand and small gravel, and the soil derived from it is rather coarse. In other places it is made up very largely of the crushed and ground-up local beds of shale and limestone, and the resulting soil resembles the residual soils derived from such rocks. Lenses or pockets of sand are present in the till a mile southeast of Pleasant Prairie School, about a mile due south of Cosby, and in many other places. Areas that contain a high percentage of local material occur in many places on the steeper upland slopes bordering the valleys of the Platte and One Hundred and Two Rivers.

Where the Shelby loam is adjacent to the Marshall silt loam, which normally lies higher up on the slopes, it is dark-colored and silty. Around the heads of small streams on long, gentle slopes and in slight depressions it is commonly dark brown to black, of a silty or very fine loamy texture, and filled with organic matter. In some small areas occurring in such positions, especially where surface drainage has not been good, the subsoil below 12 to 16 inches is a heavy, mottled, yellow and gray clay, underlain by sandy clay; such areas corresponding rather closely to the Carrington silt loam as mapped in Nodaway County. The Shelby loam also includes areas of light yellowish brown soil, too small to be shown, which belong to the Lindley series. In eroded places on steep slopes, rounded points, and knolls the lighter brown of the subsoil shows at the surface, so that in cultivated fields the soil has a mottled or spotted appearance.

The Shelby loam occurs principally as bands or strips on slopes between the higher lying Marshall silt loam and the alluvial or terrace soils, or in places residual soils below it. It also extends back into the ridges around the heads of the small tributary streams.

The largest and most continuous areas are in the southeastern part of the county, where the type occupies continuous belts along the slopes bordering Muddy Creek, the lower Platte Valley, Long Branch, and the lower part of the One Hundred and Two Valley. In all other parts of the county the belts or strips are not so wide and are broken in many places. Very little of the type occurs in

the southwestern part of the county, where the glacial deposit was probably thin and has been well covered by loess or removed by erosion.

In topography it ranges from rolling to hilly, little if any of it being too steep for cultivation. Surface drainage of the greater part of the type is good to excessive. Locally the internal drainage is restricted by the heavy sandy clay subsoil, and in places there are seepage areas.

Part of this type was originally in prairie and has the black color characteristic of prairie soils. The greater part of it, however, was forested with oaks and other hardwoods. Where the soil is largely of local limestone origin, bur oak and chestnut oak apparently predominate. Most of the type is under cultivation. It is used mainly for the production of corn, wheat, clover, oats, and to some extent for alfalfa. A very considerable area, especially where the slopes are rather steep, is in bluegrass pasture.

The Shelby loam is farmed in conjunction with the adjacent types. Much of it is good, productive soil but crop yields on the type as a whole are slightly lower than on the Marshall silt loam. Corn yields 25 to 40 bushels; wheat, 15 to 25 bushels.

This soil is naturally less productive than the black prairie or bottom land types, and greater care is necessary in handling it.

The type is well suited to soybeans, which should be grown extensively either alone or with corn. Manure preceding corn, and a complete commercial fertilizer high in phosphates applied at the rate of 125 to 250 pounds per acre with wheat, should give good results on the thinner parts of the type. Ground limestone at the rate of 3,000 to 4,000 pounds per acre would be required on much of the type to put it into favorable condition for growing alfalfa. Greater care is necessary to prevent erosion than on any other type.

In many places the surface soil has become eroded, leaving heavy, sticky, sandy clay at or near the surface. This is difficult to cultivate, and during dry weather it bakes and cracks, causing the crops on it to suffer. Where there is a surface soil of a few inches the land can be improved by applying manure and gradually deepening the cultivation. Terracing with the Mangum terrace is widely applicable to this soil.

SHELBY CLAY LOAM.

The Shelby clay loam may be described as a gray, dark gray, or brown loam to clay loam grading at a depth of 2 or 3 to 8 inches into a gray, dark-gray, or drab, heavy, tenacious sandy clay, which continues to a depth of 3 feet or more.

This soil is known locally as "gumbo." It includes rather wide variations in the color, depth, and texture of the surface soil and color of the sandy clay subsoil. In places small areas of light-gray loose soil are associated with this type. In some of the areas indicated on the map the type is not continuous but includes patches here and there of Marshall silt loam or Shelby loam.

Areas of this type are most numerous in the north-central part of the county, where they are developed in a belt extending from near the Bennett Lane School to the northern county line. Small areas, many of which are not shown on the map, are found throughout the northern part of the county.

Land of this kind occurs principally in two positions, in concave or basinlike areas around the heads of small streams and on convex slopes or rounded points. The soil is very difficult to cultivate, bakes and cracks when dry, and may be identified in many places by short, stunted growth of the crops growing on it. Where it is extensive it can best be used for pasture or grass land. It greatly reduces the value of a farm in which it is included, and every possible means should be taken to prevent more material of this kind from becoming uncovered.

LINDLEY LOAM.

The Lindley loam is a light yellowish brown to grayish-brown loam grading at 6 to 12 inches into a yellowish-brown sandy clay, which extends below the 3-foot section. Sand, gravel, and masses of rock of foreign origin are found in the surface soil and subsoil. Much of the type has a sandy loam covering 2 or 3 inches deep.

There are in the county only a few areas of this type large enough to be outlined. One of these lies 2 miles southwest of Whitesville, and another a mile west of Rosendale. Others are scattered throughout the area occupied by the Shelby loam. Near the Clanton School several areas of this type too small to be shown on the map have been included with the Shelby loam. Some of these represent sandy areas of Shelby loam from which the dark surface soil has been removed by erosion.

The type was formerly forested with hardwoods. Part of the type is cultivated, but the yields are low. A few small areas have been practically abandoned and are now grown up in weeds and brambles. The type is of small extent and low agricultural value, and can be most profitably seeded to grass and used for pasture.

LINDLEY SILT LOAM.

The surface soil of the Lindley silt loam is a gray to light grayish brown loose silt loam, with a depth of 10 to 15 inches. This is underlain by a pale-yellow silty clay or clay loam, and at about 20 inches grades into a pale-yellow heavy sandy clay. In places, especially on slopes below dark-colored soil, the surface soil is darker than the average in color. In other places it has the yellowish-brown color of the Lindley loam.

The largest areas of this type in the county lie a few miles north and east of Amazonia. Smaller areas are found throughout the county.

The Lindley silt loam occurs principally around the heads and along the slopes of small streams. In places the areas have somewhat the topography of high terraces. The lower part of these areas is usually nearly level or gently sloping, the outer or higher part having a steep slope. Surface drainage is fairly good, but internal drainage is restricted by the heavy subsoil. A deep gully usually runs through the center or along one side of these areas, interfering seriously with their use for cultivated crops except in very small fields. The type is used principally for pasture but to some extent for corn, wheat, clover, and truck crops. Owing to its limited area and low crop value it is not an important soil.

PETTIS SILT LOAM.

The surface soil of the Pettis silt loam is a light-brown, loose, friable silt loam, light at the surface but becoming heavier with increasing depth. At 10 to 14 inches it grades into a yellowish-brown heavy silty clay to clay loam, which extends to a depth of about 24 inches. Below this the subsoil is a very light brown silty clay, somewhat mottled with dark brown. The lower part of the subsoil is slightly lighter in texture than the overlying subsoil material.

The color of the surface soil has rather wide variations, ranging from dark to light brown. The dark-brown soil occurs principally on long gentle slopes that are favorable for the accumulation of organic matter and on slopes below outcrops of limestone, and the lighter colored soil occurs principally on the steeper slopes where erosion is more active. In general the type is darker colored in the eastern and northeastern parts of the county and becomes lighter colored toward the west.

In places along the outer edge of larger stream valleys narrow strips of black, heavy soil, usually only a few rods in width, extend along the valley immediately below rock ledges and outcrops, particularly in several places along the east side of the Platte River north of Rochester. Immediately above some ledges of limestone there are also narrow strips of brown to reddish-brown soil. These soils represent other series, but on account of their small extent they have been included with the Pettis series. These, if of sufficient extent, would be mapped as Summit clay loam and Crawford silt loam.

The Pettis silt loam is developed on hill slopes bordering the streams. It is most extensive in a zone extending east and west through the central part of the county, where the streams cut through the rock formations from which this soil is principally formed. The slopes are usually gradual on the lower side, but may be as steep as can be profitably cultivated on the upper side. In places some fragments of limestone are scattered over the surface, and the bedrock usually lies at no very great depth below the surface. The greater part of the type has good drainage.

The Pettis silt loam was formerly in hardwood forest. A large part of it is at present under cultivation and used for corn, wheat, clover, and the other farm crops. A considerable part, especially on the steeper slopes, is in open forest and has a good stand of bluegrass, for which it is well suited. Some alfalfa is grown. The greater part of the type is used in connection with the adjacent soils for general farming and stock raising. Corn yields 35 to 45 bushels, wheat 15 to 18 bushels, oats 30 to 45 bushels, and alfalfa 2 to 2½ tons per acre. Land values on farms consisting largely of this type range from \$75 to \$125 an acre.

Although derived partly from limestone, much of this type has through leaching become deficient in lime and would be benefited by its application. Lime is needed especially in growing clover and alfalfa. A good crop rotation should be followed, and clover, soybeans, and sweet clover should be grown more extensively. Phosphates should be applied to wheat. Measures should be taken to reduce erosion to the minimum.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the Pettis silt loam:

Mechanical analyses of Pettis silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
345404	Soil, 0 to 12 inches.....	0.2	0.4	0.4	3.6	15.0	61.5	19.0
345405	Subsurface, 12 to 26 inches....	.1	2.0	2.7	6.0	10.2	52.9	26.1
345406	Subsoil, 26 to 36 inches.....	.0	4.4	5.0	10.0	7.1	51.2	22.2

MANDEVILLE STONY LOAM.

The surface layer of the Mandeville stony loam is a gray to light grayish brown friable silt loam, with markings of light gray or brown. At a depth of 3 to 12 inches it grades into heavy yellowish-brown or dull olive green silty clay, which is underlain at a depth of a few inches by the parent shale or limestone from which the soil is derived. The soil is variable in depth but in general the underlying rock is reached at a depth of 8 to 30 inches. Thin fragments of limestone cover the surface, and outcrops and rock ledges are common.

This type, commonly occupying the steeper part of the slope, is closely associated with the Mandeville silt loam. In many places it extends as a narrow strip immediately above the valleys of the larger streams. In other places it occurs high up on the slope, with Mandeville or Pettis silt loam above and below it. Patches of stony loam too small to be outlined on the soil map have been indicated by rock-outcrop symbols.

On account of steepness of slope and abundance of stone the type is not ordinarily tillable, though small areas of cultivable land are included. Nearly all of it is still covered with a more or less open forest, which supplies fuel and timber for the farm. The type also has some value for pasture. It is held principally in connection with other types.

Limestone for agricultural purposes can be obtained in almost any place where this type is indicated on the soil map. It varies widely, however, in purity, and should be tested before it is used to determine which parts carry the highest percentage of lime carbonate.

MANDEVILLE SILT LOAM.

The surface soil of the Mandeville silt loam is a grayish-brown or light-brown friable silt loam. It becomes slightly heavier with increasing depth and at 8 to 12 inches grades into a light-brown to dull olive green rather tenacious silty clay. At about 20 inches this grades into friable clay loam, which shows faint mottling with gray. This layer may extend to a depth of 3 feet or more or may be underlain by soft rotten limestone or drab shale within 3 feet of the surface. Much of the type is shallow, ranging in depth from 10 to 24 inches, and has thin fragments of limestone scattered over the surface and in the soil.

The Mandeville silt loam includes a rather wide variation of soil material derived from the Coal Measures shale and limestone, but which has not weathered deeply enough nor accumulated organic matter enough to become suited for agriculture. Much of it is soil material rather than soil. It thus represents an intermediate stage

between the Mandeville stony loam, which is nonagricultural, and the thoroughly weathered Pettis silt loam.

This type is closely associated with the Pettis silt loam, but occupies the steeper slopes and rounded hills and points where erosion has prevented the formation of deeper and darker soils. Like the Pettis silt loam, it is most extensively developed along the slopes bordering the larger streams in a belt extending east and west across the central part of the county and along Lincoln Creek.

It occurs largely in narrow strips and bands, principally between the Pettis silt loam or Marshall silt loam on the upper side and the alluvial soils of the larger stream bottoms on the lower. In many places strips of Mandeville stony loam separate it from the alluvial soils. The topography of the greater part of the type is hilly. Many of the slopes are too steep for profitable cultivation. Drainage is good to excessive.

All the type was originally forested; less than one-fourth of it is at present under cultivation, and the greater part of the rest is in open forest with an excellent growth of bluegrass. Cultivated crops, principally corn, wheat, and clover, yield slightly less than on the Pettis silt loam. Farms in which this is an important type usually also include other types better suited to cultivated crops. Where a considerable part of the farm is of this type prices range from \$40 to \$100 an acre. Much of this land can be made more valuable by clearing out the small trees and underbrush, thus obtaining a better stand of bluegrass. On account of the ease with which it erodes, this soil should be used sparingly for corn or other cultivated crops, and the steeper slopes should not be cultivated at all.

JUDSON SILT LOAM.

The Judson silt loam is a dark-brown or almost black friable silt loam which becomes heavier with increasing depth. At about 15 inches it grades into a heavy silt loam of slightly lighter brown color, and this passes at 24 to 28 inches into a light-brown silty clay loam.

The type occupies long, even slopes. It consists principally of coluvial material coming largely from the Marshall and Knox soils. It is well supplied with organic matter, is well drained, and is a rich productive soil equal in crop value to the better grades of the Marshall silt loam.

Only a few small areas are shown on the map. These lie chiefly along the valleys of the Platte and One Hundred and Two Rivers in the southeastern part of the county. Numerous other small areas have been included either with the Bremer or with the Wabash silt loam.

BREMER SILT LOAM.

The Bremer silt loam is a dark-gray to black, loose, friable silt loam, which grades into a heavy black silt loam at a few inches below the surface. Below 18 inches it is a very heavy silt loam to silty clay loam, in places slightly lighter in color in the lower part of the 3-foot section. In places the soil has a brownish cast, approaching the Waukesha soils in color.

The largest area of this type extends along the outer edge of the Nodaway Valley in the northwestern part of the county. Other areas of considerable extent are in the broader parts of the larger valleys. Many small areas are mapped in the valleys of the smaller streams. In the Platte Valley north of Whitesville, in the One Hundred and Two Valley north of Rosendale, and in some other places considerable areas occupy a terrace position with reference to the large streams but are in part subject to overflow and deposition from small tributary streams. These are therefore classed as Wabash rather than Bremer. Only a few terraces in the county show traces of aging, such as a well-defined gray layer with compact subsoil below it.

The surface of this type is nearly level. The lower or stream side usually terminates in a well-defined bench or step 6 to 10 feet in height, but the outer edge, especially in the larger valleys, grades almost imperceptibly into the upland. Because of the nearly level surface the drainage is deficient in some places.

Practically all of the Bremer silt loam is in cultivation, being used very largely for corn, which is planted on the same land year after year. Some of it is used for wheat and clover. In crop yields and land prices it corresponds to the better grade of Marshall silt loam.

The principal needs of this type are better drainage, by open ditches or tiling, and the use of alsike clover where the land is too wet for red clover and alfalfa.

WAUKESHA SILT LOAM.

The Waukesha silt loam is a brown to dark-brown, loose, friable silt loam which becomes heavier with increasing depth. At about 15 inches it becomes slightly lighter brown in color, with a few mottlings of lighter brown, and at 18 inches it grades into a light-brown heavy silt loam. Along the west edge of the Platte Valley near Cosby some areas that are loam rather than silt loam have been included with this type. A few small areas north of Amazonia have surface soils somewhat lighter in color than the average for the type.

The Waukesha silt loam is composed largely of material eroded from the slopes of Marshall and Shelby soils and redeposited in the valleys. It is mapped in small areas in all the larger stream valleys, except that of the Missouri. A few areas are developed along the smaller streams.

The type has a level surface and good drainage. It is used largely for corn, but is also well suited for wheat, clover, alfalfa, and all other crops of the area and gives large yields. On account of its small extent it is not an important type.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam is a dark-gray, dark-brown, or black, loose and friable silt loam which is easy to cultivate when in good moisture condition. At a depth of 8 to 15 inches the soil grades into a heavy silt loam of the same color, and this in turn grades into a clay loam at 20 to 24 inches, and below 30 inches becomes slightly lighter in color.

This is an alluvial soil and therefore rather variable. In the large valleys the stream channel is in most places bordered by a narrow

strip of low first bottom which is subject to frequent overflow. Here the soil is commonly a heavy dark-brown silt loam to silty clay loam with dark-brown mottlings in the subsoil. In these areas the soil is added to by deposits of silt at each overflow. In most places this front land is overgrown by trees, underbrush, vines, and weeds. Adjacent to this and ordinarily 4 to 8 feet above it is a soil of lighter texture which is subject to much less frequent overflow. This is the typical Wabash silt loam, practically all of which is under cultivation. Along the edges adjacent to the stream it is slightly higher and frequently lighter in color and more loamy in texture than away from the stream.

Where the main valleys become narrow, thus increasing the current during periods of overflow, or where a swift current makes a cut-off from one point of the channel to another, a larger proportion of sand is frequently deposited forming a sandy loam or loam. Several small areas of this kind occur along the Platte and One Hundred and Two Rivers in the central part of the county. In some of these the proportion of sand is so large that the productiveness of the soil is rather seriously impaired. Since deposits of this kind are changed with every period of overflow, it is thought best to include them with the silt loam type rather than to attempt their separation.

In the broader parts of the larger valleys the flat or slightly depressed areas in many places have soils of heavier texture, silty clay loam or clay. Around such areas the silt loam is underlain at 8 to 15 inches by silty clay loam or clay. In many places along the outer edge of the larger valleys soil material has been carried in by the smaller streams and deposited along their courses in the main valleys. Such deposits are usually loose and loamy but are in many places underlain by materials of heavier texture. At the foot of gentle slopes bordering these larger valleys there are also in places included strips of partly colluvial, rather loamy material.

Large areas of the type as mapped are not subject to overflow from the main stream but are overflowed entirely or partly by small tributary streams, and therefore no sharp line can be drawn between first bottom and terrace soils. In places on flat low terraces a layer of light-gray silty material appears in the subsoil, indicating that the deposits have been in place for a long time. Small areas of this kind have been included with the typical Wabash silt loam, although it is a soil of lower crop value. In other places small areas in which the dark-colored surface has been removed by erosion during overflows have been included.

In the smaller stream valleys, such as those of Long Branch, Hickory Creek, and Arapahoe Creek, but not along the smallest streams, the Wabash silt loam tends to be lighter brown or gray in color and has a subsoil of light texture, in places a loam or a sandy loam.

The Wabash silt loam is the most extensive type in the valleys of the Platte, One Hundred and Two, and Nodaway Rivers and in the valleys of most of the larger tributary streams.

The type has a comparatively level surface. Large parts of it are subject to occasional overflow, but considerable areas are not. The channel of the Nodaway River has been straightened so that the val-

ley in the northern part of the county is now practically free from overflow, and the part nearer the Missouri River receives protection; but as the backwater from the Missouri River when at flood stage checks the water from the Nodaway, the lower part of the valley is still frequently flooded. Drainage work on a comprehensive scale will protect large areas of this type along the Platte and One Hundred and Two Rivers.

The Wabash silt loam is an important agricultural soil and practically all of it is under cultivation. It is used mainly for the production of corn, but also of wheat, clover, alfalfa, and for bluegrass pasture. Corn yields from 35 to 70 bushels per acre, wheat 15 to 30 bushels, and alfalfa 3 to 5 tons. The greatest need of this type is protection from overflow and better drainage.

A colluvial soil included with the Wabash silt loam in most places is black, loose, friable, and loamy at the surface and carries a high percentage of fine and very fine sand. At a depth of 3 or 4 inches it grades into a black silt loam of medium texture, which may continue to a depth of 3 feet or may be underlain at varying depths by clay loam or clay, containing a relatively large proportion of sand.

The variation occupies narrow strips along the small streams that drain the darker colored upland soils of the county. In the more nearly level regions of upland these bottoms are comparatively wide, varying from a few rods to 40 or 60 rods, the widest parts being at the junction of streams. A small part of the material has been deposited by overflow from the streams along which it occurs, but most of it consists of wash from the adjacent slopes and deposits from smaller tributaries, and some of it is wind blown from the adjacent cultivated fields.

In places this land is wet and poorly drained. In some included patches, especially around the sources of small streams and near the foot of gentle slopes, the soil gives way to a heavy almost impervious layer of mottled yellow and brown clay at a depth of about 15 inches. Such areas really represent the Carrington soils as mapped in Nodaway County.

The small streams that flow through the narrow strips of this soil rarely overflow, but occupy deep, crooked, V-shaped gullies near the center. As these can not be crossed by farm machinery, they greatly reduce the value of this land for tilled crops. In places where the valley is of sufficient width, narrow strips along the side are used for corn, but the greater part of this land supports a good growth of bluegrass and is used for pasture.

WABASH SILTY CLAY LOAM.

The Wabash silty clay loam is a dark-gray to black silty clay loam, fairly friable when dry, and underlain at 3 to 10 inches by the typical black Wabash clay. This type has been formed by the deposit of a thin layer of lighter soil over the clay. It is level or nearly level, but usually lies a few inches higher than the clay. It occurs in small areas at intervals throughout the valleys of the three larger streams of the county. Drainage is slightly better than in the clay type, but is not good. The soil is slightly easier to cultivate and produces somewhat better yields of corn and wheat than the clay. The

recommendations for the improvement of the Wabash clay apply also to the silty clay loam.

WABASH CLAY.

The Wabash clay is a dark-gray to black, heavy, silty, plastic clay. In places it has a surface covering of 2 or 3 inches of soil of slightly lighter texture. This black clay generally extends to a depth of 3 feet but in places it grades into a dark-gray or drab plastic clay below 18 inches. Upon drying this soil checks and cracks, the wide cracks often extending to a depth of 3 feet or more. When exposed along ditch banks it weathers into cubelike fragments. It is very difficult to cultivate when too wet or too dry, being sticky and tenacious when wet and breaking into large hard clods when dry.

One fairly large area lies on the east side of the Platte River south of Cosby. The rest of the type, with the exception of a few small areas, is confined to the broad valleys of the Platte and One Hundred and Two Rivers in the northern part of the county. It usually occupies rounded or elliptical areas in the central or lower part of the bottoms between the higher bottom lands along the streams and along the outer edge of the valley.

The surface is level and in places slightly depressed or basinlike. Both surface and internal drainage are poor. Much of the type is subject to overflow from the main stream or from water carried into the valley by the small tributary streams. Many of the latter have been diverted into ditches and carried across the valley along land lines. Many of these ditches, however, have become so filled with material washed from the hills that they are of little use. Drainage districts have been organized, and the work now in progress of straightening the channels of the main streams should afford considerable protection.

This type of soil is used almost entirely in growing corn and wheat and for pasture. While the soil is very fertile, the yields vary widely with the season. A season either abnormally wet or dry is not favorable for the best crop production. The average yield of corn is probably not over 25 or 30 bushels per acre, and of wheat 12 to 15 bushels, but very much larger yields are occasionally obtained. On account of the uncertainties in handling land of this kind it has been low in price compared with the better upland soils.

The greatest need of this land is prevention of overflow. Protection from the large streams can be obtained by straightening the channels and by building levees where necessary. The small lateral streams should be carried down the outer edge of the valley until fall enough is gained to divert the water into the main stream. Local rainfall should be taken care of as much as possible by means of furrows that open into surface ditches. Tile drainage will be necessary to bring the soil into its highest state of productiveness.

This type can be greatly improved by more thorough tillage, including deeper plowing, and the turning under of weeds and crop residues. Increasing the content of organic matter will make the soil more open and friable and aid drainage. Where red clover does not thrive alsike clover should be used.

RAY SILT LOAM.

The Ray silt loam has a surface soil of light-brown to grayish-brown silt loam of very light, friable nature. With increasing depth this layer grades slightly heavier and at 12 to 15 inches passes into a darker brown, heavier silt loam. The subsoil may continue to a depth of 3 feet without material change but more commonly the lower part is variable, having thin layers of sand which alternate with heavy silt loam.

Near the stream channels long narrow strips of fine or very fine sandy loam have been included with this type. Where the valleys are broad and favorable for the accumulation of organic matter the type becomes darker in color, approaching the Wabash silt loam. Along the lower course of the Nodaway River the type includes some areas which appear to be intermediate between the Ray and Wabash silt loams and consist largely of wash from the Knox and Mandeville soils.

Areas of this soil are mapped in the flood plains of nearly all the small streams that drain the region of Knox and Mandeville soils. In many places the line of separation between this soil and the darker colored Wabash silt loam is rather arbitrarily placed.

The Ray silt loam has good drainage, but much of it is subject to overflow for short periods after heavy rains. It is used principally for the production of corn, which is grown on it year after year, and to some extent for wheat, clover, alfalfa, watermelons, and truck crops. Yields of corn are good, ranging from 35 to 70 bushels per acre. On account of its small extent, this is not an important type.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Ray silt loam:

Mechanical analyses of Ray silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
345440	Soil, 0 to 12 inches.....	0.2	0.8	1.0	10.6	19.0	58.7	9.7
345441	Subsoil, 12 to 36 inches.....	.0	.6	.8	7.8	22.8	56.2	12.0

SARPY VERY FINE SANDY LOAM.

The Sarpy very fine sandy loam is a fine to very fine sand grading at 2 or 3 inches into a fine or very fine sandy loam, which becomes slightly heavier with depth and at about 18 inches passes into a very light silt loam or very fine sandy loam or fine sand.

The type occurs in the Missouri River bottoms, where it is closely associated with the Sarpy silt loam. In general it occupies slight ridges.

This is not an important type. It is used to some extent for corn and alfalfa, the yields being lower than on the silt loam. It is better adapted to watermelons, tomatoes, and other garden truck.

SARPY SILT LOAM.

The surface soil of the Sarpy silt loam is a dull yellowish brown silt loam grading slightly heavier with increasing depth. Generally the subsoil at 12 to 16 inches is slightly lighter brown in color and a heavy silt loam to silty clay loam in texture. This continues to a depth of 24 to 30 inches, where there appears a light silt loam, very fine sandy loam, or, locally, a very fine sand.

The type is rather variable. The surface soil in places is a light silt loam and in some places has a surface covering of a few inches of very fine sandy loam. In these lighter areas the light lower subsoil commonly appears at a depth of 20 to 24 inches. Where the surface is dark and heavy the light-textured subsoil is encountered at greater depths. In places the lower subsoil consists of alternating layers of fine sandy loam or light silt loam and heavy silt loam or clay. Along the channel of Dillon Creek after it enters the Missouri River bottom there is a small area of Ray silt loam which has been included with this type.

The Sarpy silt loam is the most important soil of the Missouri River bottoms in Andrew County and is the principal cultivated type on Cat Island. It is nearly level, except for low ridges and slight depressions, with differences of elevation of 3 to 6 feet. The soil on the ridges is somewhat lighter in texture than in the intervening areas. Small areas of very fine sandy loam and of silty clay too small to be mapped are included. The greater part of the type has good drainage. It is, however, subject to overflow during extremely high stages of the Missouri River.

The Sarpy silt loam is all under cultivation and nearly all used in the production of corn and alfalfa, which are grown principally as cash crops. Corn yields 40 to 65 bushels, and alfalfa 2 to 3½ tons per acre. Some wheat is grown, the yields ranging from 18 to 30 bushels. Watermelons and other truck crops are grown in a small way.

Owing to the danger from overflow and the danger of damage through changes in the channel of the Missouri River, this land is not so well improved as the other productive soils of the county.

SARPY SILTY CLAY.

The soil of the Sarpy silty clay is a dark yellowish brown to drab silty clay. This grades at 15 to 24 inches into a yellowish-brown silt loam or very fine sandy loam, though in places the heavy soil may extend to a depth of 30 inches. Locally the soil is dark in color, approaching the Wabash soils.

The Sarpy silty clay usually lies at a slightly lower elevation than the silt loam or fine sandy loam. Much of it is subject to frequent overflow, and even the slightly higher parts need drainage. A considerable part of the type is covered with a dense growth of small cottonwoods, with interspersed marshy areas, which are indicated by the marsh symbol. The cultivated areas are used almost entirely for the production of corn.

RIVERWASH.

Riverwash in this area includes low-lying land which is subject to frequent overflow and to changes through erosion or deposition. It ranges in texture from sand to clay, but with wide variations and frequent changes in both the horizontal and vertical sections. It has an uneven surface, with uprooted trees, piles of driftwood, and water-filled depressions here and there. Much of it is covered with a dense growth of small willows. It is practically nonagricultural, although small patches are occasionally planted to corn and sometimes make fair crops.

SUMMARY.

Andrew County lies in the northwestern part of Missouri. It has an area of 435 square miles, or 278,400 acres.

The greater part of the county is upland, which is nearly level to gently rolling in the northeastern part, undulating to moderately hilly in the central part, and quite hilly in the southwestern part.

Two broad belts of bottom land extend across the county from north to south and along the western and southwestern border. The difference in elevation between the valleys and the main part of the upland is about 250 feet.

The uplands are nearly all well drained and over much of the region erosion is active. Drainage and overflow conditions of the larger valleys are being improved by straightening the courses of the streams.

The county has a population of 14,075 (1920 census), of which about 10,000 live on farms.

Railroad facilities are good. There are no hard-surfaced roads but an abundance of well-kept earth roads.

The mean annual rainfall of 32.70 inches is well distributed. The average growing season is 181 days. The climate is well suited to general farming, stock raising, and dairying.

The principal crops are corn, wheat, clover, oats, and bluegrass for pasturage. A large part of all crops except wheat is fed to livestock. In the last 20 years alfalfa has become an important crop and a considerable part of this is sold. Apples, small fruits, vegetables, and melons are grown extensively in the southern part of the county, largely for the St. Joseph market. Dairying and poultry raising are becoming of increasing importance throughout the county.

There is a rather close relation between the soils, topography, and character of farming. The nearly level soils of the northeastern part are used to a large extent for corn and pasture, the moderately hilly region of the central part for general farm crops, and the steep hilly country of the southwestern part for special crops and fruit.

Andrew County includes a region of modern, well-improved, and well-equipped farms.

In 1920 the average size of farms was 111 acres, and the average assessed valuation was \$155.46 an acre. Nearly 66 per cent of the farms were operated by the owners.

The soils of Andrew County have been derived by weathering from four kinds of parent material. The material on the higher parts of the upland is of loessial or wind-blown origin. From it the Knox, Marshall, and Grundy soils have been largely formed. Underlying the loess is a layer of glacial till, which is the principal source of the materials from which the Shelby and Lindley soils are developed. Under the till is residual material from shale and limestone. From this the Pettis and Mandeville soils have weathered, but these soils have been modified by material from other sources. In the stream valleys are alluvial soils formed from material eroded from the upland soils. The recent-alluvial soils belong to the Wabash, Ray, and Sarpy series. There are some areas of old-alluvial or terrace soils which belong to the Bremer, Judson, and Waukesha series.

The Marshall silt loam is the most important type in the area both in extent and in crop value. It is a dark-brown to black silt loam of high fertility and good moisture-holding properties, well suited to all crops of this region. A brown phase and a shallow phase have also been mapped.

The Grundy silt loam is a dark-gray to black soil with heavy subsoil, well suited for corn and for bluegrass, but not a very good clover soil although used to some extent for that crop.

The Knox silt loam is a light-brown soil especially suited for clover, alfalfa, orchards, and small fruits, but on account of its hilly topography not well suited to general farming.

The Shelby loam is a dark-brown soil which contains fine sand and gravel in varying amounts and is underlain by a heavy sandy clay subsoil. It is well suited to the general farm crops but is not quite as productive as the loess soils. Since it erodes easily, great care is needed to prevent serious injury from erosion.

The Lindley types have gray surface soils and a pale-yellow to drab sandy clay subsoil. Only a few small areas of the loam and silt loam of this series are mapped in Andrew County.

The Pettis silt loam is a dark-gray to brown soil with heavy silt loam to silty clay loam subsoil. It produces fair crops of corn, wheat, and clover, but the average yields are not as high as on the Marshall soils.

The Mandeville silt loam is a light-brown, brown, or dark-gray soil underlain by shale or limestone, usually at less than 3 feet. Some of it is under cultivation, but on account of steep slope and shallow soil most of it is used for grass land.

The Mandeville stony loam is largely nonagricultural, but furnishes some grass for pasturage, wood for home use, and limestone for crushing.

The Bremer silt loam is a black and the Waukesha silt loam a dark-brown terrace soil of high crop value.

The Judson silt loam is a colluvial soil of high productivity, but occurs in only a few small areas.

The Wabash silt loam is a dark-gray to black soil, easily cultivated, and used most extensively for corn, much of it being planted to corn year after year. Parts of it are subject to overflow and some of it needs better drainage.

The Wabash clay and silty clay loam are black, heavy soils, difficult to cultivate. Under favorable seasonal conditions they produce good crops of corn and wheat.

The Sarpy silt loam, the most important type in the Missouri River bottom, has a dull yellowish brown heavy silt loam surface soil underlain by a subsoil of lighter texture. It is used for corn and alfalfa, and under favorable conditions gives large yields. The Sarpy silty clay is a dark-colored heavy soil, much of which is subject to overflow; some of it is used for corn, giving yields slightly lower than the silt loam. The Sarpy very fine sandy loam, in addition to being used for corn and alfalfa, is also used for melons and for garden truck.

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