

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF MISSOURI AGRICULTURAL
EXPERIMENT STATION, F. B. MUMFORD, DIRECTOR; M. F.
MILLER, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF BUCHANAN COUNTY,
MISSOURI.

BY

B. W. TILLMAN, OF THE U. S. DEPARTMENT OF AGRICULTURE,
IN CHARGE, AND C. E. DEARDORFF, OF THE
UNIVERSITY OF MISSOURI.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1915.]



WASHINGTON:
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., September 18, 1916.

SIR: In the extension of the soil survey in the State of Missouri during the field season of 1915 a survey was undertaken in Buchanan County. This work was done in cooperation with the State of Missouri, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this work and to request their publication as advance sheets of field operations of the Bureau of Soils for 1915, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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MAP.

Soil map, Buchanan County sheet, Missouri.

SOIL SURVEY OF BUCHANAN COUNTY, MISSOURI.

By **B. W. TILLMAN**, of the U. S. Department of Agriculture, in charge,
and **C. E. DEARDORFF**, of the University of Missouri.—Area inspected
by **THOMAS D. RICE**.

DESCRIPTION OF THE AREA.

Buchanan County, Mo., lies in the northwestern part of the State, on the Missouri River. It is the third county south of the Iowa State line. It is bounded on the north by Andrew County, on the east by Dekalb and Clinton Counties, on the south by Platte County, and on the west by the Missouri River, which separates it from Kansas. The area of the county is 404 square miles, or 258,560 acres.

The county comprises two main physiographic divisions—the upland and the alluvial lowland. The upland is thoroughly dissected, and slopes from northwest to southeast. Topographically, the county consists of the bottoms along the Missouri River, a hilly region in the western part of the county bordering the bottoms, and a broad undulating or rolling plain covering the central and eastern parts. The hilly belt is from 1 mile to 4 miles wide and is separated from the bottoms by a precipitous bluff. The country for a distance of a few miles east of the bluff is thoroughly dissected, consisting of a succession of steep hills. Small hilly areas are found in the vicinity of some of the other streams of the county, notably along Bee Creek near Agency.

To the east of the hilly belt the upland merges into a rolling plain, the slopes of which are gentle enough for successful farming. A few small areas bordering the valley of the Platte River and other small streams have sharp, steep slopes, with occasional rock outcrop. The elevation of the upland is approximately 950 feet above sea level. The highest point in the county is on the hill upon which the reservoir of the St. Joseph Water Co. is located. This hill is 320 feet above the low-water mark in the Missouri River. It is estimated that the river bluffs are slightly higher than the upland to the east.

The lowland covers approximately one-seventh of the total area of the county, the largest continuous body being in the western part along the Missouri River. Here the bottoms vary in width from

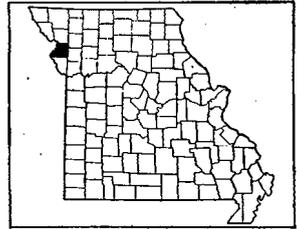


FIG. 1.—Sketch map showing location of the Buchanan County area, Missouri.

about 6 miles in the vicinity of Upper and Lower Lake Contrary to a few rods at the Andrew County line.

A central lowland belt includes the valleys of the Platte and the One Hundred and Two Rivers and smaller streams. It varies in width from a few rods to about $2\frac{1}{2}$ miles, the widest part being near the junction of the Platte and the One Hundred and Two Rivers. Except for slight ridges, lakes, and sloughs, the bottom land is smooth. It has an elevation of approximately 765 feet above sea level.

The entire drainage of Buchanan County finds its way into the Missouri River. The drainage of the eastern two-thirds is carried to the Missouri by Platte River, which enters the county from the north near the central part, and flows in a general south to southeast direction, leaving the county near the southeast corner. It divides the more or less rolling plain into two parts, both of which slope toward the river. The western part of the plain, together with the adjoining hilly belt to the west, separates the lowland of the Platte River from that of the Missouri River.

The largest tributary of the Platte is the One Hundred and Two River, which drains a small area in the northern part of the county and joins the Platte about $4\frac{1}{2}$ miles east of St. Joseph. The North Fork of the Platte River and its tributaries drain the northeastern corner of the county, and Malden, Castile, and Bee Creeks and smaller streams drain areas to the east and west of the Platte. Contrary and Sugar Creeks, with their tributaries, drain small areas in the western part of the county.

As a rule the upland divides are rather narrow, and the draws are numerous, though in places the relief is not so prominent and the surface is undulating. There are, however, a sufficient number of draws to insure thorough and frequently even excessive drainage. Drainage in the lowland on the other hand is often poor. There are fewer drainage ways, in proportion to extent, in the bottoms than in the upland. Frequently streams from the upland carry the water to the edge of the lowland, where deposits of sediment have clogged the channels, so that the water collects in depressions or spreads over the lowland, where it stands until it disappears through seepage or evaporation.

General overflows in the Missouri bottom are very uncommon. The lowland along the Platte River occasionally overflows, resulting in the complete destruction of crops. The straightening of the channel of this stream to facilitate the flow of flood waters is under consideration at this time, the need of such work being keenly felt during the unprecedented overflow of 1915.

The territory included in Buchanan County is a part of the original Platte Purchase region, which was obtained by treaty from the Indians in 1836. The county was organized in 1839.

The early settlers came largely from the neighboring counties and from Kentucky, Ohio, Indiana, Tennessee, North Carolina, and Virginia. With the industrial development of St. Joseph, foreigners, largely Germans, Russians, and Austrians, began to come into the county. In the 1910 census the population of Buchanan County is reported as 93,020. The foreign-born population numbered 8,864, the native whites of foreign and mixed parentage 16,569, and the native whites of native parentage 63,104. The negro population is given as 4,457. There was a marked decrease in the rural population from 1900 to 1910. In the 1910 census the rural population is reported as 15,617, or about 17 per cent of the total. The density of the rural population is given as 38.3 persons per square mile.

St. Joseph, the county seat, is the only city in the county. It has a population, according to the 1910 census, of 77,403. It is a city of considerable wealth. It contains about 260 manufacturing establishments, with a capital investment of over \$10,000,000, and is the largest wholesale dry goods center west of St. Louis. The important industries include woolen mills, harness and saddle factories, flour mills, wagon and buggy shops, spice houses, creameries, and meat-packing houses. The Northwest State Asylum is located here. Easton, Faucett, De Kalb, Rushville, and Agency are small railroad towns, with populations of 350 to 600. There are many other small towns and crossroads in the county.

Transportation facilities are excellent. Railroads traversing the county are the Atchison, Topeka & Santa Fe, the Chicago, Rock Island & Pacific, the Chicago Great Western, the Missouri Pacific, the St. Joseph & Grand Island, the Chicago, Burlington & Quincy, the St. Joseph Terminal, St. Joseph & Savannah Interurban, and the Kansas City, Clay County & St. Joseph Interurban. These lines all radiate from St. Joseph and connect the county with all the important markets of the Northwest, as well as with those of the East.

Improved rock and gravel roads lead into St. Joseph. The public roads almost always follow the land lines, except in small areas of rough topography along the bluffs. Considerable road-grading work is being done, and the dirt roads usually are in good condition, although when neglected they wash badly and soon become impassable.

The public-school system of the county is recognized as one of the best in the State. All parts of the county are supplied with rural mail delivery and the telephone is in general use.

CLIMATE.

The climate of Buchanan County is practically the same as that of other counties in the northwestern part of Missouri, and, in the absence of local data, the following table compiled from the records of the Weather Bureau station at Oregon, Holt County, is given as fairly representative of local climatic conditions:

Normal monthly, seasonal, and annual temperature and precipitation at Oregon, Holt County.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1894).	Total amount for the wettest year (1902).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	28.5	66	- 6	1.54	1.25	2.41	5.7
January.....	23.4	67	-19	1.55	1.21	1.38	7.1
February.....	27.9	78	-27	1.71	2.20	0.44	8.8
Winter.....	26.6	78	-27	4.80	4.66	4.23	21.6
March.....	38.7	91	- 4	2.08	2.00	0.87	5.3
April.....	52.6	95	11	3.38	1.33	1.30	0.8
May.....	63.4	96	25	4.81	2.37	6.42	0
Spring.....	51.6	96	- 4	10.27	5.70	8.59	6.1
June.....	72.4	101	44	4.85	4.82	7.52	0
July.....	75.2	107	48	4.52	0.52	10.77	0
August.....	75.1	103	46	4.37	0.04	4.42	0
Summer.....	74.2	107	44	13.74	5.38	22.71	0
September.....	67.0	100	31	3.42	3.65	7.69	0
October.....	54.9	90	20	2.64	2.15	4.72	1.1
November.....	39.7	80	- 1	1.66	0.68	2.80	1.6
Fall.....	53.9	100	- 1	7.72	6.48	15.21	2.7
Year.....	51.5	107	-27	36.53	22.22	50.74	30.4

The mean annual precipitation is about 37 inches. The rainfall is evenly distributed through the late spring, summer, and early fall months, which constitute the growing season. The mean annual temperature is about 52° F. The winters are generally mild, extremely cold weather usually being of only a few days duration. The falls are characterized by long periods of warm, open weather. The climate of the county as a whole is very favorable for the production of a wide variety of crops. Two or more truck crops can be matured on the same land in a single season.

The average date of the last killing frost in the spring is reported at Oregon as April 25, and the average date of the first in the fall as October 14, giving a normal growing season of 172 days. The earliest recorded date of killing frost in the fall is September 13, and the latest date in the spring May 20. Fruit is sometimes injured by late spring frost, especially in seasons when the buds develop during warm periods in late winter or early spring.

AGRICULTURE.

Aside from the wholesale and manufacturing interests of its chief city, St. Joseph, Buchanan County's principal industry is agriculture. At the time of settlement the natural resources of the county consisted of extensive range land, a good supply of timber, an abundance of wild game and fish, and its proximity to the Missouri River, which offered the only means of transportation except by wagon. The early settlers of the region located along the streams where timber was available for fuel and for building. Few of them undertook the cultivation of more than a few acres of corn and vegetables for home use.

Corn was the principal crop from the earliest time, although wheat, barley, rye, flax, and tobacco also received considerable attention. Decided agricultural progress was made before the Civil War, which resulted in a short period of depression. Many of the settlers left the county, and only home necessities were produced by those remaining. Soon after the war land values rapidly advanced and there was a great influx of settlers. Since then the agricultural development of the county has proceeded without interruption, with the exception of a period of financial depression in 1874-75.

The extensive range lands of the county made the live-stock industry profitable from the beginning, the stock being kept on the range during a large part of the year. This system of live-stock farming constituted the first stage in the extensive agricultural utilization of the lands of this county. The growing of garden crops and small areas of corn, rye, and other crops, although essential to the life of the pioneer, became only incidental to the raising of live stock. In later years, as conditions became more favorable for the growing of grain and difficulty in marketing was experienced, farmers began the more extensive feeding of corn to beef cattle and hogs. Wheat, oats, and red clover were introduced in the crop rotation as the need for soil renovation and forage for live stock developed. With improved railroad facilities this system of combined stock and grain farming extended rapidly and proved very profitable. It is the prevailing system of farming in the eastern part of the county at the

present time, differing from its earlier form in being more diversified as to grain and hay crops grown and in the more systematic breeding of live stock.

The development of agriculture has been accompanied by many changes, not only in the form of agriculture practiced, but also in methods of farming. The development of centers of population like the city of St. Joseph provided markets for special products, such as fruits and small vegetables; and the soils being favorable to their production, garden and truck crops and fruits have received increasing attention and now constitute the most important products of the western part of the county. The development of good markets for packing-house and creamery products has encouraged diversified farming, including stock raising, in sections more remote from the large cities.

The relative values of farm products in Buchanan County are indicated in the following table, compiled from the 1910 census:

Value of principal agricultural products of Buchanan County, 1909.

Product.	Value.	Product.	Value.
	<i>Dollars.</i>	Live stock and products:	<i>Dollars.</i>
Cereals.....	1,844,713	Animals sold and slaughtered.....	1,687,437
Other grains and seeds.....	1,122	Dairy products, excluding home use.....	322,267
Hay and forage.....	311,487	Poultry and eggs.....	328,564
Vegetables.....	333,507	Wool, mohair, and goat hair.....	10,451
Fruits and nuts.....	178,180	Total.....	5,229,681
All other crops.....	211,903		

As a source of income the live-stock industry, including the sale of both animals and animal products, holds the place of first importance. The total value, as shown in the foregoing table, exceeds 2¼ million dollars. In the following table the numbers of the various kinds of animals sold or slaughtered during the year covered by the Thirteenth Census are given.

Calves, sold or slaughtered.....	4,731
Other cattle, sold or slaughtered.....	12,473
Horses, mules, asses, and burros, sold.....	2,588
Swine, sold or slaughtered.....	47,195
Sheep and goats, sold or slaughtered.....	11,124

In addition to the large number of cattle raised each year, many feeders are shipped into the county and fattened for market. The natural advantages for feeding in the county are of the best. The quality of the cattle is generally good, and there are many herds of purebred beef cattle, chiefly Shorthorn and Hereford, in the county.

Horses and mules are raised on many farms, but the home demand for them is greater than the supply. In 1913, according to the

Missouri Red Book, 876 horses and mules were shipped into the county for local use. The prevailing type of horses used in the county are good grades of draft breeds. The introduction of large and well-bred stallions is receiving attention and promises to improve the quality of the stock.

Hog raising is a very important part of the animal husbandry. Large numbers of hogs are handled in combination with beef cattle. There are many herds of purebred hogs and the quality of the stock is generally very good. Poland China and Duroc Jersey seem to be the leading breeds, although Chester White and Berkshire are also popular. Practically all the hogs fed are raised in the county. The development of the hog industry has been seriously retarded at different times by the prevalence of hog cholera. Much attention is now given to hog-cholera inoculation work, and the value of sanitary measures in combating this disease is generally appreciated.

Several flocks of sheep are kept in the county, but the industry as a whole is not receiving the attention it deserves in a good live-stock community. Some sheep are shipped in for feeding, and this practice is said to be quite profitable. Shropshire and Hampshire seem to be the most popular breeds.

The number of dairy cows on farms reporting dairy products is given in the 1910 census as 8,821. The dairy industry is most extensively developed in the vicinity of St. Joseph. The Jersey is probably the leading dairy breed, although there are many herds of Holstein breeding. Probably no area in the State affords better opportunities for the development of the dairy industry than does Buchanan County. The pasture grasses are of excellent quality, and the region is generally well suited to the production of leguminous crops which afford rich nitrogenous feeds. However, the 1910 census reports an expenditure of \$262,959 in the county for feed in 1909. An abundance of fresh water is obtainable, often from springs. There is little danger of disease, the cost of buildings not high, and excellent local markets are available.

Records of cost and amount of butterfat production per cow of several herds in the county are being kept by experts of the dairy department of the Missouri Experiment Station. This work tends to make milk production more profitable and gives a basis for improving the quality of the milk and the individual cows. There is a general need in the county for the introduction of more purebred bulls of the leading breeds. As with other kinds of live stock, the work of improving the dairy herds is best undertaken as a community enterprise, through the organization of cooperate breeding associations. Such associations have proved of great value in the development of improved stock in other sections of the country, notably in North Dakota and Minnesota.

Poultry is kept on all the farms, and constitutes an important source of income. There is a strong local demand for poultry products. Considerable attention is being given to the improvement of poultry, through proper methods of handling, breeding, and feeding, this work being greatly encouraged by poultry contests.

In the 1910 census corn is reported on 58,592 acres, with a production of 2,025,365 bushels. In 1912, according to the Missouri Crop Review, published by the Missouri Board of Agriculture, 65,256 acres were devoted to corn, with an average yield of 41 bushels per acre, or a total of 2,675,496 bushels. Buchanan County ranks as one of the leading counties in the State in point of yield per acre of corn. Nearly all the corn is fed to live stock, principally to beef cattle and hogs. Ensilage is receiving increasing attention in connection with dairying. The corn not used for ensilage or fodder is husked in the field and stored in cribs to be used for feeding, the stalks being cut in the spring and plowed under.

Wheat is reported on 30,510 acres, yielding 567,870 bushels, in the census of 1910. The Missouri Crop Review reports 24,658 acres in 1912, with a yield of 22 bushels per acre, or a total of 542,476 bushels. Maximum yields of 45 bushels per acre sometimes are obtained. About 50 per cent of the wheat produced is ground into flour at local mills; the remainder is shipped out of the county.

For the county as a whole oats is relatively a minor crop, the acreage in 1909, according to the 1910 census, being 6,841 acres and the production 162,446 bushels. Barley is reported on 1,045 acres, the production being 23,146 bushels. It is sold to brewers. Rye is reported on a total of 133 acres. In view of its value as a cover crop it would seem that the acreage in this crop might be profitably extended. Some sorghum is grown in the hilly section in the western part of the county. It produces a good quality of sirup, for which there is a strong demand. There are a few patches of kafir and milo.

The production of hay is important. The 1910 census reports 20,357 acres in tame or cultivated grasses, with a production of 32,683 tons. Of this total area a little over 5,000 acres was in timothy alone, with about the same acreage in clover alone, and about 7,200 acres in timothy and clover mixed. Alfalfa is reported on 2,260 acres, millet on 343 acres, and other tame grasses on 265 acres. Clover is an important crop in the county, although it would seem that its more extensive use would be advantageous. Most of the soils are well suited to clover where maintained in proper condition. Occasional failures of the crop are experienced, mainly because of unusually dry seasons. The present season of 1915 was exceptionally favorable to the growth of clover, and the crop was one of the best in the history of the county. Much difficulty, however, was experienced in saving the hay, owing to excessive rains. Cowpeas are not extensively

grown, but are becoming important, particularly on soils on which clover does poorly.

Alfalfa is receiving increasing attention in Buchanan County. Since 1910 the acreage has increased materially, but no reliable estimate of the present acreage is obtainable. The 1910 census reports wild grasses on about 300 acres, grains cut green from 581 acres, and coarse forage from 337 acres.

According to the census of 1910 potatoes occupied 3,580 acres, with a production of 329,152 bushels, and sweet potatoes and yams 174 acres, yielding 25,973 bushels. All other vegetables are reported on a total of 1,678 acres.

Buchanan County is reported to have a larger number of apple trees than any other county in the State. The census of 1910 gives the number as 317,885, producing 178,335 bushels. Besides that part of the crop consumed locally the county exported 234,289 barrels of apples in 1913-14.¹ The 1910 census reports 85,549 peach trees, and there are also large numbers of cherry, pear, and plum trees in the county.

The production of grapes is given in the census as 430,386 pounds from 175,171 vines. Strawberries are reported on 101 acres and blackberries and dewberries on 259 acres. A total of 1,029 nut trees is reported.

Several years ago tobacco was extensively grown in the vicinity of De Kalb, and to the south of this place in Platte County. The area in this crop in Buchanan County has greatly decreased in recent years, largely because of a decline in price from 15 or 16 cents to 7 or 8 cents per pound. The crop is reported on only 154 acres in the 1910 census. The opinion prevails that the tobacco was equal in quality to that grown in Kentucky and other sections where tobacco is successfully produced. Many large tobacco barns were constructed, and these are now used for storing other crops. A return to higher prices would doubtless revive interest in the crop. At present prices its production is not very profitable.

In general, the crops grown in the area are well suited to the soils upon which they are grown, and the farmers confine each crop to the soil best adapted to it as far as they can consistently under the systems of rotation in practice. The most important example of the utilization of a soil for certain crops is seen in the production of orchard fruits and vegetables on the Knox silt loam. Topographically, the hilly belt in which this type occurs is better adapted to fruit growing, market gardening, and dairying than to grain production and general farming. Both wheat and corn are grown mainly on the Marshall silt loam of the upland and on the silt loams of the Sarpy and the Wabash series. Alfalfa will do well on most

¹ Missouri Red Book, 1913-14.

of the well-drained soils of the area. At present the crop is grown mainly on the alluvial soils, but there are many small productive fields in the uplands. No liming is necessary for starting alfalfa, provided an adequate supply of organic matter is present in the soil and good drainage conditions are maintained. When tobacco was grown it was confined mainly to the Knox silt loam, as this type produced more nearly than any other soil the desired quality of leaf.

The cultural methods for corn are practically the same throughout the county. Where corn follows clover or where grass land is to be planted, a common practice is to plow in the fall and disk in the spring before planting. Much of the corn is listed, the single-row lister being ordinarily used. Besides being a quick and economical means of planting, it is generally thought that listed corn withstands drought better and is more easily kept free from weeds. The results obtained with this method if taken for a long period of years would probably not compare favorably with results where a more thorough seed-bed preparation is followed, at least so far as yield is concerned.

In the first treatment of the field a common drag harrow is generally used to kill the weeds and pulverize the soil, but the first cultivation is given when the corn is a few inches high and is done with an implement known as the "snake killer," or "flying Swede," a combination of disks and shovels. After the second cultivation the 4-shovel or 6-shovel cultivator is used.

In recent years some attention has been given to corn-selection work and good varieties adapted to local conditions are easily obtained. Interest is increasing also in exhibition contests, which result in improved methods of corn production. Seed selection, however, receives little attention in the county as a whole.

Of the varieties of corn grown the Boone County White and Reids Yellow Dent are most popular. These have been found well adapted to the section by experiments carried on by the Missouri experiment station.

Land for wheat is generally plowed in late summer or early fall. Early summer plowing is beneficial, but is not extensively practiced on account of the pressure of other work at this time. The harrow, disk, and roller are used in preparing the land, and the wheat is seeded with drills, usually at the rate of $1\frac{1}{4}$ bushels per acre.

There is some complaint of damage by smut, but no extended efforts to control the disease are reported. The Hessian fly frequently causes injury to the crop. When it is known to be present late sowing is practiced to avoid damage as far as possible. The crop usually is thrashed from the shock, although stacking is practiced in some sections, particularly in wet seasons.

Very little attention has been given to the development of improved varieties of wheat. A few years ago seed of the Poole variety was

distributed through the county by the Missouri experiment station. Reports of trials with this variety by farmers indicate that it yields from 3 to 10 bushels per acre more than local varieties. It is the leading variety on the upland. The Fulcaster, a bearded variety, is grown extensively on the bottom soils. As with the Poole wheat, this variety is frequently mixed, except where grown by the more careful farmers. There is probably more pure Fulcaster grown than pure Poole. A number of local varieties of wheat are grown.

Seed oats frequently are imported from other sections, the opinion prevailing among many farmers that the seed produced locally deteriorates. Such deterioration probably is caused by the mixing of varieties and the lack of control of fungous diseases. Some injury is caused by rust. Rust-proof varieties, of which the Texas Red seems to be the most satisfactory, are being introduced and somewhat better yields are reported. Very little effort is made to control smut, notwithstanding the fact that it frequently lowers the yield of the crop by as much as one-third.

Clover usually is sown with a nurse crop of wheat, oats, or rye. As a rule it is sown broadcast in late February or early March at the rate of 6 to 8 pounds per acre. The first crop of hay is generally obtained the year following the harvesting of the nurse crop, although on the best land a fair crop may sometimes be cut the same year it is seeded. Experience shows that an application of bone meal at the rate of 100 to 150 pounds per acre is very beneficial in obtaining a stand of clover. The fertilizer is applied at the time of sowing the small grain, and where clover is seeded alone or with timothy it may be applied just before or at the time of seeding. Most of the clover dies at the end of the second year.

The most common method of seeding timothy, where a nurse crop is grown, is to use a grain seeder or grain drill, seeding it with wheat or rye in the fall. About 8 pounds of seed is used per acre. Where conditions are favorable, and especially on rather unproductive land and in dry seasons, timothy is frequently seeded alone, the land being prepared as for wheat. The crop is frequently sown on corn land in the fall, the corn being cut for ensilage or fodder. Early in September is considered the best time for seeding. Where timothy and clover are mixed, the first hay crop usually is mostly clover, the second mostly timothy, and if left a third year the crop will be practically all timothy.

Cowpeas are best grown as a supplement to clover rather than as a substitute for it. The Whippoorwill, Clay, and New Era varieties seem well suited to this region.

Usually from three to four cuttings of alfalfa for hay per acre are obtained. Considerable expense and some risk is incurred in sowing alfalfa, and on this account only the very highest quality of

seed should be used. The crop usually is left to stand for several years, and for this reason is not as well suited to a short rotation as is red clover. The value of alfalfa, however, as a rich nitrogenous feed and also as a soil improver is appreciated, and the farmers generally devote areas of 5 to 10 or even 15 acres to this crop.

Peaches are grown to a small extent in the county. There is but little trouble with brown rot, but the curculio causes great damage to the crop. Late frosts are also frequently injurious. Apples are rather extensively grown, and the large commercial apple orchards usually are systematically sprayed and pruned. The small, family apple orchards, however, frequently are neglected. Local experience indicates that spraying of all fruits is profitable when continued for a number of years. Records of cooperative spraying experiments, in the vicinity of Matney, with lime, sulphur, and arsenate of lead show a net profit in one year of \$5,000 on an orchard of 1,700 apple trees. Prior to the time of spraying this orchard had yielded very little or no profit. This work was done under the supervision of the horticultural department of the Missouri experiment station.¹

There is considerable variation in methods of planting and cultivating orchards. Both 1-year-old and 2-year-old trees are used. The most successful orchards usually are given clean cultivation for the first three or four years. If the land is considered rich, corn or some other cultivated crop is grown in the orchard during this period; if the land is less productive no crops are grown, and cowpeas are sometimes planted and allowed to decay on the ground to enrich the soil. Clover also is grown in orchards, and is considered a good crop for this purpose, as it does not form a tight sod which might check the growth of the trees. Bearing orchards are cultivated according to the needs of the trees. If they seem to be declining in vigor or are not fruiting well, the orchard is cultivated for a month or two in the spring and seeded to cowpeas. Both winter and summer pruning are practiced, the general aim being not only to train the growth of the tree, but to remove all diseased wood. By annual pruning such diseases as canker are controlled. Some attention is given to the problem of marketing fruit advantageously, and to this end a fruit-growers' association has recently been organized in the county.

The principal varieties of apples grown are the Ben Davis, Gano, Jonathan, Grimes, Wealthy, Duchess of Oldenburg, Winesap, and Arkansas. Of the earlier varieties of peaches, the Carmen, Minnie (Alton), and Greensboro are most extensively grown. The Elberta is most frequently injured by frost, and on this account is rarely grown. Of the late varieties, the Heath Cling, Smock, Krummel, Allen October, and Salway are most popular.

¹ Unpublished manuscript by Dr. J. C. Whitten.

The prevailing crop rotation in the upland is corn, wheat, clover. It frequently happens that clover fails on account of drought, in which case the land is again planted to wheat or corn. Oats frequently take the place of wheat in the rotation, usually following corn. Clover is sometimes mixed with timothy, and the land used for hay for two, or rarely three, years. Another variation in the rotation is that of pasturing after sowing to bluegrass or timothy. The fields usually are pastured when yields deteriorate to a point where they become unremunerative.

In the bottoms there is a less clearly defined rotation than in the upland. Corn often succeeds itself for three years. As a rule, corn, wheat, and alfalfa are grown in a five-year or six-year rotation, which is varied occasionally with a crop of oats or clover.

No specific rotation can be recommended for any particular soil or for any section of the county, as there are many factors upon which a successful rotation depends.

Commercial fertilizers are not used in large quantities in Buchanan County, but stable manure is used extensively, and in increasing quantities as more live stock is kept on the farms. Bone meal is used on wheat by some farmers with profit. Its use is most extensive in the vicinity of De Kalb. An ordinary application consists of 100 to 150 pounds per acre. The opinion prevails that this fertilizer helps to obtain a subsequent stand of clover on the land, a problem which has become increasingly important in some sections in recent years. As a rule, complete fertilizers are beneficial only on impoverished lands from which immediate returns are desired. Where legumes are grown extensively nitrogen is not needed. The 1910 census reports a total expenditure in the county of \$6,088 for commercial fertilizers.

It is difficult to obtain good farm labor. Monthly wages range from \$25 to \$40 with board and room. Day laborers receive \$1.50 to \$2 a day. Farmers have largely solved the labor problem by using improved farm machinery. The 1910 census reports an expenditure of \$358,012 in the county for labor.

The average size of farms is reported by the census of 1910 as 92.1 acres, and 83.3 per cent of the farm land is reported improved. Of the total area of the county about 91 per cent is reported in farms.

In general, farm improvements are good, particularly in view of the high percentage of nonresident owners. The census of 1910 reports about 61 per cent of the farms operated by the owners, and practically all the remainder operated by tenants. Cash rent outside the immediate vicinity of St. Joseph is usually \$5 to \$8 an acre.

Share rent is usually one-half of the crops produced, with special arrangements as to buildings, seed, work stock, fertilizers, etc.

The value of farm land ranges from \$70 to \$200 an acre, depending on the topography, location, and improvements, with most sales made at \$100 to \$150 an acre. In the immediate vicinity of St. Joseph land values are considerably higher.

Valuable soils and favorable location with respect to transportation lines and markets make this county one of the most prosperous and progressive in the State. The organization of rural districts for purposes of cooperative marketing and stock breeding is receiving attention. A county agricultural agent is employed to study the agricultural conditions of the county, with a view to their improvement. The progressiveness of the rural population has resulted in better schools, improved roads, better homes, and general social advancement.

SOILS.

The soils of Buchanan County may be classed, on the basis of physiographic features, into two broad groups, the upland and the bottom soils. In point of origin they are separated into four general divisions—residual soils, glacial soils, loessial soils, and alluvial soils. In extent and agricultural value the loessial soils rank first, the alluvial soils second, the glacial third, and the residual soils last.

The underlying rocks of the region belong to the Upper Coal Measures, and are composed of alternating beds of limestone, sandstone, and shale. These are covered with two extensive and deep deposits of Pleistocene age, the older of which is known as the Kansan drift, and the more recent as loess.

The underlying rocks are now exposed only along the bluffs and streams, the limestone beds being most prominent in exposures on account of their greater resistance to weathering. Shale outcrops are seldom seen, except in deep stream cuts or where protected by overlying beds of limestone. The principal shale exposures occur along Bee Creek and other small streams south of St. Joseph, near the Platte County line. The limestones vary in color from yellowish brown to light gray. The shales usually are grayish-yellow, drab to bluish drab or black, and vary in hardness from easily crumbled material to rock approximating slate. The residual soil derived from the limestone is mixed with glacial and loessial material, but it is classed with the Crawford series. That derived from limestone and sandy shales is classed with the Boone series. The Boone soils cover a slightly larger area than the Crawford soils, but neither series is of great economic importance in the county, on account of its limited extent.

The Kansan glacial drift, which immediately overlies the basal rocks, was brought by the ice from regions to the north and spread over the entire northern part of the State as far south as the Missouri River. It varies from a few feet to many feet in thickness and in Buchanan County consists of clay and silt, mainly with smaller quantities of sand and stones, many of the latter being wholly unlike any found along the local bluffs and rock ledges. Around the heads and slopes of streams, beds of waterworn gravel and pebbles are found. These contain foreign material, such as quartz and granite, and limestone, chert, and material which may be of local origin. These beds of waterworn gravel invariably occur immediately above a bed of limestone or grade into the residual soil material of the limestone and shale. A notable example of the latter condition occurs in an area of Boone soil north and west of Agency. In one or two places in the county a bright-red clay occurs in association with the waterworn material. It is not clear whether this clay deposit, which has been encountered more extensively in surrounding areas, is a part of the glacial-drift deposit or represents residual material from limestone. The soil derived from the glacial drift is mapped as the Shelby loam. It is of rather small extent, and is characterized by a relatively high sand and gravel content.

Overlying the glacial material and in most places covering it to great depths is the deposit of loess. The soils derived from this formation range in color from yellowish brown to black. The brown loess soil occurs on the top of the bluffs next to the river and is noticeably coarser in texture than the dark-colored loess soil east of it. The depth of the deposit ranges from a few feet to 75 or 80 feet or more. The deposit is deepest, as a rule, on the bluffs along the Missouri River. Numerous road cuts in the vicinity of St. Joseph show a depth of 30 to 40 feet of yellowish-brown material with little change in color or texture. The dark-colored loess in the eastern part of the county is seldom as deep as this and in places outcrops of glacial till occur.

The origin of the loess has never been explained satisfactorily, but it would seem from the uniform size of the particles, from the rarity of fresh-water fossils, the entire absence of marine forms, the lack of stratification, and the continuous and uniform depth of the deposit at varying altitudes that the suggestion of eolian origin is the most plausible.

The loess soils are among the most productive in this region. This is doubtless to be ascribed to the fact that they are of recent formation, as well as to their peculiarly favorable texture, which allows the free movement and absorption of water and aids in the maintenance of

good tilth and a generally good physical condition. In Buchanan County the loessial soils are by far the most important, covering about two-thirds of the total area. They are classed with three types belonging to distinct series—the yellowish-brown soil as the Knox silt loam and a colluvial derivation therefrom as the Judson silt loam, and the dark-brown to black soil as the Marshall silt loam. The Judson type is of little economic importance on account of its small extent.

The Marshall silt loam parallels roughly the river bluff line, and is separated from it by the Knox silt loam. Although the boundary line between these two soils is in places only an approximation, inasmuch as the two gradually merge into each other, the boundary is generally rather distinct.

The alluvial soils have two main sources. Those developed along the smaller streams of the county, including the Platte River, are derived from the glacial and loessial material of the upland, mixed in the vicinity of Agency with a small percentage of material from the residual soils. They are classed with the Wabash series in the first bottoms and with the Bremer and Judson series on the second bottoms, or terraces. The Bremer soils closely resemble the Marshall soils of the upland, from which they are doubtless largely derived.

The alluvial soils in the flood plain of the Missouri River are derived from material transported by that stream. The general conditions attending their formation are easily traced. The river is constantly changing its channel, cutting in on one side and depositing reassorted material on the other. Frequently the current changes to a new channel, leaving standing water in the old bed, where a thin deposit of silty clay is made over sandy or silty material, forming areas of soil of variable texture. In times of overflow heavy deposits of very fine sand, silt, and clay have been made, and soil areas, differing in texture and other characteristics, have in this way been developed.

The principal distinguishing feature of the Missouri-bottom soils is the sandy or light silty character of the subsoil underlying the heavier surface soil. They are classed with the Sarpy and Cass series.

In Buchanan County 14 soil types, exclusive of Marsh, are recognized and mapped. These represent 10 soil series.

The Marshall series includes the dark-colored upland loessial soils with light-textured subsoils, which predominate in the great prairie region of the Central West. The types of this series are characterized by a large content of organic matter in the surface soil, which gives them a dark-brown to black color and distinguishes them from the Knox soils. The topography is level to rolling.

The Knox series comprises light-brown soils derived from loessial or other wind-blown deposits. The loessial covering is in all places thick enough to form the subsoil as well as the surface soil, the deeper lying glacial till being far enough from the surface to have no marked influence on the general character of the soil. The topography is gently undulating to rolling and the surface generally is well drained.

The soils of the Crawford series have dark-brown to reddish surface soils and reddish-brown to red friable subsoils. The series includes the residual limestone soils of the prairie region. These soils contain a fair percentage of lime. The surface is undulating to rolling, with some local areas of rough, broken topography. The Crawford soils are generally well drained.

The Boone series includes light-gray soils containing a small percentage of organic matter, underlain by pale-yellowish to slightly reddish yellow and often mottled, porous subsoils. A bedrock stratum is frequently encountered at shallow depths. The soils of this series are residual in origin and are derived from sandstone and shales, principally of Carboniferous age. The topography is rolling to steeply sloping, and the soils usually are forested.

The Shelby soils predominantly are brown to dark brown. The subsoils are composed of yellow, reddish-yellow or light-brown sandy clay and are heavier than the surface soils. The subsoils frequently contain iron pipes and nodular masses and streaks of calcareous material. These soils are derived from sandy glacial drift and occur in a region of complete dissection and rolling topography.

The Bremer soils are dark in color, ranging from dark gray to black. The material consists of an ancient flood-plain deposit derived largely from the upland glacial and loessial soils. Under the present classification the soil should properly be mapped as the Waukesha silt loam, but the correlation with the Bremer series is made to conform with the classification of the same soil as made in Nodaway County.

The surface soils of the Judson series are light brown to yellowish brown and of silty texture. The subsoils are of slightly lighter color and somewhat more compact structure. The series occupies stream terraces and flat alluvial lands along streams, through which the channels are so deeply cut that overflows are of rare occurrence. In places narrow strips of colluvial material occur, usually adjoining terraces or bottom lands. Drainage is well established.

The surface soils of the Wabash series prevailingly are dark brown to black, and the subsoils drab or gray. The dark color of the soil material is due to the presence of a large content of organic matter. These soils are developed in the first bottoms of streams in the central prairie States. They extend for long distances along the

Mississippi River. The material is derived principally from the loessial and associated soils of the region.

The soils of the Sarpy series range from light gray to dark brown. They differ from the Wabash soils in possessing loose silty or fine sandy subsoils distinctly lighter in texture than the surface soils. This characteristic gives better subsurface drainage than is the case with the Wabash soils of similar position and surface texture. The Sarpy soils occur in the bottoms of the Mississippi and Missouri Rivers and their larger tributaries. When leveed or otherwise protected from floods the soils are very productive.

The soils of the Cass series range in color from dark brown to black, and the subsoils are lighter in both color and texture than the soils. Usually at a depth of 2 feet the subsoil is a sandy loam or sand. These types differ from the Sarpy in the darker color of the surface soil.

The following table gives the names and the actual and relative extent of the various soils mapped in Buchanan County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Knox silt loam	45,376	33.6	Wabash clay	3,584	1.4
Heavy-subsoil phase.....	41,600		Sarpy fine sandy loam.....	2,240	.9
Marshall silt loam	84,352	32.6	Bremer silt loam.....	2,176	.8
Wabash silt loam.....	30,464	11.8	Boone silt loam.....	1,856	.7
Sarpy silt loam.....	13,120	5.1	Wabash silty clay.....	1,792	.7
Cass clay	12,736	4.9	Crawford stony loam.....	1,664	.6
Shelby loam.....	7,488	2.9	Marsh.....	960	.4
Sarpy very fine sandy loam...	5,376	2.1			
Judson silt loam.....	3,776	1.5	Total.....	258,560

MARSHALL SILT LOAM.

The Marshall silt loam consists of a black silt loam which grades, generally at about 15 inches, into a dark-brown slightly heavier silt loam, extending to a depth of 20 or 22 inches. Below this the subsoil is a chocolate-brown to brown silty clay loam, which either continues uniform throughout the remainder of the 3-foot section or becomes heavier with depth, until below 28 or 30 inches it consists of a friable silty clay. In some places the subsoil below about 20 inches shows slight mottlings of yellow and brown. Neither the soil nor the subsoil is sufficiently calcareous to effervesce with acid.

The type has one rather important variation, which is encountered in the vicinity of De Kalb. The soil is lighter in color than typical and consists of a dark-brown silt loam to a depth of 14 to 16 inches, underlain by a brown to yellowish-brown friable silty clay loam, which continues without change throughout the remainder of the

3-foot section. This variation is found in a more or less continuous area, following in a general way the course of the Chicago, Rock Island & Pacific Railway from a point a few miles southeast of the town of De Kalb to a point $1\frac{1}{2}$ miles east of Rushville. It represents an extreme variation of the type toward the Knox silt loam, with which this type is closely associated. Smaller areas of this variation occur in the vicinity of Taos, about $4\frac{1}{2}$ miles east of the main body.

In some places the black silt loam layer of the Marshall soil continues without change to a depth of 25 to 30 inches before the brown subsoil layer is encountered. Such areas lie more often on the gradual slopes to streams, but occur also on level divides. They merely represent areas where organic matter has penetrated deeper into the soil mass, except along the bottom slopes, in which case there is probably considerable colluvial wash present to account for the greater depth of the porous black layer. On the steeper slopes of streams, on the other hand, the brown subsoil frequently is encountered within a depth of 10 to 12 inches. The surface soil in such cases is a heavy silt loam, somewhat lighter in color than typical. When freshly plowed such areas have a spotted appearance, as a result of bringing the subsoil layer to the surface in spots where erosion has thinned the darker surface layer. When allowed to continue erosion frequently develops clay points on such land, greatly depreciating its agricultural value.

The Marshall silt loam occupies a broad, broken strip extending entirely across the county along the eastern boundary. It also forms extensive areas in the divides between South Bee Creek and Contrary Creek, between the Platte River and a broad area of Knox silt loam bordering the Missouri River lowland in the vicinity of Saxton, and west of De Kalb. Small, isolated areas are found throughout the county.

Originally the more nearly level areas of this type were for the most part prairie land, the largest continuous prairie area being in the eastern part of the county. A forest growth consisting of black walnut, elm, white oak, hackberry, honey locust, ash, and wild cherry extended up the stream slopes and along narrow ridges. Practically all the type is now cleared and in cultivation, only a few of the steeper slopes being forested.

The topography varies from undulating to rolling, with long, gradual slopes to streams. Rarely are the slopes so steep that modern farm machinery can not be used satisfactorily.

The structure of the soil and the topography are favorable to thorough drainage. In the more rolling areas the run-off is rapid and excessive and may result in the removal of large quantities of soil material. This susceptibility to erosion constitutes one of the

most important problems in the management of this soil. The excessive losses from erosion have not been appreciated. Nevertheless the erosion should be controlled because of the expense and difficulty of maintaining the organic-matter supply where this is not done. In addition the gullies that form greatly reduce the value of the land. When erosion reaches the gully stage it is very difficult to stop.

The Marshall silt loam is regarded as one of the best upland corn soils in the Mississippi Valley. Good yields are obtained in normal seasons, and in dry seasons the yields are larger than the average on other soils. An average yield of corn for several years would probably be as much as 45 bushels per acre. Yields of 70 to 80 bushels are obtained under good farming systems. Oats yield from 20 to 50 bushels per acre, the average for the four years, 1911-1914, according to the Missouri Crop Review, being 31 bushels. The crop is grown for stock feed. Wheat averaged 22 bushels per acre for the same period. It is an important cash crop. Clover yields about 1½ tons of hay per acre, and alfalfa about 6 tons per acre per season. In addition to the clover and alfalfa hay produced, considerable mixed clover and timothy is grown. Bluegrass does well on the type. The growing of cowpeas is increasing. There are many successful commercial orchards on the type, although it is not so extensively used for fruit as is the Knox silt loam. The soil is generally well supplied with lime.

Three classes of live stock are produced extensively on this type—beef cattle, hogs, and dairy cattle—and live-stock products constitute the most important source of income. Practically all the corn is fed on the farms, most of it to beef cattle and hogs. Dairying is most extensively practiced near the city of St. Joseph, both milk and cream being marketed. Silos are found on many dairy farms. Although the ensilage is fed mainly to dairy cows, some is used in beef production. Where cream is sold, the skimmed milk is largely fed to hogs.

The feeding of beef cattle is the most important and most highly specialized industry on this type. The importation of stockers and feeders is not as common as in former years, although still practiced to a considerable extent. Many farmers have begun both to raise and to feed cattle. The manure is relied upon to maintain the productiveness of the soil, but the supply is generally inadequate.

The Marshall silt loam includes many large, well-improved farms. Little of it is for sale, and its value ranges from \$135 to \$175 an acre in more remote sections to as much as \$300 an acre near the city of St. Joseph.

With an extension in the acreage of clover the present system of farming on this type will tend to keep the soil in a productive condi-

tion. Liming is not necessary as a rule, except for alfalfa on land which has been rather heavily cropped to grain without proper provision for maintaining the organic-matter supply. The use of nitrogen in commercial form will be less necessary where frequent leguminous crops are grown.

KNOX SILT LOAM.

Next to the Marshall soil the Knox silt loam is the most important type in the county, both in extent and in agricultural value. As typically developed on the bluffs bordering the Missouri River lowland, the soil to a depth of 12 inches or more consists of a light silt loam of brown color. The subsoil has a similar texture, but the color is lighter, becoming light yellowish brown with increase in depth. In road cuts, the material at depths of 10 to 20 feet frequently is a very fine sandy loam. The surface soil is characterized by the high percentage and uniformity in size of the coarse silt particles. Neither soil nor subsoil is so highly calcareous as to effervesce with acid, but in many places concretions of calcium carbonate are present in the subsoil at varying depths. This soil occurs in a continuous body along the bluff line of the Missouri River bottom, having an average width of about 3 to 5 miles.

Erosion constitutes one of the most important problems in the agricultural use of the Knox silt loam in this county. This soil is even less stable than the Marshall soil described above, and it is on account of its tendency to wash that the sharp topography which characterizes its western border has developed. It has a high water-holding capacity however, as is noticeable during periods of dry weather, when the crops on this soil withstand drought better than those on the other soils of the region. The problem of controlling erosion is not so difficult where gullies have not formed, and every effort should be made to prevent erosion from reaching the gully stage. This is best accomplished by keeping the soil under crops most of the year, particularly in the winter.

This soil was formerly forested with a heavy growth of laurel, white and bur oak, elm, walnut, hickory, cherry, ash, honey, locust, and sassafras. Only a very few small areas on steep slopes remain uncleared. Where forested the surface soil usually is somewhat darker colored than the subsoil, but the color soon becomes lighter under cultivation.

The Knox silt loam is a friable, easily cultivated, well-drained soil, and, as a whole, is well adapted to alfalfa, clover, fruit, and garden vegetables. It is particularly well adapted to orchard and garden products, which constitute the most important source of income on

much of the type, although wheat and corn also are important. Tobacco was extensively grown in the vicinity of De Kalb some years ago, but the acreage has been greatly reduced as the result of a decline in prices. Small fruits and vegetables are most extensively grown within a radius of 5 or 6 miles of St. Joseph and constitute the most important cash crops of this section. Their production is very profitable.

Among the garden fruits and vegetables, potatoes, sweet potatoes, strawberries, blackberries, asparagus, beans, beets, cabbage, lettuce, radishes, onions, peas, rhubarb, and tomatoes are most important. Of these, potatoes are most extensively grown, and very large yields are obtained with proper cultural methods. The prevailing method is to plow the land in the fall and pulverize it thoroughly before planting, usually as early in the spring as possible. The commercial growers usually spray systematically to control the Colorado potato beetle. There is some complaint of scab and blight. The principal varieties of potatoes grown are the Burbank, Early Ohio, and Early Rose.

The Knox silt loam produces grapes abundantly, even where the land is too steep for other crops. While this crop receives considerable attention, the industry could profitably be extended on much of the steep land near the river bluffs. Good local markets are available. In order to obtain good grapes, however, fungus diseases, particularly black rot, and insects must be kept down by proper spraying. One and two year old vines are used. The grapes usually are cultivated about the same as corn or orchard trees, where the land is fairly level. On the steeper hills the usual practice is to cultivate only around the plants, leaving the area in between undisturbed in order to prevent erosion. Where clean cultivation is practiced cow-peas frequently are planted between the rows and allowed to decay on the land. This supplies organic matter and prevents the washing of the soil. A renewal system of pruning usually is practiced.

Orchard products, particularly apples, are grown commercially on all parts of the type, and the soil has been demonstrated to be well suited to this class of fruits. Of the varieties of apples grown, the Ben Davis, Jonathan, Gano, and Winesap are most important. A fruit growers' association has recently been organized in the county for the purpose of increasing the production and improving the quality of the fruit, as well as obtaining better prices for the fruit produced. The successful orchards are sprayed systematically.

Probably more clover is grown on the Knox silt loam and its heavy-subsoil phase than on any other soil in the county. As on the Marshall silt loam, one of the serious obstacles to the growing of clover is the uncertainty of securing a stand in dry years. The Knox

silt loam is well supplied with lime, and further applications, as a rule, will not promote the growth of clover.

There is considerable variation in the methods of seeding clover in this county. Much of the crop is seeded in the spring in wheat, but sometimes the seed is harrowed in; at others it is merely sown on the surface. Some farmers sow in February, while others wait, apparently with equal success, until April. Probably most farmers plant early, while the ground is in the so-called "honeycombed" condition. Early sowing also has the advantage of not interfering with other farm work.

There is a general appreciation of the important relation clover bears to profitable systems of agriculture. The bad effects of growing corn continuously on the same land for a period of years without heavy applications of stable manure or the turning under of green manuring crops is well understood, and the use of clover for maintaining the productiveness of corn land is receiving attention. Observations indicate that the best results are had where clover is seeded alone, probably because the nurse crop robs the young clover plants of moisture. Applications of bone meal or a top-dressing of manure also are found very beneficial.

The areas of this soil that have a sharp, steep topography are not adapted to the use of modern machinery. Erosion is very active in such areas where cultivated. They are valuable for pasture, however, and practically all this land is particularly suitable for apple and peach orchards, in which erosion can easily be controlled.

The Knox silt loam is not as high in organic matter as the Marshall silt loam. This is partly due to its extremely porous nature, which permits a free circulation of air and maximum oxidation of the vegetable material. This thorough drainage and aeration is of great advantage, however, where provision for an abundance of leguminous organic matter is made.

Many highly improved farms are found on the Knox silt loam and its heavy-subsoil phase, particularly in the sections devoted mainly to orchard and garden products. Land of this type sells for \$100 to \$175 an acre, depending on location and improvements. Near the city of St. Joseph prices average higher.

Where it is found necessary to cultivate steep land, the plow row should follow the contour of the hill, and narrow strips of sod left to alternate with the cultivated strips. It is also beneficial in places to leave strips of sod running with the slope where the surface water flows.

An increase in the acreage of pasture land would enable more live stock to be kept, and this would result in an increase in the quantity of manure produced. As a rule the live-stock industry is not highly

specialized next to the river bottoms. By extending this industry more clover and alfalfa could be grown on the adjoining Missouri River lowlands, to be fed to live stock in feed lots on the upland. The dairy industry could well be developed to a higher degree on this type. By supplementing the supply of manure produced by green manuring crops the supply of organic matter can be increased and the soil kept in a productive condition.

Knox silt loam, heavy-subsoil phase.—This phase differs from the typical Knox silt loam only in the texture of the subsoil. The surface soil to a depth of 14 to 18 inches is a brown silt loam, grading into a yellowish-brown silty clay loam, which in turn frequently passes into slightly heavier material approaching a silty clay.

This soil is found farther from the river than the main type. The largest development occupies the slopes along the Platte River and reaches its maximum width in the southern part of the county. Important areas occur along Sugar Creek in the southwestern part of the county and along Contrary Creek near De Kalb. The boundary line between the phase and the typical Knox silt loam is more or less arbitrary from De Kalb northeastward. Small isolated areas of the phase are found west of the North Fork of the Platte River and east of the Platte River northeast of Agency. This soil in places is much like the Boone silt loam in some respects, but it is not of the same origin. It occupies a position above the Shelby loam, and there is no evidence that it is not derived from loess. It occupies slopes where a light subsoil might be expected, but instead the subsoil is somewhat plastic and much heavier than that of the typical Knox silt loam.

Most of the heavy-subsoil phase is of slightly higher agricultural value than the typical Knox silt loam, not only because of its smoother topography, but also because it is less susceptible to erosion. There are included areas, notably in the vicinity of Garrettsburg, near Agency, and between Malden Creek and the Platte River south of Frazier, where the soil is rather shallow and the slopes are steep. These areas are less desirable than the deeper soil on the bluffs.

There is some evidence, such as small areas of typical Crawford soil and an abundance of limestone outcrops, that some of the material of the phase as developed in the vicinity of Frazier and Malden Creek may be residual from the underlying limestone. But the soil nowhere approaches the physical characteristics of the typical Crawford soil or the limestone soils of this region. The typical Knox silt loam covers the entire surface, including both ridges and valleys. The heavy-subsoil phase occupies slopes and lower ridges only, except along Malden Creek, west of Gower, where it occurs on high ridges, bordering the creek, the Marshall soil occupying the lower areas at the foot of the divides.

As far as the soil is concerned, there is no difference in crop adaptation between the typical Knox silt loam and its heavy-subsoil phase. The fact that less grain and more fruit is grown on the typical silt loam is due to its rougher topography and nearness to market rather than to any particular soil feature. The phase is regarded as somewhat more drought resistant than the Marshall silt loam. The type of live-stock and grain farming is the same as on the Marshall soil, but the slopes are somewhat steeper, and on this account farming is somewhat more difficult. The yields of wheat and oats are practically the same as on the Marshall soil. The wheat is sold for cash, and the oats are grown largely for feed. Yields of corn usually are lower than those obtained on the Marshall silt loam.

CRAWFORD STONY LOAM.

The thin soil covering of the stony hills in the county is mapped as the Crawford stony loam. Limestone fragments occur in such quantities as to make these hills worthless for farming. The interstitial soil material ranges from a silt loam to a clay loam, but the areas of the different grades of material are too small for satisfactory separation into types. The color of the soil material is prevailingly reddish, although in some areas it is dark brown to black, much like that of the Summit stony loam.

The type occurs in small isolated strips, including much of the bluff line along the Missouri bottoms and the slopes of the smaller streams throughout the county. It is formed through the weathering in place of beds of limestone of the upper Coal measures. Outcrops of the limestone are of common occurrence. In many places the interstitial soil material is very shallow, resting upon the underlying bedrock at a depth of 1 foot or less.

This type is valuable only for pasture and for its forest growth, which consists mainly of oak, locust, elm, and scrub hickory. In favorable seasons a fair growth of bluegrass covers the less stony areas.

BOONE SILT LOAM.

The Boone silt loam is prevailingly a light-brown silt loam, underlain at 14 to 18 inches by yellowish-brown silty clay loam to silty clay. The type has a rolling to hilly topography and occurs along stream slopes. The material is residual from sandy shale, but it probably also contains a considerable admixture of glacial and loessial material. In places along steep slopes both the soil and subsoil contain shale fragments, but usually these are absent and the soil is difficult to separate from the Knox silt loam, heavy-subsoil phase. A thin stratum of limestone lies just above the shale from which the soil apparently is largely derived, and the weathered product of this

limestone has in places modified the soil material, giving rise to small patches of a reddish soil resembling the Crawford silt loam. There are also included with this type small areas of residual soil derived from limestone, which would be mapped as the Crawford silt loam if of sufficient extent and importance. The soil of these areas is a reddish-brown, mellow silt loam grading below 18 inches into a reddish-brown to red or mottled yellow and red, friable silty clay. The areas are small and irregular and occur east of the Platte River, mainly in the belt of country between Malden Creek and the river. They lie for the most part on the tops of eroded ridges or on the slopes to streams. The soil is well drained and is nearly all under cultivation. It originally supported a forest growth of black walnut, red oak, elm, and locust. It is a good general-farming soil, particularly for wheat and clover, and where carefully farmed ranks with the best land in the county. The slopes usually are steep, and on this account the soil is less desirable than land which is no more productive but which has a smoother surface.

The main areas of the Boone silt loam lie in the vicinity of Agency, along Bee Creek, about 2 miles north of this place, and east of Garrettsburg. A small area is mapped southeast of Taos and another about $4\frac{1}{2}$ miles south of Agency. These areas occur on steep slopes forming narrow strips along the streams between the bottoms and the Knox silt loam of the upland. The glacial till is seldom present in sufficient quantity noticeably to modify the soil material, although the presence of waterworn gravel is evidence that the till at one time covered the underlying limestone and shales. Some of the type is forested with post oak, white oak, and small hickory, but the greater part has been cleared and is in cultivation.

The Boone silt loam usually is moderately productive, but on account of the completeness of stream dissection it is of relatively low agricultural value. It is very low in organic matter and dries out quickly. Most of it is subject to destructive erosion.

The Boone silt loam includes small areas of fine sandy loam, occurring in the vicinity of Bee Creek Junction, in which the soil consists of a yellow to grayish-yellow fine sandy loam to a depth of about 18 inches, below which a mottled yellow and reddish sandy loam is encountered. The surface soil in places contains small fragments of brownish shaly sandstone and waterworn gravel from the glacial till.

The staple farm crops common to the region are grown on the Boone silt loam, and fair yields are obtained. Over most of the type it is difficult to use modern farm machinery because of the rough topography, and much of the type is best adapted to grazing. Bluegrass and other cultivated grasses, as well as clover and cowpeas, are successfully grown. A material improvement in the productive ca-

capacity of this soil can be made by the extensive use of manure, by green manuring, and by growing clover. The thinness of this soil renders it susceptible to drought, and corn and the cereals are less certain and less profitable than on the typical loessial soils. Dairying offers good opportunities in the section of the county in which this type occurs.

This soil is farmed in conjunction with associated types, and its separate value can not definitely be stated.

SHELBY LOAM.

The Shelby loam, to a depth of 12 to 15 inches, consists of brown to dark-brown loam. This grades quickly into yellowish-brown sandy clay, which continues throughout the remainder of the 3-foot section. The texture varies in places to a fine sandy loam or coarse sandy loam. The subsoil frequently contains sand, coarse sand, and gravel. In places it contains considerable clay and is quite plastic when wet and hard when dry. In some places the surface soil consists of a dark-brown to black heavy soil about 18 inches deep, and in such areas the texture may approach a silt loam, differing but little from the Marshall silt loam or the loessial soil overlying it. Small areas of a fine sandy loam are encountered along the Andrew County line in the northeastern part of the county. The soil of such areas consists of the Shelby fine sandy loam, but is not sufficiently extensive to warrant separation.

The Shelby loam is clearly derived from glacial drift. The occurrence of this type in isolated areas of wide distribution indicates that the deposit of glacial till extends over most of Buchanan County, but that it is nearer the surface in the eastern part. The Shelby soils are encountered only where the covering of loess has been removed by erosion, and the fact that the Shelby soils are less frequently encountered in the western section of the county than in the eastern part is due to the deeper deposit of the loess in the western part.

The type occupies narrow strips along the slopes of streams. The areas are not large, but are rather continuous along the streams. The slopes vary from gradual to steep, and the surface drainage of the type is often excessive.

Originally this type was forested, but practically all the tillable areas are now cleared and in cultivation. The forest growth remaining consists of black oak, red oak, and small hickory, and is confined to the steeper, more eroded slopes. The rough areas are best suited for pasture, leaving the more gentle slopes for cultivated crops. The soil of the less rolling areas is easily improved by increasing the organic-matter supply, through manuring, green manuring with legumes, and the use of winter cover crops.

In general the type is well suited to the grain crops commonly grown in the county. Corn is the most important crop and good yields are obtained, particularly in areas of the type that contain an admixture of loessial material. This is an early soil, owing to its sandy texture, and on this account it is well suited to the production of small fruits and vegetables. Wheat yields from 15 to 30 bushels an acre. Bluegrass does particularly well.

This type is held in conjunction with other types, particularly the Marshall silt loam.

BREMER SILT LOAM.¹

The soil of the Bremer silt loam is a brownish-black to black silt loam 20 inches deep, underlain by a slightly lighter brown heavy silt loam which passes into a silty clay loam to silty clay. In places the subsoil is not heavier than a silty clay loam.

This type occurs along the Platte and the One Hundred and Two Rivers and their tributaries. It is a terrace soil and lies above normal overflow. In places it is slightly eroded. The boundaries between this type and the upland on the one hand and the first bottoms on the other are clearly defined in the more extensive areas. The soil evidently consists of reworked Marshall silt loam material and the type closely resembles the Marshall silt loam in physical characteristics. The surface as a rule is almost level, although there are areas of slightly undulating topography and small areas which slope toward the first bottoms. The drainage is good.

One small area of silty clay loam is included with this type. In this area the surface soil to a depth of 12 to 15 inches is a black silty clay loam, which becomes dark gray on drying. This grades downward into a very dark gray to drab-colored clay, which contains some mottlings of yellow and brown and is plastic below about 30 inches. The soil is very productive, although drainage is deficient. The area of the soil is encountered east of the Platte River, about 2½ miles southwest of Stockbridge. The soil is derived from wash of the upland soils, and like the silt loam represents a former flood plain of the river. It occupies a lower level than the main type and consequently is not so well drained. Corn and wheat are grown and produce good yields. The soil is better adapted to alsike than to red clover, owing to its deficient drainage.

All the Bremer silt loam is in cultivation and in a high state of productiveness. It is one of the best soils in the county. Corn, wheat, and clover are extensively grown. Corn yields are estimated

¹ In the present knowledge of soil classification this type would be classed as the Waukesha silt loam, but it is mapped as the Bremer silt loam in this survey to conform with the classification used in Nodaway County.

by farmers to range as high as 80 bushels per acre, with an average of about 50 bushels. Wheat yields about 30 bushels per acre and clover as high as $1\frac{1}{2}$ to $1\frac{3}{4}$ tons of hay per acre. The type is less susceptible to drought than the upland soils. It is a strong alfalfa soil, and the crop is grown to a small extent.

This land is valued as high as \$175 an acre, although no farms consist entirely of this type.

The adaptation of this soil to the leguminous crops, particularly clover and alfalfa, make it valuable for live-stock farming. Small upland areas of other soils of rough topography are held in conjunction with the Bremer silt loam and supply good pasture, leaving all the Bremer soil for cultivation. There is some need of crop rotation and the careful use of manure on this type to maintain its productivity. An occasional crop turned under is also beneficial.

JUDSON SILT LOAM.

Three classes of material are included with the Judson silt loam as mapped: (1) The terrace soil composed of wash from the loess uplands; (2) the colluvial deposits at the foot of the loess areas; (3) a small area of terrace soil along the Platte River.

The terrace soil consists of a brown to dark-brown silt loam, underlain by a brown to light-brown silt loam subsoil, faintly mottled in the lower part by iron stains. There is little difference in texture between the soil and subsoil. Both may contain small percentages of very fine sand.

The largest area of this terrace soil occurs as a long strip along Contrary Creek. This stream has its drainage basin entirely within the Knox silt loam, and the terrace material of this type consists of reworked Knox material. The material has been transported into the Missouri River valley by creep, and it is deposited over the river alluvium for some distance. Along the outer margin of the type the river alluvium frequently is encountered within the 3-foot section, but farther inland the deposit frequently has a depth of 25 to 30 feet. It is entirely loessial in origin and has been washed down from the Knox upland and redeposited by streams in its present position.

The soil on this terrace is well drained and ranks with the most productive in the county. Corn sometimes produces as high as 80 bushels per acre, and other crops, including wheat, clover, and alfalfa, give correspondingly high yields. Owing to its texture and structure, it warms up early in the spring, and is well suited to truck crops. Small areas are used for trucking near South St. Joseph. Most of it, however, is devoted to corn and wheat, which are the cash crops. The soil is easy to cultivate and maintain in proper physical condition for crops.

The original forest growth consisted chiefly of oak and hickory, with some maple and basswood. Practically all the timber has been removed and the land put in cultivation. This is a highly desirable soil, and all of it is available for cultivation. Owing to its level surface it is not subject to erosion and is suited to the use of modern farm machinery. This soil is easily maintained in a highly productive state by careful farming. Crop failures on account of drought are unknown.

This terrace soil is valued at \$140 to \$175 an acre. No farms are composed of it entirely.

The colluvial variation of the Judson silt loam is not extensive in Buchanan County. It is encountered at the foot of the bluffs along the Missouri River lowland south of St. Joseph and bordering the lowland along the One Hundred and Two and Platte Rivers and their tributaries. The surface soil consists of a dark-brown silt loam, about 2 feet deep, below which the material is heavier in texture and of light-brown color. In places this soil differs but little from the Knox silt loam. Its entire area is above the limits of overflow. It usually rises with a gradual slope 10 to 20 feet above the level of the stream valley along which it occurs and lies from 25 to 50 feet below the tops of the ridges occupied by the Knox silt loam.

The agricultural value of this soil equals or exceeds that of the Marshall or Knox soils. Corn, wheat, clover, oats, and garden fruits do particularly well. All the soil is under cultivation, and in a high state of productiveness. Corn is the principal crop grown, and yields of 60 to 85 bushels per acre are not uncommon. Wheat, clover, oats, and vegetables also are successfully grown. The productiveness of this soil is easily maintained where good methods, including a proper rotation of crops, are employed.

The alluvial areas of the Judson silt loam along the Platte River are not typical in all respects but can not satisfactorily be mapped separately on account of their small extent. The soil of these areas to a depth of about 12 inches is a dark-brown very fine sandy loam, ranging in places to a loam. The subsoil is quite variable in texture, consisting of a loam, heavy very fine sandy loam or a sandy clay loam of brownish color.

This alluvial variation is confined to several small areas about 1½ miles northeast of Agency. It is well drained except in periods of very high water. It consists of material washed down from the upland soils, principally the Shelby loam. All this soil is cultivated, and good yields of all the farm crops commonly grown in the county are obtained. Corn and wheat are the principal crops, although the soil is well suited to clover and alfalfa. The soil is adapted to

the production of truck crops, but is not used for this purpose. The floods of the 1915 season resulted in total crop losses.

WABASH SILT LOAM.

The soil of the Wabash silt loam, to a depth of 18 or 20 inches, consists of a very dark brown to black, mellow silt loam. This grades into a very dark gray to drab-colored silty clay loam, which becomes heavier with depth and shows occasional mottlings of yellowish brown below 30 inches. The subsoil varies in places to a clay. At the foot of the upland this type frequently is modified by loess overwash, giving the surface soil a lighter color. The lighter textured subsoil usually is found along the small streams, and the heavy subsoil bordering the heavy types. The subsoil frequently contains rusty-brown stains.

As mapped this type includes small areas of colluvial material along the smaller streams. It usually consists of a deep, porous black silt loam, slightly heavier in the lower than in the upper part, and rich in organic matter. It is very productive, yields of crops frequently exceeding those on the typical alluvial soils, particularly in dry seasons.

The Wabash silt loam is the most important first-bottom type of the smaller streams. It is composed of material washed down from the loessial and glacial soils of the upland and redeposited by the streams. The largest areas occur along the Platte and One Hundred and Two Rivers. The flood plains of the Platte River along which this type is extensively found vary in width from several miles in the vicinity east of St. Joseph to a few rods in the north-central part of the county, where limestone ledges extend on both sides to the edge of the stream channel. Even as far north as Garrettsburg the bottom land is less than one-fourth mile wide.

The surface of the type is flat except where broken by stream channels, with a gentle slope toward the stream along which it occurs. The type is subject to occasional overflows, which sometimes cause crop loss. The natural drainage is poor. While crops are successfully grown, there is always the possibility of losing a part of or all the crop as a result of floods.

The Wabash silt loam is one of the most productive soils in the State, and were it not for the danger of overflow it would doubtless rank as one of the best soils in the county. In a way the occasional overflows serve to improve the type, as each inundation leaves an additional deposit of rich soil material over the surface.

Corn is the principal crop grown on the type, and yields of 60 to 80 bushels are not uncommon in years when the land is not flooded. This is one of the best corn soils in the county. The crop is fed

largely to live stock on the upland. Wheat also does well, some of the highest yields in the county being obtained from fields on this type. The higher lying and consequently better drained areas produce red clover and alfalfa successfully, but on account of the possibility of overflows the acreage of these crops is small. Alsike thrives on the type and is particularly well suited to areas that are too wet for red clover. The type is also well adapted to bluegrass and other tame grasses, and a large part of it is used as pasture, for which it is especially valuable. Small grains, especially oats, make a rank growth and are likely to lodge badly.

Land of this type ranges in value from \$100 to \$150 an acre, depending upon location and drainage.

The problem of drainage is very important on this type. A large part can be improved by tile drainage. It is possible that small dikes could be constructed to advantage in some places to protect the fields from overflow. The periods of inundation could be considerably shortened by straightening the stream channels and ditching the fields. Such work is being considered, the need thereof having been seriously felt during the unusually destructive floods of 1915. Aside from the drainage and flood protection, the type requires only careful management to be kept in a very high state of productiveness.

WABASH SILTY CLAY.

The Wabash silty clay, to a depth of 12 inches, is a very dark gray to black silty clay. This is underlain by a drab or mottled drab and yellowish-brown, plastic clay, which continues throughout the remainder of the 3-foot section. In places the heavy clay subsoil lies below 18 inches. This type is on the whole somewhat lighter colored than the Wabash clay, is much more friable, and does not crack so badly.

The Wabash silty clay is alluvial in origin and is most extensively developed in the bottoms of the Platte River. Only a few small areas occur in the Missouri River bottoms. The type occupies a position slightly higher than the Wabash clay, but lower than the silt loam of the series.

The topography is flat. All the type is either cultivated or pastured. It is used largely for corn, and yields of 60 to 70 bushels are obtained in favorable seasons. The type is subject to overflow, and crops are frequently lost. It is an excellent pasture soil, and yields of 2 to 3 tons of hay per acre are obtained. Bluegrass does particularly well. The type generally is in need of artificial drainage and is likely to be cold and late in wet years. The establishing of good drainage would greatly improve this condition. The soil is difficult to till, because of its stiff plastic structure. This deficiency

can be remedied by incorporating organic matter and by plowing in the fall. The latter exposes the soil to the effects of thawing and freezing during the winter, which tend to make it more friable. Owing to its low position and the danger of overflow, this type has a lower value than soils which, though inherently no more productive, are better situated. The average selling price would probably not be over \$75 to \$100 an acre, the type being held in conjunction with other types of higher value.

WABASH CLAY.

The soil of the Wabash clay to an average depth of 10 or 12 inches consists of a very dark gray to black, heavy, plastic clay. Below this to 18 or 20 inches the soil gradually becomes lighter in color, being a very dark grayish to dark-drab clay, grading into a light-drab, heavy, plastic clay, mottled occasionally with iron stains or rusty streaks in the lower part. In places the material is a uniformly drab colored, plastic clay below 15 inches. In other places the black surface clay extends to a depth of 20 inches or more before the drab-colored clay subsoil is encountered.

The Wabash clay is known as "gumbo" land. It occurs most extensively in the flood plain of the Platte River and its tributaries, but is also developed to a small extent in the Missouri bottoms. The most extensive single area in the Missouri lowland is found between Upper Lake Contrary and the river.

The type is alluvial in origin, being formed by the deposition of fine silt and clay particles in standing water in times of overflow. The subsequent growth and decay of plants has supplied the large percentage of organic matter characteristically present. The type has a flat topography, with a gradual slope toward the stream along which it occurs. All this soil along the Platte River is subject to overflow. The Missouri-bottom area is above usual overflow, but otherwise is as poorly drained as the Platte River areas.

Tillage of this soil is very difficult, especially for the first few years of cultivation. Only a small part of the type is farmed at present. When dry the soil bakes and cracks. It puddles easily, and on this account must be handled when in just the right moisture condition or its physical condition will be greatly impaired for at least one cropping season. Subsequent alternate freezing and thawing and alternate wetting and drying will restore granulation.

A large part of the type is used for pasture. It supports a rank growth of wild grasses such as bluestem, and bluegrass also thrives on it. Besides the pasturage they afford these grasses frequently are cut for hay, giving yields of $1\frac{1}{2}$ to 2 tons per acre. Much of the Wabash clay soil is acid, and therefore better adapted to alsike than

to red clover. Corn and wheat constitute the principal cultivated crops. The opinion prevails that this soil is better suited to wheat than to corn, but good yields of both are obtained, particularly in dry years. There is always considerable danger of crop loss by floods, and on this account the type probably is best used under present conditions for hay production and pasture, particularly where it is farmed in conjunction with other better drained types on which cultivated crops are more certain.

The great need of this soil, as well as of practically all the Platte River lowland, is better drainage and flood protection. Drainage can be adequately provided by constructing ditches and laying tile laterals. Protection from floods is more difficult to accomplish, and the expense of building levees and diking under present economic conditions probably is not always justified, especially in view of the fact that the land has a high value for grazing without this improvement. However, with proper drainage and flood protection the Wabash clay, like the other first-bottom soils, will rank with the best agricultural land in the county. The period of overflow may be shortened by straightening the stream channels and ditching.

SARPY FINE SANDY LOAM.

The Sarpy fine sandy loam consists of a yellowish-gray to light grayish brown, smooth fine sandy loam, usually slightly heavier in texture below 5 or 6 inches. At a depth of 14 to 20 inches the sub-surface material grades into a lighter fine sandy loam or fine sand of grayish-brown color, which either continues to a depth of 3 feet or is underlain by alternating strata of silt loam and fine sandy loam material.

The type is alluvial and occurs in the Missouri bottoms as isolated narrow strips. It is not extensive in this county. The areas occurring at some distance from the river are usually high enough to be well drained. Such areas are in cultivation and produce good yields of corn, wheat, cowpeas, clover, and alfalfa. They are particularly well suited to garden and truck crops. As mapped along the river, notably west of Beck Slough, this type includes areas of Riverwash, none of which is in cultivation. In other places, such as the area 1 mile south of Lower Lake Contrary, the type includes a grayish-brown sand of loose, incoherent structure. This consists of the Sarpy fine sand, but is too inextensive for satisfactory separation. In general the sandy variation of the type is droughty, owing to its low water-holding capacity, and crops frequently suffer from lack of moisture. It is very difficult to produce profitable crops of clover and cultivated grasses. Corn and rye seem to do best in such areas, although wheat apparently is more extensively grown than these crops, and produces fair yields.

The typical Sarpy fine sandy loam is well suited to the production of potatoes and other truck crops. The soil is easily cultivated, and warms up early in the spring. Best results with garden truck are obtained where liberal applications of manure are made. The soil readily responds to the addition of organic matter in any form, and an increase in its organic-matter supply, preferably through growing legume crops, is its greatest need.

The Sarpy fine sandy loam is held and farmed in conjunction with other types, and its separate value can not definitely be given.

SARPY VERY FINE SANDY LOAM.

The soil of the Sarpy very fine sandy loam consists of a light-brown very fine sandy loam, which changes to grayish brown at a depth of 15 to 22 inches. Frequently the material in the lower part of the 3-foot section is a very fine sand. In places the color of the surface is dark brown, owing to accumulations of organic matter. This soil has a total area of 8.4 square miles in the Missouri bottoms. In places it occupies rather extensive single areas, usually lying between the Sarpy silt loam and the river. As mapped, the type includes areas of fine sandy loam and of fine sand which on account of their irregularity of occurrence and small extent can not be shown satisfactorily on the soil map. Thin layers of soil approaching a silty clay in texture are encountered in some areas within the 3-foot profile. These variations in texture generally occur in areas having a billowy surface and are due to the action of the water at the time of the deposition of the material. The type is alluvial, the material having been brought down and deposited by flood waters of the Missouri River.

The drainage of this soil usually is good, although there are small areas near the river where drainage is deficient. The soil can be handled earlier and with greater ease than the heavier soils of the bottoms.

Most of the type is cleared. The poorly drained areas are forested with sycamore, cottonwood, maple, and pecan. Corn, small grains, clover, and alfalfa give good yields, the grain crops being most extensively grown. The type is not used for pasture, and is not suited to extensive stock feeding, but it is one of the best truck soils in the county. Like the Sarpy silt loam this soil is greatly benefited by the use of manure and green manuring crops, such as clover and cowpeas. Alfalfa does particularly well on the type. The soil has a high productive capacity, which is easily maintained by proper crop rotation. Some market gardening is practiced on the type near St. Joseph, and in view of the warm, porous nature of the soil and its general adaptation to garden crops, it seems that this industry could be profitably extended.

The value of this type varies according to drainage conditions and its location with respect to the river. Where well drained and not subject to damaging overflow it forms highly desirable land. Practically all the type is above ordinarily high water.

SARPY SILT LOAM.

The Sarpy silt loam usually is stratified, and includes three distinct sections or zones. The upper, or surface section, consists of a light-brown to dark-brown, mellow silt loam, usually 12 to 14 inches deep. The subsurface soil extends to a depth of 20 or 22 inches and is a dark yellowish gray to brownish silt loam. In some areas the subsurface layer approaches a silty clay loam in texture, while in others it is slightly lighter than the surface soil. The subsoil grades through a very fine sandy loam of grayish-brown color into a very fine sand, which is encountered below about 30 inches. Although these three strata are subject to considerable variation in different areas, they are fairly uniform in any one body of the type. There are places where the surface silt loam layer quickly grades into a very fine sandy loam subsurface layer, which continues without change throughout the remainder of the 3-foot section. There are also included in the type small areas having a billowy surface in which the crests of the slight ridges are frequently a very fine sandy loam. Such areas are too irregular in occurrence and too small to be shown separately on the map, and it is also believed that through cultivation the very fine sandy loam layers will be mixed with the heavy silt loam soil of the intervening depressions to form a more nearly typical silt loam.

Another variation in the type is found in the vicinity of the stockyards in St. Joseph and farther southward along the foot of the upland, where the soil material is in part composed of colluvial wash from the upland, more or less intricately mixed with the river alluvium. The soil of this variation is a brown silt loam, grading at a depth of 18 or 20 inches into a dark-brown heavy silt loam to silty clay loam. The subsurface soil and subsoil frequently contain strata of black silty clay loam material very much like that of the Wabash soils. This variation is not sufficiently extensive to be separated on the map. It is more like the Sarpy silt loam in physical characteristics than like the Wabash silt loam.

The Sarpy silt loam occupies an intermediate position between the heavier clay soils on the one side and the lighter textured sandy soils on the other. It occupies fairly high areas, lying above normal overflow. It is well drained, except in small, isolated areas where rain water from the upland collects over the surface. Frequently fair-sized draws carry the run-off from the upland into the valley below,

and occasionally, owing to deposits of sediment, the channels become clogged and the water is impounded and stands until it escapes by evaporation or seepage. Such conditions of poor drainage can be remedied by ditching, which has been done in a few instances with profitable results.

This soil consists of alluvium brought down by the Missouri River. The subsoil probably represents former sand bars laid down along the river and the soil a later covering of river-borne silt. The decay of vegetation which grows luxuriantly under moist conditions has added organic matter to the surface soil and emphasized the difference between the soil and subsoil. The type is very drought resistant, crop failures due to drought being unknown.

In agricultural value and in area the Sarpy silt loam is one of the more important types of the Missouri River lowland. All the grain crops common to the region are grown, and good yields are obtained. White corn, of which the Boone County White variety predominates, is extensively grown and yields from 40 to 75 bushels or more per acre. Fulcaster is the leading variety of wheat. Yields of 30 bushels per acre frequently are obtained on the better drained areas of the type. The average yield is probably not over 25 bushels. Oats yield from 20 to 50 bushels per acre, depending largely on the season. Both alfalfa and clover do particularly well on the type. Alfalfa yields as high as 8 tons per acre per season, the average yield being about 6 tons. Most of the clover and alfalfa is sold, though some is fed to stock kept on the upland.

The acreage in grain is proportionately too great and that in leguminous crops too small for a well-balanced system of farming. This is largely due to the difficulty of feeding live stock on the bottom land, where feed lots which will not be too muddy can hardly be found. It is necessary therefore, in order to maintain the organic matter supply of the soil to plow under crop residues and leguminous crops as often as possible. It is only because of their great natural productiveness that the Sarpy silt loam and other river-bottom types have retained their fertility under the exhaustive system of grain farming that has been practiced. However, there is evidence that some of this soil is becoming deficient in organic matter, and in places light-colored, unproductive spots are appearing. The only remedy, where liberal quantities of manure are not available, is the incorporation of green manuring crops, as well as straw and other crop residues. The type is in need of a system of farming that will provide for a wider use of leguminous crops, as by the sowing of clover in wheat to be plowed under either as the first or second crop, and the planting of cowpeas either in corn or following wheat to be hogged off or plowed under. Poorly drained areas are better suited to alsike than to red clover.

The yields of corn are materially increased by careful selection of the seed. There is a growing desire among farmers on this type to develop high-yielding strains not only of corn, but of the small grains as well. The Sarpy silt loam is adapted to small fruits and vegetables. It is used to some extent for these crops in the immediate vicinity of St. Joseph, and the acreage devoted to them probably could be advantageously extended.

This soil is one of the most highly prized in the county. Little of it can be bought for less than \$150 an acre, except in areas which are endangered by the river. Near St. Joseph prices are much higher than this.

CASS CLAY.

As mapped in Buchanan County, the 3-foot section of the Cass clay consists of three distinct strata. The surface layer extends to a depth of 12 to 14 inches, and consists of a dark-brown to black or, in places, yellowish-brown, heavy, plastic clay, commonly called "gumbo." The subsurface layer, extending to a depth of 22 to 25 inches, is a dark grayish brown to light yellowish brown, slightly plastic silty clay to silty clay loam. Below this the subsoil to a depth of 36 inches or more is a yellowish-gray to grayish-brown very fine sandy loam, of open porous structure. The surface and subsurface layers are more uniform in different areas than the subsoil, the latter being quite variable. For example, there are places, of irregular distribution, where the subsoil consists of strata of very fine sandy loam, silt loam, silty clay, and clay. In other areas it consists of a friable silt loam throughout. It is always lighter textured in some part of its profile than the surface soil.

Small areas of silty clay are included with the Cass clay, in which the soil consists of a dark-brown to almost black, when wet, silty clay to a depth of about 12 inches, grading through a very fine sandy clay into alternating strata of silty clay loam, very fine sandy loam, and sometimes pockets of very fine sand. The surface soil frequently is yellowish brown, particularly near areas of the Sarpy silt loam. In places the subsoil below about 18 inches consists of a very fine sandy loam, grading downward into a very fine sand. This variation of the Cass clay is not very extensive, although there are many small areas 40 to 60 acres in extent scattered throughout the Missouri River bottoms. The soil is alluvial in origin and occupies a position slightly higher than the main type, but lower than the Sarpy silt loam. It owes its origin to the deposition of fine soil particles from slowly moving or standing water. The drainage usually is rather deficient.

The usual farm crops, particularly corn and wheat, are grown on this soil with good results. Corn frequently yields as high as 65

to 70 bushels per acre in the better drained areas. White varieties are grown almost exclusively. Alsike does better than red clover. This soil is not suited to truck crops, on account of its close structure, which makes it late to warm up in the spring and difficult to work.

On account of the irregularity of occurrence and small areas of this variation no definite value can be given for it separately. It is highly desirable land, however, and is easily maintained in a very productive state by a rotation of crops which will maintain and increase the organic-matter content. Its greatest need is better surface drainage, which can be provided by ditching and tiling.

The Cass clay is one of the most extensive types of the Missouri bottom. The topography is prevailingly level, the surface being broken in places by abandoned stream channels. This soil usually occupies the lowest parts of the bottoms, although there are a few scattered areas of relatively high position. The lower areas largely have poor drainage. Rain water accumulates on the surface, and on account of the plastic, heavy nature of the surface soil it percolates slowly through to the porous subsoil, where the subsurface drainage is good. Frequently small streams from the upland carry the surface run-off from large upland areas to the edge of the broad river valley, where, on account of the decreased velocity of the current, the channel of the stream becomes filled with sediment, leaving the water to collect in the lower lying areas of this type. It is because of this condition that much of the type can not be cultivated.

Of the crops grown on the type corn, wheat, oats, clover, and alfalfa are important, corn and wheat being most extensively grown. Corn yields from 35 to 80 bushels per acre, the variation in yields being due almost entirely to drainage conditions. Failures on account of drought are unknown on this type. Wheat as a rule is not so sure a crop on this soil as corn, owing to the fact that its period of growth is in the winter and spring when the drainage is poorest. As a rule, however, good yields of wheat are obtained, and some of the largest yields of wheat in the county are produced on the higher lying land of this type.

White corn is grown almost exclusively, the Boone County White and St. Charles White being the main varieties. Seed-corn selection to improve the quality of the crop receives but little attention. The corn usually is listed, but better results are obtained by plowing in the fall and permitting the soil to weather over winter. The alternate freezing and thawing improves its physical condition and makes it easier to cultivate in the spring. Care should be taken, however, not to plow the soil when too wet, as it has a tendency to puddle and form clods which are very difficult to pulverize. The

soil expands when wet and shrinks when dry with the result that large cracks form. This causes an excessive loss of moisture and injury to the roots of plants. Proper cultivation, with the maintenance of a surface mulch, largely prevents the cracks from forming.

The higher lying, better drained areas of the Cass clay are well suited to the production of clover and alfalfa, although these crops are not grown extensively. Alfalfa production in conjunction with hog raising is profitable.

The value of the Cass clay varies widely. The higher lying, better drained areas are valued as high as \$150 an acre. Areas of deficient drainage have a much lower selling price. The type lies above normal overflow.

The removal of the surface water is the most important and a very difficult problem on this soil. Ditching apparently is the only satisfactory method, and many small ditches have been constructed, but these usually are inadequate for the proper drainage of the type. The construction of large main canals is generally needed. This would enable farmers who have only small areas of the type on their farms to construct laterals. Without such an outlet many of the small areas must remain in their present condition.

MARSH.

Several small areas of Marsh are mapped. These areas include two kinds of soil, according to their occurrence near the river or farther inland.

The areas near the river consist of Riverwash, and include alternating sandbars, sandflats, and narrow depressions of silty clay. They are in the formative stage, and each inundation results in an additional deposit of alluvium. A continuation of present processes of formation will develop these areas into soils similar to those of the main bottoms.

Three inland areas of Marsh are mapped: One about 3 miles northeast of Kenmoor, one west of Old Mud Lake, and one $1\frac{1}{2}$ miles northeast of Agency. These areas occupy depressions some distance from the rivers. The soil material consists largely of a brownish-black clay with surface accumulations of organic matter resulting from the decay of various water-loving plants, such as flags and wild grasses. In the spring and winter water usually stands over the surface of such areas. Unlike the areas of Marsh near the river, these areas receive but little addition of sediment. They require drainage before they can be used for agriculture.

SUMMARY.

Buchanan County, Mo., lies in the northwestern part of the State. It has an area of 404 square miles, or 258,560 acres.

The county comprises two main physiographic divisions, the upland and the almost level flood plain, or bottom land. The upland ranges from hilly to rolling and undulating, and is thoroughly dissected by drainage ways. Its general slope is from northwest to southeast and its average elevation about 950 feet above sea level. The total area of the lowland is about one-seventh of that of the county.

The drainage of the county is into the Missouri River, the drainage of the eastern two-thirds being carried by the Platte River, a tributary of the Missouri. The upland is thoroughly, and in places excessively, drained; the bottom-land drainage is generally imperfect.

The population of Buchanan County is reported in the 1910 census as 93,020, and of this about 17 per cent is classed as rural. St. Joseph, the county seat, is the only large city in the county, its population being reported as 77,403. Transportation facilities in the county are excellent. This, with accessibility of such markets as St. Joseph and Kansas City, valuable soils, and good climatic conditions, makes this one of the most prosperous counties in the State.

The climate is similar to that of all northwestern Missouri. The mean annual temperature is about 52° F., and the mean annual precipitation about 37 inches. There is a normal growing season of about 172 days.

According to the 1910 census, there are 2,572 farms in the county, of an average size of about 92 acres, so that about 91 per cent of the county is in farms. Of the farm land about 83 per cent, or about 77 acres per farm, is improved. About 61 per cent of the farms are operated by the owners, and practically all the remainder by tenants.

The average assessed value of farm land is reported in the 1910 census as \$106.70 an acre. Although the valuation is high, the yields obtained apparently warrant it. The county offers good opportunities in the development of intensive systems of live-stock or grain farming, orcharding, and trucking.

Aside from the manufacturing interests of its chief city—St. Joseph—the predominant industry in Buchanan County is agriculture. Live-stock farming in conjunction with grain production and fruit growing, with some trucking, is the prevailing type of agriculture. Dairying is increasing in importance.

The soils of Buchanan County are grouped by physiographic divisions into upland and bottom soils. According to origin they are separated into loessial, glacial, residual, and alluvial soils.

The loessial soils are the most important and cover about two-thirds the total area of the county. The loessial soils are mapped as the Marshall silt loam, a black loess soil, the Knox silt loam, a brown loess soil, and the Judson silt loam, a colluvial soil resembling the Knox. These soils are very productive naturally and are

well suited to a wide range of crops. General farming, stock raising, dairying, and fruit growing are important interests.

The glacial soil is mapped as the Shelby loam. This type occurs only on the slopes of streams where the loessial deposit has been eroded away. It is less productive than the loessial types, and of small extent.

The residual soils are derived from the underlying rocks of the region, consisting of limestone, sandstone, and shale of the Upper Coal Measures. These soils, where residual from limestone, are classed with the Crawford series, represented in this county by the stony loam. Where derived from shale they are classed with the Boone series, represented by the silt loam. Like the Shelby or glacial soil, the residual soils are less productive than the loessial types. They have only a small extent in Buchanan County.

The alluvial soils of the smaller streams are mapped as the Wabash, in the first bottoms, and as the Bremer in the second bottoms or terraces. The Wabash soils are in part subject to overflow and in some places are poorly drained. They include, however, some of the most productive land in the county. The Bremer soils are above normal high water, and are very valuable for the production of all the crops common to the area.

The Missouri River bottom soils are classed mainly with the Sarpy and Cass series, but include small areas of some Wabash types. They lie above normal overflow, except in a few small areas, and are well adapted to corn, wheat, clover, and alfalfa. The sandy types of the series are good truck soils, but are not extensively used for this purpose.

A few small areas of Marsh are mapped in the county. These can be used for agriculture only when reclaimed by drainage.

The cropping systems, in general, are fairly well adapted to the maintenance of the productiveness of the soils. There is a general need for growing legumes more extensively in the rotation and for more attention to systems of green manuring to increase the organic-matter supply.

Erosion and drainage are very important problems in parts of the county. Ditching is especially needed in some bottom-land areas.

[PUBLIC RESOLUTION—No. 9.]

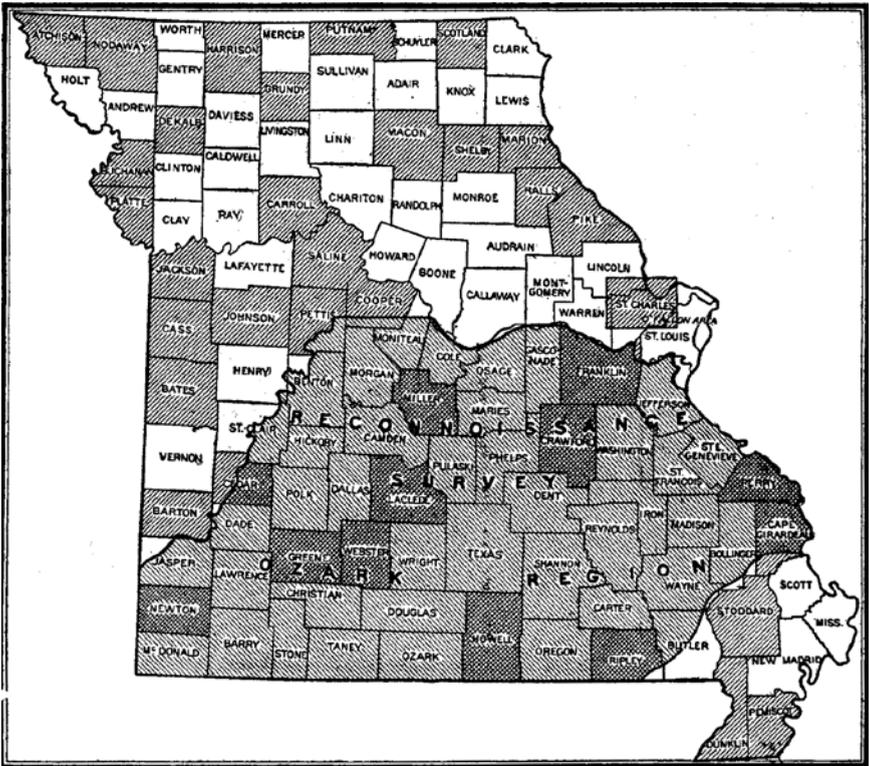
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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

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

Approved, March 14, 1904.

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



Areas surveyed in Missouri.

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