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UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

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The Soils of Audrain County

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THE SOILS OF AUDRAIN COUNTY.

SOILS.

INDIVIDUAL SOIL TYPES.

THE SOILS OF AUDRAIN COUNTY, MISSOURI.

R. C. DONEGHUE and B. W. TILLMAN of the Missouri Agricultural Experiment Station.
Inspected by A. T. SWEET of the U. S. Department of Agriculture.

LOCATION.

Audrain county is located in the southern part of Northeast Missouri.

It is separated from the Mississippi on the east by Pike county, and from the Missouri on the south by Montgomery, Callaway and Boone. Boone and Randolph counties bound it on the west, Monroe and Ralls on the north.

Mexico, near the central part of the county, is about 100 miles in a direct line northwest of St. Louis and about 145 miles almost due east of Kansas City.

TOPOGRAPHY.

The upland region of Northeast Missouri as a whole, regardless of the stream valleys which have been cut into it, presents a topography peculiarly its own. Its fundamental features is a smooth plain, the southern part of which slopes very gently to the north, the northwestern part to the southeast, and the eastern part to the west, thus forming a broad shallow trough the southern part of which has a north and south trend.

Audrain county extends across the southern part of this trough.

In detail, the topography of the county is of three principal types—the smooth, almost perfectly flat prairie, the undulating bordering prairies which have been slightly eroded, and the hilly broken type with sharp, steep slopes, which border the lower level valleys.

The main body of the flat prairie lies between the main drainage systems, while arms extend out from it between the stream tributaries. In the eastern part of the county the main divide separates the drainage of Salt River on the north and west from that of Cuivre on the south and east. It enters the county at Vandalia near the northeast corner and follows the line of the Chicago and Alton rail-

road to a point about five miles southwest of Laddonia, when it turns to the south and west, crossing the Wabash railroad about half way between Mexico and Martinsburg. It then extends almost due south until it passes out of the county. In the western part of the county several long finger-like areas of this level prairie extend north and east between the tributaries of Salt River.

Between these strips of level poorly drained upland are broader areas of gently undulating prairie extending on each side of the shallow streams which drain them. The hilly topography is confined to a few comparatively small eroded areas along Salt River in the central and north central parts of the county and to other small areas along Loutre and Cuivre in the southeastern part.

The central and northern parts of the county are drained by Salt River, the upper tributaries of which in Audrain county follow the northward slope of the Northeast Missouri Basin, while the southeastern portion is drained by Cuivre, which escapes from the same basin in a southeasterly direction between the east end of its northward slope and the west end of its westward slope.

DRAINAGE.

Salt River has several tributaries in the county. Henry's Fork and Beaver Dam Creek, both of which rise in the southwestern part of the county, unite about a mile north of Mexico to form the North Fork. This stream receives Littleby Creek from the east and Skull Lick Creek, Fish Branch, Young's Creek, and Long Branch from the west. The extreme western portion of the county is drained into Elk Fork of Salt River by Saling and Judith creeks, while a considerable area north of Laddonia is drained into Salt River proper by the east and west branches of Lick Creek.

Cuivre River, with its two tributaries, Sandy Creek and Hickory Creek, drain nearly all of the southeastern part of the county into the Mississippi River. A small area south and west of Martinsburg is drained into the Missouri River by Loutre Creek, and another small area in the extreme southwestern part of the county is drained into the same stream by Cedar Creek and by Seven Mile, a branch of Muddy Creek.

GEOLOGY.

The geology of this region is simple and easily understood.

In the central and north central part of the county along the steep slopes bordering the valleys of Salt River, Littleby and Young's Creeks, rocks outcrop. The lowest of these rocks consist of alternating beds of black shale and thin layers of limestone without chert

or flint. Above these shale and thin limestone layers is a bed of thicker limestone which contains chert nodules and in place thin layers of chert.

These beds belong to the Coal Measure formations and extend over the entire county, being covered by more recently deposited material except where exposed along these streams.

During glacial times a sheet of silt and clay, with some sand, gravel and foreign boulders, was spread entirely over this area by the ice sheet which covered it and by the waters which flowed out from the edge of this sheet as it retreated northward.

The thickness of this deposit varies from about seventy feet in its thickest part to only a few feet where it has been eroded along the edges to the streams.

That portion of this glacial material which rests upon the underlying rocks is seen only along the slopes of streams which have cut away the upper portions Where exposed it consists of clay through which is distributed coarse sharp sand, gravel, and small well rounded boulders. These boulders are usually not larger than a croquet ball, although sometimes larger ones called "negro heads" are found. They must have been transported considerable distances to their present position, for no rock beds of the same kind are to be found near this region.

In places in the glacial clay there are also found chert and limestone fragments. These are less rounded than the foreign boulders and have evidently been carried from the beds of the same material found in this region. Some of the limestone fragments also have long scratches across their surfaces which were probably caused by the movement of the ice in which they were bedded.

Above that portion of the glacial material which contains the sand, gravel, and boulders is a layer of yellowish and mottled silty clay entirely free from such material. This silty clay layer extends almost to the surface, but on the uplands which have not been eroded is overlain by a thin layer of silt which constitutes the principal agricultural soil of the county.

SETTLEMENT.

Owing to its location away from the navigable streams of the region and also to the fact that it was largely a prairie country, Audrain county did not receive the attention of early settlers as did the timbered areas which bordered on the Mississippi and Missouri rivers.

While it is quite probable that hunters and trappers often visited the region before this time, no permanent settlements were made until

1816, when a trapper named Littleby located on the stream which afterward received his name. Benjamin Young located on Young's Creek in 1821, and other settlers came slowly. In 1834 there were not over thirty families is the county and these were widely scattered, the settlements usually being ten or fifteen miles apart and often from twenty-five to fifty miles from the mill and postoffice.

At this time there were stretches of timber along the principal streams and usually a larger timbered area at their junction. This timber consisted principally of white and black oak and hickory, but burr oak, elm, hard and soft maple, walnut, sycamore, linn and birch were abundant.

The new settlers came largely from timbered sections of Kentucky and Tennessee and naturally selected the timbered areas along the streams, not only because they could there find timber for building houses and fences, water, and game, but also because they felt more at home in a timbered country.

Audrain county was organized in 1836 and named for Colonel Charles H. Audrain, of St Charles county. Settlement continued to be slow for many years. In 1865 the population was 6,500, and only about one-tenth of the land was in cultivation. The price of improved land at that time was about $15.00 per acre, while unimproved land was held at only about $7.00 per acre.

POPULATION.

In 1910 the population, according to the U. S. Census Report, was 21,582, the population being fairly well distributed over the county, but being somewhat more dense in the hilly and undulating prairie regions than on the flat prairie.

TOWNS.

Mexico, the county seat, is a thriving small city having in 1910 a population of 5,961. It is located near the center of the county, is surrounded by a good farming country, and is the principal railroad center of the county.

Vandalia, Laddonia, Martinsburg, Farber, Benton City and Rush Hill are prosperous railroad towns in the eastern part of the county.

Thompson, Larrabee, Saling, Rowena, Molino, Gant, Skinner, Worcester, Ortiz, and Mt. Carmel are postoffices and trading points.

Sturgeon and Centralia are in Boone county only a short distance from the Audrain county line, and are important trading points for the western part of the county.

RAILWAYS.

Audrain county is well supplied with railroads. The main lines of the Wabash and Chicago and Alton pass entirely across the county from east to west, the Wabash entering the county near the southeastern corner and the Chicago and Alton near the northeastern corner. These lines converge toward the west, meeting at Mexico, from which point they run approximately parallel until they pass out of the county to the west. From Mexico a branch of the Chicago and Alton extends south to Jefferson City and from the same point a line of the Burlington extends east, connecting with the main line of the Burlington at Old Monroe in Lincoln county.

An electric line is at present being built from Perry in Ralls county to Mexico, and is being extended to Columbia in Boone county.

St. Louis and Chicago are the principal markets for the products of the area, while the markets of Kansas City supply much stock which is shipped to the county for feeding purposes.

CLIMATE.

The climate of Audrain county does not differ essentially from that of other parts of the Mississippi Valley of about the same latitude, and is well suited for general farming and stock raising.

The average annual rainfall is about thirty-eight inches, well distributed during the year, slightly the heaviest precipitation occurring during the months of May, June, July, and September.

Drought during the spring and summer occasionally causes short crops, but injury is more often done by heavy rainfall in the spring, which gets the soil into a bad physical condition and prevents proper cultivation, followed by periods of very dry weather. The most serious effects of such conditions are felt on the flat poorly drained areas.

The growing season is long and well suited for pasture grasses. Early in April the pastures furnish much feed, and if the season is favorable practically the only feed used for much of the farm stock from that time until late October or November.

Corn is planted from about April 10 to May 20 and can usually be cut early in September. Injury to farm crops rarely occurs from frosts, although occasionally very early corn is injured in the spring and late corn in the fall by them. Injury to wheat and to clover also occurs at times in the winter and spring, through frequent freezing and thawing. Fruit is also injured at times, usually through periods

of warm weather in the winter and early spring, followed by severe freezes. Injury rarely occurs from excessive cold alone.

As a whole the climate of this region is good and crop failure for the entire region almost unknown.

The following table from the U. S. Weather Bureau shows the rainfall:

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION.

At Mexico.

MONTH.	TEMPERATURE.			PRECIPITATION.			
	Mean.	Absolute maximum	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	33	70	—21	2.2	2.5	2.3	3.2
January	29	72	—28	2.0	2.4	1.7	5.9
February	29	71	—25	2.5	2.1	5.0	9.3
Winter mean	30			6.7	7.0	9.0	18.4
March	41	87	— 3	2.8	3.1	2.7	2.8
April	55	91	16	3.3	2.2	5.8	1.5
May	65	94	28	4.7	0.7	8.8	0.0
Spring mean	54			10.8	6.0	17.3	4.3
June	74	105	39	5.5	2.1	3.7	0.0
July	78	112	49	4.1	2.1	9.0	0.0
August	76	105	47	2.6	0.6	2.3	0.0
Summer mean	76			12.2	4.8	15.0	0.0
September	69	108	29	3.8	0.7	3.8	0.0
October	57	95	20	2.2	1.1	1.4	Trace
November	42	79	1	2.5	0.9	2.6	1.0
Fall mean	56			8.5	2.7	7.8	1.0
Annual mean	54	112	—28	38.2	20.5	49.1	23.7

Average date of first killing frost in autumn, October 13.
Average date of last killing frost in spring, April 19.
Date of earliest killing frost in autumn, September 13.
Date of latest killing frost in spring, May 21.

AGRICULTURE.

Audrain county is strictly an agricultural region, there being only a very small part of it which is not under cultivation.

The early settlers raised corn, wheat, rye, oats, buckwheat, potatoes, sorghum, and tobacco. The same crops, with the exception of buckwheat and tobacco, still form the leading crops, although timothy, clover, cowpeas, alfalfa and millet have been added.

On account of the good open range afforded by the prairies, the early settlers soon became interested in stock raising, cattle being the principal stock produced, and the county is at present one of the leading stock growing counties of the state.

For many years the prairies were covered by splendid growths of native blue stem, this often growing high enough, it is said, to completely hide horses and cattle which were feeding on it. Through over pasturing this gradually became somewhat subdued, but still required much hard labor to completely kill it out even after cultivation began.

As the native grasses were killed out, however, they were gradually superceded by blue grass, which has spread of its own accord and has been sown to a considerable extent until blue grass pastures at the present time are one of the principal assets of the county.

Although being more easily injured by drought than some of the other pasture grasses, blue grass furnishes excellent spring and fall pasturage and when not too heavily pastured earlier in the season often furnishes much feed during a considerable portion of the winter.

The raising of cattle continues to be an important industry in Audrain county, but other kinds of stock, especially horses and mules, are receiving much attention, and in 1908 it was the leading county in the state in the production of jacks and stallions, producing almost four times as many as its closest competitor, Jackson county. It also ranked second in the production of sheep, only one county, Boone, surpassing it in that respect.*

The agricultural importance of Audrain county is well shown by a comparison of its surplus products with those of the state as a whole for the year 1908.*

Although this county occupies a little less than one one-hundredth of the area of the state, it produces 1-21 of all the sheep, 1-39 of the horses and mules, 1-55 of the hogs, 1-69 of the cattle, and 1-52 of the total live stock. It also produces 1-27 of all the oats, 1-52 of the corn, 1-65 of the hay and forage crops, 1-60 of the total farm crops, and 1-64 of the poultry and eggs.

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* Report of Missouri Bureau of Labor Statistics, 1908.

It will be seen from this comparison that the agriculture of the county consists of general farming, a combination of grain growing and stock raising. To this more than to any other one thing the county owes its continued prosperity and to a considerable extent the retention of the fertility of its soils.

When the prairies were first fenced and cultivated thirty-five to fifty years ago, the custom was to plant corn for a number of years in succession and in many parts of the county this practice was persisted in until seriously decreasing yields convinced farmers that a change in methods must be adopted. At that time a large part of the corn was shipped out of the county and thus became a total loss to the soil.

During the past twenty years, however, a more rational system of farming is gradually being adopted and while there is still much room for improvement the soil in many parts of the county is in better condition and more productive than it was twenty years ago. This improvement has been brought about in three ways: More attention has been given to the rotation of crops with the introduction, in many cases, of a legume crop; manure has been more carefully saved and systematically used; and a much larger part of the crops are fed and the waste returned to the soil in that way.

However, with the increased price of land, the greater cost of work animals and higher price of labor, the farmers must improve their present methods of farming very materially if they are to remain prosperous.

When a low rate of interest based on the value of the land, and taxes amounts to from $2.50 to $5.00 per acre, no man can afford to produce a poor crop or to let land lie idle to "rest up." He cannot afford to grow corn year after year, but must adopt a rational system of rotation which will give the best crops possible and at the same time keep the soil in a high state of fertility. To do this some legume crop such as clover, cowpeas, or alfalfa must have a place in the rotation. Nearly all soils in the county are deficient in nitrogen and these crops are able, through the bacteria which form the nodules on their roots, to collect free nitrogen from the air and thus give it up to the soil for the use of other crops which follow. For this reason a good crop is usually obtained on clover sod. The leaves and stems of leguminous plants, however, contain the greater part of the nitrogen which is collected and by plowing under the entire crop when green much greater benefits are derived than from plowing under the stubble alone. This method of plowing under, when green, an entire crop of clover or cowpeas is one of the surest and

quickest methods of restoring run down soils to a high state of productivity.

The following table shows approximately the part of the area used for the principal crops grown:

Corn, 45%
Pasture, 25%
Meadow, 15%
Oats, 16%.
Timber, 3%
Wheat, 2%.
Clover, 1 1-2%
Waste, 1-4%
Miscellaneous, 2¼%. (Millet, kaffir corn, cane and flax).

The following table shows the approximate maximum and average yields of the principal crops:

	Max.	Avg.	
Corn	90 bu.	35 bu.	Flax 8 or 9 bu. per acre.
Wheat	30 bu.	12 bu.	Timothy seed 6 or 7 bu. per acre.
Oats	50 bu.	25 bu.	
Clover	2 tons	1 ton	
Timothy or timothy and clover	2 tons	1 ton	

Erosion is doing considerable damage to some of the rougher areas along the larger streams and to some extent along the smaller streams. In many places along Cuivre the surface soil has been entirely washed off leaving the red clay subsoil exposed and the same is true along the small tributaries of Loutre and Salt River.

The arrangement of these soils with a thin silty surface layer underlain by an almost impervious clay subsoil makes them especially easy to erode. The subsoil cannot take up the water which reaches it and the surface silt is easily carried in suspension by swiftly running water and soon removed. After the silt has been removed erosion goes on even more rapidly for practically all the water then runs off as it falls and the cutting increases much more rapidly as the volume and swiftness of the water increases.

On areas which erode badly the loss of the best part of the soil in a single season is often many times as great as would be the loss from the production of a heavy crop.

After washes have become well developed they can be checked only by placing brush or some other material in them, which will check the water and hold the soil carried by it until the ditch is filled.

Much can be done, however, to check erosion before it reaches this advanced stage.

Soil which is subject to heavy erosion should be used for meadow or pasture as much as possible and when cultivated should be protected by a growing crop the greater part of the time. Rye sown on easily eroded cultivated land not only furnishes good winter and early spring pasturage, but also does much to prevent erosion. Erosion can also be checked by deep cultivation, by cultivating across instead of down the slope, and by plowing under large amounts of organic matter which gives the soil a larger water holding capacity, thus checking the rapid runoff following heavy rains.

The drainage problem in Audrain county is one of the most important with which the farmer has to contend. The more level phase of the gray silt loam is exceedingly hard to drain, on account of being so level. It has such a stiff clay subsoil that it is absolutely necessary that the excess water shall be drained off, for it will not soak into the soil below twenty inches. The opening of roads with surface ditches on each side has done much toward draining this land and as yet surface drainage has been the only means tried of draining these areas. Tile drainage is yet an experiment, but bids fair to give good results when the tiles are properly laid and covered. The principal cause of failure has been that the stiff clay subsoil has been placed immediately over the tile, preventing the entrance of water.

Some areas of the gray silt loam alluvium could be tile drained to a very good advantage. Otherwise all of the other types are very well drained, in some cases being excessively so, thus causing the crops to suffer in a dry season.

The effects of poor drainage are most noticeable on the flat prairies during seasons when spring rains are excessive. The wet condition of the soil then delays planting and cultivation and when the soil finally becomes dry enough it is often in a very bad physical condition.

Another result of poor drainage is the tendency of clover and wheat to "heave" and freeze out due to frequent freezing and thawing of the wet soil.

This soil is also not suited to clover on account of its low percentage of lime. The gray silt loam alluvium may also in places be slightly acid.

Where the soil is acid this condition can be improved by the

Bulletin No. 7a, Some Experiments on Missouri Soils, issued by the Missouri State Board of Agriculture, gives valuable information on the handling of the flat prairie soils of Northeast Missouri.

use of lime or ground limestone applied at the rate of from 1000 to 2000 pounds per acre.

Manure is not used very extensively as the principal part of the stock is pastured and fed in the fields, so that the manure produced is returned directly to the land. More attention, however, should be given to the careful saving of manure from the barns and feed lots and to its application to the soil. This manure may be applied to the fields as produced during the winter or if this is not convenient it may be safely left in the stables and sheds, or if removed placed under cover where there will be no waste from leaching until spring. In either case it should be applied by means of a manure spreader in a thin uniform sheet, and so far as possible, it should be used at a regular time in the crop rotation. Its application preceding a corn crop is usually found most profitable.

Commercial fertilizers have been used in this area to only a very small extent. Some bone meal has been used on wheat by the farmers in the vicinity of Martinsburg, and a little south of Mexico.

When the land is already fairly productive an application of bone meal at the rate of from 100 to 150 pounds to the acre will give good results, but where the soil has been heavily cropped for several years and is badly run down, one of the grain growers which will supply the three principal elements needed, nitrogen, phosphorus and potassium, will probably prove more beneficial.*

Crop rotation has not received the attention in Audrain county which it deserves. Although most farmers practice it in some form it could in most cases be greatly improved.

The customary rotation is corn for two, three, or more years, followed by oats or wheat and back to corn. Where the land is becoming thin the small grain is followed by timothy meadow, sometimes mixed with clover, which is cut for hay two years and then pastured a few years, after which it is returned to corn.

A rotation which would prove more beneficial in building up the soil and also more remunerative should include a legume crop such as ** cowpeas or clover every three to five years.

Where the soil is thin the following rotation is recommended: The application of manure in winter and spring and planted to corn; corn cut and wheat sown with clover sown on wheat in spring. Clover or clover and timothy two years, then return to corn, making a four years' rotation. Where the soil is not suited for clover, cow-

* Bulletin No. 85, issued by the Missouri Experiment Station, gives analysis of all fertilizers sold in the state for the year 1909.

** Bulletin No. 9, Growing Cowpeas in Missouri, issued by the Missouri State Board of Agriculture, gives a valuable discussion of this subject.

peas may be used to follow wheat, being cut for hay or plowed under for green fertilizer. Oats may also take the place of wheat.

Where the soils are more productive, two or in extreme cases even three crops of corn may be profitably grown, but in this case catch crops of cowpeas should be sown in the corn when it is laid by. Rye can also be used as a profitable catch crop, which will furnish early spring pasture, prevent erosion, and when plowed under improve the soil.

Very little attention has been given to the varieties of corn grown, but Reid's Yellow Dent, Boone County White, Iowa Silvermine, Leaming, and Golden Beauty are among the principal varieties grown, yellow corn being raised principally on the uplands and white in the bottoms.

The best corn land in the county is the rolling prarie which has sufficient slope for good drainage, but is not steep enough to wash badly. The alluvial bottom soils also produce good corn, and so do the flat prairies whenever the seasons are favorable.

Wheat is sometimes sown on corn ground after the corn has been cut, but more often corn is followed by oats. Where grain stubble is plowed under the plowing should be done as soon as possible after the grain is removed, and the subsoil well packed and covered by a surface mulch to hold the moisture.

Fultz is the principal variety of wheat grown. Red chaff would probably also be found well suited to this section.

The rolling well drained portions of the area are best suited to wheat, but if more attention were given to surface drainage on the level prairie wheat could be profitably grown to a much greater extent than is the case at present.

Strictly speaking, there are no stock farms in the county. There are several breeders, however, who raise a high class of pure bred animals. A large number of high class saddle horses are raised, being sired by Forest King, Rex McDonald, Carter, Ortiz Rose and other noted saddle stallions. Percherons are the principal draft horses raised.

There are a few herds of Shorthorn cattle in the county and also many Herefords of excellent breeding.

There are several herds of pure bred Duroc Jersey hogs which are as a rule high class animals.

Poland Chinas are bred carefully by a number of farmers and nearly equal the Durocs in number. These two are crossed quite commonly.

There are one or two pure bred herds of Berkshire although they are not much in evidence in the feed lots. The hogs of Chester White breeding probably outnumber those of the Berkshire breeding.

There is probably not a pure bred flock of sheep in the county, but a great many of the farmers use pure bred sires on their grade ewes so that some very high class animals are raised. Most of the sheep belong to the mutton classes, principally Shropshires.

The farm buildings are usually small, but fairly well kept. The dwellings are often quite small one-story cottages with two or three rooms, but there are a few nice large residences in the county.

Very little of the feed raised is stored in barns, so that the barns are nearly all small, just large enough to keep the mules and horses used in the farm operations. The wheat and oats are usually taken to the market directly from the thresher, and the corn is piled into a crib sometimes being covered with a roof, but more often left uncovered. It is claimed that the corn absorbs moisture in this way and makes it much better for feeding to cattle.

The farm machinery is very seldom housed and it is quite common to see the implements standing in the field in which they were used last.

As a rule the fences in the county are quite good. The most common fence consists of a 24-inch woven wire above which are placed two or three barbed wires. Some few barbed wire fences are used and occasionally rail fences of various types, and board fences are seen. Hedge fences were formerly planted in all parts of the county and they comprise a large part of the fences of the area.

The farmers of the county have very few conveniences. In some localities they have windmills which pump deep well water and this affords them an excellent water supply. In other cases the water for the live stock is furnished by digging a pond of which the stiff clay subsoil forms the bottom, making it water tight. This fills up and makes a very cheap water supply. Cisterns furnish the principal water supply for the houses.

Nearly every farmer has all the implements necessary to carry on the farm operations. Corn harvesters are used in most cases where the stover is harvested at all. A large number of stackers are used in putting up the hay crop.

The county has a very good rural free delivery mail system, there being a route on nearly every good road of importance. Very little of the county is far distant from shipping points, and the Wabash, Chicago & Alton, and Burlington railroads connect the shipping points with Chicago, St. Louis, and Kansas City.

Audrain county is a stock farming section but more animals should be kept in the county than are kept at present. More care should be taken to reduce the waste of the farm which takes place under the present system of farming. This could be done by adopting a system by means of which the labor on the farm would be more evenly distributed throughout the year and at the same time afford the opportunity of a rotation of crops which would prevent the depreciation of the fertility of the soil and keep down the weeds, which are the cause of a low yield of a poor quality of hay on many of the timothy meadows of the county. If this were done better yields would be secured for less labor and thus more stock could be very easily kept on a smaller area than is done at the present time.

SOILS.

THE SOILS IN GENERAL.

The soils of Audrain county may be divided according to origin into three broad divisions, the residual soils, the glacial soils, and the alluvial soils.

The residual soils have come from the weathering in place of the underlying beds of shale and limestone and cherty limestone where they have been exposed along the slopes bordering the streams. Where shale is exposed it breaks down rapidly forming a heavy clayey soil. Limestone upon weathering forms a silty soil often black at the surface, but with a yellowish or reddish subsoil. Where the limestone contains chert the limestone disintegrates more rapidly than the cherts, thus leaving fragments of the latter scattered through the soil and over the surface.

The areas of residual soils are few and comparatively unimportant, being confined to a few small areas along Salt River, Littleby Creek, and Young's Creek.

Above the residual soils and resting upon the rocks from which the residual soils were formed are the glacial soils.

As has already been noted, the lower portion of the glacial deposits contain considerable amounts of medium to coarse sand, boulders, and rock fragments. Where the upper portion of this glacial material has been cut away leaving this sandier portion exposed, a sandy loam is found. Higher up the glacial material contains less sand with more silt and clay, and a loam has been formed. Above

the loam and covering the greater part of the county, including both the flat prairie and that which is gently undulating, is a silt loam.

The soils of glacial origin are much the most important soils of the county, covering over ninety per cent of the area and including the best agricultural soils of the county.

Along all streams of the area level stretches of soil occur. Where the streams extend well out into the prairie, this soil has come almost entirely from the upland silt, but farther down the streams it contains more sandy material from the lower lying glacial soils. Farther down it probably contains small amounts of material washed from the residual soils. The greatest part of it, however, is of glacial origin.

The bottom soils also vary in another way. Portions of those which are found along the upper course of the smaller streams have been carried down the slopes a little at a time and left near the place from which they were carried. Other portions have merely worked down the slopes without having been carried in suspension at all, so these level areas of deep black soil are not truly alluvial, but rather a wash from the adjacent areas. On the other hand, those soils which have been deposited along the flood plains of the larger streams have been carried in suspension usually for a considerable distance, sorted and redeposited, and therefore are true alluvial soils.

The soils of alluvial and partly alluvial origin have been correlated with the soils of the Waverly series and called Waverly sandy loam.

INDIVIDUAL SOIL TYPES.

THE PUTNAM SILT LOAM.

The Putnam silt loam as found in Audrain county may be divided into two phases, the level poorly drained phase and the undulating phase.

The level phase consists of a silt loam dark gray when dry, but almost black when wet, which extends to a depth of from ten to fourteen inches where it grades into a very light gray, in places, almost white silt. At a depth of from sixteen to nineteen inches below the surface, this rests upon a layer of heavy tenaceous brown clay almost impervious to water and varying from five to ten inches in thickness. Below this layer of brown clay the soil becomes yellower in color and more silty in texture, often being a mottled yellow and gray silty clay to a depth of several feet.

On account of its level topography and the impervious subsoil, this soil is usually poorly drained, is not well aerated, gives an acid

reaction, and is therefore not well suited to deep rooted crops as clover, alfalfa or trees. As noted elsewhere, it can be greatly improved by thorough surface drainage, and where an outlet can be obtained it is believed that tile drains if properly laid may prove beneficial. It can also be improved by the application of lime or ground limestone at the rate of from 1000 to 2000 pounds per acre. This will not only correct the acidity of the soil, but will also improve its texture, making it more granular and friable.

The undulating phase of the Putnam silt loam differs from the flat phase principally in the character of its subsoil. The surface soil is in places somewhat lighter in color, the silty surface and subsurface layers are usually somewhat thinner, and the layer of heavy brown tenaceous clay below the silt is not so well developed as in the flat prairie or may be wanting entirely, the silty surface soils resting directly upon the yellow and mottled silty clay.

This phase not only has better surface drainage, but the subsoil also permits of underdrainage much better than does the clay layer of the flat prairie.

The origin of the heavy clay layer in the subsoil of the level prairie is not fully understood, but it is believed to be due to the deposition of fine material carried from the surface soil and deposited along the zone of maximum penetration of rain water. Lime and iron in the soil are also taken into solution and where the downward movement of the water is checked lime and iron concretions are found.

Where the country is undulating there must be a lateral as well as a downward movement of the percolating water so that the tendency to form a heavy layer is less, and where a drainage course works back into an area of the flat prairie the tendency is toward the breaking up of this heavy layer through the lateral movement of water and soil particles.

The undulating phase of the Putnam silt loam is an earlier and more productive soil better suited to wheat, corn, clover and to fruits than is the level phase.

The value of the land on this type varies somewhat, but very little of the type however can be bought for less than $50 and it ranges from this up to $75 per acre.

The following table shows the results of mechanical analyses of this type of soil.

Mechanical Analyses of Putnam Silt Loam.

Numbers of Samples.		Sand.	Silt.	Clay.
721	Soil, 1 to 7 inches	10.18	70.60	13.92
722	Soil, 1 to 7 inches	8.06	71.06	14.74
684	Soil, 1 to 7 inches	4.48	71.24	17.28
716	Subsurface, 7 to 20 inches	7.38	62.34	25.26
717	Subsurface, 7 to 20 inches	7.72	68.24	15.40
679	Subsurface, 7 to 20 inches	6.28	69.56	19.06
715	Subsoil, 20 to 40 inches	2.90	61.00	30.68
718	Subsoil, 20 to 40 inches	4.22	55.42	35.76
678	Subsoil, 20 to 40 inches	2.66	50.88	40.68
Soil, average of five typical samples		6.91	69.19	17.40
Subsurface samples		8.77	63.70	22.13
Subsoil samples		4.31	55.43	34.83

THE SHELBY LOAM.

Ranking next to the Putnam silt loam in acreage is the Shelby loam type. Its origin is also glacial, being formed from the lower layers of the drift. Its topography is quite rolling, in places being quite deeply eroded. It is the rough broken lands we find along the larger streams where they have cut deep narrow valleys. Aside from the flood plains there is but one type lying below it topographically. The typical timber growth is oak and hickory. Where this type has been badly eroded this growth is quite scrubby. In texture it is a light gray to white sandy silt loam to a depth of about eight inches. The surface varies a little in texture, in some places being rather silty, especially where it approaches a level, but no large, level areas occur. We also find in areas where it has been badly washed that the heavy clay subsoil is exposed at the surface. The subsoil which occurs at a depth of about eight inches is usually a heavy clay through which coarse sand grains are scattered. The humus supply is very low in this type, the color being almost white in places. This would indicate a deficiency in nitrogen, and as it responds well to applications of bone meal it is evident that it is also low in phosphorus.

Wheat, corn, oats, timothy, and clover do fairly well on this type, but great care should be exercised in keeping the edges of streams and hollows well sodded where any cultivated crop is raised

as a great amount of damage is done by washing when they are left unprotected. Whenever it is possible, it is best to grow some grass crop on this land. Where the scrubby growth of oak and hickory can be kept down and a good stand of blue grass secured, it makes excellent pasture land.

The Shelby loam is the cheapest land in the county, and is in many cases very badly neglected. It sells in some cases as low as $20 per acre, although some of it which is better improved and better cared for sells as high as $50 per acre. The average is about $35 per acre.

The following table shows the results of mechanical analyses of samples of this soil type.

Mechanical Analyses of Shelby Loam.

Numbers of Samples.		Sand.	Silt.	Clay.
681	Soil 1 to 7 inches	34.06	48.98	13.00
285	Soil 1 to 7 inches	46.50	33.60	13.07
694	Soil 1 to 7 inches	30.74	53.32	10.60
677	Subsurface 7 to 18 inches	23.28	36.74	34.34
698	Subsurface 7 to 18 inches	26.62	44.78	25.28
686	Subsoil 18 to 40 inches	26 04	28.46	39.70
286	Subsoil 8 to 36 inches	39.71	41.59	17.55
693	Subsoil 18 to 40 inches	26.34	36.68	32.66

THE PUTNAM SILT LOAM, WELL DRAINED PHASE.

Intermediate between the Putnam silt loam and the Shelby loam is a type which ranks next to the latter in extent. In some localities this type resembles the Shelby loam very closely. Its origin is glacial, being a mixture of the upper silty layer of the drift with the lower sandy layer. Its topographic position is between the two types. It is gently rolling in topography, being found along small streams and where the larger ones are just beginning to cut into the sandy part of the drift. In texture it is a dark gray loam to a depth of eight inches, the sand grains being quite small. It varies considerably from the typical phase in some areas, containing only a small percentage of fine sand, while in others it contains a rather large percentage of coarse sand. In many cases it is difficult to separate the Shelby loam from this type. Below eight inches we find a stiff reddish yellow clay subsoil similar to that of the more rolling phase of the Putnam silt loam. In some cases we find a light gray

layer beneath the surface soil which is quite silty and resembles the gray layer in the more level phase of the Putnam silt loam. The timber growth on this type is usually rather sparse, consisting principally of hickory. The humus supply of this type is also low and it has the same evidence of a deficiency of nitrogen and phosphorus as the two preceding types. It has about the same crop adaptations as the Putnam silt loam, with one or two exceptions. It produces clover better and truck gardening is carried on quite successfully on a small scale on this type in the vicinity of Mexico. It has better drainage than the preceding types.

This type also varies somewhat in value. It usually sells at from $40 to $50 per acre, but cases occur where land is sold at higher prices.

The following table shows the results of mechanical analyses of samples of this soil type.

Mechanical Analyses of Putnam Silt Loam, Well Drained Phase.

Numbers of Samples.		Sand.	Silt.	Clay.
495	Soil	17.06	69.20	9.23
498	Soil	17.90	70.87	6.50
496	Subsurface	14.16	64.34	17.18
499	Subsurface	14.00	63.67	17.90
497	Subsoil	11.00	54.72	30.08
500	Subsoil	13.00	62.78	21.06

ROUGH STONY LAND.

Where the underlying limestone outcrops it produces a stony loam which ranks next in extent of the upland types. It occurs usually in loam areas and occasionally in silt loam areas. It occurs most extensively along Young's Creek, Littleby Creek, and the lower part of Salt River. It is of very little value agriculturally, being fit only for pasture and is in many cases too stony for that. It consists of a mixture of limestone with a loam or sandy loam soil. There are two distinct kinds of limestone mapped in this type. In the northern part of the county it is a large massive thick bedded limestone, while in the southern and along Littleby Creek it is a cherty fragmental limestone. The timber growth is similar to that of the loam when it occurs in loam areas and to the silt loam when occurring in silt loam areas. It is of so little value agriculturally and the areas so limited in extent it would be hard to attach any definite value to this type.

THE LESLIE CLAY.

The lowest type with regard to its geological position is the Leslie clay. Its origin is residual, being formed by the weathering of the black shales of the coal measures. It is found below the drift where the streams have cut entirely through to the rock below. It occurs most typically in the extreme north part of the county where Littleby Creek enters Salt River. Its timber growth is similar to the sandy loam, being a little larger growth as a rule. It is a heavy black clay grading into a stiff black clay as we go down until we reach the unweathered rock. This varies greatly, in some cases being seven or eight inches from the surface and in others occurring at a much greater depth. In some localities considerable fragmental limestone is scattered through it. It is evidently quite fertile and high in humus content, but the humus in all probability contains a large percentage of carbon. As yet very little of it is in cultivation as it occupies quite steep slopes and is covered with heavy timber. Where cultivated it is especially adapted to corn and should raise good wheat and oats. As its area is very small in extent it would be hard to assign a value to it, but it should be worth at least $50 when compared with the other soils of the county.

The following table shows the result of a mechanical analysis of this type of soil. No subsoil sample has been analyzed.

Mechanical Analysis of Leslie Clay.

NUMBERS OF SOIL SAMPLES.	Sand.	Silt.	Clay.
289, Soil 1 to 7 inches.....	15.54	39.35	38.10

THE WAVERLY SILT LOAM.

The most important bottom land type is a light gray silt loam. It is of alluvial origin and quite level in topography. The surface eight inches is usually a gray silt loam often quite light in color. Below this we find a white ashy layer to a depth of about twenty inches. This varies considerably, however, but as a rule from twenty inches down it is a stiff bluish gray clay. Very often iron concretions occur in the white ashy layer; these vary somewhat in size, but are usually about the size of a pea. This layer often extends to a depth of forty inches or more. Oak, maple, elm, hickory and ash grow on this type, but as a rule it is not very heavily timbered.

It is adapted to cultivated crops, especially corn, as nearly all of it overflows and the crop which remains on the land during the driest part of the year is the one best adapted to it, as it will not be as

apt to suffer from the overflow. Wheat, oats and timothy are also raised quite successfully on this type. It seems that alfalfa should do well in some localities on this type. It produces fairly good yields of any crop when conditions are favorable. It is very low in humus content. This type sells at from about $50 to $75 per acre.

The following table shows the results of a mechanical analyses of this soil type.

Mechanical Analyses of Waverly Silt Loam.

Numbers of Soil Samples.		Sand.	Silt.	Clay.
719	Soil 1 to 8 inches	10.96	72 40	12.58
560	Soil 1 to 8 inches	11.94	74.02	9.32
279	Soil 1 to 8 inches	12.74	72.90	11.55
714	Subsurface 8 to 20 inches	5.04	57.80	34.30
280c	Subsurface 8 to 20 inches	5.94	74.28	18.85
724	Subsoil 8 to 20 inches	7.58	50.12	36.76
280b	Subsoil 8 to 20 inches	5.48	69.77	22.69

THE WAVERLY SANDY LOAM.

The smallest extent of any type is occupied by the sandy loam bottom. This is, strictly speaking, a wash from the adjoining sandy hills, although some areas were mapped out in the bottom some distance from the bluff. It differs very little from the gray silt loam alluvium in topography, being at a slightly higher level as a rule. Very little timber is still growing on this type. The greater part of it is a sandy loam, but in places it becomes heavier at a depth of about ten inches. It varies in texture considerably, often being nearly sand and often approaching a loam. It is quite productive and without doubt is the best truck soil in the county. It would also, in all probability, prove to be adapted to alfalfa growing. It produces excellent corn and in fact all kinds of farm crops. It is of course subject to overflow, which would prevent the raising of some crops. It is worth about $75 per acre at present prices of land in the county.

No samples of this soil have been subjected to mechanical analysis. A partial analysis indicates a composition of about 34, 53 and 10 per cent of sand, silt and clay respectively.

SUMMARY.

Audrain is one of the leading agricultural counties of Missouri, ranking high in the production of live stock and other farm products.

Its principal crop is corn, to the raising of which nearly half the area of the county is devoted. Next to corn, blue grass pasture and timothy meadows are the most important crops. Considerable areas are sown to oats. Wheat and clover are raised to a very limited extent only. The average yield for all crops is fairly good.

The soils are of three principal kinds — glacial, residual and alluvial. Of these the upland prairie silt loam of glacial origin is much the most important, both on account of its extent and also its productiveness.

Owing to the system of general farming and stock raising which has been practiced the soils have retained their productiveness fairly well. The soils of many portions of the area have been seriously injured, however, by continuous cropping to corn and with the increased cost of land and labor better methods of handling the soils will undoubtedly be necessary if farmers are to continue prosperous. More attention must be given to drainage, to preventing erosion, to the saving and careful use of manure, to the growing of clover, cowpeas, or some other legume crop, and to systematic crop rotation.