THE SOILS OF MISSOURI

A landscape in the region occupied by the Knox silt loam

COLUMBIA, MISSOURI
MARCH, 1918
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<tr>
<td>F. L. Daley, A. M.</td>
<td>Assistant, Soils</td>
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</tr>
<tr>
<td>G. W. Hervey,² B. S.</td>
<td>Assistant, Poultry Husbandry</td>
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The Soils of Missouri

M. F. Miller and H. H. Krusekopf

The demand for a general soil map and a soil report, covering Missouri, has been constantly increasing during recent years. This demand has come not only from men wishing to buy land, but from schools, banks, land appraisers and commercial organizations. The detailed surveys of individual counties answer this demand for the counties concerned, but detailed mapping is necessarily slow. At the present rate of progress, twenty years must elapse before the state is covered by these detailed county surveys. The desirability of issuing a more general map covering the entire state is therefore apparent and work having to do with its preparation has been in progress for a number of years. In the preparation of this map1, use has been made of the detailed county soil maps prepared by the Federal Bureau of Soils, and of those made by the Bureau in co-operation with the Missouri Experiment Station. That part of the map covering the Ozark region is a modification of the reconnaissance soil map of that region prepared by C. F. Marbut2. The remaining counties of the state have been covered by special reconnaissance surveys. The soil analyses included in the report were made by the Department of Agricultural Chemistry of the University of Missouri from samples collected in part during the making of the detailed maps of individual counties, and in part during the course of the reconnaissance work.

VARIABILITY OF MISSOURI SOILS

In variety of soils few states are comparable with Missouri. In fact the state may be considered the meeting ground of all the important soil regions of the Mississippi Valley. Thus, the extensive

1The major part of the descriptive matter in this report is the work of the junior author, who is also responsible for much of the reconnaissance field work in preparing the map.
2Marbut, C. F.; The Soils of the Ozark Region; Missouri Experiment Station Research Bulletin 3, 1910 Marbut, C. F.; Soil Reconnaissance of the Ozark Region of Missouri and Arkansas; Field Operations of the U. S. Bureau of Soils, 1911.
glacial and loessial soils of the northern part of the state are closely related to the glacial and loessial regions of the states to the north and east. The prairies of Southwest Missouri form the eastern edge of the Great Plains region extending to the Rocky Mountains. The limestone soils of the Ozark region are comparable to the soils of similar origin in Arkansas, Kentucky, Tennessee, Alabama and Virginia. The southeast lowlands represent the northern extension of that great belt of alluvial soils extending to the Gulf of Mexico. The resultant of such varied soil conditions is a varied agriculture, of which it can be said that it is neither northern nor southern, eastern nor western. It possesses the characteristics of all of these regions. The report deals, therefore, with the origin, distribution, character and crop adaptations of the various soil areas of the state, as determined by field and laboratory studies and by field experiments.

DESCRIPTION OF THE AREA

The state of Missouri, located between the thirty-sixth and forty-first parallels of north latitude, and between the eighty-ninth and ninety-sixth meridian of west longitude, lies approximately in the center of the United States. It embraces an area of 68,727 square miles, or 43,985,280 acres. Of this amount, 34,591,248 acres make up the 277,244 farms of the state, an average of 124.8 acres per farm. Of the land in farms, 24,581,186 acres are under actual cultivation, leaving 10,010,062 acres either entirely unworked or used only for rough grazing. Adding this to the 9,394,032 acres which are not in farms it is seen that Missouri has approximately 19,000,000 acres uncultivated. Practically all of the unimproved land is found in the Ozark region and in the southeast lowlands. Much of it will probably always remain timbered, but large areas can be utilized for agriculture.

The population of Missouri at the time of the 1910 census was 3,293,335. Of the 295 cities and towns in the state, St. Louis is the largest with a population of 687,029 in 1910 and Kansas City is second with a population of 248,381 in the same year. St. Joseph, Springfield and Joplin had 77,403, 35,201 and 32,073 respectively. The aggregate population of the 295 cities was 1,655,061 or 50.3 per cent of the total population of the state. The population living in unincorporated territory represented 46.6 per cent of the total. The average number of persons to the square mile was 47.9.
PHYSIOGRAPHY OF MISSOURI

To furnish a better knowledge of the soils of Missouri brief mention will be made of the more important geological and topographical features, since these are influential in determining the character and utilization of the soils. The relation of soils to climate and to vegetation is also of great importance, and striking differences produced by these factors will be discussed in connection with the description of each soil area.

GEOLOGY

The geological history of Missouri is complex both in age and character. In the southeastern part of the state the oldest and the most recent formations are seen almost side by side. In kind the rocks range from massive granite to the various forms of bedded rock (limestone, sandstone and shale). In general, it is only in the southern part of the state—south of the Missouri River—that the indurated rocks lie near the surface, covered for the most part only by the debris of their own decomposition. In the northern part of the state, with few exceptions, the rocks are everywhere covered with a thick mantle of unconsolidated material deposited by glacial and aeolian action during Pleistocene times.

The crystalline rocks, confined entirely to the St. Francois Mountains in the southeastern part of the state, are the oldest and the low-
est geologically. Above them, and occurring in more or less concentric rings around this basal structure, are several beds of limestone and sandstone which make up the greater part of the Ozark region. They belong to the Cambrian, Cambroordovician, Ordovician, Silurian, Devonian and Carboniferous systems.

In the Tertiary period the rocks of the Ozark region were subjected to a gentle folding with the greatest uplift in the St. Francois Mountain region. This folding produced a dome like structure with the rocks gently dipping in all directions from the center. In consequence of this uplift, erosion was accelerated with the result that the overlying rocks have been stripped from the Ozark dome. The erosion has been long and vigorous so that hundreds of feet of rock have been removed and in the area of greatest uplift the old floor of igneous rocks is exposed. The higher and younger rocks thus originally extended across the Ozarks, but have receded scores of miles from the center of the uplift. The uplifted edges of the various formations are being worn back from the center, not evenly, but irregularly, retreating more rapidly where erosion is most vigorous.

Each formation possesses characters more or less distinct from those adjacent to it on either side. The character of the soil will thus reflect in a more or less modified form the character of its parent material. The several sandstone formations are comparatively thin, and the granite is exposed in small areas only, so that these two rocks are of little importance as sources of soil material. That part of South Missouri included in the Ozark region, therefore, is essentially a region of limestone rocks. Some beds are pure carbonates, or practically so, but the majority contain a high percentage of silicious matter. Some beds, in fact, have been almost wholly replaced by silica in the form of chert and flint.

The Mississippian limestone, of the Lower Carboniferous, forms a continuous belt around the Ozark region just described. It has a wide distribution, and covers extensive areas in Southwest and Northeast Missouri. It is made up chiefly of beds of massive, crystalline, pure limestone, with a rather large amount of chert. Of the several beds in the Mississippian group, the Burlington is by far the most important. It is a very pure, coarse grained, highly fossiliferous lime carbonate, containing a moderate amount of chert. The decomposition of this rock gives rise to moderately gravelly, but rather productive soils.
All that part of Missouri lying north and west of an irregular line extending from the southeast corner of Clark county to the northwest corner of Jasper county, is underlain by Carboniferous rocks. The lower beds of these consist chiefly of shales and sandstones, and the soils they form are varied in texture. In the region of the upper coal measures there is a greater alternation of shales with limestones. In general, the various horizons of the Carboniferous rocks occur in irregular belts, extending from northeast to southwest. This condition is of great importance in determining the distribution of the various soils.

The part of the state north of the Missouri River, with the exception of a few small areas, was covered during Pleistocene time by the ice sheet of the Kansan glaciation. Upon receding, the latter left a mantle of drift from ten to two hundred feet in thickness, consisting of the ground up material of the underlying shales, limestones and sandstones, together with soil material and boulders brought down from the north. Where the basal material consisted largely of shales and sandstone, of the Lower Carboniferous, the soil is clayish, but where the limestone predominated, the till is quite calcareous. This condition, together with the varying thickness of drift deposit, is of great importance in determining the character of the soil.

Succeeding the period of glaciation, there was spread over the glaciated area, and for a good distance to the south of it, a fine earth deposit known as loess. Adjacent to the Missouri and Mississippi rivers the deposit sometimes reaches a depth of 150 feet but gradually thins out away from the streams. In the northwestern part of the state this material is of great depth over large areas, altho over much of the central and eastern parts of North Missouri it has been largely removed by erosion.

The unconsolidated materials in the extreme southeastern part of Missouri belong to the Tertiary and Quaternary. They consist of clay, sand and gravel, but are nearly everywhere covered by recent alluvium. Approximately six counties are included in this area, commonly known as the Southeast Missouri lowlands.

**TOPOGRAPHY**

The surface features of Missouri are largely the result of the underlying rocks and the agencies that have acted on them, so that the several physiographic provinces of the state coincide with the several geological provinces. The Ozark region is not only a distinct geologi-
Topographically, Missouri is naturally divided into four great provinces, the North Missouri glacial region, the Southwest Missouri prairies, the Ozark region and the Southeastern Lowlands. It is to be remembered that these provinces are not confined to Missouri alone, but that each forms a part of the larger area which extends into the adjoining states. Thus the glacial region is the southern portion of that great topographic unit including the greater part of the North-Central United States. The western prairie region is the eastern edge of the vast sloping plain, stretching west to the foot of the Rocky Mountains. The Ozark region extends southward into Arkansas and Oklahoma. In the southeastern lowlands are the broad alluvial plains of the southern states.

**NORTH MISSOURI GLACIAL REGION**

In Pleistocene times, immediately after the deposition of the glacial till, North Missouri was a broad, relatively smooth plain, sloping gently toward the south. Since that time drainage channels have
been established, valleys have been eroded and widened, and tributary drainage ways developed, so that only a comparatively small part of the original plain remains intact. In the eastern part of the state remnants of the ancient plain which have escaped the wide-spread degradation of the country, may be seen in the broad divides, of which the most extensive is the level prairie extending from Howard county to Pike county, and from northern Callaway county to the Iowa state line. On this plain the surface is level or gently undulating, broken only by small drainage channels barely sufficient to dispose of the water after heavy rains.

To the east and south of this plain the country slopes to the Mississippi and Missouri rivers respectively, with a maximum difference in altitude of about 400 feet, from the level of the river flood plain to the level of the prairie. This slope represents the belt of rolling to moderately hilly topography that includes approximately one-half of each of the counties bordering the Mississippi River and those bordering the Missouri River from its mouth to the west side of Howard county. Altho there is very little level land in this belt, very little of it is too steep for cultivation, and it is only along the larger streams and adjacent to the rivers that the topography is of the bluff type.

The level prairie region breaks off rather abruptly to the west into a region that is rather completely dissected, so that none of the old plain remains and the surface everywhere is more or less rolling. The divides are mere ridges, and the streams have extended their tributaries to drain the entire surface. There is little of the badly dissected type, but much of it is sharply rolling, particularly near the streams. Drainage channels have been established more plentifully than in any other part of the state, and there are no extensive areas that are not eroded by streams enough to give some variety to the topography. This rolling area is the triangular region having the Grand River, the Chariton River and the Iowa state line as its sides.

The western part of the glacial region includes the territory between the Grand River on the east, and the Missouri River on the west. It is characterized by a gently rolling to smooth or undulating surface. It is not crossed by any large streams, except in the northwest portion, and the smaller drainage systems have cut down to only moderate depths. There are large areas many miles in extent that have a billowy surface which insures ideal surface drainage. Over a considerable part of this region is spread the wind formed material known as loess, which gives the pleasing contour characteristic of this material wherever it occurs in a humid region and where it has not been ex-
posed to excessive erosion. In general the topography of the glacial region is constructive in origin, and the smoothness is that of new erosion.

SOUTHWEST MISSOURI PRAIRIE REGION

This region represents the smoothest portion of the state and is characterized by level to gently rolling topography. These features are due to the character of the underlying rocks which consist largely of shales, limestones and sandstones, and which dip to the northwest at a very low angle. From such a structure is derived a succession of flat plains and rolling escarpments. Where the clay shale beds prevail the country is flat; where sandstones or limestones prevail the hills are generally low and rounded. Where the rocks of the upper Carboniferous occur, as in Jackson and parts of Cass and Lafayette counties, there are very frequent alternations of limestones with shale, and the resultant surface is more rolling or undulating. In the remainder of the prairie region, wide, gently sloped valleys, and streams with gentle grades, broad flood- plains and broad rounded divides, are characteristic. In short, it is a mature topography—a smoothness of long continued erosion.

OZARK REGION

The Ozark Region, frequently known as the Ozark Mountains, includes all that portion of the state south of the Missouri River not included in the southwestern prairie and southeastern lowland regions. Its boundaries on the south, east and north are the Arkansas state line, the Mississippi and Missouri rivers respectively. The western boundary extends from near the northwestern corner of Cooper county in a southerly direction to the southwestern corner of Jasper county. The region as a whole is higher and more dissected than the adjoining prairies to the north and west. The stream valleys are usually deep and narrow, and are bordered by belts of rough, dissected country. Only a small part of the area can be called smooth. However, the total area that is topographically too rough for agricultural purposes is relatively small. The roughest part of the Ozark region, as well as of the state, is found in Crawford, Washington, Iron, Madison, Wayne, Reynolds, Shannon, Carter and portions of the adjoining counties. This area is frequently known as the Ozark center—not the geographical center but the geological center. The topography varies from hilly to almost mountainous. The highest peaks in the state are
located here. The valleys are numerous and deep, and may be 500 to 700 feet below the tops of the ridges. The former are very narrow and few of them have alluvial belts wide enough to be of agricultural importance. It is the region of the oldest rocks, the granites, surrounded by flinty limestones with some sandstones. The soils therefore are full of rocks, which tends to intensify the rough appearance. As a whole, the greater part of this area is non-agricultural. It is represented on the soil map by the Clarksville stony loam and the Ashe loam.

Another area that is closely related topographically to this rugged section occurs along the Osage and Niangua rivers in Camden county, and the northern part of Dallas and Laclede counties. Here the dissection is complete and intricate. It is almost an uninterrupted series of narrow branching valleys and sharp ridges. The occurrence of even small areas of smooth land is so infrequent as to be practically negligible. Such a topography together with the large amount of stone in the soil makes cultivation practically impossible.

The central part of the Ozark region, embracing about twenty counties, and extending from Cole county on the north to the Arkansas state line on the south, is frequently known as the Ozark plateau. The topography varies from almost level to hilly, the former representing the broad interstream divides. Extensive smooth to gently rolling areas, varying from one to ten miles in width, occur in Laclede, Dent, Texas and Wright counties. The St. Louis and Springfield and the Kansas City and Memphis lines of the Frisco railroad follow these almost level divides. The streams of this region are bordered by belts of very rough country, which gradually become less rugged as the higher uplands or divides are approached. In general, the southern part of the plateau region including the greater part of Douglas, Taney and Ozark counties, has more streams and is more completely dissected than the northern part of the area. In fact, a large portion of this southern area is non-agricultural.

The western part of the Ozark region and that portion (approximately the width of a county) bordering the Missouri and Mississippi rivers, is known as the Ozark border. It is transitional between the dissected Ozarks and the level prairies to the north and west. It is not so rough as the main body of the Ozark region, and the soils are less stony. The topography is varied, but in general may be described as rolling to hilly. In Greene, Lawrence and the counties to the north and west, the surface is comparatively smooth, except where minor streams have cut down to moderate depths. That portion along the
Missouri and Mississippi rivers is rolling to hilly, but by far the greater part of it is suitable for cultivation. The hilly areas are most extensive in Osage, Jefferson and Ste. Genevieve counties, where the belt is crossed by the Gasconade, Merrimack and other streams, and is completely dissected. On the watersheds between streams the relief is not so strong, the topography being neither smooth nor very rough.

SOUTHEAST LOWLANDS

The Southeast Lowland region is one of the most pronounced physiographic areas of Missouri. It is the northern extremity of that vast lowland region extending thru Arkansas and Louisiana to the Gulf of Mexico, known as the Mississippi lowland. In Missouri, the boundaries of this region are clearly defined. The region is set off from the Ozark region by a distinct bluff line, running from Cape Girardeau southwestward to the state line in southwestern Ripley county. The Lowland region as a whole is a broad flat plain, with a gentle slope to the south. With few exceptions the surface variations are not more than 10 feet, which explains why large areas have poor surface drainage. Two prominent topographic features occurring in the Lowland are Crowley's Ridge and Commerce Hills, remnants of an old upland standing from 20 to 150 feet above the level floor of the
general plain. The east and north slopes of these ridges are abrupt, but to the west they grade off imperceptibly into the lowland. Crowley's Ridge varies in width from one to fifteen miles, being widest in the northern end. Like the Commerce Hills, it is completely dissected, and in its general surface features resembles the uplands to the north. Sikeston Ridge is a low, inconspicuous ridge standing about 25 feet above the adjoining bottoms, and extending from Commerce Hills southward to New Madrid.

**ALTITUDE**

The greatest altitude in Missouri is about 1800 feet, attained by a few peaks in Iron county, in the Ozark Center region. Here also occur the greatest variations in altitude for a given area. In general, the average altitude of the Ozark region is about the same as the average altitude of North Missouri.

The highest portion of considerable area in the Ozark region is the extensive plateau or Ozark Divide, which extends from St. Francois county southwestward to the Arkansas state line in Barry county. In St. Francois county it is about 1100 feet above tide level. In Iron and Reynolds counties it is about 1600 feet. There is then a gradual fall to 1400 feet in Dent county, where there is a large area of level upland lying at about this altitude. In the eastern part of Wright county the height increases to 1700 feet, but thence southwestward near the state line in Barry county and Taney county there is a decrease in elevation to about 1550 feet. This divide is surrounded on the north, east and south by a broad marginal zone, deeply trenched by water courses, that decreases gradually in altitude until the lowlands bordering the Missouri, Mississippi and White rivers are reached.

The altitude of North Missouri varies from about 800 feet, fronting the Mississippi River, to 1200 feet in the extreme northwestern corner of the state. This variation is characterized by a gradual rise in elevation northwestward. The central part of the region lies near the 900 and 1000 feet contour levels.

The Southwest Missouri prairie region has about the same altitude as North Missouri, and like the latter is lowest in the eastern part and highest in the northwestern part. The rise is at the same rate as that north of the Missouri River, and reaches an elevation of about 1150 feet on the high prairies of Cass and Jackson counties.

The lowest elevation in Missouri is about 290 feet in the extreme southeastern corner of the state. The average altitude of the south-
eastern lowlands is between 300 and 350 feet, the higher areas occurring in the northern part of the region.

**FORESTS**

At the time of settlement, probably more than 60 per cent of Missouri was forested. With the exception of occasional prairie ridges,
higher ground elm, gum, hickory, oak and catalpa are most abundant. Post oak and white oak predominate on the gray soils of the high second bottoms.

The timber growth of the Ozark region can be divided into several fairly distinct types. As shown on the map page 16 the short leaf pine area occupies one large block with several small scattered lots in the southeastern counties. With the exception of small stands, the pine is always mixed with hardwoods, consisting mostly of white, red, black and black-jack oak. Practically all of the pine has been removed. In general, this type is confined to the dry stony lands represented largely by the Clarksville stony loam.

White, black and red oak make up the bulk of the timber of the Ozark region. Any one of the species may be dominant at any given place, but in general they are more or less evenly distributed. These occur where the soil has considerable clay and a moderate amount of stone, represented largely by the Clarksville gravelly loam.

The scrub oaks prevail over the barren plateaus and ridges, including most of the Clarksville silt loam, Hanceville loam and much of the stony land. The principal trees are black-jack and post oak, altho black, red and white oak are usually present in varying amounts. Neither the black-jack nor post oak is of any particular value except for fuel. The post oak is used as tie timber where it is large enough. These trees, especially the second growth, are usually dense and bushy. On some of the flat ridges with heavy clay sub-soils, such as the Lebanon soils, included within the Lebanon silt loam area on the map, post oaks often occur in nearly pure stands and are known as post oak ridges. Altho such areas are usually small, they are distributed throughout the Ozark region. These flat ridge tops are commonly called "post oak flats" and constitute some of the poorer lands of the Ozark region.

On all the red and brown soils of the Ozark border region, no one species may be called dominant, the principal trees being white, red and black oaks, hickory, hackberry, linn, walnut, sugar maple and elm, and in places laurel oak and pin oak. The undergrowth is dogwood, hornbean, haw, viburnum and hazel. Cedar occurs often in pure stands on limestone outcrops along river bluffs. Some of the most extensive areas are found along the White, Big and Osage rivers.

**CLIMATE OF MISSOURI**

The climate of Missouri is essentially like that of the corn belt. The annual mean temperature ranges from 50 degrees in the north-
western to 58 degrees in the southeastern counties, the average for the state being 54 degrees. The average temperature for July, the warmest month, ranges from 77 degrees in the northwest to 80 degrees in the extreme southeast. The mean temperature in January is 26 degrees in the northwest, 30 degrees in the central counties and 36 degrees in the southeast. Periods of extreme cold are of short duration, and the temperature seldom falls lower than 5 to 10 degrees below zero. During the summer months the temperature frequently reaches 90 degrees or more, the average annual number of days with such maximum temperature being 34 for the entire state.

The average date of the last killing frost in spring varies from April 12 in the southern section of the state to April 22 in the northern, the first killing frost in autumn from October 18 in the southern section to October 12 in the northern. The average length of the growing season is approximately 180 days. For North Missouri it is 172 days, and for South Missouri 188 days. The difference in topography is not sufficient to cause any marked differences in the climatic features of the so called lowlands and plateaus. It frequently occurs that in the late spring fruit is killed in the valleys by frost, while that on the hills escapes injury. This, of course, is nothing more than the result of air drainage.
The average annual precipitation, covering a period of 20 years, ranges from 34 inches in the northwestern to nearly 50 inches in the southeastern counties, the average for the state being 39 inches. In general, the precipitation decreases from south to north and from east to west. The annual snowfall is about 23 inches in the northwest, 22 inches in the northeast, 17 inches in the Ozark region, 19 inches in the southwest and 10 inches in the southeast. The seasonal distribution of precipitation is heaviest in spring and early summer and lightest in late summer and early autumn; this is true for the entire state, altho there is some variation in different regions. The average growing season precipitation—March to September inclusive—is about 27 1/2 inches.

The prevailing winds are southerly and southwesterly altho during the winter months northwesterly winds prevail a considerable part of the time. There are occasional periods of drought, usually in July and August, but in the main the climatic conditions are favorable to the highest type of agriculture.

SOILS

The term soil in its broadest sense, refers, with few exceptions, to the unconsolidated mantle of disintegrated and more or less decomposed rock powder, together with more or less organic material which under favorable conditions will support the growth of plants. As it
is the surface portion of this material that most concerns the agriculturalist, it has become a common practice to apply the term soil to the surface material that has been darkened by organic matter, while the underlying part is termed subsoil. In general, the depth to which the bulk of the roots of grasses and other herbaceous plants penetrate marks the depth of the so-called surface soil. In the case of many alluvial soils the surface soil may extend to a depth of two to three or more feet, but on the uplands it will probably not average more than
twelve inches deep. The subsoil is usually lighter in color and more compact than the surface soil. This is primarily due to the lack of organic matter and to infiltration of clay.

In many soils, generally those of a level topography, the surface soil and the subsoil are separated by a layer of material that possesses distinct characteristics and is easily distinguished from the soil above and the subsoil below. This layer is sometimes called subsurface soil. It may vary in thickness from one to several inches, but rarely exceeds twelve inches. In texture it is usually like the surface soil, but in color it more nearly resembles the subsoil. At some experiment stations it has been customary in sampling soils to consider the top seven inches as soil, the layer from this so-called soil down to 20 inches as subsurface soil and from 20 to 40 inches as subsoil. The Missouri Experiment Station is following the practice of designating the surface 7 inches as soil, the layer from 7 inches down to change in color as subsurface soil and from the change in color to 36 inches as subsoil. All soil descriptions in this publication apply only to the upper three feet of soil material and the lower substratum is referred to only when it possesses such peculiar characteristics as might affect in some special way the growth of plants. It should of course be understood that the surface soil proper is always more or less affected by wind action, which may at times overshadow all other formative agencies.

SOIL CLASSIFICATION

By virtue of the great variation in geological formations and formative agencies, the soils of Missouri present extreme variations in their characteristics. However, a study of these variations will show that certain regions possess certain similarities and when such similarities have a well defined relationship they form a basis for grouping the soils. In general the nature of the soils of a given region are determined by the kind of rock from which they have been derived, by the formative processes, by the topography and by the age of the materials. Thus the soils of the Ozark region have relationships in that they are derived from limestones, and almost universally contain more or less gravel; the soils of North Missouri have the common characteristic of being glacial in origin or they have resulted from glacial action. It is therefore on the basis of their origin, topography and mode of formation that the soils of Missouri are divided into four great groups or provinces, these provinces coinciding with the four physiographic divisions of the state.

The soils of each of these provinces are divided into several groups according to the source of the material and the agencies by
which they were accumulated. Thus the soils from the pure limestones make a separate group from the soils of the moderately cherty limestones; the soils of aeolian deposition are grouped separately from those of mixed loessial and glacial deposition.

Based on the physical properties of the soil, such as color, texture, and content of organic matter, these groups are divided into one or more series, and they are designated by giving them locality names such as Shelby soils or Bates soils. To each series name the descriptive terms of the soil class are added, such as Shelby loam and Bates fine sandy loam. The soil unit is the soil type. It is uniform in all physical and chemical characteristics in all places where it is found. This classification is according to that in use by the United States Bureau of Soils.

In this report those soil areas that are closely related in their characteristics and properties have been included in the same soil type. The name used is that of the soil type which makes up the major part of the area. Such types necessarily must often include smaller areas of material quite different from the prevailing material. A reconnaissance map can therefore not be used as a guide to the selection of an individual farm, for instance, unless the prospective purchaser views the land. The value of such a general map is to show the prevailing character of soil in different parts of a state. It shows the soil resources of the state and is an accurate guide for those seeking a new location. It is the purpose of the detailed county maps to give accurate information regarding individual sections and quarter sections.

In general, the soil types in the northern and western parts of the state are more uniform or contain fewer variations, than the soil types of the Ozark region. This is due to the fact that the soil forming material and soil forming agencies have been more uniform over large areas in the former regions than in the latter. The lowland soils, particularly those of Southeast Missouri are quite variable within the types. Such variations are due both to actual differences in material and to differences in drainage.

Finally, the change from one soil type to another is usually gradual, and frequently extends over a considerable distance. Bottom land types are set off from upland types by distinct change in topography, but divisions between upland types are not so apparent. It is evident, therefore, that in a reconnaissance survey the soil boundaries cannot be as accurately drawn as in a detailed survey. In using such a map these various limitations should be understood and due allowance made.
<table>
<thead>
<tr>
<th>Province</th>
<th>Soil Groups and Types</th>
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<tbody>
<tr>
<td>Glacial and Loessial</td>
<td>Soils from loessial deposits</td>
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<tr>
<td></td>
<td>- Knox silt loam</td>
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<td>- Marshall silt loam</td>
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<td>- Grundy silt loam</td>
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<td>- Putnam silt loam</td>
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<td>- Alluvial soils</td>
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<td>- Wabash loam and clay loam</td>
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<td>Residual Plains</td>
<td>Soils from limestone and shale</td>
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<td></td>
<td>- Summit silt loam</td>
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<td>- Soils from shale</td>
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<td>- Oswego silt loam</td>
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<td>- Cherokee silt loam</td>
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<td>- Soils from sandstone and shale</td>
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<td>- Bates fine sandy loam</td>
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<td>- Alluvial soils</td>
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<td>- Osage silt loam</td>
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<td>Ozark Region</td>
<td>Soils from chert free limestone</td>
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<td></td>
<td>- Hagerstown silt loam</td>
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<td>- Soils from cherty and moderately cherty limestones</td>
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<td>- Lebanon silt loam</td>
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<td>- Clarksville gravelly loam</td>
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<td>- Clarksville stony loam</td>
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<td>- Crawford gravelly and silt loams</td>
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<td>- Union silt loam</td>
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<td>- Soils from limestone, sandstone, and shale</td>
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<td>- Tilsit silt loam</td>
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<td>- Hanceville loam</td>
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<td>- Ashe stony loam</td>
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<td>- Alluvial soils</td>
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<td>- Huntington loam</td>
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<td>Southeast Missouri Lowlands</td>
<td>Alluvial soils</td>
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<td>- Sarpy fine sandy loam</td>
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<td>- Lintonia loam</td>
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<td>- Sharkey clay loam</td>
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<td>- Waverly silt loam</td>
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<td>- Waverly fine sandy loam</td>
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SOIL COMPOSITION

The composition of a soil indicates its potential fertility. The agricultural value of a soil is however dependent not only upon its composition but upon various additional factors, such as the texture, topography and drainage. Nevertheless, it is of great value to know the composition of a soil as compared with that of other soils, or with what might be termed the standard for a very fertile soil. When it is shown that a soil is deficient in one or more of the important elements, nitrogen, phosphorus or potassium, as compared with a very fertile soil, the probabilities of producing large crops would be lessened, unless means were adopted to correct the difficulty. It should not be understood, however, that a chemical analysis will show the exact crop return to be expected from a soil, or the exact amount of fertilizer to apply to bring a given crop yield, because this depends upon many additional factors, such as season, drainage, character of subsoil and the method of handling. Nevertheless, when one knows that a soil is deficient in one or more of the important elements as compared with a fertile soil, his judgment would suggest that such elements should be
supplied. In other words the analysis indicates systems of soil management to be followed. It indicates which elements need particular attention. It gives an idea of the capacity of the soil for continued crop production. It does not, however, determine the exact forms or amounts of the deficient elements which must be supplied to bring the greatest money return in any given season.

Considerable quantities of lime are needed in soils in order to keep them sweet. Soils lacking lime are said to be sour or acid. The lime required to sweeten the surface, 2,000,000 pounds of an acre of soil, (that is, approximately the surface 7 inches) is therefore known as the "lime requirement". This can be determined with considerable accuracy. For Missouri soils it varies from zero up to four or five tons of ground limestone. It is not always necessary to add lime to a soil, however, in order to produce the ordinary crops, even tho it has a lime requirement of two or three tons. This is particularly true where the soil is high in nitrogen and organic matter and otherwise fertile. It will be found, nevertheless, that this addition of lime to soils showing a medium to high lime requirement, materially benefits crops and its use is often necessary if clover or alfalfa is to be grown. Lime is needed on many Missouri soils.

The analyses here reported were made on soil samples which were mostly taken in two parts, the soil proper, representing the dark surface layer from 6 to 18 inches deep, and the subsoil layer, extending from the soil down to 3 feet. The analyses were made by the so-called "total method," which determines the total amounts of nitrogen, phosphorus and potassium present. For the purpose of ready comparison they have been expressed as pounds in a given weight of soil. They are therefore given as so many pounds of each of the elements in 2,000,000 pounds of the surface soil and of the subsoil, that is, approximately an acre seven-inch layer in each case.

The standard which has been rather commonly used as representing the composition of a very fertile soil is nitrogen 6,000 pounds, phosphorus 2,000 pounds, and potassium 30,000 in 2,000,000 pounds of soil (approximately the surface 7 inches of an acre).

It will be observed that a very high standard has been set as the ideal, particularly in nitrogen and phosphorus. Very few soils reach the nitrogen standard, and comparatively few the phosphorus standard, altho the potassium standard is more commonly reached. It should be observed, however, that this standard is based on the surface 2,000,000 pounds of soil, while the analyses reported herein are based on 2,000,000 pounds of a mixture of the soil layer proper, thus caus-
ing these analyses to show a rather low nitrogen figure as compared with this standard. Doubtless for the methods of analyses and calculation employed, a standard of 5,000 pounds of nitrogen would be better. As a matter of fact some very productive soils in the corn belt contain as low as 4,000 pounds of nitrogen in 2,000,000 pounds of surface soil.

For some purposes the average of all available analyses of Missouri soils, including between four and five hundred separate samples, is a better standard of comparison than an arbitrary composition. These averages are: nitrogen 2,490 pounds, phosphorus 1,245 pounds, and potassium 28,810 pounds, in 2,000,000 pounds of Missouri surface soil, including all available analyses.

It will be observed that the nitrogen and phosphorus are both materially beneath the standard set for a very fertile soil. This is of course to be expected since these analyses cover a wide range of soils of all degrees of fertility.

DESCRIPTION OF THE SOIL TYPES

GLACIAL AND LOESSIAL REGION

The glacial and loessial soils include, with few exceptions, all the northern part of the state north of the Missouri River, and several limited areas south of the river. The latter are most extensive in Saline, Lafayette, Jackson and St. Louis counties with smaller areas on the upland bordering the valley of the Missouri and Mississippi rivers. In total area, the glacial and loessial province covers approximately one-half of the state.

The general surface features of the province are that of a plain, with a gentle slope to the south and east. Bordering the large streams and their tributaries is a belt of rolling country, so that only a small part of the original level plain remains. In general, the surface is level to gently rolling, and practically everywhere permits the development of the highest type of agriculture. The area of non-agricultural land in this province is very small.

LOESSIAL SOILS

After the deposition of the till by glaciers, there was spread over much of the Missouri glacial region and for a short distance to the south, a fine dust material that gave rise to the loess. The deposit was thickest near the Missouri and Mississippi rivers, and gradually
thinned out away from the streams. In this report only these soils are classed as loessial which are derived from material that is generally accepted as aeolian in origin.

It is a significant fact, indicative of the origin of this material, that the loess soils in Missouri occur mainly along the Missouri and Mississippi rivers, and have their greatest distribution where the flood plains of the streams are widest. The largest areas occur in the northwestern part of the state, where the maximum width of the belt is approximately 50 miles. To the east of Kansas City the belt again widens, attaining its greatest width near the longitude of the west line of Saline county, where it again narrows, so that from Boonville to St. Charles it occurs as a broken belt varying from one to six miles in width on both sides of the river.

In their original condition the glacial and loessial soils of northern Missouri formed a vast prairie, broken along the larger streams by narrow bands of timber. All the level and rolling land was covered by a dense growth of prairie grass. The steeper slopes bordering stream valleys, and many of the bottom lands had a growth of oaks, elm, hickory and walnut. Practically all of the original prairie grass has long since disappeared, and only small areas of timber land remain. In general, the glacial and loessial soils of North Missouri are characterized by their remarkable uniformity over large areas, by high fertility and prevailing dark color. Along the Mississippi River the loess belt extends from the northern part of Marion county to the Arkansas state line, reaching its greatest width in St. Louis county. It does not cover the entire surface in the region of its occurrence, altho along the Missouri River it covers the entire surface, excepting the bottom land and some of the steeper slopes from which it has been washed down to lower levels. The loess soils are found in 45 counties, and cover approximately 1,000 square miles, or 13 per cent of the state.

Loess rarely contains gravel or coarse sand, neither does it contain a very large per cent of clay, altho it is fine textured. The soil particles are of such size as to be classed as silt, or very fine sand, and this character is the one to which the loess really owes its value as a soil. It is almost ideal in texture, readily freeing itself from excess water and yet retaining moisture well for growing crops.

That portion of the loess soils lying adjacent to the river valleys has been subjected to excessive erosion, and the consequent rolling surface has not been favorable for the accumulation of large quantities of organic matter. In general, too, the eroded portion has a somewhat coarser texture than the more level areas. Based on these character-
istics the loess soils have been separated into two types, Knox silt loam and Marshall silt loam.

**Knox Silt Loam**

The Knox silt loam represents the light or brown colored and more eroded portion of the loess soils. It forms an almost unbroken belt bordering the Missouri and Mississippi rivers, and is locally known as bluff land or loess. Along the Missouri River it occupies the river hills and rolling areas adjacent to the stream, but along the Mississippi River it includes the entire area of the loess deposits.

The surface soil to an average depth of 10 to 15 inches is a brown to yellowish brown silt loam. On areas deficient in organic matter as on steep slopes and poorly drained flats the lighter shades of brown and yellow prevail. The subsoil is uniformly a brown or pale yellow silt loam, usually becoming more clayish in the areas farthest away from the river bluffs, and extending to the bottom of the loess material without any appreciable change. In the substratum, fossils, snail shells and calcareous concretions are found.

In general, the texture of the Knox silt loam is coarser nearest to the river and finer away from the stream. This characteristic is most pronounced in the northwestern part of the state, where the soil on the river hills is almost a fine sandy loam. Along the Mississippi River the type averages heavier in texture, especially in the subsoil, than the Missouri River loess. Even where the subsoil is a silty clay it is never hard, compact or plastic but is usually rather soft and friable.

The topography of the Knox silt loam varies from rolling to hilly. The latter prevails along the rivers, where it includes the bluffs that rise from fifty to three hundred feet above the bottom lands. These rough belts usually border both sides of the river valley and extend back for a distance of one-half to three miles, and are cut by deep tributary valleys, giving a region of steep slopes and eroded surface. Back from the bluff land the surface is universally rolling with few areas of level land. The total area of the type that is too broken to permit cultivation is rather small and all of it can be used for pasture. In general, that portion of the type extending from Cooper county on the west to St. Louis on the east, and thence southward to the Arkansas boundary is prevalingly hilly and somewhat less fertile than that in the western part of the state.

The silty texture of this soil aided by the rolling surface causes rapid and very destructive erosion. Gullies formed are usually deep with perpendicular walls. Cuts fifteen to thirty feet deep are com-
common near the rivers, and frequently are made in one season. Speaking generally, it may be said that erosion is more severe in that part of the area extending from the center of the state east and south, than in the part in Western and Northwest Missouri, altho the rolling surface and excessive erosion are everywhere the limitations in the use of this soil.

Practically all of the Knox silt loam is occupied for agricultural purposes. All the staple crops common to the state are grown successfully on it and as a fruit soil it is excellent. Where the surface is not too rolling, most of the type is used for corn and wheat. Yields of from forty to sixty bushels per acre of the former and of eighteen to twenty-five bushels of the latter are common. Clover and alfalfa grow well, which is resulting in the more widespread use of the type for the production of these crops. The steep rolling land is largely used for grass and pasture. In St. Louis, Jackson and Buchanan counties large areas are used for trucking. Tobacco is rather extensively grown in Platte county, while cotton constitutes one of the principal crops in the extreme southeastern part of the state.

As a fruit soil, the Knox silt loam probably is superior to any other type in the state. In certain locations hundreds of acres have been successfully planted to orchards, many of them of commercial size. The deep porous subsoil, well supplied with lime, permits of the largest root development, so that the trees make a strong growth and come into bearing at an early date. An excellent quality of fruit is produced. The possibilities of extending the fruit industry are great. All of the type is well located with respect to markets and transportation facilities. Those areas, however, which are poorly drained, or of insufficient elevation to secure adequate air drainage should not be devoted to fruit.
On account of its position near the large rivers the Knox silt loam was one of the first soils to be occupied in the settlement of the state. In the eastern part of the state, however, the Virginia and Kentucky people who first settled the land have largely been replaced by Germans. The equipment of farm buildings and of farm machinery is as a rule good. Near the larger cities, the tendency toward dairy farming is making rapid growth. Land values are very variable, depending on topography, location and improvements. They range from $30 to $150 per acre. Well located fruit farms may reach $200 per acre.

The composition of the Knox silt loam does not give a good indication of its fertility for the reason that the very similar character of soil and subsoil gives plant roots a greater feeding range than in the average upland soil. It is a newly formed material which has not yet had time to differentiate sharply into soil and subsoil, so that the subsoil is much more fertile than that of the average upland soil. The content of the important plant food elements and the lime requirement of the soil are shown in Table 1.

**Table 1.—Composition of Knox Silt Loam**

(From western part of state. Average of 3 analyses)

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<tbody>
<tr>
<td>In 2,000,000 pounds of soil . . .</td>
<td>2660</td>
<td>1205</td>
<td>33375</td>
<td>0</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil . . .</td>
<td>1505</td>
<td>1115</td>
<td>27715</td>
<td>960</td>
</tr>
</tbody>
</table>

(From eastern part of state. Average of 8 analyses)

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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil . . .</td>
<td>1830</td>
<td>865</td>
<td>35940</td>
<td>1290</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil . . .</td>
<td>1050</td>
<td>915</td>
<td>38005</td>
<td>1380</td>
</tr>
</tbody>
</table>

The low nitrogen content indicates a low content of organic matter, but the deep loose character of this soil and the more favorable conditions for bacterial action seem to make this deficiency less serious than would be indicated. Likewise the phosphorus content while comparatively low is more effective than might be expected. Experiments have shown that the phosphates in the subsoil are much more available in this soil type than in the ordinary soil. The potas-
adium is seen to be high and the availability of this plant food in the
subsoil is also higher than in most other soils. The lime requirement
is low. Most samples analyzed showed no lime requirement what­
ever. The somewhat poorer quality of this soil in the eastern part of
the state is shown in the analyses.

The problem of soil management on this type is principally one of
maintaining the supply of organic matter and nitrogen thru proper
systems of rotation and the return of organic matter in manure or
green manures. This is particularly true of the type west of the center
of the state. East of the center the productivity is somewhat less and
the use of phosphates will often give good returns on wheat, corn and
clover. As a rule the land grows excellent clover and where it has
been properly handled it grows good alfalfa. The wide range of crops
allows a wide choice of possible crop rotations in general farming, as
well as the growing of special crops, such as fruits and tobacco.

The control of erosion is the most serious problem on this soil.
While small washes do not start quite so readily as on many other
types, when once started they very rapidly assume the proportions of
deep gullies with vertical walls. If not controlled early they become
almost impossible to control. Practically every neighborhood on this
soil type has examples of these gorge like washes, altho a reasonable
amount of care will prevent them. A proper handling of this soil type
makes it one of the most satisfactory soils of the state from the stand­
point of profitable soil management.

Marshall Silt Loam

The Marshall silt loam is agriculturally the most important as
well as the most extensive soil type found in Missouri. Like the Knox
silt loam it is of loessial origin, and has its widest distribution in the
western and central parts of the state. It is a prairie soil and thruout
the region of its occurrence it occupies practically all of the upland
area.

The surface soil of the Marshall silt loam consists of a dark
brown to black, mellow silt loam, easily tilled and well supplied with
organic matter. In depth it ranges from 10 to 20 inches, the shallower
soil prevailing on the rolling areas and the deeper soil on the more level
prairies. The subsoil is a brown, dark drab or yellowish brown silt
loam or silty clay loam. This material normally extends to a depth of
six or eight feet, tho it may possess a total depth of twenty-five to
seventy-five feet over wide areas. Frequently in the lower portion of
the three foot section less clay and more silt is present than in the up-
per subsoil, but in all cases the subsoil is readily pervious to water. Not infrequently concretions and accumulations of lime carbonate are found in the subsoil. In general, the soil and especially the subsoil are heavier near the margin farthest from the Missouri River and lighter where the type borders on the Knox silt loam.

The topography of the Marshall silt loam is undulating to gently rolling, with generally just enough slope to insure good drainage without inducing excessive erosion. The rounded, billowy, rather smooth outline of the slopes is one of the most characteristic and pleasing of the contour features. In addition to good surface drainage, the loose, friable subsoil insures good under-drainage except in a few flat depressions. Many such areas have been tiled, and have been found to be as productive as, or even more productive than, the higher ground. The cost of artificial drainage is low, since the ditches are easily dug and in the majority of instances only a single line of tile laid thru a depression or draw is necessary to remove the surplus moisture. In wet seasons, the lower slopes are often very wet from seepage water. This can be corrected readily by a tile laid across the slope.

In all of its physical properties the Marshall silt loam is an excellent soil. The gentle slopes, the favorable texture and structure, and the great depth of the soil, with a high content of organic matter, tend to make this type one of the most productive and valuable soils in the state. Considerable of the surface soil is, however, beginning to develop acidity as shown by lime requirement determinations.

The Marshall silt loam is the dominant corn soil of the corn belt. Counties principally covered by this soil are the premier corn counties, and the yields obtained average higher than for any other upland type. Yields range from thirty-five to ninety bushels per acre. Oats, clover, alfalfa, timothy and fruit thrive exceedingly well and give high average yields. The yields of oats per acre are usually about the same as those of corn, ranging from forty to seventy bushels. Wheat is not quite so well adapted to this land as corn and oats, altho the yields are quite satisfactory. It is most extensively grown in Saline and surrounding counties, and the tendency is toward increasing the acreage.

The prevailing type of agriculture is that of general farming combined with the production of livestock. The average high fertility and the predominantly smooth to gently rolling surface of the land adapts it to a wide range of crops. It supports a high class corn belt agriculture. The standard crop rotation consists of growing corn for two or more years, sowing wheat or oats and seeding down to grass, usually timothy and clover mixed, which is used for meadow and pasture two
to four years. In general this rotation is adequate and well suited both to the soil and to the agricultural necessities.

Like the Knox silt loam, the Marshall silt loam is well suited to the production of fruits and vegetables. The deep porous soil, together with high fertility, permits excellent root development and insures strong, vigorous trees. In Buchanan county and in several other localities fruit growing on this soil is of commercial importance. The

land is so well adapted to corn and general crops that the fruit industry has not been greatly developed thus far.

The livestock industry as a whole is the most important source of revenue and is largely responsible for the prosperity prevailing on this soil type. Well bred stock is used almost exclusively. Each year large numbers of high grade feeder cattle are brought in. Practically all of the corn crop is used for fattening animals. In addition to cattle, large numbers of horses, mules and hogs are marketed annually.

Practically all of the type may be classed as highly improved land. Farm buildings are generally substantial and well kept. The farm equipment is far above the average of that found on less productive soils. The farm units are relatively large, averaging around 150 acres. Approximately thirty-three per cent of the farms are operated by tenants and the number is slowly increasing. This tendency is usually accompanied by a decrease in the livestock industry and an extension of the cultivated grain crops. Land values range from $80 to $200 per acre, and occasionally reach $250. In general the Marshall:
silt loam sustains as high a type of agriculture as has been established within the state, and its crops, its animals and its homesteads are all of unusual quality.

Soil management on the Marshall soil is largely a matter of proper crop rotation and a reasonable care of farm manures. The use of commercial plant foods is thus far very little known. The soil composition shown in Table 2 is of interest.

Table 2.—Composition of Marshall Silt Loam

(Average of 12 analyses)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>3685</td>
<td>1675</td>
<td>33720</td>
<td>3960</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>1965</td>
<td>1550</td>
<td>33410</td>
<td>2630</td>
</tr>
</tbody>
</table>

These analyses show the soil to be comparatively well supplied with phosphorus and potassium. The nitrogen supply while not as high as in some of the bottom lands of the state is distributed to good depths, and where the soil is properly managed it is not difficult to maintain sufficient nitrogen for excellent crop yields. The need for lime is becoming evident, altho with the generally high fertility it is not greatly felt. Clover which is widely grown on this soil type and alfalfa which is also grown on the better phases of the soil will both respond to lime in the more acid areas.

Field experiments have been conducted on this soil for a number of years, but have thus far shown little profit from the use of commercial plant foods. The more worn areas will doubtless respond to the application of phosphorus but such applications are on the whole little needed yet.

MIXED GLACIAL AND LOESSIAL SOILS

There is little doubt that most of the surface soils of North Missouri have been considerably affected by wind action. It can be said at least that the glacial and loessial materials are more or less mixed. Continued study of the glacial deposits, however makes it increasingly evident that the large part of this material is derived from the country rock rather than from rocks to the north. This fact is of great significance, because it has influenced the character of the soils derived from the till. In the western part of the glacial region where the limestones
and shales of the Upper Carboniferous prevail, the till is calcareous and loamy; in the eastern part of the region where the shales and sandstones occur it is argillaceous and comparatively shallow. The percentage of local material is greater also where the drift is thinnest. Based partly on these differences in origin and partly on topographic and textural differences, these soils have been divided into four types, the coarser, Shelby and Lindley loams, largely of glacial origin, and the finer, Grundy and Putnam silt loams, which are probably largely loessial in origin. There is little doubt that the Grundy silt loam has been considerably affected by loessial material, but since both of these soils pass into typical glacial deposits in the lower subsoil and are at least in part weathered till, it has been thought best to class them with the mixed loessial and glacial soils.

_Shelby Loam_

The Shelby loam is extensively developed in the northern and western parts of North Missouri, and occupies practically all the rolling land of that region. Typically, it consists of a black, dark brown or yellowish brown, friable loam, varying from 6 to 12 inches deep. The content of sand in the surface soil is sufficient to give a gritty feel, and to make it loose and friable. The percentage of silt, however, is nearly always rather high for a loam, and in many cases it might be called a silty loam. The subsoil, from 15 to 36 inches, is a yellow or yellowish brown, tenaceous, sandy clay, mottled brown, red and gray, usually becoming lighter in color in the lower subsoil, especially on the more nearly level areas. The content of organic matter in the surface soil varies considerably; on the rolling lands it is quite low, but on gently rolling areas and especially at the base of slopes the soil is well supplied as is indicated by the deep black color.

The characteristic feature of the Shelby loam is the presence of sand and fine gravel throughout the soil mass. Both sand and gravel are rounded and water worn, and are largely of foreign origin, consisting of quartz, granite, greenstone, gneiss, diabase and many other crystalline rocks. This coarse material is not present in quantities sufficient to affect the soil appreciably, altho it tends to make it more porous. Occasionally the gravel is stratified as thin lenses, but as a rule it is thoroly disseminated throughout the soil section. Lumps of lime concretions and calcareous streaks are present in considerable quantity in the subsoil and extend to great depth. Deep excavations frequently show such an abundance of calcareous material as to give the soil a chalky appearance. The greater abundance of the calcareous material where
the drift is deepest would indicate that the soil material was not leached before its deposition, and explains its high potential fertility. The separation of the Shelby loam from the Lindley loam would be justified on this basis alone because of the greater productiveness of the glacial limestone soil as compared with that of shale and sandstone origin.

It is thus easy to distinguish the Shelby loam from the adjoining loess soils. The latter never contain gravel or stones. The presence of the gravel has given good internal drainage, to which is due the yellow or reddish color, since good drainage and aeration are favorable to oxidation. The Lindley loam being less gravelly and more clayey is not so thoroughly oxidized, and therefore is lighter colored.

The surface features of the Shelby loam are gently rolling to moderately hilly with a rather billowy appearance. The hills are usually rather low and rounded, but are sometimes sufficiently steep to offer considerable difficulty in cultivation. In general, the type is more rolling in Sullivan and Putnam counties than it is farther west. It is one of the most easily eroded soils in the state, and this constitutes the most serious problem in its management. This condition has influenced the type of farming and large areas are kept in grass.

The greater part of the Shelby loam was prairie, and it was only along the streams and the more hilly areas that timber occurred. It consisted largely of oaks, walnut, elm, hickory and cherry. The tree-
less areas were covered with prairie grass, and near the edges with hazelbrush and sumac. Practically all of the type is now highly improved farming land.

As a whole, the Shelby loam is not as well supplied with humus as the Marshall soils, nor does it produce quite as large yields of corn. It also requires greater care in handling to maintain the humus supply and to prevent injury from washing. It is, however, a warm soil, and is easily handled. It is a good grass and clover soil, and under proper conditions will grow alfalfa satisfactorily. Bluegrass grows well on it, and the acreage devoted to this crop exceeds the total area devoted to small grains.

The agricultural practices prevailing on the Shelby loam are essentially the same as those on the silty prairie soils. Corn and grass are the predominant crops. The acreage of wheat and oats is relatively small, as it is generally held that the glacial land is not as well adapted to these crops as are the loess soils. The rotation most commonly followed is corn two or three years, followed by oats, with which timothy and clover are seeded. The land is left in sod from two to six years, and usually pastured after the first hay crop. On much of the more rolling land many of the pastures are more or less of the permanent type. The luxuriance with which bluegrass grows on this soil is equal to that of the Marshall silt loam. Probably fifty per cent of the type is pasture and hay land. Orchards, small fruits and vegetables produce well, but are grown mainly for home use, with an occasional surplus for market.

Farm improvements show a rather wide range of conditions, altho they are prevalingly good. The farms are generally large, and possess the characteristics of those of a live stock region. Land values show a considerable range, from $50 to $125 per acre, depending largely upon the topography and proximity to railroad towns.

Approved methods of soil management on this soil should include rotations suited to livestock or mixed farming. As most of the land grows clover quite well, where it has been reasonably well cared for, this crop may well form the foundation of a soil maintaining rotation. Other crops such as corn, oats, wheat, timothy and soybeans may well be included, altho the soil is not known as very good wheat land.
The composition of the soil is shown in Table 3.

**Table 3.—Composition of Shelby Loam**

(Average of 11 analyses)

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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil ....</td>
<td>2990</td>
<td>1225</td>
<td>23660</td>
<td>3835</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil</td>
<td>1110</td>
<td>1105</td>
<td>22640</td>
<td>2510</td>
</tr>
</tbody>
</table>

It will be seen that nitrogen and phosphorus are somewhat deficient. The need for lime in the surface soil is considerable, on the average, but over most of the area it is not sufficient to prevent the growth of clover. It is probable that the fairly high supply of lime in much of the subsoil has a considerable influence on this.

The need of the land for phosphorus is shown in the effect of phosphates when applied. Experiments which have been conducted on this soil show a good return from available phosphates and some return from lime and potash. Increasing the supply of organic matter thru the use of manures and the growing of clover and cowpeas will be accompanied by paying returns.

The topography of the land makes it highly important that efforts be made to prevent erosion. Land should not be left bare over winter. Corn should rarely occur more frequently than once in four years or twice in five years, and if the rotation contains two or three years of clover and timothy it will be advantageous in preventing erosion. Over considerable areas of this land a large per cent may well be left more or less permanently in grass, largely because of soil erosion.

**Lindley Loam**

The Lindley loam includes practically all of the rougher glacial land in the northeastern part of the state. It represents the bulk of the timber land of this region and thus is in striking contrast to the adjoining prairie land. It is the so called rough white oak land along the streams of Northeast Missouri. Of the glacial soils the Lindley loam is the most variable, both in its physical properties and in agricultural importance. The surface soil to an average depth of 5 to 10 inches is dominantly a yellowish brown, yellowish gray, or light gray loam or silt loam. Usually there is enough sand to give the soil a gritty feel, but
on many of the gently rolling areas the texture is a silt loam. On the steeper slopes there is always present enough sand to give a loam or even fine sandy loam texture. The subsoil to a depth of 12 to 16 inches is a light yellowish brown granular loam, which grades into a compact, silty clay, containing considerable sand, and it is mottled yellow and gray. The lower subsoil, below thirty inches, usually is a light gray or drab, and of a silty texture. In many places, notably in Randolph, Howard and Marion counties, bedrock of sandstone and shale and occasionally limestone, is encountered within the three foot section. The overlying soil in such areas partakes of the nature of the bedrock and the only indication pointing to glacial influence is the occasional occurrence of foreign gravel in the material. Sand, gravel and chert fragments in small quantity are scattered thru the soil and subsoil.

The Lindley loam is characteristically low in organic matter, due to excessive erosion and to the small amount of lime in the soil. The surface soil therefore is shallow, light in color, and often is not markedly different from the subsoil. In fact, on some of the uncultivated areas where erosion is severe, the subsoil lies at the surface.

The origin of the Lindley loam and its similarity to the Shelby loam has already been pointed out. While the greater proportion of the material is undoubtedly true glacial till, a large part of it consists of residual material. This is especially true near the outer margin of the glacial region where the till is shallowest. On the steeper slopes outcrops of the underlying rocks are much in evidence, and part of the soil is undoubtedly of residual origin. In some places the soil is apparently of glacial origin, while the subsoil is purely residual. However, scattered fragments of crystalline rocks are found thruout the entire area, even where the soil is almost entirely of residual origin. Near its southern margin the subsoil of the Lindley loam frequently contains many chert fragments which are, of course, of local derivation. Such areas are numerous in Callaway, Montgomery and Boone counties. In general, the Lindley loam in the northern part of the state is more largely derived from true glacial till, and in these areas closely resembles the Shelby loam.

The topography of the Lindley loam varies from gently rolling, in the areas adjoining the prairies, to very rolling or hilly near the large stream courses. A large part of the type, probably fifty per cent in places, is too broken for profitable cultivation. Such areas are most extensive in Adair, Putnam, Randolph, Callaway, Montgomery, and Warren counties. The hills are low but steep and cultivation is diffi-
cult. Erosion is excessive, and this constitutes one of the most difficult problems in the management of the type. The necessity of keeping the steep slopes sodded with grass for permanent pasture is therefore apparent. Much of the more rolling land remains timbered with white oak, red oak and hickory.

The Lindley loam is not nearly so highly esteemed as is the Shelby loam. While about eighty per cent of the type is occupied for the pro-

The Lindley loam in Randolph county. The broken topography with land commonly in timber or grass is characteristic of much of this type, although a considerable area is cultivated to corn and small grain. Farm improvements are usually poor.

duction of farm crops or for grazing purposes, less than fifty per cent is used for cultivated crops. The cultivated areas are used largely for corn and oats; in fact the acreage of the former seems disproportionately large when the topography and the quality of the soil are considered. The yields vary considerably between the best fields and those which have been neglected. In Callaway and adjoining counties much of this type was formerly used for the production of tobacco. Much of this old tobacco land is used for pasture and has been allowed to grow up to scattered brush and timber. In the northeastern counties rye is extensively grown. This is an excellent practice, as it not only provides fall and spring pasture, but also retards the washing of the soil.

In general, the Lindley loam is a grass soil. Stock farming is the type of agriculture best suited to it, for by this system the grass producing qualities of the soil are utilized to the most efficient degree, and soil loss due to erosion is reduced to a minimum. Near the railroads,
dairying should be the leading occupation, but the growing of beef cattle, the feeding of sheep and hogs, and the breeding of horses, all have their place upon this soil. In some localities apples and small fruits may be grown.

Land values show a wide range, varying from $10 to $70 per acre. In general, the lower values prevail in the southern areas of the type, and represent the hilly, timbered land. Farm improvements are of medium quality, and in many cases the farm equipment is incomplete.

Soil management on this land will ultimately be limited largely to growing forage crops and grass for animals. It is not adapted to profitable grain farming and grain production must be limited. It lies near the better corn growing lands of Northeast Missouri and it will doubtless be found cheaper to buy a part of the corn fed. Some corn will be grown but the acreage will be limited. Wheat grows quite well on the better phases of this type and where properly handled and fertilized it will prove profitable in limited areas. Oats will also be grown to a certain extent but as a feed crop. Clover does fairly well on the better areas of this land but not so well on the poorer areas. Timothy does well where the land is properly handled.

The composition of the soil is shown in Table 4.

Table 4.—Composition of Lindley Loam

(Average of 11 analyses)

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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
<td>1995</td>
<td>775</td>
<td>26395</td>
<td>2670</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>955</td>
<td>860</td>
<td>25005</td>
<td>5295</td>
</tr>
</tbody>
</table>

It will be seen from these analyses that the Lindley loam is markedly low in nitrogen, which also indicates a low supply of organic matter. It is quite deficient in phosphorus, slightly deficient in potassium, while much of it needs lime. The nitrogen and organic matter can be supplied economically, by growing legumes, such as clovers, soybeans and cowpeas, by returning to the soil all manure and crop refuse, and by pasturing grass and legume crops on the land. The application of phosphates, preferably acid phosphate, before the grain crops or with manure, can be expected to give returns. The use of ground limestone at rates varying from one to two and one-half tons per acre will assist greatly in growing clover on those areas most deficient in lime. The
use of potassium will often pay on grain crops, altho it should be applied in rather small quantities. Such soil treatments are advisable on the areas of land devoted to cultivated crops, especially for the man who is farming most intensively.

While grass grows naturally on much of this soil, the poorer areas do not produce satisfactory pastures. Such areas are largely in timber and for the most part had probably best be left so. Such timber offers a rough range for cattle and hogs which is often a more profitable means of handling the land than that of attempting to clear it and put it into grass. Where clearing is done, however, the use of goats and sheep for getting rid of sprouts is advisable.¹

Grundy Silt Loam

The Grundy silt loam like the Marshall silt loam, constitutes one of the dark colored prairie soils of North Missouri. It is extensively developed in the north central part of the state, but large areas occur also in Knox and surrounding counties. The type is confined to the broad interstream divides of undulating prairie areas, which are characterized by a dark surface soil. Numerous areas, on account of their small size and extent, have not been indicated on the soil map. The Grundy silt loam is very probably largely loessial in origin.

The surface soil, to an average depth of 12 to 15 inches consists of a black to dark brown, mellow silt loam. In the level areas, and in the areas in the northeastern corner of the state the soil layer is not so deep and the color is rather uniformly a dark gray.

The upper zone of the subsoil, extending to an average depth of about 18 inches, is a gray to grayish brown, heavy silt loam or clay loam. This material grades below into a dark drab or yellowish brown, heavy, tenacious silty clay or clay. The deeper subsoil from about 30 to 36 inches is a moderately friable silty clay loam, predominantly yellowish gray in color with brown, gray and yellow mottlings. Small iron concretions are present in limited quantities throughout the subsoil.

Practically all that portion of the type found in the northeastern part of the state possesses characteristics which make it an intermediate phase between the typical soil of this type and the Putnam silt loam. The surface silt layer consists of two zones, forming soil and subsurface. The former is dark like that of the main type, the latter is a gray or light gray, mealy material, varying in thickness from two to six inches and it is essentially the same as the gray layer in the Putnam.

¹Miller, M. F., and Hutchison, C. B., Grass Investigations in the Ozark Upland, Missouri Experiment Station Bulletin 108.
soil, altho not so pronounced. In its agricultural value this phase is almost equal to the Grundy silt loam and has therefore been included in the latter. In its physical properties and agricultural value the Grundy silt loam is similar to the Summit silt loam in the western part of the state and to the heavier phases of the Marshall soil.

Originally the Grundy silt loam was covered with a rank growth of prairie grasses. This condition together with the level surface, the fine texture of the soil, and the presence of lime favored the accumulation of a large amount of organic matter to a considerable depth.

Topographically, the type occupies the broad, almost level divides and the gentle slopes. In general, the surface averages smoother than that of the Marshall silt loam, altho this difference is of no appreciable importance. There is usually sufficient slope to carry away the excess water.

In every respect, the better phase of Grundy silt loam is an excellent soil for general farming. It is easily tilled, fairly well drained and contains a large amount of humus. The heavy subsoil rarely has any serious injurious effect on plant growth.

All of the type is in a high state of cultivation and is used for general farm crops. Corn is the most extensively grown cereal and yields of thirty-five to seventy bushels per acre are obtained, running somewhat lower than on the Marshall silt loam. Wheat and oats do remarkably well, but are not as extensively grown as on the loess soil. The oat crop is more extensively grown than wheat. The latter is
frequently injured in winter by soil heaving. Much of the type is in sod, and the excellence of the bluegrass pastures is not excelled in any part of the state. Alfalfa is being grown with some success, although the acreage is comparatively small. The hay crop consists of clover and timothy, yields of one and a half to three tons per acre being secured. In general, a somewhat larger per cent of this soil is in sod than of the Marshall silt loam. Owing to the high percentage of organic matter present and the silty character of the soil, cultivation is easy and no difficulty is experienced in securing an excellent tilth.

Some of the finest farms in the state are located on this type of soil, and in general the methods of farming followed are good. As in the case of the Marshall soil a common rotation of crops, where a rotation is followed, is corn for one or two years, then small grain for about one year, followed by clover and timothy mixed. After this the field may be pastured for a year or two before being again plowed for corn. Hog raising is carried on in conjunction with extensive cattle feeding. In the methods of cultivation followed, the crop rotations practiced and in the general conditions existing, the Grundy silt loam is fairly comparable with the Marshall silt loam. Highly improved farms and farm equipment are characteristic of the regions where this soil occurs. Land values range from $75 to $150 per acre, averaging somewhat lower than for the Marshall silt loam.

Experiments on the Grundy silt loam have shown a rather general response of the soil to the application of phosphates and lime. The supply of organic matter is in general fairly high but on the older farmed areas the need of it is being seriously felt. This is particularly true of that area in the northeastern part of the state. Table 5 shows the composition of this soil.

**Table 5.—Composition of Grundy Silt Loam**

(Average of 17 analyses)

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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
<td>3370</td>
<td>1280</td>
<td>30385</td>
<td>3960</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>1785</td>
<td>1335</td>
<td>30815</td>
<td>1380</td>
</tr>
</tbody>
</table>

In general the things which must be given most serious attention as indicated by these analyses and by the field experiments, are the
phosphorus and the lime needs. Where the soil is well drained and well handled the potassium supply for general farm crops is usually sufficient. The generally high supply of organic matter lessens to a considerable degree the injury from soil acidity so that the lime requirement as given is not quite as serious as would be expected. Experiments have shown, however, that liming is very beneficial on this land, particularly in the northeastern area, and under the best systems of farming it is practically essential. The application of phosphates to wheat has been found to be generally profitable while the effects upon the clover and grass crops following are likewise beneficial. A proper system of rotation, under mixed or livestock farming, including the return of farm manure and the use of lime, as well as phosphate, is to be recommended for most of this soil area.

**Putnam Silt Loam**

The Putnam silt loam represents the extensive areas of level prairie land in the eastern part of North Missouri. The silty surface soil, to a depth of 8 to 12 inches, varies in color from light gray to dark gray when dry, to dark brown or almost black when wet. In flat and poorly drained areas the lighter colors predominate, while in areas of better drainage the color is darker. The texture is uniformly a silt loam, which normally consists of sixty to seventy per cent of silt. The surface soil is pervious to water, but in areas where the content of organic matter is low the soil has a tendency to run together and become compact.

The subsurface soil consists of gray silt loam which when dry is medium to very light in color, containing, especially in the lower portion, numerous small concretions of hydrated iron oxide, sometimes called "buckshot." It is on the level areas that this so-called gray layer is most highly developed, and it usually varies from 6 to 9 inches in thickness. On most of the gently rolling land it is not so well developed.

The true subsoil begins abruptly at a depth of 16 to 20 inches and is usually made up of two zones. The upper zone is a grayish brown or dark brown stiff impervious clay, having an effect upon the soil similar to that of a hardpan layer. The stratum below twenty-four to thirty inches is a yellowish gray or drab, rather friable, silty clay, mottled red, brown and gray. In general the subsoil is darker in color and more intractable on the poorly drained areas. Nowhere, however, is there a cementation of material, and the hardpan characteristic of the subsoil is due to the accumulation of clay particles in the upper portion.
of the subsoil. The various horizons described, altho differing in thickness, are invariably present in this soil type, in the order given. It is therefore easily distinguished from the other soils of the region in which it occurs by the gray colored surface soil, the gray ashy subsurface and the almost universal presence of the very stiff clay subsoil. It differs from the Grundy silt loam in the more level topography, lighter colored surface soil, more pronounced gray subsurface layer and the more abrupt change from the subsurface silt layer to the clay subsoil. The soil is probably largely loessial in origin.

In general, the Putnum silt loam, near its northern limit, is darker in color than the areas further south, and grades insensibly into the Grundy silt loam. In St. Charles county the soil has a distinct yellowish cast, and its greater relative fertility in this region would indicate that it is influenced by comparatively recent loessial deposits. In all of its physical characters the type resembles the Oswego silt loam of the residual plains in the western part of the state.

All of the Putnum silt loam is in cultivation. Corn, grass, oats and wheat are the most important crops grown in the order named. Corn does not do as well as on the Grundy silt loam, but yields ranging from twenty-five to sixty bushels per acre are obtained. Oats produces from twenty-five to fifty bushels per acre, the average being around thirty bushels. In general, the yields obtained depend on the amount of rainfall, since the soil is too poorly drained to stand excess water and too impenetrable in the subsoil to stand drought well. A
few areas of wild prairie grass remain. Clover makes a fair growth on the better drained areas which contain a good supply of organic matter, altho most of this prairie is not well adapted to the crop. Bluegrass occupies the soil naturally, and most forage crops thrive well. The soil is not alfalfa land and if alfalfa is grown successfully, drainage, lime and soil enrichment are necessary. The best results can be obtained in the somewhat rolling areas where the subsoil is less impervious. The soil is rather heavy for potatoes and is not particularly suited to fruit or orchard crops.

The prevailing type of agriculture is that of general farming combined with livestock raising and feeding. Large numbers of cattle and hogs are prepared for market annually. In some areas the feeding of western sheep is extensively carried on. Probably the most important phase of the livestock industry is the raising of horses and mules. Both draft and light horses are produced. Raising and feeding mules is most extensively developed in Audrain and the surrounding counties and the animals produced are noted for their superior quality. Dairying is practiced to a considerable extent, this land being well suited to this industry, where market facilities are favorable, because of the adaptability of the soil to the production of hay and forage crops.

Because of the prevalence of some form of stock raising within the territory occupied by the Putnam silt loam, the farm units are rather large, averaging more than 160 acres. The farm buildings are large and substantial and the farm equipment is good, which give the appearance of a well cared for farming territory. Land values range from $50 to $125 per acre, altho near some of the towns higher values prevail.

Soil management on the Putnam silt loam includes a number of problems. The lack of adequate drainage of this soil, due both to the level topography and to the very heavy subsoil is the most serious. The common drainage practice is to plow the fields in narrow lands from thirty to fifty feet wide, leaving rather deep dead furrows between. Where these lands are bedded high enough and the dead furrows kept open, quite satisfactory results are secured. Tile drainage has been tried by a considerable number of farmers and the Experiment Station has carried on drainage experiments for a number of years. The results show that where tile are laid as close together as five rods, paying results are secured, altho it requires a number of years for the increased crops to pay the cost of tiling. The imper-

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1 Miller, M. F., Hutchison, C. B., Douglass, T. R., Hudelson, R. R.; Drainage Investigations on Northeast Missouri Prairie; Missouri Experiment Station Bulletin 118.
vious nature of the subsoil prevents the tile from acting rapidly. There is little doubt, however, that on the very level areas of this prairie, tile drains will come into use, altho the tight subsoil layer will require that these be laid close together. While it is often difficult to secure proper fall and good outlets for tile, these difficulties can usually be met.

Certain problems in the handling of this soil result from its composition. Table 6 shows the content of the important plant foods and the lime requirement.

**Table 6.—Composition of Putnam Silt Loam**

(Average of 9 analyses)

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen lbs</th>
<th>Phosphorus lbs</th>
<th>Potassium lbs</th>
<th>Lime requirement lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil</td>
<td>2335</td>
<td>950</td>
<td>29840</td>
<td>2300</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil</td>
<td>1330</td>
<td>1195</td>
<td>28635</td>
<td>3835</td>
</tr>
</tbody>
</table>

The wide-spread occurrence of acidity in this soil, together with its poorly drained condition and the low supply of organic matter, necessitates the use of lime if best results are to be expected. Experiments on this soil type show that applications of from one to two and a half tons can be expected to bring returns. If combined with reasonable drainage it will usually make clover growing much more satisfactory.

The low supply of nitrogen and organic matter requires careful attention to crop rotation, manuring and legume growing if this land is to give best returns. In addition the application of phosphates has been shown to give excellent results.¹

**ALLUVIAL SOILS OF NORTH MISSOURI**

One of the most striking features of the glacial and loessial soil province is the great extent of the alluvial or bottom lands along all the streams. This contrasts strongly with the narrow alluvial valleys of the Ozark region, where the rate of erosion thru the rocks is extremely slow. The streams of the glacial region have readily cut wide valleys thru the soft drift material, so that even the smallest lateral is

¹Miller, M. F., Hutchison, C. B., Hudelson, R. R.; Soil Experiments on the Level Prairies of Northeast Missouri; Missouri Experiment Station Bulletin 126.
bordered by a comparatively wide lowland plain. Associated with the wide flood plains is the comparatively fine texture of all these alluvial soils. This character is due both to the low gradient of the streams, which enables them to carry only fine material, and to the uniformly fine texture of the uplands from which the alluvial soils are derived. Exceptions might be made to this statement in the case of the soils which occur along the Missouri and Mississippi rivers, since these represent a mixture of material from a greater variety of sources than do the soils along the smaller streams of more restricted drainage area.

The character of the upland soils is further reflected by the dark color of the alluvial soils. The latter contain a high per cent of organic matter, as well as soluble material leached out of the former. They are therefore of high average productiveness, and tend to retain this condition by reason of occasional overflows.

With the exception of the Missouri and Mississippi bottoms, the texture of the alluvial soils is rarely coarser than a loam. Of the finer textures all gradations from loam to the heaviest clay are present. Of these the silt loam is the most extensive, and by far the most important agriculturally. For this reason all the alluvial soils have been grouped under the class name of Wabash silt loam. Due allowance should therefore be made for the limitations of this classification.

**Wabash Silt Loam**

The surface soil of the Wabash silt loam is prevailing a black or dark brown silt loam. In depth it is rarely less than 12 to 15 inches, but it may be three feet and even more. The deeper soil occurs on the loamy and silty areas, while the shallower depth prevails on the clayey areas. The subsoil is rarely lighter than a silty clay, and for the most part consists of a rather plastic clay loam. In color it varies from black to dark drab; the lighter shades are associated with the heavier textures. In general, the lower subsoil is a drab or yellowish gray clay loam with a few brown mottlings. At this depth there are frequently encountered veins or pockets of sand, especially near stream beds.

Bordering the streams, and in most of the narrow valleys the texture is uniformly coarser than it is back from the streams and in the wide valleys. This is especially true along the large rivers, which are always bordered by a belt of comparatively coarse textured soil. It represents the natural levee built up by overflow waters and generally stands from a few inches to several feet above the general level of the bottom, with a gentle slope to the landward side. In these locations
the soil may be a fine sandy loam and of a lighter color than the average of the type. Old stream beds and bayous are also bordered by belts of lighter soil similar to that along the streams.

The heavy or clayey soils included in the Wabash silt loam occupy level or depressed areas within the broader bottom lands. They are extensively developed along the Grand River and its tributaries, the Chariton and Platte rivers, and in large isolated areas along the Mis-

The Wabash silt loam of the Missouri River bottoms. Where well drained the land is very fertile, growing excellent alfalfa, corn, small grains, clovers and grasses. The topography is level, often resulting in a need for drainage.

souri and Mississippi. Land of this character is usually known as gumbo. In general it occurs as almost level tracts lying somewhat back from the lands bordering the main stream channels. In addition to being flooded practically every season, the soil retains an excess of moisture until far into the summer, and is consequently not well suited to agricultural purposes in its natural condition. Such soil represents the finest sediments deposited by overflow waters and is therefore difficult to work even when drained. It is, however, very fertile land. Tile drainage, with the tile laid 4 to 8 rods apart, is essential to its proper management.

By far the greater part of the alluvial soil included in the Wabash silt loam is of a silty texture. Soil of this class includes practically all the bottom land along the creeks and small streams, as well as a large part along the rivers. Owing to its mode of formation it possesses a considerable depth of mellow surface soil, heavily charged with organic matter, and is easily cultivated.
The Wabash silt loam as a whole is characterized by its dark color and high content of organic matter. In general that part of the type occurring in the region of the Marshall and Shelby soils averages darker in color and is more productive than that in the northeastern part of the state. Occasional isolated areas of poor drainage frequently contain such large quantities of organic matter as to approach a muck.

The pronounced inherent fertility of the Wabash silt loam is well known. Protection from inundation and provision for adequate surface drainage are of prime importance in the improvement of the soil. In fact, approximately twenty-five per cent of this valuable type is yet to be reclaimed by drainage. The cost of such reclamation is high, but the fertility of the soil and its excellent adaptations to the production of all the staple crops will make such an investment profitable. Land values vary from $30 on some of the poorly drained areas to $150 or even $200 on the most highly improved tracts.

Corn is the one universal crop for which the areas of the Wabash silt loam are especially sought wherever it occurs. The yields obtained are relatively higher than on upland soils, and frequently the crop is grown many years in succession with little apparent injury to the land or reduction in the yield. Wheat and oats are grown on the well drained areas with excellent results. All the grasses and meadow crops including clover and alfalfa, thrive remarkably well wherever drainage is properly established. Poorly drained areas produce large yields of coarse hay. All the lighter phases of this soil type are well suited to growing potatoes, and the possibilities along this line have not yet been fully appreciated. It is only in the loamy alluvial lands in Ray, Carroll and Osage counties that potatoes are commercially grown.

Soil management on the Wabash silt loam and allied types is largely a matter of establishing good drainage and adopting a satisfactory cropping system. The drainage problem is the largest one, including in some cases leveeing and the installation of large open ditches. Many large drainage projects are in successful operation on these bottom lands. While large areas are well drained naturally and still others by the use of surface drains, tiling is in some cases necessary for best results. Thus far, however, the use of tile has not been extensive.

The cropping system adapted to this land should include such crops as corn, oats, wheat, clover, timothy, and where the land is well drained, alfalfa. A rotation of corn, oats or wheat, clover is good. Another good one is corn, corn, oats or wheat, clover and timothy. Al-
falfa is best left out of the regular rotation. It should be seeded down for several years, but the field should be plowed occasionally and thrown into the regular rotation. At the same time alfalfa should be established on a new field.

Wabash silt loam of Mississippi River bottoms. The rather level topography and the excellent crops grown are characteristic of the type. While the land sometimes suffers from lack of drainage it is on the whole one of the most fertile soils in Missouri.

The composition of this soil shows a comparatively high content of plant food. The figures are given in Table 7.

**Table 7.—Composition of Wabash Silt Loam**

(Average of 8 analyses)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
<td>3585</td>
<td>1590</td>
<td>30275</td>
<td>2300</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>2020</td>
<td>1555</td>
<td>31505</td>
<td>2715</td>
</tr>
</tbody>
</table>

Fertilizing materials other than barnyard manure and green manures are rarely used on this land. The deep character of this alluvial material, coupled with a comparatively high content of plant food, makes the soil very productive where it is well drained and well handled. Acidity is present to a considerable degree in much of this land, but the fertility of the soil tends to offset the injury, so that clover, alfalfa and other plants, sensitive to an acid soil, are usually-
grown with success wherever the drainage is sufficient. On some areas, however, liming will prove economical.

Considerable areas of this soil are very heavy in character and approximate the true gumbo soil in texture. Such areas are difficult to handle, both because of the heaviness of the land and the fact that they are usually among the most poorly drained parts of the bottom. Thorough surface drainage, in some cases tile drainage, care in plowing and the use of wheat, grass, alfalfa and other non-cultivated crops are to be recommended.

**RESIDUAL PRAIRIE REGION**

The region of residual prairie soils of Southwest Missouri occupies a triangular shaped area, covering about seventeen counties, or an area about one-third the size of the glacial and loessial province. On the north it blends imperceptibly into the soils of the latter province, but the irregular eastern boundary is everywhere rather clearly defined by the presence of the cherty and hilly soils of the Ozark region. In general, these prairie soils form the eastern edge of that great prairie region which is so extensively developed in Kansas and Oklahoma. In their agricultural importance they rank second among the upland soils of the state.

It is interesting to note that the rocks from which the residual prairie soils are derived, also form the basal structure of most of the northern part of the state, and it can be assumed that were it not for the glacial covering, the soils of this region would be similar to those south of the river. Such areas of residual soil as do occur north of the river (parts of Ray, Clay, Caldwell, Livingston and Carroll counties) are the same as in the residual prairie region. Moreover, the fact that some of the glacial prairies are similar to the residual prairies, indicates that they are in large measure derived from the country rock, or that both have been considerably affected by wind action.

The character and distribution of the residual prairie soils present some very interesting considerations, and illustrate in a remarkable way how soils may be affected by the parent rock, especially in the presence of limestone. It has already been pointed out that the rocks of this region consist of limestone, shale, and sandstone. The first occurs in the northwestern part of the area, the last in the southeastern part, with the shales forming an intermediate zone. Where the limestone occurs and has actively entered into the composition of the soil, the black prairie or Summit silt loam prevails. Originally the limestone extended much farther east, and where its residual effects
remain, the soils are dark gray in color, contain a medium per cent of organic matter, and are classed as Oswego silt loam. The soils derived from the shales and sandstones, and not influenced by limestone, are prevailingly light colored, and have been classed with the Cherokee and Bates series. The dark color in the soils and the corresponding higher content of organic matter thus seems to be associated with an abundance of lime carbonate in the soil. Further illustrations of this condition are the isolated mounds and ridges capped with limestone, so numerous in Bates, Vernon and Henry counties. The weathering of the limestone keeps the slopes of the mounds well supplied with lime, with the result that they are covered with a deep dark soil, in striking contrast to the gray and less productive soils surrounding the mounds and beyond the influence of the weathering limestone.

The residual prairie soils, as a whole, are not as productive as the soils of the glacial province. This, no doubt, is partly due to their greater age, to the consequent greater leaching they have undergone, and to the greater compaction of the material in the subsoil.

Topographically, the region of the southwestern prairie soils forms the most extensive area of almost level land in the state. Except along its eastern border, where the streams have cut down to moderate depth, the whole surface is that of a level to gently undulating plain. The streams have wide, shallow floodplains, and in many places grade almost imperceptibly into the uplands. In general, the surface features are very good and permit the highest type of agriculture.

**SOILS FROM LIMESTONE AND SHALE**

**Summit Silt Loam**

The Summit silt loam, frequently known as black limestone land, includes the greater part of Jackson, Cass, Bates and Johnson counties, and portions of Vernon, Henry, Pettis and Lafayette counties. Detached areas of the type occur in Clay, Caldwell and Carroll counties north of the Missouri River. It is prevailingly a heavy silt loam with a rather heavy, plastic silty clay subsoil. Typically, the surface soil is a black, dark brown or very dark gray silt loam, 10 to 18 inches in depth, and containing a good supply of organic matter. The subsoil is a dark drab to dark gray clay loam, changing at about 24 inches to a yellowish gray, granular, silty clay, mottled yellow and gray. The gradation from soil to subsoil is gradual, and is not marked by a sudden change in color or texture. Usually the true subsoil is not reached at less than 18 inches where the soil material becomes compact and
waxy and the content of organic matter quickly decreases. Lime concretion and calcareous streaks are found at various depths in the subsoil. The Summit silt loam as a whole is rather uniform, such variations as occur being of minor importance, and needing only brief consideration.

Poorly drained areas, usually at the head of shallow draws, are black in color in both soil and subsoil, and in texture are almost a clay loam. Such areas are frequently known as gumbo. Another variation is the so-called mulatto land, the surface soil of which is a dark brown mellow silt loam, grading at about fifteen inches into yellowish brown or reddish brown crumbly, silty clay loam. The subsoil averages lighter in color and texture than the corresponding layer in the Summit silt loam. The soil material is derived chiefly from limestone and shale, the former probably entering into the formation more largely than the latter. The mulatto land occurs along streams, and averages more rolling in topography and has more limestone outcrops than the typical soil. In its agricultural value it is equal or superior to the latter, and is especially prized for alfalfa. It is extensively developed in Jackson, Cass and Johnson counties.

Included in the Summit silt loam are small areas of Summit stony clay loam. These occupy the isolated hillocks, the sides of ridges and escarpments and stony slopes near streams. In these areas thin bedded limestone outcrops and fragments of the stone are scattered over the
surface making cultivation difficult. The soil material is dark gray to yellowish brown plastic clay. Most of the land of this character is in pasture and orchard to which it is well suited. The larger part of the Summit soil in Clay, Ray and Carroll counties belongs to this phase.

Throughout its entire extent, the Summit silt loam has a level to gently rolling surface, admirably adapted to an extensive type of farming. The undulating topography is everywhere sufficient to insure good drainage. The streams and draws flow thru shallow valleys, and the level of the plain is rarely more than twenty to fifty feet above the valley bottoms. In general, the areas north of the Missouri River average more rolling than the main body of the type south of the river. The depth of the soil mantle is deep, frequently fifty to sixty feet, and the underlying rocks are rarely exposed. Limestone has entered more largely into the composition of the soil in the northern part of the area than in the southern part. The original vegetation consisted of prairie grass, with narrow belts of elm, oak, hickory and walnut timber along the streams.

The Summit silt loam is one of the best soils in the state, and compares favorably with the better glacial and loessial soils of North Missouri. All of the type is highly improved, and is used for general farm crops, such as corn, wheat, grass and oats. Corn yields from 35 to 75 bushels, wheat 12 to 25 bushels, oats 20 to 50 bushels, hay 1 to 2 tons per acre. On the better farms the higher figures are approached more frequently than the lower. Grass and small grain do especially well. In Cass county tobacco is grown on a commercial scale, with yields of 1000 to 1600 pounds per acre. Clover and alfalfa thrive on most of the type.

In general the farm practices prevailing on the Summit silt loam are the same as those on the better prairie lands in the northern part of the state. Large numbers of livestock are marketed annually. Dairying is an important industry in Cass and Jackson counties but could well be developed to still greater proportions. Special crops, such as sorghum, millet, soybeans and cowpeas are grown to a small extent. In former years flax was an important crop but it is no longer grown.

Land values range from $65 to $150 an acre, depending upon location and improvements. Most sales are made at $80 to $100 an acre. In a few areas values reach $200 per acre. The farms are uniformly large and are well developed.
The composition of this soil is shown in Table 8.

**Table 8.—Composition of Summit Silt Loam**

(Average of 11 analyses)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
<td>3290</td>
<td>1645</td>
<td>30390</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>1900</td>
<td>1705</td>
<td>27030</td>
</tr>
</tbody>
</table>

It will be seen that this soil is among the better upland types from the standpoint of reserve food supply. While the lime requirement is rather high in many instances, in other cases the soil is not acid. The average requirement is approximately one and a half tons but the resulting injury is partly offset by the fertile condition of the soil. The nitrogen supply is not exceptionally high so that good systems of rotation and the saving of farm manures are necessary for continued productivity. Phosphates can be expected to give returns on the more worn areas, when properly used.

**Soils from Shale**

*Oswego Silt Loam*

The Oswego silt loam, like the Summit silt loam, forms part of the dark prairie soils of Southwest Missouri. In fact, where these two types come in contact, separation is extremely difficult and the boundaries therefore are in some places more or less arbitrary. Geographically and agriculturally the Oswego silt loam lies between the Summit silt loam on the north and the lighter Cherokee and Bates soils on the south. In its physical properties it is characterized by a dark gray silty surface soil, nearly level topography, and a compact clayey subsoil. Typically the surface soil is a dark gray or grayish brown to black, mellow silt loam, becoming somewhat lighter in color at about 10 or 12 inches, or in the lower 6 inches of the top silty layer. This light colored subsurface is not always present, altho in general, the subsurface is lighter colored than the surface soil. Usually the well developed gray layer occurs only on broad, level areas, and is absent where the surface is rolling. The subsoil at a depth of about 16 to 18 inches is a dark drab to yellowish gray, stiff, tenaceous clay, passing gradually at about 30 to 36 inches into a more friable silty clay, mot-
tied gray and yellow. The layer of heavy clay outcrops in banks and cuts as a brown, granular clay. Where the heavy subsoil is hard and compact as on the flat poorly drained areas, it is locally known as hardpan. In very wet or dry seasons these areas give considerable trouble to the farmer. The impervious character of the subsoil seems to be due to a compaction of the clay, rather than to a cementation of iron or other material.

The Oswego silt loam in Henry county. The level to slightly undulating topography, the fair to good crops and the lack of timber growth are characteristic. Farm improvements are generally good.

The Oswego silt loam occurs as an irregular belt extending from Moniteau county to the Kansas state line, and includes parts of Cooper, Pettis, Johnson, Henry, Bates and Vernon counties. In the latter two counties it forms the level basin-like areas within the Summit silt loam, but to the east it occupies the broad interstream divides. The characteristic topography, which is level to undulating, is due largely, to the uniform weathering of the shales from which the soil is derived, and the underlying horizontal beds of limestone upon which the type rests. In general, the surface drainage is well established, but subdrainage is deficient.

The Oswego silt loam is a general farming soil, and in its productivity compares rather favorably with the Summit silt loam, altho the average yields are considerably lower. Corn is the chief and usually the most profitable crop. Wheat and oats are also extensively grown. Clover is not an important crop on this soil but in recent years cowpeas and soybeans have come into wide use. Alfalfa can be
made to grow only where the land is limed and sometimes drained and fertilized. In general, a larger per cent of the Oswego silt loam is used for grass and small grains than of the Summit silt loam. Systematic crop rotation is little practiced. Where rotations are used they do not usually include enough legumes. Land values range from $40 to $100 per acre.

Table 9 shows the composition of this soil.

**Table 9.—Composition of Oswego Silt Loam**

(Average of 8 analyses)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>2910</td>
<td>1510</td>
<td>27785</td>
<td>5440</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>1905</td>
<td>1575</td>
<td>28935</td>
<td>1425</td>
</tr>
</tbody>
</table>

The deficiencies of nitrogen and phosphorus are the important ones in this soil area.\(^1\) The need of lime, while variable, is usually significant. Proper soil management includes the establishment of a crop rotation which contains a leguminous crop at least once in four years. Where lime can be secured cheaply it should be applied in order to make clover growing more certain and clover should then be included in the rotation. Soybeans and cowpeas may be substituted for clover under some conditions. Farm manures should be carefully saved and applied to the land. Phosphates can be applied with profit to wheat and usually to corn. Good results may also be expected on clover and grass.

Fall plowing is practiced quite largely on this soil. Where this is done the fields can be worked earlier in the spring, and a good seedbed can be secured more readily than in the case of spring plowing. Spring plowing is often late because of the rather poor subdrainage of this land. On the more level areas and under careful systems of farming, tile drainage will be found profitable. Certain areas such as seepy hill slopes and low lying tracts in the rolling areas will also respond to tiling.

**Cherokee Silt Loam**

The Cherokee silt loam is closely related to the Oswego silt loam, but has undergone more weathering and leaching with a resultant loss

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\(^1\)Miller, M. F., and Hudelson, R. R.; Soil Investigations—Jasper County Experiment Field; Missouri Experiment Station Bulletin 119.
in plant food and change in soil structure. The soil particles have disintegrated so that they are of clayey texture, and have been washed down and have accumulated in the subsoil, giving the latter a clayey texture and a compact structure. The numerous iron concretions indicate poor drainage and deficiency of available plant food.

The surface soil of the Cherokee silt loam is a gray or brownish gray, silt loam to a depth of about 10 inches, and is underlain by a light

![The Cherokee silt loam. The view is one of an experiment field located on this type. There are more trees shown than commonly occur on this land but many of these have been planted and are not native.](image)

ashy gray, floury, silt loam, somewhat more compact than the surface portion, and frequently mottled with rusty brown ferruginous material. The subsoil, beginning abruptly at 16 to 18 inches, consists of a brown or dark drab to nearly black, stiff, tough, waxy clay, changing in the lower section to a light drab, friable silty clay, mottled yellow and gray. Where the type occurs near streams, the surface soil contains some fine sand, while the subsoil averages gray or light drab in color, and is highly mottled red and yellow.

The ashy gray subsurface and the brown, stiff clay subsoil, are the distinguishing characteristics of the type. The subsoil when wet is gummy, but when dry is hard and intractable. Water passes thru it very slowly. Iron concretions are numerous thruout the soil section. Fine argillaceous shale constitutes the material from which the soil
originates. The topography is level, and averages smoother than any other upland type in the state. The type is frequently surrounded by soils of a more rolling topography, thus giving it a basinlike appearance. Other areas occur along streams, and resemble high flat terraces.

The surface drainage of this soil is poor and the underdrainage incomplete. The level surface, lack of organic matter, and the almost impervious subsoil combine to produce unfavorable moisture conditions, and can be improved only by open ditches and tile drains. The soil does not stand drought well.

A large proportion of the type, particularly in Vernon and Barton counties, remains as virgin prairie sod, and produces one to two tons of hay per acre. The cultivated areas are used for corn, wheat, cowpeas and kafir. Yields of corn range from twenty to thirty-five bushels, but on unfavorable seasons frequently average less than ten bushels per acre. The type is best suited to grass and small grains, and in recent years the acreage of the latter has been increasing. Cowpeas, kafir and sorghum are cultivated successfully, and are largely depended upon for forage.

On account of the large amount of hay produced, the livestock industry consists largely of horse raising. The fattening of beef cattle can not hold rank with that on the better corn soils to the north. The keeping of sheep in connection with dairy cattle has proved profitable in several locations. In general, the Cherokee silt loam is not suited to any specialized form of agriculture. It gives most satisfactory returns under a system of farming based on growing hay, forage crops and raising livestock. Land values range from $25 to $75 per acre.

The composition of this soil is shown in Table 10.

Table 10.—Composition of Cherokee Silt Loam
(Average of 7 analyses)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1950</td>
<td>810</td>
<td>24845</td>
<td>2215</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>1380</td>
<td>895</td>
<td>23290</td>
<td>4155</td>
</tr>
</tbody>
</table>

Experiments on this soil have shown that it responds to the application of all the fertilizing elements as well as to liming.1 Under the

1Miller, M. F., Hutchison, C. B., Hudelson, R. R.; Soil Experiments on the Gray Prairie of Southwest Missouri; Missouri Experiment Station Bulletin 130.
extensive system of agriculture practiced, however, nitrogen is usually
best supplied by means of crop rotations containing cowpeas and soy-
beans. Where the land is limed and drained, clovers, particularly
alsike clover, may be grown, altho phosphates are usually necessary to
success. Phosphates are badly needed for grain crops also, and the
more available forms, such as acid phosphate and the bone meals, give
good returns. When the prices are normal, potash in fair quantities
(4 or 5 per cent) in the fertilizer has paid. The land responds to lime
in most cases and where clovers or soybeans are grown, from one to
two tons of ground limestone once in four to six years will be needed
for best returns. Cowpeas grow well on this land without lime. Where
lime cannot readily be secured the cropping system should consist of
such crops as small grains, sorghum, kafir, grasses and cowpeas. Corn
should be grown in limited amounts. It is not alfalfa land and it is
doubtful if alfalfa can be grown economically in most cases, even with
the best of treatment. Tile drainage experiments on this soil have
shown that it can be tiled economically altho the tile should not be
laid more than five or six rods apart. Where the land is farmed
rather extensively surface drainage may be more economical. The
foregoing statements refer to the typical Cherokee silt loam. The area
shown on the map is not all typical Cherokee, since areas of other soils
are included.

SOILS FROM SANDSTONE AND SHALE

Bates Fine Sandy Loam

The Bates fine sandy loam has a wide distribution in the south-
western part of the state, and is one of the most variable types mapped.
The prevailing texture is that of a coarse loam, but ranges from silt
loam to coarse sandy loam. The subsoils are somewhat heavier but
friable. The surface soils range in color from dark brown to yellow-
ish gray, the darker shades predominating on the smoother areas, es-
pecially in the northern areas of the type. The subsoils are some shade
of brown and show bright mottlings of red, brown and yellow. Sand-
stone fragments are scattered thru the soil, and frequently bed rock
is encountered on the steeper slopes.

The silty areas included in the Bates fine sandy loam consist of a
dark brown to grayish brown silt loam, grading at about 8 to 12 inches
into light brown friable silt loam, which is underlain at about 18 to 20
inches by crumbly silty clay or fine sandy clay, highly mottled red,
brown and yellow. This silty phase occupies the almost level areas
of the type and is typical prairie land. The Bates loam and Bates fine
sandy loam have brown or grayish brown surface soils, with yellowish
brown subsoils, usually of a somewhat heavier texture than the surface material, altho sometimes the subsoil is coarser than the soil. The latter condition obtains when the sand rock is within three or four feet of the surface. The sand content ranges from very fine to medium, but the finer grades are usually greatly in excess. Associated with the more rolling areas is a large amount of shale and sandstone fragments disseminated thru the soil and subsoil. Sandstone outcrops are common and steep slopes of stony loam are found.

The most persistent characteristic of Bates soils is the bright red mottling of the subsoil, frequently so intense as to give the lower subsoil a red color. The soil material is derived from sandstone and shale. The former is only a few feet in thickness, so that the resultant soil is varied and rather silty where the shales predominate.

The Bates fine sandy loam forms an irregular belt along the southern and eastern edge of the residual prairie region. It occurs most extensively in Barton, Vernon, Cedar, St. Clair and Henry counties, altho numerous small areas are found in adjoining counties. The general location of the area is indicated on the soil map. However, it must not be considered as occupying all the country indicated as this type on the map. In many places small patches of Cherokee silt loam are included which are usually only a few acres in extent and therefore too small to be indicated. Near the eastern edge of the area there are included small amounts of stony loam that belong to the Ozark soils.

The surface features of the Bates fine sandy loam vary from level to steeply rolling. The former represents the typical prairie land, while the latter includes the mounds or hillocks, and timbered land bordering the streams. Practically all of the type can be easily cultivated.

Corn, grass and cowpeas are the most important crops grown. A considerable part of the type remains as virgin prairie sod. Corn is extensively grown, and where the soil is well supplied with organic matter fair yields are obtained. Wheat is not extensively grown except on the silty areas, and it usually requires fertilization to produce profitable crops. Cowpeas and kafir thrive remarkably well. The lighter textured soil is highly prized for small fruits and truck. Strawberries and bush fruits are successfully grown in some localities. Wherever areas of Bates fine sandy loam are located near transportation lines, so that potatoes do not need to be hauled more than three or four miles to the shipping point, this crop may prove an excellent money crop. Alfalfa has been tried with some success but owing to
the deficiency of lime carbonate in both soil and subsoil and the rather low fertility, this land is not particularly adapted to the crop.

While the Bates fine sandy loam is not considered a strong soil, and while it quickly deteriorates under bad management, it can, by the use of proper rotations and treatment, be maintained in a fairly high state of productiveness. The cultural methods ought to be such as to counteract as far as possible the droughty tendency and to prevent erosion. It is not a grass soil, altho orchard grass and clover can be made to grow fairly well. Greater dependence must therefore be placed on forage crops, such as sorghum, kafir, cowpeas, soybeans and rye to supply feed for the livestock.

Altho the greater part of the Bates fine sandy loam has been brought under cultivation, much of the sandier and more rolling land remains timbered. The latter occurs extensively in Cedar, Dade and St. Clair counties. The silt loam phase and most of the loam are under cultivation. In general, the proximity to railroads determines the extent to which the type is tilled, the more remote areas being thus only partially developed.

Land values range from $10 to $25 per acre for the timber and poorly improved areas and $50 to $85 per acre for the better land near the towns. Farm improvements are of fair quality. Better transportation facilities would add greatly to the extension and profitableness of farming on this soil type.

Soil management on this land varies with the phase of the soil and the location. It cannot be considered particularly valuable agricultural land, altho areas of it are very good and proper systems of management will bring good money returns. It is a soil which is well drained so that the principal problems are those of erosion and of fertility maintenance.

The composition of this soil area, showing the Bates silt loam samples and the Bates fine sandy loam samples averaged separately, is given in Tables 11 and 12.

Table 11.—Composition of Bates Silt Loam
(Average of 7 analyses)

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
<td>2920</td>
<td>1260</td>
<td>25425</td>
<td>4845</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>2795</td>
<td>760</td>
<td>22645</td>
<td>2040</td>
</tr>
</tbody>
</table>
Table 12.—Composition of Bates Fine Sandy Loam
(Average of 4 analyses)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>2235</td>
<td>610</td>
<td>18115</td>
<td>1630</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>1190</td>
<td>595</td>
<td>21570</td>
<td>3120</td>
</tr>
</tbody>
</table>

The analyses show decided deficiencies of nitrogen, phosphorus and potassium, particularly in the more sandy areas. While little experimental data dealing with this land is available there is little doubt from its general composition that it will respond to both phosphates and potash while in many cases lime will be needed for successful legume growing. The fact that the land is not very good bluegrass land warrants the recommendation of hardier grasses, such as orchard grass, timothy, and meadow fescue, combined with alsike and white clover for pastures. Red clover will grow satisfactorily on much of this land which is not too acid and it can be be combined with timothy for a hay crop. Liming and the use of phosphates will usually make red clover satisfactory on practically all of this soil. On the better areas, alfalfa may be grown economically, where lime and manure are used.

Alluvial Soils

Osage Silt Loam

The Osage silt loam area represents the alluvial soils within the residual prairie region. The type as mapped has a wide range in texture, but the class name has been used to indicate the predominating character. Aside from the difference in origin, the Osage soils are lighter in color than the Wabash soils of the glacial region, but are darker than the Huntington soils of the Ozark region. In general, the Osage soils vary from black to light gray in color, altho dominantly they are dark brown or dark gray. Texturally they range from fine sandy loam to heavy clay, with a preponderance of the finer grades.

The Osage silt loam is by far the most extensive type, and almost completely occupies the valley bottoms along all the larger streams, except where interrupted by the Osage clay. It consists of a black, dark gray or gray, mellow silt loam, with a drab or gray silty clay subsoil. Frequently there is little change in color or texture thruout the soil section, but in general the subsoil contains more clay and is lighter
in color than the surface soil. That portion of the type in the region of the Summit and Oswego soils is much darker in color and the surface soil deeper than in the southern areas. In the region of the Cherokee and Bates soils—notably in Vernon, Barton and Henry counties—the surface soil is prevailingly a light colored, ashy material carrying many iron concretions, underlain at about twenty-four inches by a gray silty clay. This light colored phase is poorly drained and is not productive. The greater part of it is timbered with willow, oak, ash, elm and hickory.

The Osage silt loam, particularly the dark colored phase, is easily cultivated and where well drained is very productive. The greater part of it is used for corn and yields of 40 to 75 bushels are obtained. Areas not subject to overflow and having good internal drainage are well suited to alfalfa. The greatest need of the soil is good drainage.

In the region of the Bates fine sandy loam the alluvial soil is usually of a loam texture. The surface soil to a depth of 10 to 15 inches is a dark brown or grayish brown loam or fine sandy loam with a yellowish brown subsoil. The most extensive areas of this phase occur along Horse and Clear creeks in Benton and Vernon counties. It is highly prized as corn, clover, alfalfa and truck soil.

The areas of heavy clay soil within the Osage silt loam are locally known as gumbo. The soil consists of a black silty clay, 8 to 12 inches in depth, underlain by bluish black or drab, waxy, tenaceous clay. The latter, when dry, cracks and becomes hard and intractable. The surface soil, altho it contains a large amount of organic matter, is difficult to work, except under the most favorable moisture conditions. The most extensive areas of Osage clay are found along the Osage river and its large tributaries, in Bates, Cass, Henry and Vernon counties. All of the type is subject to prolonged overflows, and therefore little of it is under cultivation. It produces coarse hay, averaging one to four tons per acre. When moisture conditions are favorable corn and grass do well. Large areas have been reclaimed by ditching and tiling.

Where properly drained the high agricultural value of the Osage soil is well known. Land values vary mainly with the character of the drainage, but also with the grade of the soil. They range from $25 to $100 per acre.

The composition of the Osage silt loam is shown in Table 13.
Soil management on most of the Osage soil consists merely in the selection of proper crops, and providing proper drainage. Tiling will be necessary on much of it. The soil is usually sufficiently well supplied with plant food to make fertilization unnecessary. Liming is sometimes of benefit.

**THE OZARK REGION**

The soils of the Ozark region as a whole possess characteristics that distinguish them from all others in the state. In general, they tend toward the lighter shades of color, they are comparatively low in organic matter and many of them are stony in character. That they are for the most part timbered, hilly in topography, and that they are rather low in mineral plant food may be given as other characteristics which apply to a large part altho not to all of the region. The prevailing colors are gray, with some brown and red and an almost total absence of black. The subsoils are gray, yellow and red, the brighter colors usually being associated with corresponding shades in the surface soil. The content of chert gravel in the soil varies greatly; in some places it covers the entire surface while in others it is almost entirely absent. In general, the more level areas are the least stony. True clay surface soils do not occur. The surface material is almost universally silty, and the subsoil is rarely heavier than a silty clay. It is true that the latter frequently is compact and more or less impervious, but this is due to the small amount of organic matter and to more or less cementation of iron material, and not to a thick accumulation of clay.

On the basis of color and content of chert gravel, the Ozark soils form two general groups, those of a red or brown color and moderately cherty, and those of a gray color and very cherty. The former sur-
round the latter and are frequently known as the Ozark border soils. They are derived from moderately cherty limestones, belonging mostly to the Lower Carboniferous group. The gray soils are from very silicious limestones of the Cambro-Ordovician system. They have a more broken surface and are of lower agricultural value than the red soils.

Since all the important soil forming rocks of the Ozark region are limestones, it has required many feet of rock of the purer beds to form even a thin layer of soil. In the small amount of residue there is a relatively great concentration of iron, the concentration being greatest where the parent rock was purest. The oxidation of the iron gave to the soil particles the characteristic red or brown coloration. Where the cherty limestone soils occur, a gray coloration prevails. Since much of the iron oxide has been carried from the surface soil into the subsoil, the latter is always of a brighter shade than the former. It is of interest to note that iron concretions rarely occur in these limestone soils.

The Ozark soils are the oldest in the state, and in most cases have become thoroughly leached. Moreover, the hardness of the rocks from which they are derived has required a long time for weathering. In this process most of the lime has been removed from the surface soils, and organic matter has not accumulated in sufficient amount and in proper form to give the soil a dark color. Even the areas overlying

One of the better tilled valleys in the Ozark region. The soil is mostly of colluvial origin, fairly deep and fairly productive. The higher lands are covered with timber. Such valleys include most of the better land of the region, outside the overflow strips of Huntington silt loam next to the streams.
the pure carbonate stones usually show an acid reaction, and only the lower subsoil overlying the parent rock shows effervescence with acid. The effect of age has been greatly intensified by the open, porous nature of the soils. This is indicated by the pale, gray color of the soil material of the gravelly members of the group. In general, the greater the content of gravel, the lighter the color of the soil. The effects of weathering extend to a depth of ten or more feet as is indicated by the discolored material found at such depth when digging wells.

Thru the erosive action of water the Ozark soils are continually losing their finer silt and clay particles almost as fast as they are formed on account of the hilly surface. The tendency of the soil material to occur as zones or layers is therefore retarded, and the deep, heavy, clay subsoils, such as characterize the North Missouri prairies, are rarely found. It is probable that both the action of erosion and the character of the parent rock do not permit the translocation of the soil particles so as to form layers. The removal of the clay and the leaching away of the soluble material tends to make the soil of all formations somewhat similar in character. The matter of the geological age of the rocks and to a large extent the character of the rocks are therefore of only general interest. It is probable that in the soils from the purer limestones, leaching and clay filtration have been retarded to a greater degree because of the less gravel and therefore they are heavier in texture and contain a larger per cent of plant food.

SOILS FROM CHERT FREE LIMESTONE

Hagerstown Silt Loam

The Hagerstown silt loam is the red limestone land of the eastern Ozark border region. It occurs in belts with a general north and south trend conforming to the outcrop of the limestone horizons from which the soil is derived. The eastern belt extends from southern Cape Girardeau county to Jefferson county; the western belt occurs in Madison and St. Francois counties. North of the Missouri River the type occurs in Pike, Lincoln, and adjoining counties. The total area is probably little more than 800 square miles.

Thruout the region of its occurrence, the Hagerstown silt loam is characterized by a brown or a reddish brown, silty loam surface soil, which varies in depth from 8 to 14 inches. It is mellow, stone-free and contains a fair supply of organic matter. The subsoil is a brown, reddish brown or yellowish brown, silty clay, which grades into a heavier
clay loam at a depth averaging 30 inches. On the relatively smooth areas, especially in St. Francois county, the immediate surface soil is gray, the lower subsoil being mottled brown and yellow and of a very friable structure. Near limestone outcrops the soil has bright reddish brown color, grading into a dark brown or almost black color in areas where the organic matter is abundant.

The soil mantle giving rise to the Hagerstown silt loam is of great thickness, and it is only on a few of the steep slopes and in the bluffs bordering the larger streams that the bedrock comes to the surface, or that limestone fragments are scattered thru the soil. In general the area in Bollinger county is more stony than the typical soil and includes some stony loam.

The topography is prevailingly undulating to rolling, except along the creeks where it is hilly. The Pike and Bollinger county areas average more rolling than the remainder of the type. Sink holes are of frequent occurrence in Cape Girardeau and Perry counties.

The Hagerstown silt loam is derived from limestones belonging to a wide range of geological ages, from the lower part of the Ordovician to the Mississippian, all alike, however, in being rather pure, chert free limestones. The soils therefore are stone free. In St. Francois county some of the limestone is dolomitic and is more argillaceous, passing in a few localities into shales. Such places are usually associated with a heavy soil, that has a gray or yellowish color. In general it seems to hold true, that where a magnesian limestone gives rise to this type, the surface soil is lighter in color than the typical soil, and the subsoil more of a reddish brown. The content of organic matter seems to be lower, bluegrass grows less vigorously and the soil appears less productive than where the calcium limestone prevails. In Pike county more or less glacial material has been mixed with the limestone soil.

The Hagerstown silt loam is easily distinguished from the other soil types occurring within the same region (i. e. Ozark region) on account of its brown color, smoother topography and freedom from stones. However, in many respects it is closely related to the Crawford gravelly loam. In fact, were it not for the gravel in the latter, these two types could be correlated as one.

The Hagerstown soil is old, since it was derived from some of the oldest rocks in the state. Much of the clay has therefore been washed out of the surface soil and filtered into the subsoil while most of the calcium carbonate has been removed. The subsoil rarely shows effervescence when treated with acid, differing thus from the Craw-
ford subsoil which usually effervesces freely. The uniformity of the soil in the different areas indicates further that it is not so much the age or even the physical differences in the rocks, but rather the differences in weathering, that determine the character of the soil.

The Hagerstown silt loam was one of the first soils in Missouri to be farmed. Much of the type has been in continuous cultivation for more than a hundred years. The superior productiveness of this soil in the eastern Ozark region was early recognized. As a result, little land of this character remains uncleared, except where it is very hilly, and most of it maintains a high class agriculture. Wheat is by far the most important crop. Corn, clover, oats and grass are also extensively grown.

Land that has been well treated, manured and carefully cultivated will produce twenty to thirty-five bushels of wheat, forty to sixty-five bushels of corn and one to two tons of clover hay per acre. In the St. Francois county area the yields are considerably lower than this, partly on account of the somewhat poorer quality of the land, but largely because of the inferior farm practices prevailing there. The continued growing of grain has greatly reduced the amount of organic matter in the soil, with a consequent reduction in crop yield. Alfalfa can be grown with proper treatment, but it is to clover that this soil is especially well suited. The soil is well adapted to fruit but is little used for that purpose because of its value as a general farming soil.

The Hagerstown silt loam in Cape Girardeau and adjoining counties is occupied almost exclusively by Germans. The prevailing type of farming is that of grain growing, but livestock raising receives considerable attention. In Ste. Genevieve, Pike, and Lincoln counties and in parts of Perry county a considerable portion of the Hagerstown silt loam is hilly, and much of it is still timbered. Erosion on all the more rolling areas is serious, and cultivation difficult, but the slopes are not too steep for growing all the tame grasses and occasional small grain crops. Tobacco and orchard fruits are grown on a commercial scale on the northern areas. On the whole, the Hagerstown silt loam offers splendid opportunities for profitable improvement, since the potential productiveness of much of this type has not yet been fully appreciated.

Land values range from $25 per acre for the hilly, partly improved areas to $75 and $100 for the better lands. The higher values prevail throughout Cape Girardeau and Perry counties, and are indicative of the quality and improvement of the land.

Profitable soil management on the Hagerstown silt loam is limited principally by the farmer himself. At present too much grain, particularly wheat, is being grown for the good of the soil, which is necessar-
ily losing in organic matter, nitrogen and available mineral plant foods. A more systematic crop rotation and the use of either green manures or the feeding of more livestock would result in a better maintenance of the soil and in greater ultimate profits.

The composition of this soil is indicated in Table 14.

<table>
<thead>
<tr>
<th>Table 14.—Composition of Hagerstown Silt Loam</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Average of 7 analyses)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Lime requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs.</td>
<td>lbs.</td>
<td>lbs.</td>
<td>lbs.</td>
</tr>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1470</td>
<td>705</td>
<td>30730</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil.</td>
<td>995</td>
<td>850</td>
<td>31995</td>
</tr>
</tbody>
</table>

Nitrogen and phosphates are the most important deficiencies, but the nitrogen with proper systems of farming can well be maintained at a rather high level on this land, since clover usually grows well. Phosphates are quite low in the soil and their use is more or less common for wheat. The extension of their application, especially with barnyard manure, would be highly desirable. Lime in many instances will pay, altho much of the type still contains enough lime to grow good clover. Little potash need be used for general crops.

SOILS FROM CHERTY AND MODERATELY CHERTY LIMESTONES

Lebanon Silt Loam

The Lebanon silt loam represents the relatively smooth, stone free plateau or ridge top soil of the Ozark region. There is combined with it in this classification, the Clarksville silt loam, a soil very similar in character. The most extensive areas of these soils occur along the Ozark Divide, with subordinate belts of greater or less width and length running northward and southward between the watersheds of the main streams. The largest areas are found in Laclede, Texas and Webster counties but much of the smooth land in eastern Ripley county and the extensive prairie lands in Lawrence, Jasper, Newton and Polk counties also have been included in this type.

In their general characteristics these soils consist of grayish silt loam 5 to 8 inches deep rather low in organic matter and underlain by yellowish gray to brown rather heavy silty clay with chert usually encountered within the three foot section. The lower substratum consists of the stony or gravelly clay of the typical Ozark region, a residual product of the decay of the cherty limestones.
The Lebanon silt loam, proper, consists of a grayish brown silt loam, 5 to 8 inches deep. It is underlain by a gray to grayish brown silt loam, the lower subsoil being a gray silty clay mottled with brown and drab and containing fragments cemented together into a typical hardpan. The soil occupies the more level parts of the ridge tops and is poorly drained. It is usually surrounded by an irregular belt of Clarksville, the latter being distinguished by its more rolling topography and

![Lebanon silt loam showing a new clearing in which the sprouts have been killed by the use of goats. Much of this type is cleared and in cultivation.](image)

the absence of post oak and black jack oak, which characterize the typical Lebanon silt loam. That portion of the Lebanon silt loam occurring in Lawrence, Newton, and Jasper counties is in many ways similar to the Cherokee silt loam in Barton and Vernon counties.

The absence of chert in the surface of these soils is partly accounted for by the fact that in some cases they have been derived from rather chert free material and partly by the weathering of the surface chert on these more or less level areas. In the northern part of the Ozarks the original material seems to have been Coal Measure shales while in Ripley county the soil is undoubtedly residual from limestone containing little chert.

The Clarksville silt loam proper is better drained than the Lebanon and has greater agricultural value. It is more drought resistant and has a greater range of crop adaptations. It does not show the extreme age of the Lebanon since it lacks a well developed hardpan. It was originally timbered with good sized, altho often scattered, white oak and black oak and today is often covered with good growths of
these trees, particularly the latter. Under cultivation it grows fairly good fruit trees.

The Lebanon silt loam comprising the high flats with a well developed hardpan, and an accumulation of iron concretions in the subsoil, shows every indication of extreme age. It is so poorly drained naturally that its crop adaptations are rather limited. Much of it was

Typical black-jack on the Lebanon gravelly loam. This timber indicates much gravel and shallow soils.

originally prairie or covered with scattered post oak timber. Today many of the areas are covered with a dense growth of post oak or black jack oak. The level topography allows easy cultivation, however, and where not too poorly drained it is cultivated to advantage.

The principal crops grown on these soils in Missouri are corn, oats, wheat, clover and grass. Tobacco was formerly grown, truck crops are now grown in certain areas, and on the Clarksville fruit does fairly well. Corn yields vary from 15 to 40 bushels, oats 20 to 35 bushels, and wheat 8 to 15 bushels. The typical Lebanon grows fair crops of corn, oats and hay, and where it is fertilized, wheat gives a fair return. It is not very good clover land, and attempts at growing fruit on it have usually failed. Cowpeas and soybeans do fairly well, altho kafir, sorghum, and millet are grown rather commonly for forage crops. Land values on these soils run from $15 to $50 per acre.

There is no doubt that the most profitable use of both of these silty upland Ozark lands is in livestock farming, altho the Clarksville silt loam has truck and fruit possibilities. The fertility of these soils
is not high, and the Lebanon silt loam, in particular, is not at all drought resistant, so that care must be exercised in a judicious selection of systems of farming and systems of cropping. The low supply of organic matter necessitates particular care in its conservation. There is a great tendency for the soils to run together and become compact under careless farming.

Tables 15 and 16 show the compositions of these soils.

**Table 15.—Composition of Lebanon Silt Loam**

(Average of 9 analyses)

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>2010</td>
<td>625</td>
<td>24130</td>
<td>2130</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil</td>
<td>1105</td>
<td>580</td>
<td>21625</td>
<td>4500</td>
</tr>
</tbody>
</table>

**Table 16.—Composition of Clarksville Silt Loam**

(Average of 9 analyses)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
<td>1330</td>
<td>615</td>
<td>24620</td>
<td>2295</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil</td>
<td>845</td>
<td>615</td>
<td>26320</td>
<td>4120</td>
</tr>
</tbody>
</table>

The deficiencies of plant food are marked. The soils will respond to the application of all three of the important elements of plant food. These are not soils which can be developed into a very high state of productivity even by the best efforts altho proper systems of soil management will bring returns, particularly on the Clarksville type. The supply of organic matter should be the first concern of the farmer. Rotations should be followed, including cowpeas, soybeans, grass crops, and if it can be grown, clover. Alsike clover is more satisfactory than the red on the Lebanon soil. Mammoth clover can often be used. The use of lime will aid materially in clover growing, particularly where phosphates are used in addition.
Clarksville Gravelly Loam

The Clarksville gravelly loam covers extensive areas in the Ozark region, being exceeded in area only by the Clarksville stony loam. It is closely related to the latter but differs from it in that the soil contains less chert rock and the topography is less rugged. In character it varies from gravelly to moderately gravelly soils, gray to brown in color, and from friable red clay thru gravelly and stony clays to hard-pan subsoils. The Lebanon, Baxter and Decatur gravelly loams are included in this area.

The surface soil of the prevailing Clarksville gravelly loam, to a depth of 5 to 8 inches, consists of a gray or pale yellow gravelly loam or gravelly silt loam. This material grades into a heavy yellowish or brownish gray silt loam, which changes at about twenty-four inches into a stiff, silty clay. Probably the most persistent characteristic is the gray color of the surface soil. In some cases, especially near the central part of the Ozark region, the entire three foot section is marked by gray or yellow colors, but in the vast majority of areas the deeper subsoil is reddish brown in color. The content of chert gravel varies from almost nothing to seventy-five per cent, and the amount usually increases with depth. The chert free or moderately cherty areas border the Clarksville silt loam, or occupy the ridges and divides which closely correspond in position and topography to the latter. As a whole, the chert is more dense and higher in silica than that of the...
Crawford soil, but it is not as hard as that of the Clarksville stony loam. In nearly all cases where the surface soil is stone free or only moderately stony, the subsoil is denser and more impervious, than in the more gravelly areas, and approaches the Clarksville silt loam subsoil in character.

The areas of Clarksville gravelly loam found in Ripley and Howell counties and in the southwest corner of the state have reddish brown subsoils, and are superior in agricultural value to most of the remainder of the type. In detailed soil surveys, much of this red subsoil phase has been correlated with the Baxter and Decatur series. It does not have hardpan characteristics, contains more clay and less chert and is fairly retentive of moisture. The timber growth consists largely of red or black oak, and is characterized by stronger growth than on the lighter colored soils.

The surface features of the Clarksville gravelly loam vary from almost level to hilly. Where the type surrounds the Clarksville silt loam, and in all the southwestern part of the state, the topography is level to gently rolling, but approaching the streams or the Clarksville stony loam, the surface becomes more rugged. In Howell county the type includes the broad shallow valleys, but to the east in Oregon and Ripley counties the surface is prevailingilly hilly. The several areas occurring in St. Francois and the surrounding counties are sharply rolling but rarely are the slopes so steep as to make cultivation impossible. In general, it can be said that the content of gravel in the soil, rather than the topography, is the limiting factor in the agricultural utilization of the Clarksville gravelly loam.

The underlying rocks are cherty limestones and magnesium limestones. The latter are the same as those of the Clarksville stony loam. In the southwestern part of the state the cherty Burlington limestone is the parent material. In this region, too, are remnants of Coal Measure clays that have escaped erosion, and have added considerable fine material to the stony mass. Where it is present in considerable quantity it gives rise to areas of Clarksville silt loam, many of which, on account of their small extent, have been included in this type. In general, the distribution of the calcium limestones is associated with the red subsoils and also a larger amount of clay in the substratum.

The native timber growth consists of the various oaks with some hickory and walnut. Black-jack and black oak occur on the more gravelly and dry areas. The red oak and black oak lands are considered the most fertile. Probably less than fifty per cent of this type is now cleared and in cultivation. Much of the timbered portion is too-
stony to permit profitable agriculture, but can be used as woods pasture. Of the cultivated crops corn is the most important, but the yields are low, averaging from fifteen to thirty-five bushels per acre. Wheat does fairly well. Clover makes a fair to good growth, the best results being obtained on new land, on north slopes and on the moderately gravelly areas.

Apple trees do fairly well, especially on such areas as have a red subsoil. Strawberries and other small fruits are commercially grown in the southwestern counties. Peach growing is an important industry in Howell county, on the red subsoil land, and in seasonable years hundreds of carloads are shipped. Grapes are grown in quantities near some of the railroad towns.

Along the Frisco railroad large quantities of dairy products are shipped out, but the amount could be greatly increased if all the land suitable for this purpose were utilized.

In general, the Clarksville gravelly loam can support a fairly prosperous agriculture, altho the initial cost of clearing the land of both rocks and timber is comparatively high. It probably possesses greater possibilities for development and occupation than any other Ozark soil type. The future agriculture will consist of general farming based primarily on stock raising, dairying and poultry raising with the growing of fruit near the railroads. Land values show a very wide range, varying from
$15 per acre on some of the undeveloped timber lands to $150, or even more on the best fruit farms.

Systems of soil management on this type are very varied, depending upon the type of farming adopted. The larger part of this land is now handled under a general system of farming, including the growing of stocker cattle and of hogs. Under such a system the timber land is largely used for rough range. The young timber is usually so thick as to prevent the growth of anything but small amounts of wild grasses and legumes. Where the trees are large and the undergrowth thin, a much better growth of grass occurs and a rather good range results. Orchard grass is the tame grass best adapted to this land and where the timber is not too thick, or where it is removed and the sprouts kept down, this grass makes a pretty good pasture. Bluegrass will grow to a certain extent under these conditions but the soil is most too dry and gravelly for it to produce satisfactory pastures. The clearing of this land and the establishing of pastures, consisting of orchard grass, some bluegrass, timothy and red top, together with the clovers, will greatly increase pasture production. The greatest difficulty in connection with this is found in killing the sprouts which spring up following the clearing. The use of goats is common for this purpose and hand sprouting during May and August is fairly effective.¹

Under systems of livestock farming little difficulty is found in growing fair amounts of corn and other feed crops on the better phases of the upland, altho the best plan is to include some of the so-called valley land along the streams with these upland tracts and use this principally for growing feed crops. The most profitable systems of general livestock farming on this soil type necessitate the use of rather large farms, a part of the land being made up of tillable valleys. Practically the same can be said of dairy farming, altho in this case the farms may be somewhat smaller and more attention must be given to developing upland pastures. Dairy farming is best followed near the towns and where exceptionally good valleyland or upland is available for the production of corn and forage crops. Dairying is too intensive a business to gain much success on the rougher range land.

The fruit possibilities of this land are important, altho fruits are thus far grown commercially in restricted areas. Tree fruit growing or small fruit growing pays best when developed as community enterprises in order to facilitate marketing the product. Much of this soil is very well adapted to such types of farming, but individuals interested in such work will find it desirable to associate themselves with others having similar interests. Isolated fruit farms rarely pay.

¹Miller, M. F., and Hutchison, C. B.; Grass Investigations in the Ozark Upland; Missouri Agricultural Experiment Station Bulletin 108.
The composition of this soil is shown in Table 17.

**Table 17.—Composition of Clarksville Gravelly Loam**
(Average of 3 analyses)

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1080</td>
<td>430</td>
<td>24420</td>
<td>1460</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>540</td>
<td>660</td>
<td>21925</td>
<td>1825</td>
</tr>
</tbody>
</table>

Clarksville gravelly loam in tomatoes. The better phases of this soil are well adapted to this and similar crops as well as to small fruits. As a rule one does not see such large areas cleared, as that shown in this view.

This soil is naturally low in nitrogen and phosphorus. In fact the low supply of organic matter, associated with this lack of nitrogen, is one of the important characteristics of this land. For general crop production, therefore, the deficiencies in organic matter, nitrogen and phosphorus are such as to limit yields materially. Yield of such crops on the average areas of this gravelly land can be increased only by proper soil treatment. Fortunately clover grows quite satisfactorily on much of this land and this offers the best opportunity for increasing the supplies of organic matter and nitrogen. The use of phosphates can also be depended upon to give material crop increases. The potash, while deficient, is not so seriously lacking as the other elements. It can nevertheless be used with material profit when prices
are normal. The need for lime is as a rule not important, altho it is needed badly on some areas, particularly those of level surface that are poorly drained.

*Clarksville Stony Loam*

The Clarksville stony loam is one of the most extensive soil types in the Ozark upland. The main area occurs in the east-central part of the region, with minor areas bordering the larger Ozark streams. In every case, this soil type represents rough and stony land a comparatively small per cent of which can be utilized for agricultural purposes. It is distinguished from the Clarksville gravelly loam by a more broken surface and a higher per cent of stone material. Included in this are necessarily considerable areas of Clarksville gravelly loam while the broader ridges are Clarksville silt loam.

In its general characteristics the Clarksville stony loam is a gray, very stony silt loam with a gray or pale yellowish stony, silty clay subsoil. The fine material of the lower subsoil is usually reddish brown in color, and a clay in texture. In general, the gray color of the surface material extends to a greater depth, and the red coloration of the subsoil is not as highly developed as in the Clarksville gravelly loam. From twenty-five to ninety per cent of the soil mass consists of chert fragments ranging in size from small particles to pieces several feet in diameter. Sometimes the surface is so thickly strewn with these fragments as to form almost a complete covering. In the subsoil of the very stony areas the chert is commonly fitted together somewhat in the form of the original rock, but in most places the lower stratum consists of a compact mass of cherty gravel and reddish clay. Rock outcrops and stony cliffs are numerous. In general, the south and west slopes always contain more stones than the north slopes, a condition found in all the gravelly and stony soils of the Ozark region.

On the narrow ridges and on many of the north slopes, the soil is a gravelly loam and can be cultivated fairly easily. These areas, on account of their small extent, could not be indicated on the soil map. At the base of long slopes bordering the larger valleys, small areas of silty or moderately gravelly soil, frequently occur, representing the wash from the hills. Such land commonly known as valley land is rather productive and makes up a considerable part of the cultivated land in this type. That part of the Clarksville stony loam bordering the White River in Taney, Stone and Barry counties contains comparatively little chert gravel, and correspondingly more soil material, but rock outcrops are so numerous, and the surface is so broken, that the land is largely non-agricultural and has been included in the main type.
As a whole, the Clarksville stony loam is the most thoroly dissected land of the Ozark region. The surface consists of narrow ridges, steep slopes and ravines. There are some small areas of smooth land occupying the broader ridges but these constitute a small per cent of the total. The tillable area is therefore small and will always remain so, not simply on account of the roughness of the topography, but also on account of the large amount of stone.

The rocks giving rise to the Clarksville stony loam consist mainly of very cherty limestones, with occasional thin beds of sandstone. The resulting soil therefore is very stony, and such fine material as is formed is largely washed away. In general, the rocks in the southern part of the area are more silicious than in the northern part. The soil in the former region therefore contains more stone, is more porous and is drier. Leaching has occurred to a great depth, and practically no organic matter has accumulated. It is the region of pine timber.

Practically all of the Clarksville stony loam is timbered. On all the very stony and drier land, black-jack, black oak and white oak predominate, but for the most part they are rather scrubby. In hollows and on the lower slopes, red oak, white oak and hickory are more plentiful. Altho much of the merchantable timber has been removed, the making of cross ties is of great importance, and is a source of revenue throughout this region. The southern half of the Clarksville soil was originally largely covered with yellow pine, but practically all of this has been removed.

In general, the character of most of this stony loam fits it mainly for forest and range land. Most of it should remain permanently in forest or wooded range. Such small farms as have been established within the type represent the valleys or ridges where the stone content is relatively small. The crops grown are the same as those on the other Ozark soils. On the better areas corn yields from ten to twenty-five bushels, and timothy and clover from one-half to one ton of hay per acre. Attempts at growing fruit have not been entirely successful, altho peaches seem to thrive best in the southern areas where climatic conditions are more favorable. The soil is not drought resistant and in seasons of small rainfall crops are generally a failure.

A large part of the Clarksville stony loam is still used as free range, and thousands of head of cattle and hogs are raised with practically no attention. In some counties stock laws have been passed and much of the land is under fence. Bluestem grass and several wild legumes grow fairly well where the timber is not too thick. In comparatively recent years, most of the Ozark region has been taken by Japan clover (Lespedeza striata) and this is now found over much of
this type of soil. It thrives in forested as well as in open areas, and furnishes considerable grazing thru the latter half of the summer and early fall. It is a small growing clover that comes late in the season and disappears with frost, but it adds materially to the value of the range during the warm summer months.

Lands of this type sell for $2 to $10 an acre, altho occasional areas of better land are held at $25 to $30. In general, the timber determines the value of the land to only a slight extent.

The Clarksville stony loam. The ridge tops and valleys comprise the principal tilled areas on this type. The large amount of stone, the fairly heavy timber growth, the rough topography and the farm improvements are characteristic of this land.

The composition of this type is given in Table 18.

**Table 18.—Composition of Clarksville Stony Loam**

(Average of 2 analyses)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1050</td>
<td>490</td>
<td>27840</td>
<td>1920</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>900</td>
<td>860</td>
<td>28610</td>
<td>3070</td>
</tr>
</tbody>
</table>

Soil management on this land is principally a matter of handling the tilled valleys and the few cultivated upland areas. The valleys grow fairly good corn, small grains and forage crops without serious
attention to fertilization. The use of crop rotations, the growing of legumes and the maintenance of the organic matter are most important. In the poorer valleys, phosphates are seriously needed while potash fertilizers will also bring returns. Lime is rarely needed.

On the uplands which are farmed, the dry gravelly nature of the land makes consistently large yields impossible. In seasons of abundant rainfall the use of phosphates and of potash fertilizers can be expected to give good returns where a man is farming rather intensively, but even a slight deficiency in rainfall greatly interferes with their action. Attention to the supply of organic matter and nitrogen is usually the most important consideration. As a matter of fact the uplands of this region, since they are primarily forest and range lands, should be handled in connection with valley lands if liberal returns are to be expected. The valleys should be used for cropping and large acreages of the upland should be used for range. The territory occupied by this soil type was formerly covered with a fair growth of blue-stem prairie grass, and it was customary to burn it over each year. The burning kept down the small timber but had little effect upon the larger trees. With the fencing of considerable areas, this was largely abandoned, resulting in the growth of brush and small timber which has greatly decreased the value of the range.

**Crawford Gravelly and Silt Loams**

The Crawford gravelly and silt loams are generally known as red lands or red limestone lands on account of the characteristic red or brownish color. The main area of the type occurs on the western Ozark border, and extends from Christian county northward thru Greene, Lawrence, Dade and Cedar counties. Smaller areas are mapped in Cass, Jackson, Pettis, Cooper and Cape Girardeau counties. The total area is approximately 1000 square miles.

In its typical development the Crawford gravelly loam consists of a brown, reddish brown or grayish brown mellow silt loam, grading at about 8 to 15 inches into a reddish brown friable silty clay loam, which becomes redder and more gravelly with depth passing gradually into red crumbly clay generally carrying angular chert fragments. The latter are distributed throughout the soil section, but are much more abundant in the lower strata. The soil contains approximately 10 to 30 per cent, and the subsoil 20 to 70 per cent, of this material. In general, the more rolling the surface, the higher is the content of gravel. On many of the ridges and steeper slopes plowing is difficult. In the northwestern part of Greene county and the region to the north, the soil mantle is thin and bedrock is usually encountered within a few feet
of the surface, with limestone fragments scattered thru the soil. Such areas are not very drought resistant, and are therefore used largely for pasture land. In general, the southern areas of the type in Christian county are more gravelly than the northern areas. On many of the ridge tops along the western edge of the type the soil is a sandy loam or gray silt loam, very similar to the Bates soil of the residual prairie region. These ridge tops are derived from Coal Measure shales and sandstone which have escaped complete erosion. Near Springfield, in fact throughout the central part of Greene county, the soil is a silt loam, and even the subsoil is stone free. This area represents one of the most desirable farming sections in the state. The undulating surface, and the depth and mellowness of the soil make it adapted to a wide range of crops.

The areas mapped as Crawford gravelly loam in Cass, Jackson, Pettis and Cooper counties are more correctly silt loam in texture. The surface soil is a dark brown mellow silt loam grading downward into a reddish brown friable silty clay loam. Chert gravel is absent except on some of the steep slopes, and here bed rock is usually encountered within the three foot section. In Jackson county, especially, rock outcrops occur along most of the drainage ways, which tend to give the surface a rugged appearance. In Pettis and Cooper counties the surface soil has a yellowish brown color, and is slightly heavier than that in the areas to the west.
In general, the topography of the Crawford soils is smooth to gently rolling. There are belts of moderately hilly country along both sides of the main streams, but when not too stony, these are rarely too steep for cultivation. In fact, the surface features of this soil type are not as broken as much of the glacial lands in the northern part of the state. The Crawford is the typical soil of the coarsely crystalline, pure, moderately cherty, massive bedded, fossiliferous Burlington limestone. Altho much of the soil in Southwest Missouri is derived from this same formation, it is only where the latter is moderately cherty and thickly bedded that it gives rise to the true Crawford soils. The two predominant characteristics of the Crawford soils are a fair amount of chert and a relatively large amount of fine material which has prevented excessive leaching, yet permitted thorough oxidation to a great depth. The relatively small amount of soil material in the pure limestone caused a greater concentration of the iron, and the oxidation of this gives to the soil particles the characteristic red coloration.

Originally much of the Crawford gravelly loam, particularly all the silty areas, was prairie. This condition in the presence of an abundance of moisture and lime, caused a considerable accumulation of organic matter in the soil, and imparted to it a dark brown or chocolate color. It is thus probable that the native vegetation is largely responsible for the difference between the Crawford and Hagerstown silt loam soils, since both were derived from similar material and were formed under similar climatic conditions. The small area of Crawford soil in Cape Girardeau county, derived from Burlington limestone, is a timber soil, and lighter in color than the main areas in the western part of the state.

The Crawford silt and gravelly loams are practically all under cultivation, and they are probably the most productive of all upland Ozark soils. They are excellent grain and clover soils, a considerable part being sown to wheat each year. Yields range from 10 to 25 bushels per acre. Corn yields vary from 25 to 50 bushels. Where the soil is gravel free and fairly well supplied with organic matter, alfalfa may be grown. Of the cultivated grasses, orchard grass is best suited to these gravelly and open subsoil lands. It is hardy and withstands the summer heat better than bluegrass.

The main body of the Crawford gravelly loam embraces one of the most important fruit growing districts of the state. The apple is the principal fruit grown. In Greene, Lawrence and Newton counties, orchards of 40 to 100 acres are common, while some containing 200 to 400 acres or more are occasionally found. The trees make a strong growth, and produce fruit of good flavor and coloration. Peach
growing is not extensive as the climatic conditions are not so favorable for the production of this fruit. Cherries and grapes are grown in a few localities in considerable quantities. Raspberries, blackberries, dewberries and strawberries are grown on a commercial scale, particularly in Lawrence, Newton and Jasper counties. Strawberries have probably been more uniformly profitable than any other kind of fruit. Approximately 3000 cars of this fruit are shipped annually. Tomatoes also are one of the important money crops. They are often grown in connection with apples and are planted between the young apple trees, where they pay for the cultivation of the orchard until the trees come into bearing. Associated with fruit growing is the canning industry and several thousand cars of canned products are exported annually.

Important as the fruit industry is, few farms are devoted to it exclusively. Most growers who formerly made a specialty of fruit growing are now giving some attention to other lines of farming, combining this with fruit production.

For the Crawford gravelly loam, as a whole, general farming, supplemented by stock raising, dairying and fruit growing is the prevailing type of agriculture. Probably no other soil type in the state supports a more diversified system of farming. The many substantial farmhouses, thrifty orchards and well tilled fields indicate a general condition of prosperity throughout most of this region. Land values show a wide variation and range from $20, for the more stony or inaccessible areas, to $100 per acre for the more level, stone free lands near the towns. In the regions where fruit growing is most highly developed, land prices may reach $200 per acre for good fruit land that is well located.

The Crawford silt loam is much better than the gravelly loam for general farming purposes. It is more fertile, more easily worked, more drought resistant and as a whole it lies better. Land values on the silt loam vary from $40 to $125 per acre or, sometimes more in the better areas. The problems of soil management on this type are not as serious as those on the gravelly loam. Its composition is shown in Table 19.

The analysis of the Crawford silt loam scarcely does it justice. It is one of those warm early soils from which more can be expected of a given plant food content than from soils which tend to be cold and wet. The comparatively low nitrogen supply can rather readily be improved by the use of systematic rotations containing clover, which on most of this type grows luxuriantly. The low phosphate supply means
that phosphates are needed, however, and experiments have shown good returns from their application to corn, wheat and clover.\(^1\) With potash at a normal price, small quantities of potash have also been used with profit but this is not an important treatment for this land. Lime will pay on clover and alfalfa on parts of this area. The need for lime varies widely, however, and must be determined locally.

The Crawford gravelly loam while not so well adapted to general farming as the silt loam, nevertheless gives very satisfactory returns under proper management. It is much more variable in character than the silt loam, however, the rougher, more gravelly areas are practically nontillable. It is much better adapted to dairying and general livestock farming than to grain farming and in connection with fruit growing is generally so used.

Table 20 indicates its general composition.

**Table 20.—Composition of Crawford Gravelly Loam**

(Average of 2 analyses)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil.....</td>
<td>2500</td>
<td>610</td>
<td>24550</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>(No samples taken because of stones)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The low supply of nitrogen requires a more careful system of farming and less grain growing than on the silt loam, if satisfactory yields are produced. The low phosphorus supply makes the use of phosphates important where grain crops form any considerable part of the crops grown. When prices for potash are normal, potash fertilizers applied in moderate quantities will usually pay.

\(^1\)Miller, M. F., Hutchison, C. B., and Hudelson, R. R.; Soil Experiments on the Red Limestone Lands of Southwest Missouri. Missouri Experiment Station Bulletin 129.
The pasture problem is rather serious on much of this land. The more rocky and gravelly areas had best remain in timber in most cases, altho such timber pastures give little return as a grazing proposition. The moderately gravelly areas, where they are cleared, are better adapted to orchard grass, timothy, red top and meadow fescue than to bluegrass. Livestock farming on such lands necessitates fairly large acreages.

The Union silt loam in Franklin county. The rolling to rough topography with the land partly timbered, is characteristic. Crops of clover such as that shown in the foreground are not uncommon.

**Union Silt Loam**

The Union silt loam includes the greater part of the northern and northeastern border of the Ozark region. It begins in Bollinger county and runs northward as a belt of varying width to Franklin county, where it turns westward and finally ends in the eastern part of Cooper county. A considerable part of the northern belt lies north of the Missouri River, and includes the southern parts of Callaway, Montgomery and Warren counties. The details of the distribution of this soil type are shown on the soil map.

In its prevailing characteristics the Union silt loam is a brown, grayish brown or yellowish brown, mellow, stone free silt loam with yellowish brown silty clay subsoil. The depth of the surface soil, and the content of organic matter vary considerably. The subsoil is rarely heavier than a silty clay, and is usually distinctly friable. Probably the most persistent and distinctive characteristic is the faint gray and
brown mottling of the lower subsoil. Occasionally this strata shows a slight cementation of iron material, but in no case can it be considered as a hardpan nature. The substratum sometimes consists of a mass of chert, and chert fragments scattered thru the soil. The cherty areas occur in patches, and represent knolls and steep hillsides. They are most numerous in the southern part of the type where it borders the Clarksville soils and represents a gradation into the latter. Here too, are found outcrops of bedrock, and the subsoil is of a reddish coloration. In Franklin county much of the soil contains varying proportions of sand, usually small, except on the higher land close to the outcrop of sandstone. In general, the soil mantle giving rise to the Union silt loam is of great thickness and in this respect is similar to the other reddish limestone soils of the Ozark border.

That portion of the Union silt loam west of Gasconade county and extending across Osage, Cole and Moniteau counties averages lighter in color, and contains more clay and chert outcrops than the eastern part of the type. The surface soil is gray to yellowish brown silt to clayey silt, underlain by grayish, yellowish brown silty clay subsoil which is as a rule rather friable. The country rock, a thin bedded magnesian limestone with a small amount of chert, outcrops rather frequently on steep slopes, but very rarely in the fields. The soil layer is occasionally thin, but limestone "glades" do not occur typically. Much of it remains timbered.

The topography of the main portion of this type varies from rolling to hilly, with practically no smooth land. As a rule the hills are rounded with long slopes, but bordering all the larger streams is a belt of rough country, much of which is too steep for cultivation. Along the Meramec and Big rivers the surface is thoroly cut to pieces, and the same is true of all the area north of the Missouri River. In Warren and Montgomery counties an almost mountainous topography prevails. Variations in altitude of 500 feet are common, and probably 50 per cent of the land is too steep for cultivation. A similar area of strong relief occurs along the Osage and Gasconade rivers where these streams cross this belt of soil. Probably thirty per cent of the land is made unfit for cultivation by the rough surface, but practically all of this is fairly well suited to pasture purposes. Erosion is, of course, a serious problem.

The origin of the Union silt loam is not perfectly understood. That portion of the type near the Missouri River both to north and south is essential the same as the Knox silt loam, and is undoubtedly of loessial origin—either wholly or in part. The greater depth of the soil
mantle, the almost complete concealment of all rock outcrop, and the “rounded” topography are very suggestive of loess instead of residual material. Away from the Missouri River the soil is undoubtedly residual, and is derived largely from the highly magnesian Jefferson City limestones.

The native tree growth consists almost entirely of white, red, black and post oak, with walnut, elm and other soft wood trees occurring on the browner lands and in the valleys. On all the steeper slopes where bed rock lies near the surface, cedar is the characteristic growth, and frequently occupies the land exclusively.

The Missouri River belt, south of the river, is practically all in cultivation, and is settled almost exclusively by Germans. Throughout the extent of the type, wheat is the most important crop. The soil not only seems especially well adapted to this crop, but the type of people farming it favor the growing of small grains. Corn is not extensively grown. Red clover makes a good growth on most of the area and is profitable both as a forage and seed crop. Bluegrass thrives fairly well, but does not form as good a sod as on the other reddish limestone soils of the Ozark region. In fact, good bluegrass pastures are rare. It is probable that the grass does not thrive as well on magnesian limestone soils as on those derived from calcium limestone. In all the Union soil area north of the Missouri River, the hill tops are capped with Burlington limestone and the soil is largely derived from this formation. It is observed that in all these places the bluegrass makes a luxuriant growth, but further down the slope, where the magnesian limestone is found, only a sparse growth occurs. In fact, it is not incorrect to say that throughout the Ozark region where the magnesian limestones prevail, bluegrass does not thrive naturally or make a very profitable crop. Apples, small fruits and vegetables all do well, altho grown at present only for home use. In Gasconade and Osage counties grape growing is of considerable importance.

In general, the Union silt loam is best suited to a type of farming that is largely dependent on dairying and livestock raising, but which includes some small grains, especially wheat. The soil is not strong enough, and washes too readily to permit frequent cultivation. However, it grows clover and other leguminous forage crops successfully, and can therefore be easily improved and made to produce a large amount of feed. Most of the type is favorably located with respect to the St. Louis market. The possibilities of the soil are many, and have been only partially realized.

Improved farms on this type sell for $25 to $75 an acre, depending upon location, improvements, and proportion of improved land. In Franklin and Cole counties the higher values prevail on account of the
superior quality and better improvement of the land. Unimproved land sells at $15 to $30 an acre.

The composition of this soil is shown in the following table:

**Table 21.—Composition of Union Silt Loam**
(Average of 10 analyses)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1600</td>
<td>650</td>
<td>35265</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>800</td>
<td>950</td>
<td>37580</td>
</tr>
</tbody>
</table>

The analyses show this soil to be particularly deficient in phosphorus with a nitrogen content that is also low. The fact, that this land will in most cases, grow clover quite well, gives the farmer a much more ready control of the nitrogen supply than is common on many soils. The need of lime is apparent on some areas, and in such areas liming is often necessary to success with clover, but the thorough drainage helps materially in securing a stand. On the whole there is no great difficulty in growing clover on this land, particularly where phosphates are used.

The need of phosphates as shown in the analyses is reflected in the farm practice. Many farmers make good use of phosphates and highly phosphatic mixed fertilizers in growing wheat. While corn does not respond in quite the same way as wheat, returns can usually be expected from such applications. Where barnyard manure precedes the corn crop an application of 40 pounds of acid phosphate per ton of manure to be plowed under with it is good practice. Where wheat is the important money crop the manure can often be applied to best advantage as a top dressing on the wheat in the fall or winter. The phosphate should be applied with the wheat at time of seeding.

**SOILS FROM LIMESTONE, SANDSTONE AND SHALE**

*Tilsit Silt Loam*

The Tilsit silt loam occurs on the eastern border of the Ozark region. The most extensive areas are found in Cape Girardeau, Perry, Ste. Genevieve and Jefferson counties, but numerous smaller areas, too small to be shown on the soil map, occur in all the adjoining counties. As will be pointed out, the northern areas of the type differ considerably in topography and composition from the southern areas.

In Cape Girardeau, Perry and St. Francois counties the typical Tilsit silt loam consists of pale yellowish brown silt loam, grading at
about 6 to 8 inches into a yellowish silt loam or silty clay loam. The lower subsoil is a rather stiff silty clay, highly mottled yellow and brown. On the steeper slopes and wherever the underlying sandstones come near the surface, the surface soil contains more or less fine sand, but such areas are small in extent and of little importance. Freshly

plowed fields have a distinctly grayish or yellowish appearance, the latter color indicating the eroded areas. Occasionally chert and sandstone fragments are scattered thru the soil section.

The topography is gently rolling and with the exception of a few small areas in western Perry county, is well suited to cultivation. The surface drainage is thoro. The soil is low in organic matter and is easily eroded.

Practically all of the southern half of the type is in cultivation and is used for corn, wheat, clover, timothy and cowpeas. The yields are not as large as on the adjoining Hagerstown soil, but are higher than on the Clarksville soils. As a rule little difficulty is experienced in getting a stand of clover, except when the supply of organic matter has become largely depleted.

The Tilsit silt loam as found in Jefferson and Ste. Genevieve counties is lighter in color and contains more fine sand than in the areas to the south. Moreover, the surface everywhere is completely dissected,
so that much of it is too broken to permit cultivation. There is practically no smooth land except small areas along the main watersheds. Probably less than half of this area is cultivated, and the yields obtained average lower than in the southern areas of the type.

The rock from which the Tilsit silt loam is derived is a fine grained sandstone. The bed is rather thin, never exceeding one hundred and fifty feet in thickness and like all formations of this region, dips eastward. The actual width of outcrops of the rock is often less than a quarter mile. The farther from the existing outcrop, the less is the amount of sandstone material in the soil; the nearer to it, the greater is this amount. The farther away, the more there is of the material from underlying rocks; the nearer, the less of that material. There is more or less gradation, therefore, from a soil with a small amount of sandstone material in it in the western and southern parts of the soil areas to one made up wholly or mainly of that material lying along the foot of the escarpment and upon its face.

The Tilsit silt loam is an interesting illustration of a soil, the distribution and character of which is determined by the parent rock. Since the sandstone from which it is derived weathers at about the same rate as the surrounding limestone, the surface features are the same, but the soil from the former contains less humus and, being more porous, has been leached to a greater degree.

The prevailing system of farming on the Tilsit silt loam is similar to that on the Hagerstown silt loam. Corn, wheat and clover are the principal crops, but the yields average lower than on the adjoining red soils. Clover does not make a good growth unless the land is well supplied with organic matter. The growing of winter cover crops is important in checking erosion on this sloping land.

In Cape Girardeau county the greater part of the type is in cultivation and supports a fairly prosperous agriculture. Of the remainder of the type, probably less than fifty per cent is in cultivation. The cleared land is largely used for pasture. The uncultivated areas consist of timber and abandoned land. The latter is largely grown up with persimmon and sassafras brush, and could be reclaimed. In general, the low fertility is the limiting factor in the economic utilization of this soil type. This low fertility is indicated in the chemical analysis shown in Table 22.

The low supply of nitrogen in this soil is the most striking feature of these analyses. This indicates a very low supply of organic matter and low productive capacity. The phosphorus supply is likewise quite deficient so that systems of soil management on this land must either be sufficiently extensive to allow rather low yields or the soil must be highly fertilized if it is to be very productive. Growing clover and
Table 22.—Composition of Tilsit Silt Loam
(Average of 3 analyses)

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1320</td>
<td>620</td>
<td>23990</td>
<td>1580</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>695</td>
<td>725</td>
<td>25445</td>
<td>3765</td>
</tr>
</tbody>
</table>

other legumes is essential to building up the nitrogen and organic matter, and feeding these crops on the farm is highly desirable. The soil is not suited to the sale of much grain. Where rightly used, phosphates and potash at normal prices will both pay well on this soil. Land values vary from $5 to $50 per acre.

_Hanceville Loam_

The main area of the Hanceville loam lies in Dent county, but numerous areas, either small in extent or with boundaries not well determined, have not been indicated on the soil map. Several isolated areas occur in Douglass, Ozark and Shannon counties and show the rather widespread distribution of the material that gives rise to this soil type.

The surface soil is dominantly a loam, but varies from stony sand, to sandy clay loam in texture, and from light gray to yellowish brown in color. The subsoil is usually heavier than the soil, and varies in accordance with the material from which it is derived. Where sandstone is the dominant source, sandy loam prevails, but where limestone is the most important parent material the subsoil is heavier, usually containing some chert. This latter phase occurs around the northeastern and southern borders of the type, as well as along some of the larger valleys, and is a much better phase of this soil than the typical material. The stones scattered thru the soil and subsoil are never present in sufficient quantity to interfere seriously with cultivation.

The main area of the Hanceville loam lies on or near the Ozark Divide, and in a locality where the surface has not yet been deeply dissected. The topography therefore is level to rolling. The streams are small, and have eroded only shallow valleys with gentle slopes. As soon as enough of the small drainage channels have united to form one large enough and deep enough to hold a perennial stream it has cut beneath the sandstone level into the underlying limestone and another type of soil results. All of the surface therefore is of such character as to permit easy cultivation. The topography of the narrow belts and
small areas occurring irregularly over the adjacent region is usually somewhat rougher than that of the main area.

The Hanceville loam is derived from a medium to coarse grained brown or reddish brown to gray sandstone, consisting mainly of imperfectly rounded quartz grains with small amounts of chert grains. It is underlain by a very cherty limestone (Gasconade) and in a part of its area it is separated into two beds by an interbedded limestone.

Black-jack and post oak form the prevailing timber growth, altho the black oak occurs on the heavier phase. Originally the greater part of the type was open woods and blue stem grass covered the entire surface. At the present time every spot not in cultivation is covered with a growth of oak timber or brush.

Cultivation is confined principally to the valleys and valley slopes. The ridges are rarely cleared. Very little land has been cleared during the last decade. Probably a larger amount has been abandoned than has been cleared during this time. This is one of the areas of the Ozark region in which abandoned land is to be found. Land values are generally rather low, ranging from $2 or $3 on the poorer timber land to $30 or $40 on the better improved cleared land, near the railroads.

Altho the soil is thin, it is not hopeless. It responds to good treatment. It will not support a prosperous agriculture, but it can be made to yield a fair income. A combination of a small amount of grain with grass, legumes and livestock is the only plan that suits existing natural conditions over most of this soil area. Bunch grasses do well, and with liming, clover can usually be made to grow. Of prime
importance, to make the soil produce fair yields, is the supplying of organic matter, and when this is done commercial fertilizers can be depended upon to increase the crop returns.

Table 23 shows the composition of this soil.

**Table 23. --Composition of Hanceville Loam**

(Average of 2 analyses)

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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>920</td>
<td>335</td>
<td>16465</td>
<td>910</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>750</td>
<td>510</td>
<td>17410</td>
<td>3960</td>
</tr>
</tbody>
</table>

Experiments on the Hanceville loam have shown its response to the addition of phosphates and potash fertilizers and to the building up of the nitrogen supply thru the use of legumes. Its low fertility as shown in the foregoing analyses would suggest the rather general use of such treatments. In case of livestock farming where the soil is largely used for growing hardy grasses, such as orchard grass, timothy and red top, and where large areas of cheap land are available, fertilizer treatments have a less important place, but even in such a system the feed grains that are grown should be fertilized for satisfactory yields. Lime is also needed in case of more intensive farming.

The rather sandy nature of this land should make it fairly well adapted to potatoes and other truck crops under systems of intensive fertilization. At this time, however, transportation facilities and the distance from large markets combine to make such a use of the land unprofitable, excepting in a very limited way. On the whole the present agricultural possibilities of the most of this soil are limited to cheap land systems of livestock farming, altho near the towns and on the better areas, the production of small amounts of truck and fruit crops and poultry raising offer opportunities. The occurrence of small cut-over timber over much of the area, however, exposes the poultry raiser in the newer sections to depredations of the usual varmints of this region.

**SOILS FROM GRANITE**

**Ashe Stony Loam**

The area of Ashe stony loam contains only a small amount of land of agricultural value. It occurs in the eastern Ozark region, mainly in Iron, Madison and St. Francois counties. Smaller areas occur in several other counties.

The soil is a gray, and usually very stony loam with a yellowish gray subsoil, containing considerable sand, stones and boulders. Limit-
ed areas in the nature of valley lands are level and comparatively free of stone. Some of the upland is also tillable and other areas are used for rough pasture. The rocks underlying the area are igneous, consisting of granites and rhyolites. The most abundant rock is a dense hard porphyritic trachyte. The granite underlies the smoother areas while the peaks are made up of the more resistant porphyry.

The whole area of this soil is covered with greater or less amounts of granite boulders. The timber growth is small and tillable land is limited in extent.

Topographically the Ashe stony loam is the roughest land in the state. The greater part of it consists of steep mountain sides, and the tops of the peaks are from 200 to 700 feet higher than the adjacent valleys. These valleys are made up of a silt loam. They are usually narrow but frequently are wide enough to include considerable tillable land.

The whole area, except the small valleys and limited upland areas that are cultivated, is covered with a growth of black, white and red oak with some post oak, the white oak predominating.

The single analysis in Table 24 gives an idea of the composition of the soil.

Table 24.—Composition of Ashe Stony Loam
(One analysis only)

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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1475</td>
<td>275</td>
<td>32065</td>
<td>2910</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>740</td>
<td>360</td>
<td>30080</td>
<td>7600</td>
</tr>
</tbody>
</table>
As a whole this region may be considered practically untillable. The tilled areas will respond to the building up of organic matter, growing legumes and the use of phosphates. The farm owners rarely farm with sufficient intensity, however, to give consideration to such treatments. The range in the rocky upland is rather poor. Little fruit is grown. Land values are low.

**ALLUVIAL SOILS OF THE OZARK REGION**

The alluvial soils of the Ozark region make up a relatively small, but nevertheless an important part of the area. It has been estimated that one-fourth of the grain produced is grown on the alluvial soils. In the economy of the region they are therefore of much importance. In fact, they are the only soils in large parts of the region on which profitable grain growing can be carried on. This is especially true of the Clarksville stony loam area and the rougher parts of the Clarksville gravelly loam. Even along the largest streams, however, the belt of alluvial land does not average more than one-fourth mile in width, and usually much less than this.

**Huntington Loam**

The Huntington loam has been mapped to include all the alluvial land, since these lowlands are predominantly a loam in texture, altho they also include gravelly loams and silt loams. In color the soil is brown, reddish brown to dark brown. Gray to nearly white soil sometimes occurs, the latter representing terraces of limited distribution. In the region of the Clarksville stony loam and along many of the smaller streams, it is more or less gravelly. The gravel consists wholly of chert. Bordering the streams, the soil is almost universally a loam or fine sandy loam. In the wide valleys, and back from the streams the texture is commonly a silt loam. There is usually little difference in the physical properties of soil and subsoil, altho the latter is often of a light texture, and frequently is sandy or gravelly in the lower portion. This is but natural since all the streams flow at a rather steep gradient, and deposit mainly coarse material. Taken as a whole, the Huntington loam does not stand drought as well as heavier bottom lands, especially in areas coarser than a loam. However, the water usually lies sufficiently near to the surface to be in reach of deep rooting crops, and total crop failures are rare.

The Huntington loam is alluvial in origin except in the narrow valleys where it is partly colluvial. The surface is level altho there are many shallow depressions and abandoned channels. All of the type is subject to overflow, but inundations are of short duration, rarely lasting more than two or three days.

Practically all of the Huntington loam is in cultivation. It was the first to be settled and in large areas of country it is yet practically
the only soil that is cultivated. Corn is the most important crop, and rather high average yields are obtained. Wheat, clover, alfalfa and grasses thrive. A very small acreage is used for pasture purposes, as the less fertile hills adjoining supply sufficient grass for this purpose.

The composition of the silt loam phase of this soil is shown in Table 25.

Typical Huntington silt loam of the Ozark region. These narrow overflow lands along the streams are all classed as Huntington silt loam, altho some contain a good deal of gravel and sand washed in from the hills. The soil is the best corn and general crop land in that section.

The content of fertility is not so high in this soil as in the lowland soils of North Missouri nor is the soil as productive, altho its fertility is high enough to produce very good crops indeed. It has a wide range of crop adaptations and is the most valuable soil in the Ozark region proper. Profitable soil management on this type is principally a matter of proper crop selection and the adoption of good systems of crop rotation. The frequent overflows supply fertility and make the need of rotation less than on upland soils. In connection with the upland range of much of the Ozark region the Huntington silt loam is used to excellent advantage for furnishing the grain and forage crops for livestock farming. Little of the grain on this land is sold from the Ozark counties. Practically all of it is used on the farms producing it or in the neighborhood.

Land values on this type range from $30 to $100 per acre, depending upon location and width of the valley as well as upon the amount of gravel in the soil. The gravelly phases are less valuable than the loam or silt loam. The land is rarely sold separate from the adjoining upland, however, so that farm prices are necessarily influenced by the amount of upland included.
THE SOILS OF MISSOURI

Table 25.—Composition of Huntington Silt Loam

(Average of 6 analyses)

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<tr>
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</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>2270</td>
<td>1330</td>
<td>26615</td>
<td>85</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>1470</td>
<td>1110</td>
<td>26900</td>
<td>785</td>
</tr>
</tbody>
</table>

SOUTHEAST LOWLAND REGION

The Southeast Lowland presents one of the most varied and interesting soil regions in Missouri. Altho the soils are of alluvial origin, they show extreme variations in the various physical properties, while in age they range from the oldest to quite recent deposits. Unlike the alluvial soils in other parts of the state, however, most of the southeast lowland area is now receiving little in the way of alluvial deposits.

The deposits from which the lowland soils were derived were largely brought down by the Mississippi and other large rivers and are therefore of complex origin. They represent material from the great plains, the glacial and loessial prairies and the residual uplands. It is probable that the alluvial lands between Crowley's Ridge and the main upland consist largely of loessial material washed down from the adjoining uplands (particularly Crowley's Ridge) so that they are more homogenous in source than are the alluvial lands east of the Ridge. The similarity of the alluvial soils along the streams within Crowley's Ridge to that of the main body of alluvial lands west of the ridge is almost conclusive evidence that they are of similar, and therefore largely of local origin.

Altho all the lowland soils have been formed by stream action, the deposition of the soil material occurred under varied conditions of stream flow. Such areas as were subject to frequent overflow with a swift current consist of sandy soils while areas deposited by slow flowing or standing water consist of silt and clay loams. The occurrence of the extensive area of sandy soil near the Mississippi River is therefore easily explained. This area in the northern part, within the bend of the river, is mixed with more fine textured soil than in the southern part where the river flows in an almost straight line.

The belt of heavy soils extending thru the interior of the area from near Cape Girardeau to the Arkansas state line represents the old river channel. After being closed at its upper end, it received only slow flowing water which carried only fine material in suspension. The process of building up was slow and permitted the growth of rank vegetation. The decay of the latter incorporated a large amount
of organic matter and gave the soil a dark color. On the front or sandy lands, vegetation grew well, but decayed much faster, so that not so much organic matter was incorporated with the soil, leaving it as a rule lighter colored.

The second bottoms include the sand ridge in Dunklin and Stoddard counties and Sikeston Ridge in Scott and New Madrid counties. These two areas represent old river banks, and therefore owe their coarse texture to causes similar to those now acting along the present banks of the Mississippi River.

The pronounced color differences of the several lowland soils are of interest not only to the student of soils, but also to the farmer who uses them as a basis for determining the productiveness of the soil. In general, these color differences are due to differences in moisture, degree of weathering and age of the soil material. The dark color of the clay and sandy land has already been mentioned. In the case of the second bottom or ridge soils, on account of their greater age, better drainage and open texture, oxidation and leaching have progressed to an advanced degree. The iron is so completely oxidized that it has imparted to the soil a characteristic brown color. The color of the oxidized iron has taken the ascendancy over the dark color from the organic matter. Weathering has been more complete than on poorer drained first bottom soils.

The lowland soils west of Crowley's Ridge represent the old valley of the Mississippi River. They are therefore very old—much older than the soils east of the ridge, and are probably as old as the oldest Ozark soils. Their great age and poor drainage has caused excessive leaching, with the loss of iron, lime and even phosphorus. The removal of the iron, or at least the leaching of it from the upper soil to the lower strata and the failure to accumulate organic matter because of the leaching out of the lime, have resulted in the gray color of the soil and the accumulation of numerous iron concretions in the subsoil. Moreover, on account of age and leaching and the low organic content, there has been a greater translocation of the finer particles from the surface downward. The color of the lowland soils is therefore of great significance as it indicates their age, drainage condition, relative amount of leaching and the loss of fertility that they have undergone.

Most of the sandy soils of this region contain enough of the finer soil particles to make them loamy, while the heaviest clays are more easily managed than sticky clay soils of other parts of the state. Of the dark colored soils, but little difference is observed between the fertility of the heavier and lighter loams. A few cypress brakes have a surface soil of muck or humus on top of the alluvium. Such areas are of very high fertility, but their total area is small.
On the basis of color and textural differences, the soils of the lowland region have been separated into six types, belonging to four series. Only the prevailing characteristics of each type are here described, for the variations within each type are many. However, these variations are not so important agriculturally as in upland soils, owing principally to the much shallower depth of the water table and to the relatively larger amount of organic matter. Both of these factors tend to diminish the effect of differences in texture upon the moisture relations of lowland soils.

**Drainage Conditions**

There is a prevailing but erroneous opinion that practically all of the southeast lowland region is subject to overflow from the Mississippi River, and that large areas represent true swamp conditions. Only those lands lying immediately adjacent to the river and outside the levees, are subject to inundation in periods of high water, and the total area thus affected is small. The Federal Government maintains a levee extending from the Commerce Hills in the northeastern part of Scott county to the Arkansas state line which effectively guards against overflow. Breaks in these levees are rare. Such overflows as do occur within the lowland region are primarily due to numerous small streams and rivers flowing from the eastern slope of the Ozark hills. Since the fall or slope is much less in the lowland than in the territory to the north, the water received does not flow south as rapidly as it enters, and the overflow is the result. It is, however, only during the winter and spring months that water covers these poorly drained areas.

Throughout the lowland region hundreds of miles of open dredge ditches have been constructed within the last fifteen years, and many thousands of acres of the most productive land have thus been reclaimed. Large drainage projects are now in process of construction and with the completion of these, practically the entire region should be made suitable for agriculture. The largest area of undrained land is that represented in general by the Sharkey clay loam, commonly known as the Little River Valley, which has recently been organized into one drainage district. It extends from the southern part of Cape Girardeau county to the Arkansas state line, and includes approximately 500,000 acres. It is being reclaimed by the construction of more than 600 miles of open ditches and 40 miles of levee, at a total cost of approximately $5,000,000. In general, the ditches are parallel, and about one mile apart, running chiefly north and south, and having a grade of one foot per mile. The water from the upland streams, draining into this valley, is to be diverted into the Mississippi River at the north end of the district by means of large impounding basins and
diversion channels. The region to the west of Crowley's Ridge, represented by the Waverly soils, is yet only partially drained, but there too, rapid progress in reclamation is being made, so that in time the whole region will be utilized for farming.

In many cases the open ditches must be supplemented by tile drainage, particularly on the heavier soils. On the sandy lands or those underlain near the surface with a sandy substratum, tiling is rarely necessary. In general, the success and effectiveness of draining the lowland by open ditches has been established and is assured. The cost of such reclaiming varies from one to fifteen dollars per acre, depending upon the system and the benefits accruing to the land. The cost of this drainage is assessed against the land for a series of years in the nature of a ditch or drainage tax.

**LOWLAND SOIL VARIATIONS**

The lowland soils are extremely variable. It is difficult to find even a ten acre field which is of the same character throughout. Sandy spots or streaks occur commonly in the prevailingly heavier soils while the generally sandy areas are intersected by swales of lower lying land of heavier character. This variability renders a general classification of these lowland soils very difficult. It must be understood therefore that in this lowland region, to a much greater extent than in the upland sections of the state, the soil types, as indicated, represent general, rather than more specific characters.

*Sm·py Fine Sandy Loam*

The Sarpy fine sandy loam represents the frontal land along the Mississippi River south of the town of New Madrid. Much of it also occurs mixed with the heavier Sharkey soils in Eastern Mississippi county.

The texture of the Sarpy fine sandy loam ranges from fine sand to very fine sandy loam, with included areas of loam, silt loam and even some clay. Prevailing it is a fine sandy loam or loam to the extent of more than eighty per cent of the area. The color varies from gray thru brown to black with all intermediate shades. Probably the most persistent and distinguishing characteristic of the type is the texture of the subsoil, which is almost without exception a grayish brown fine sandy loam. The depth of the surface soil is about ten to fifteen inches. In general, there is no very sharp line of demarkation between soil and subsoil, and the principal difference is the somewhat lighter color and coarser texture of the latter. It is of special interest to note that while this sandy soil consists largely of rather fine sand it contains a large amount of silt, so that it is coherent and can retain a fair amount of moisture.
Probably the most conspicuous variation of the type occurs in Scott and Mississippi counties. Here are found large areas of fine sand, which do not contain enough fine material to bind the soil particles, and are therefore subject to “blowing” during dry periods. This condition has been aggravated in recent years by the continued cultivation of the land and the consequent burning out of the organic matter which acts as a binder.

Sarpy fine sandy loam in Southeast Missouri. The rather level topography and well improved condition of the country are characteristic. While some of this land lies so low as to be wet, the larger part is dry and well drained.

Thruout the area of the Sarpy find sandy loam, excepting the higher land adjacent to the river, are small mounds of sand called sand blows. These, where they have been undisturbed by cultivation, range in diameter from ten to fifty feet or more and in height from only a few inches to two or three feet. They are elongated, and have a northeast-southwest trend, which indicates their origin to have been from rapidly moving water in time of high overflow. The material of these mounds is largely quartz sand, medium to coarse in texture, averaging coarser and sharper than that of the surrounding soil.

The Sarpy fine sandy loam owes its origin to comparatively recent deposition of fine sandy sediments from Mississippi River overflows. During the period of formation there remained innumerable old stream beds, bayous and sloughs that carried water only at times of overflow. The natural levees built up along the banks of these old channels, like the banks along the river, not only caused the great variation in the soil, but also made the surface uneven. The banks form the low sandy ridges. The greater depth of water in the depressions,
and their longer submergence under such conditions, accounts for the greater accumulation of fine material on the lower ground. This in part explains the variations in texture and color of the soil in this area. The darker color is as a rule associated with the heavier soil.

The Sarpy fine sandy loam seems to carry a high proportion of available plant food in spite of the fact that the open, porous character of the soil does not offer conditions favorable to the accumulation of much organic matter. The light soil and sandy substratum facilitate drainage, allowing this land to be worked soon after a rain. The water table rarely comes near enough to the surface, even at high stages of the river, to affect crops seriously. With the exception of the very sandy areas and some of the sandy ridges the depth and fineness of the soil is sufficient to retain enough moisture to meet the demands of a growing crop in any short period of drought. There is possibly some capillary rise of water from the underlying water table, never very far below the surface, into the root zone of plants, so that drought conditions are not usually serious.

In general, the whole of the Sarpy fine sandy loam is under cultivation and includes some of the best improved land in the lowland region. All of the crops common to the region are successfully grown. In Scott and Mississippi counties, corn, wheat and cowpeas are the staples, while alfalfa, melons, sunflowers and peanuts make up the special crops. In Pemiscot and the southern part of New Madrid counties, corn, cotton and alfalfa are extensively grown. Cotton is mostly confined to the lighter soil. Excepting on very sandy areas, the Sarpy soils grow good alfalfa. The deep, porous subsoils permit good root development to great depth. Probably no other section of Missouri has made such rapid development during the last decade as the region of Sarpy soils. The influx of farmers has been mostly from the northern states, and they have brought with them improved types of agriculture which are rapidly replacing the indifferent and extravagant methods of the early settlers.

On account of the long growing season and abundant rainfall it is possible to grow two crops on the same land. Over considerable areas of this land it is common to grow wheat and cowpeas the same season. The wheat is harvested the early part of June and the ground sown to cowpeas. Usually a good yield of hay and seed is obtained. After pea harvest the land is again sown to wheat.

Truck gardening is at present of little importance but the possibilities in this line of agriculture are excellent and it only awaits the proper economic conditions for its development. Potatoes do well and
yields of 150 to 200 bushels per acre are obtained. Watermelons are very extensively grown on the lighter phases of this sand, and they form one of the important money crops in this region.

Grasses and clovers have been greatly neglected. This is partly because the agriculture has been based upon grain and cowpea growing rather than upon livestock farming, and partly because it is rather difficult to get stands of these crops on this sandy land. In recent years, however, the cowpea wilt has made its appearance in this section and as this develops it will doubtless be necessary to give greater attention to clovers, soybeans and other legumes for maintaining the soil. While it is true that it is only on the heavier areas of this sandy land that timothy and common tame grasses do well, experiments have shown that Bermuda grasses will make a very dense sod and excellent pasture. Unfortunately this grass does not lend itself well to use on rotated land as it is difficult to eradicate, but where lands are left in permanent pasture it will give good results.

Few other soils in Missouri are adapted to a greater diversity of crops than these Sarpy soils. They still offer much in the way of development, not only for grain and special crop farming but for stock raising and for truck farming. Land values are variable, depending upon the drainage, location and the improvement of the land. Prices range from $30 in the uncleared, poorly drained areas to $150 and even $200 an acre, in the highly improved areas near the larger towns.

The composition of this soil is shown in Table 26.

| Table 26.—Composition of Sarpy Fine Sandy Loam  
(Average of 6 analyses) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
</tr>
<tr>
<td>lbs.</td>
</tr>
<tr>
<td>In 2,000,000 pounds of soil...</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
</tr>
</tbody>
</table>

The plant food content of this soil does not indicate its real agricultural value. Its depth and its alluvial nature, together with the water bearing layer of sand at no great distance from the surface, give it a productivity above that of upland soils of similar composition. Experiments on this soil have shown that it responds principally to organic matter and nitrogen; turning under cowpeas brings large returns. As cowpeas can readily be grown between regular grain crops, with no great loss of use of the land, it is perfectly feasible to grow them occasionally for turning under. Some such means of adding to
the stock of nitrogen and organic matter in the soil is essential for best results. The more sandy the land, the greater the need of special attention to this matter. This is the most important point in soil management on this land. Too many farmers have been handling the land under a system of removing everything, even the peas. Such a system should be replaced by one providing for crop rotation and growing legumes, such as cowpeas, soybeans and others, an occasional crop of which should be turned under. Experiments indicate that the use of fertilizers except on melons or other special crops is not accompanied by as high returns as on the upland soils of similar composition. The soil needs little lime.

_Lintonia Silt Loam_

The principal area of Lintonia silt loam forms one of the most pronounced physiographic divisions of the Lowland region—the Sikeston Ridge. Other smaller areas are found in Stoddard, Scott and Dunklin counties. The Sikeston Ridge, extending from near the center of Scott county to New Madrid in New Madrid county, varies in width from three miles near the northern end to six miles near the southern extremity. On the west side the ridge is marked by an abrupt off-set of twenty to thirty feet to the level of the lower bottoms, but on the east it grades rather gradually into the Sarpy soils.

The surface soil of the Lintonia silt loam consists of a brown or grayish brown silt loam or fine sandy loam to a depth of ten to fifteen inches. The subsoil is a light brown to grayish brown silt loam or silty clay, mottled brown and gray in the lower portion. In general, the soil on the west side of the ridge is siltier than that on the east side. Numerous areas of sandy soil are found, in some respects resembling the “sand blows” of the Sarpy soils, and varying in extent from a few square rods to several acres. The sandy surface soil is usually associated with a sandy subsoil, but in many places the latter is almost sand free. The occasional shallow, pond-like depressions, and shallow swales, or abandoned bayous, have light gray surface soils with gray or drab clay subsoils. These areas, while small in extent, are much inferior to the main type, and resemble the Waverly soils.

The Lintonia silt loam represents outwash from the loess hills, probably from Scott and Cape Girardeau counties, which became intermingled with sand during the process of deposition. The soil is loamier and the subsoil not so compact as that of the hill soils, which affects to some extent its moisture holding capacity. In some of the exposed cuts and banks the soil material resembles in every way the typical loess deposits, and were it not for the intermixed sand and evi-
dences of stratification in the substratum, this soil could not be distinguished from the upland.

On account of the relatively high position, and sandy substratum, both surface and underdrainage are good. Aeration is effective to great depths and this is doubtless the chief cause of the high degree of oxidation of the iron and the rapid decay and comparatively small accumulation of organic matter in the soil.

The Lintonia loam of the famous Sikeston Ridge country in Southeast Missouri. This is a region devoted largely to grain farming. It is one of the most completely utilized agricultural regions in the state, practically every acre of the land being cultivated.

The Lintonia silt loam is one of the oldest, if not the oldest, settled soils in the state. A large area of the type is divided into grants which were donated to the early settlers during the Spanish regime. Cotton, corn and wheat were formerly the principal crops, but on the Sikeston Ridge cotton is now little grown. Small grains, corn and cow-peas are now the most important crops. In general, the Lintonia silt loam is a highly desirable soil for general farming. It represents the highest priced land in the lowland region. Prices range from $100 to $150 per acre, while near Sikeston the land is held at $200 to $250 an acre. These high values are due not only to the desirable qualities of the soil, good drainage, and transportation facilities, but to the fact that much of the land is held by wealthy owners who have given it a high social value.

The composition of this soil as shown by a single analysis is given in Table 27.
Table 27.—Composition of Lintonia Silt Loam
(One analysis only)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>1640</td>
<td>1280</td>
<td>37525</td>
<td>2135</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>860</td>
<td>2740</td>
<td>34700</td>
<td>4500</td>
</tr>
</tbody>
</table>

This soil is somewhat low in nitrogen and organic matter. The use of cowpeas, which has been common for many years, has not maintained the soil in these constituents since the peas are almost always removed. The turning of an occasional pea crop or the use of more clover would help to remedy this difficulty. On the older farmed areas the use of phosphates would give results, altho the uniform character of this material to considerable depths gives it a productivity much greater than the content of phosphorus would indicate. On some areas liming would be beneficial. Since this soil is given over very largely to grain growing, more cowpeas turned under, more clover or more livestock would give greater final returns from the land.

_Lintonia Fine Sandy Loam_

The Lintonia fine sandy loam like the Lintonia silt loam, represents a distinct physiographic area of the lowland region—the Dunklin Sandy Ridge. It begins near Dexter in Stoddard county and extends south thru Dunklin county to the Arkansas line. In the northern part it varies from four to six miles wide, but south of Kennett it is twelve to fourteen miles wide. As already stated, this ridge is a second bottom, standing from ten to twenty-five feet above the first bottom to the east. On the west it is bordered by Crowley’s Ridge and the first bottoms along the St. Francois River. Numerous other small areas occur in Ripley county and in the northern part of Stoddard county, but only those in the latter location are of sufficient extent to show on the soil map.

While this soil is dominantly a fine sandy loam, there are included in it areas of fine sand and loam. The surface soil varies from twelve to twenty inches in depth and is of a brown or dark brown color. The subsoil is very similar to the surface soil, but is somewhat lighter in color and usually contains slightly more clay—especially in the lower portion.

In general, the Lintonia fine sandy loam becomes heavier from east to west. Along the eastern edge of the ridge, the soil is a brown, loose, incoherent fine sand of about the same texture and color thru-
out the soil section. It contains so little fine material and is so loose, that it is subject to drifting or blowing. To the west of this light sandy phase, the typical fine sandy loam prevails. It consists of a dark brown fine sandy loam, underlain at about twenty to twenty-four inches by a yellowish brown friable silty clay or fine sandy clay subsoil. Along the western edge of the ridge the heavy subsoil lies somewhat nearer the surface, and is lighter in color due to poorer drainage. The heavier texture of the subsoil is no doubt due to filtration, a process that readily occurs in such open soils. However, the relatively small amount of material that is of a clay texture, explains why the subsoil is rarely heavier than a silty clay and is heaviest where the surface soil contains a higher per cent of fine material.

Probably the most pronounced characteristic of the Lintonia soils is their distinct brown color. This is due to the high degree of oxidation of the iron associated with good aeration and drainage. For the same reasons the content of organic matter is not very high and is not present in sufficient quantity to conceal the brown coloration of the iron. In this respect the Lintonia fine sandy loam differs from the Sarpy soil of the same texture. The latter, on account of a higher per cent of fine material, and somewhat poorer drainage and aeration, contains a much larger amount of organic matter, and is not as thoroughly oxidized as the former. It is possible, too, that this difference is intensified somewhat by the greater age of the Lintonia soil.

The surface of the Lintonia fine sandy loam, with the exception of faint undulations, is nearly level. Slight mounds and low ridges from a few inches to several feet in height occur, as well as slight depressions, representing old overflow channels. The soil in the latter is a gray loam with gray sandy clay subsoil, mottled brown and gray. In origin the Lintonia fine sandy loam is the same as the silt loam type. Drainage is good except in the swales, found most extensively in the western part of the area.

Like the Sikeston Ridge, the Dunklin Sandy Ridge has been settled and farmed for a long time. Cotton is by far the most important crop and the acreage devoted to it is probably greater than that on any other lowland type. Yields range from one-half to one and one-half bales per acre. The quality of the lint is high. Corn, cowpeas, and melons are extensively grown. Alfalfa does well where drainage conditions are good and where the soil is not too coarse in texture. Potatoes, peanuts, truck and other crops which require a warm light soil, are successfully grown. Land values range from $20 on the undrained land to $100 or more on the better improved areas.

In Table 28 is given the composition of the Lintonia fine sandy loam.
The low content of nitrogen is particularly apparent, while the phosphorus supply is likewise deficient. The soil has lost much of its nitrogen thru excessive cotton and grain growing. The desirability of growing winter cover crops and legumes for turning under is being realized, and progress is being made in that direction. This is the great need of the land. The ease with which various green manures can be produced on this worn land during the long seasons and the little loss of time resulting where these can be grown between the regular crops, make it possible to improve the soil with comparatively little expense. Fertilizers are being used to some extent on cotton. Undoubtedly the use of phosphates will be found to increase the yield and hasten maturity so that their use is very likely to increase.

Table 28.—Composition of Lintonia Fine Sandy Loam
(Average of 8 analyses)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil . . .</td>
<td>1680</td>
<td>1035</td>
<td>31240</td>
<td>500</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil</td>
<td>950</td>
<td>1085</td>
<td>32440</td>
<td>1365</td>
</tr>
</tbody>
</table>
Sharkey Clay Loam

The Sharkey clay loam forms the belt of heavy soil extending from Cape Girardeau county thru the center of the lowland region to the Arkansas state line. The region lying along the upper course of the Mississippi has been included in this type since it contains much fine-textured, low-lying soil of Sharkey clay loam character. It also contains large areas of the Sarpy soil. It should be said that the soils of such a large area have considerable variation, and only the general soil characteristics can here be described.

The typical Sharkey clay loam consists of a black, drab or dark gray silty clay to clay loam underlain at depths varying from eight to fifteen inches by drab to bluish gray, heavy, plastic clay loam or sandy clay usually mottled with rusty brown. The gradation from soil to subsoil is not distinct and frequently there is little change in color or texture throughout the soil section. The surface soil contains a rather large amount of organic matter, which makes it fairly friable. The surface two or three inches almost everywhere contain a small amount of sand, which in places is present in sufficient quantity to give a loamy texture. The close structure of the subsoil makes aeration imperfect, resulting in only a faint development of brown mottlings, but wherever these extend to a depth of two feet or more, there is a decided tendency of the material to be granular. Such a condition is preferable to that where the light bluish gray coloration prevails, for in the latter the underdrainage is extremely slow, altho in no instance does the material seem to be entirely impervious. On the borders of the areas of Sharkey clay the depth to the sandy substratum is not more than a few feet, but in the interior where the accumulations of clay are deeper, the depth to coarse textured material is correspondingly greater.

In the southern part of Stoddard county and in New Madrid county, much of the Sharkey clay loam occupies the wide, shallow swales or depressions, varying from a few rods to one or more miles in width. The soil in these is a deep black, waxy clay loam with black to bluish black clay subsoil. It consists of the finest sediment and contains a very high per cent of clay. The content of organic matter is considerably higher than for the type as a whole, and in restricted areas—a long the east side of Dunklin Ridge, the west side of Sikeston Ridge and the northern part of Stoddard county it is almost a muck soil. These black soil areas usually extend in a north and south direction, and represent the lowest land in the entire lowland region. They possess almost true swamp characteristics, and are for the most part subject to prolonged overflows, even serving as natural drainage ways. The timber growth on these areas consists almost exclusively of cy-
press, ash and tupelo gum. Such areas as have been drained have been found exceedingly productive, and are used largely for corn.

In general the Sharkey clay loam in Cape Girardeau, Stoddard and Scott counties averages darker in color and contains more organic matter than the area to the south. This is probably due to the more recent deposits brought down by the streams from the upland. In many respects this dark soil is like the Wabash soil in the northern part of the state. In most instances the transition from the Sharkey soil to the lighter soils on the east is marked by numerous small sand and silty ridges surrounded by moderately heavy soil. Such phases are higher, more easily tilled, and considerably earlier than the lower ground.

The Sharkey clay loam is more easily cultivated than the Wabash clay loam. As a rule the soil improves in physical condition after being cultivated a few years. If properly handled in the field it mellows down and assumes the tilth of a heavy silt loam. Cultivation can be performed with comparative ease under a wider range of moisture conditions than on most soils of a corresponding texture. If plowed wet it becomes hard and intractable, yet it will mellow down with alternate wetting and drying in the early spring so that little trouble will ordinarily be experienced in securing good tilth.

The surface is flat to slightly hummocky, but frequently there is very little or no difference between the soil on the hummocks and that in the depressions. Locally the Sharkey clay loam is termed "swamp"
because it is lowlying and subject to overflow from local rains or from the Ozark streams. Drainage is necessary before the land can be cultivated. Many ditches have already been constructed, and with the completion of the Little River drainage project practically all of the type can be utilized. There is little doubt that in time this vast area of heavy soil will be as valuable and productive as any part of the lowland region.

In its natural fertility the Sharkey clay loam is similar to the Wabash soils. Practically all of the cultivated land is used for corn production, and the yields obtained indicate the adaptability of the soil to this crop. As a grass soil it is superior to any of the lowland types. Red clover, alfalfa and various forage crops have been tried to a limited extent, with good results. In favorable seasons, cotton yields from one to two bales per acre, but frequently the plants make such a rank vegetative growth that they do not mature properly before the early fall frosts.

Land values are at present determined largely by the drainage conditions. Undrained, cut-over-timber land is held at $20 to $40 per acre. Drained and cultivated land sells at $50 to $90 per acre. Practically all of the land is subject to drainage tax, varying from twenty cents to one dollar per acre per annum, such taxes usually running for a period of twenty years.

The composition of this soil is shown in Table 29.

**Table 29.—Composition of Sharkey Clay Loam**

(Average of 5 analyses)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>3180</td>
<td>2135</td>
<td>29095</td>
<td>1560</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
<td>1470</td>
<td>1450</td>
<td>25890</td>
<td>0</td>
</tr>
</tbody>
</table>

It will be seen that the total amount of plant food in this soil is high. It is one of the most fertile soils in the state. The principal problem is that of drainage. When the region is thoroly drained there is no reason why this land will not become very productive.

**Waverly Silt Loam**

The Waverly silt loam includes practically all of the western part of the lowland region, between Crowley's Ridge and the main body of the upland. The type is easily distinguished from the other alluvial soils by the lighter color, the silty texture of the soil and the smaller
timber. The latter consists primarily of oak, elm and hickory but contains little gum, cypress, ash, catalpa or hackberry so characteristic of the east lowlands. Included with the Waverly silt loam are members of the closely related Calhoun and Olivier series.

The typical soil is a light gray to dark gray, compact silt loam or silty clay, which grades at a depth of 6 to 10 inches into a light gray to almost white silt loam mottled with rusty brown and containing small iron concretions. The subsoil below 15 or 18 inches is almost uni-

The Waverly silt loam of the western part of the lowlands of Southeast Missouri. The level topography and the presence of considerable timber is characteristic. The gray color of the soil is seen thru the scattered weed growth on this field.

formly a light gray or drab, plastic, impervious silty clay or clay, mottled with brown and yellow. Where the surface soil is a silt loam, the heavy subsoil is not reached until about 24 inches, but where the surface averages a silty clay, the subsoil is correspondingly heavier, and generally lies within 15 inches of the surface. The light gray subsurface layer is always present and is most highly developed in the silty soil, but it may be absent or only faintly developed in the heavier areas.

That portion of the Waverly silt loam lying between the northern part of Crowley’s Ridge and the main upland, consists largely of recent alluvium, having been brought down by the Ozark streams that enter the lowland at this place. The soil is silty to a great depth, contains considerable organic matter, and in general does not have the leached appearance of the older soils to the south. Much of this area possesses almost true swamp or bog characteristics. The outer edge of these bogs is covered with cypress and ash, but in the center there is either open water or flags and water loving grasses. When drained the soil
will be similar to the surrounding Waverly silt loam, but will contain a much higher percentage of organic matter.

Throughout the Waverly silt loam, particularly near Crowley's Ridge there are places where the surface soil to varying depths is brown like that of the Lintonia soils. Where these areas are small and shallow, they are always underlain by the characteristic gray and heavy subsoil of the Waverly. Other areas, usually shallow basins, carry so many iron concretions or “buckshot” on the surface and throughout the soil section that they are called “gravelly crayfish land”. Along the St. Francois and Black rivers are many hummocks or low elongated ridges of a brownish sandy loam similar to the Lintonia soil.

The main portion of the Waverly silt loam must be considered a terrace soil, which was formed in the same way and probably at the same time, as the Lintonia soils. The soils of the two series are vastly different, however, due to the character of the material deposited, and the moisture conditions under which they existed. There is no question that the Waverly silt loam is largely of local origin, washed down from the adjoining uplands and therefore consists of reworked loess.

The present characteristics of the soil are doubtless due to drainage and the consequent leaching and filtration of the clay particles into the lower subsoil. The alternate wetting and drying of the soil, in the presence of decaying organic matter is the direct cause of the gray color and the abundance of iron oxide concretions. Normal oxidation, which in this region gives a uniform brown color to a soil, was prevented by the very poor aeration. The surface soil is lighter-colored
—white when dry—in those places where the subsoil is heaviest and most intractable. The accumulation of iron in the substratum, in many places, cements the soil particles and forms a hardpan.

It is the prevailing opinion among farmers that when this soil is drained and thoroly cultivated, it becomes darker in color, more friable and more productive. This no doubt is due to the better aeration and consequent oxidation. In the heavier areas of these soils, however, the surface soil is subject to much packing and crusting even after cultivation for a number of years. It is also natural that a soil so thoroly leached should show an acid condition, particularly in the surface soil.

Less than fifty per cent of the Waverly silt loam is cleared and in cultivation. Large areas yet remain undrained, and not until drainage is provided can the land be cultivated. In years of normal rainfall, fair to good returns are obtained from corn and wheat, but damage occasioned by wet seasons lowers the average yield considerably. It cannot be considered a good corn soil, but it best adapted to wheat, peas and grass, and it is on these crops that the future agriculture of the type will probably depend. Attempts at growing rice have been reasonably successful, and it is probable that this industry can be extended with profit. Land values vary with location, drainage and improvements from $20 to $50 an acre.

The composition of this soil is shown in Table 30.

Table 30.—Composition of Waverly Silt Loam
(Average of 3 analyses)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil...</td>
<td>2240</td>
<td>945</td>
<td>30805</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil...</td>
<td>955</td>
<td>755</td>
<td>28365</td>
</tr>
</tbody>
</table>

The analyses show the soil to be low in phosphorus and fairly low in nitrogen, with a medium lime need. The depth of the alluvial deposit, however, gives the soil greater productive capacity than the analyses would indicate. While little experimental evidence as to the economic use of phosphates on this land is available there is little doubt that for grain crops such applications would materially increase yields, probably with good economic return. The ease with which cow-peas can be produced makes it possible to control the supply of nitrogen. With proper drainage, clovers, especially alsike clover, should
give good results also. At present the drainage of most of this land is entirely inadequate and there is little doubt that much of it must be tile drained after the surface drains have been installed.

This soil cannot be classed as very fertile. This is especially true of the lighter colored areas, some of which are almost chalk-like in color when dry. The buckshot which occurs in quantities in the under soil, shows the long continued water logged condition to which the soil has been subjected. With thorough drainage, the incorporation of organic matter thru turning under those legumes which are adapted to this soil, and thru systems of rotation, liming and in some cases thru the use of phosphates, these lands may be made quite productive. The fact that rice has been successfully grown on some areas of this land indicates special possibilities which may greatly influence its future development.

Waverly Fine Sandy Loam

The Waverly fine sandy loam is found in Stoddard county east of Crowley’s Ridge, and in the southeastern part of Ripley county. It consists of a grayish brown to yellowish gray, fine sandy loam to very fine sandy loam, grading at about 8 to 12 inches into yellowish brown, rather compact, fine sandy loam. The subsoil from 18 to 36 inches is sandy clay, sometimes more or less stratified as sandy and clay layers. The Ripley county area averages considerably lighter in color than the Stoddard area and usually shows a rather distinct demarkation between soil, subsurface and subsoil. The latter contains many iron concretions, and in places has true hardpan cementation in the lower portion. The surface soil has a tendency to become compact and form a crust, and when in this condition appears much heavier than it really is.

The Waverly fine sandy loam includes slight rises or ridges that stand as much as one to three feet above the lowest land. These are the natural levees along the present bayous or the remnants of former stream fronts. That portion of the type in Stoddard county is first bottom and probably was deposited when the Sharkey soil was formed. The Ripley county area is undoubtedly of the same age as the Waverly silt loam, and existing under similar conditions, has become thoroughly leached. Most of this area is subject to annual overflow which comes in from the Black River.

In Stoddard county most of the type has been drained, and is in cultivation. It is a good agricultural soil, well suited to corn, cotton and forage crops. Wheat is extensively grown and averages 18 to 25 bushels per acre. Clover and cowpeas do well when the soil is thoroughly drained. Potatoes and various truck crops are successfully grown.
The Ripley county area of the Waverly fine sandy loam is now being drained and will be cleared within a few years. Cultivated areas are used for corn, timothy and cowpeas. The yields are much lower than in Stoddard county, due to poorer drainage.

The composition of this soil is shown in Table 31.

The better drained and better improved land in the region occupied by the Waverly fine sandy loam. Poorly drained areas are occupied by the timber shown in the background.

| Table 31.—Composition of Waverly Fine Sandy Loam
<table>
<thead>
<tr>
<th>(Average of 7 analyses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2,000,000 pounds of soil....</td>
</tr>
<tr>
<td>In 2,000,000 pounds of subsoil..</td>
</tr>
</tbody>
</table>

The nitrogen deficiency is the most important one on this soil, altho the need of lime is rather marked for alluvial land. The nitrogen content may rather readily be controlled as in the case of the Waverly silt loam. The sandy nature of the land makes drainage more easily brought about than in the former soil.
Statistical Data Relating to Missouri Agriculture

The maps and charts shown on the following pages have been compiled largely from census data. They show in graphic form certain facts which are of importance to men interested in Missouri agriculture. As most of the material has been summarized by counties the information bears more or less directly on agricultural regions and soil areas.

AMOUNT OF FERTILIZERS
USED IN TONS - 1916.

- 2000 tons and over
- 1500 - 2000 tons
- 1000 - 1500 tons
- 500 - 1000 tons
- 1 - 500 tons
- None
PER CENT OF IMPROVED LAND PER COUNTY.

- 80 per cent and over
- 60-80 per cent
- 40-60 per cent
- 20-40 per cent
- Less than 20

MAP OF MISSOURI

SHOWING AVERAGE VALUE OF FARM LAND PER ACRE.

AVERAGE $1.25
U.S. CENSUS 1910

- $100 and over
- $75 to $100
- $50 to $75
- $25 to $50
- Less than $25
THE SOILS OF MISSOURI

INCREASE IN AVERAGE VALUE OF LAND PER ACRE 1900 - 1910.

MAP OF MISSOURI ANALYZING AVERAGE VALUE OF ALL PROPERTY PER FARM.

AVERAGE 1910
U.S. CENSUS 1910
AVGAE ACREAGE OF CORN 1906-1916.

- 115,000 acres and over
- 85,000-115,000 acres
- 55,000-85,000 acres
- 25,000-55,000 acres
- Less than 25,000.

YIELD OF CORN IN BUSHELS PER ACRE.

- 32 bushels and over
- 28-32 bushels
- 24-28 bushels
- 20-24 bushels
- Less than 20.
AVERAGE ACREAGE OF WHEAT 1906-1916

YIELD OF WHEAT IN BUSHELS PER ACRE.
APPLE ACREAGE

- 4000 acres and over
- 2000-4000 acres
- 1000-2000 acres
- 500-1000 acres
- Less than 500

AVERAGE ACREAGE OF TAME HAY
1906-1916.

- 55,000 acres and over
- 40,000-55,000 acres
- 25,000-40,000 acres
- 10,000-25,000 acres
- Less than 10,000.

Comparative Values of Missouri Farm Products for 1909 Computed from 1910 Census.