THE SOILS OF MISSOURI

by

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THE SOILS OF MISSOURI

The increasing demands for the production of larger crops have made apparent the need of a greater knowledge concerning soils. Without such knowledge the investigational work on soils conducted by Agricultural Experiment Stations and individuals will lose much of its significance. No definite conclusions can be drawn from the results of the experiments unless the character and the distribution of the soil has been determined. More than 130 soil types have already been discovered in the progress of the soil survey work in Missouri. The existence of such a great number of types makes evident the need of a study of their differences and relations, in order that their influence upon the growth of plants may be understood.

In the variableness of soil conditions, few states are comparable to Missouri. In fact, it may be considered the meeting ground of all the important soil regions of the Mississippi Valley. Thus, the extensive areas of glacial and loessal soil of the northern part of the State are closely related to the glacial regions of the states to the north and east. The prairies of western Missouri form the eastern edge of the Great Plains region extending west to the Rocky Mountains. The limestone soils of the Ozark region are comparable to the soils of similar origin in Arkansas, Kentucky, and Tennessee. The southeast Lowlands represent the northern

extension of the costal plains region of the southern states. The resultant of such varied soil conditions is a varied agriculture. It can be said of the latter that it is neither northern nor southern, eastern nor western, but possesses the characteristics of all of these. To make possible, therefore, a greater agricultural development of the State, accurate and detailed knowledge of the soil,--its character, varieties, capabilities and adaptations--is of great importance.

Object of Reconnaissance Survey

It is the purpose of this thesis to describe briefly the origin, distribution, and character of the soils in the different parts of the State, as determined by extensive field and laboratory studies and experiments, and to show their composition, utilization, management and adaptations. A special effort has been made to indicate the causes of the characteristics of each soil type PER SE, and the causes for the variations of the soils of the State as a whole.

Previous Work

Practically all the early work on the soils of Missouri was by geologists, and the early writings appear in various geological reports and publications. One of the earliest and most prolific contributors was G. C. Swallow, who in 1855 described in a general way the soils of Missouri, and also classified them by their indigenous trees and other plants⁽¹⁾. A general description of Missouri soils by G. C. Broadhead appeared in 1874⁽²⁾. Numerous other geological workers made mention of

the general soil characters of each area covered by a geological survey⁽³⁾. It is interesting to note in this connection that in these early writings little effort was made to show the origin of the soils, much less to base their classification on geological origin.

The beginning of a systematic classification and mapping of the soils of Missouri dates back to 1902 when the U. S. Bureau of Soils made a detailed soil survey of Howell county. In 1905 the Missouri soil survey was organized and in 1909 a plan of cooperation between the Missouri soil survey and the U. S. Bureau of Soils was agreed upon. Since that time all soil survey work in the State has been done by these two organizations working cooperatively.

The first general soil map of the State was made by Prof. Marbut in 1904 for the Louisiana Purchase Exposition⁽⁴⁾. The divisions were very general, and only the broad physiographic areas were recognized. While geology forms the principal basis of the classification, other factors such as texture, color, percentage of stone, and topography were also taken into consideration.

A regional soil map of the Ozarks⁽⁵⁾ was published in 1910, and a revision and amplification of the same in 1914⁽⁶⁾. Here again geology forms the principal basis of classification.

From this brief resume of the more important work which has been done in classifying the soils of Missouri, it can be seen that this line of soil study has been carried on for a considerable time, and has been undergoing a constant development.

Physiography

To furnish a clearer understanding of the soils of Missouri, a brief discussion of the factors determining their variableness and distribution will be given. The most important of these are geology and topography; the former determines the origin and character, while the latter determines to a large extent the economic utilization of the soil. (The relation of soils to climate and to vegetation is appreciated, but such changes as have been produced by these factors will be discussed in connection with the description of each soil type.)

Geology

The geological history of Missouri is complex both in age and composition. In southeastern Missouri 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, being for the most part covered 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 lowest geologically (Plate I). 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 Pre-Cambrian, Cambrian, Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian systems. In the following table⁽⁷⁾ are given in tabular form, beginning with the highest, a few of the most important horizons of these various formations.

<u>System</u>	<u>Formation</u>
Quaternary	Alluvium Iowan Loess
Tertiary	Lafayette gravel
Pennsylvanian	Missourian Des Moines
Mississippian	Chester St. Louis Spergen Warsaw Keokuk Burlington Chouteau Hannibal Louisiana
Devonian	Grand Tower Clear Creek
Silurian	Bailey Bainbridge
Ordovician	Kimmewick Plattin (Trenton) Joachim St. Peters
Upper Cambrian (Ozarkian of E. O. Ulrich)	Jefferson City Roubidoux (Incl. Bolin sandstone) Gasconade (Incl. Gunter sandstone) Proctor Eminence Potosi
Middle Cambrian (Taconic or Cambrian, restricted, of E. O. Ulrich)	Elvins Bonneterre Lamotte
Pre-Cambrian	Diabase Granite Rhyolite

Plate 1

The processes of deformation and erosion have been such as to cause these several beds to occur in this form. 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. (Plate II)(8a). In consequence of this uplift, erosion was accelerated with the result that the overlying rocks were stripped from the Ozark dome. The erosion was long and vigorous so that hundreds of feet of rock were removed and in the area of greatest uplift the old floor of igneous rocks was exposed. The process, indeed, is still in progress. The higher and younger rocks thus originally extended across the Ozarks, but have receded scores of miles from the center of 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. Marked peculiarities of soils can generally be traced to similar geological causes.

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 southern Missouri included in the Ozark region, therefore, is essentially a region of limestone rocks. Some

Plate II

Ideal
Geological
Section of
Missouri.

(Emerson-Modified by Branson)

(50)

□ Quaternary and Tertiary	▤ Devonian
▨ Pennsylvanian	▧ Cambrian-Ordovician-Silurian
▩ Mississippian	▦ Pre-Cambrian

Geological Section (Northwest-Southeast)
of Missouri

beds are pure carbonates or practically so, but the majority contain a high percentage of siliceous matter. Some beds, in fact, have been wholly replaced by silica in the form of chert.

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 southwestern and northeastern 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 underlaid by Carboniferous rocks. The lower beds of these consist chiefly of shales and sandstones, and the soils they form are either clayey or sandy. 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 northern 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 10 to 200 feet in thickness, consisting of the ground up material of the underlying shales, limestones, and sandstones, together with the clay and boulders brought down by the ice. Where the basal material consisted largely of shales and sandstones of the lower Carboniferous the soil is argillaceous, but where the limestone predominated the till became quite calcareous. This condition, together with the varying thickness of drift deposit, are of great importance in determining the character of the soil as will be subsequently pointed out.

Succeeding the period of glaciation, there was spread over the entire glaciated area, and for a short 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 or more, but gradually thins out away from the streams. In the northwestern part of the State it is of great depth over large areas.

The unconsolidated materials in the southeastern part of the State belong to the Tertiary and Quaternary. They consist of clay, sand and gravel, but are nearly everywhere covered by recent alluvium.

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 geological province, but also represents a physiographic unit. The prairie plains of western Missouri and the glacial area of the northern part of the State each possess distinct geologic and physiographic features.

Topographically Missouri is naturally divided into four great provinces--North Missouri glacial region, West Missouri prairie, Ozark region, and Southeast Lowlands (Plate III).

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 anticipated the broad costal plains of the Southern States.

North Missouri Glacial Region

This region, in Pleistocene times, immediately after the deposition of the glacial till, was a broad, relatively smooth

Physiographic Provinces of Missouri

(Marbut)

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 widespread degradation of the country may be seen in the broad divides, of which the most extensive is the flat 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, being broken only by small drainage channels barely sufficient to dispose of the water after heavy rains.

To the east and south this plain 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 of 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 thickly than in any other part of the State, and there are no extensive areas that are not eroded by streams so as to give some variety to the topography. This rolling area is the triangular region having Grand River, 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 depth. There are large areas many miles in extent that have a billowy surface, which insures ideal surface drainage. Over the greater part of this region is spread the loess, which gives the pleasing contour characteristics of this material wherever it occurs in a humid region and has not been exposed to excessive erosion. The belt of eroded country bordering the Missouri River is almost down to grade, and therefore has few slopes that are too steep for cultivation.

In general, the topography of the glacial region is constructive in origin, and the smoothness is that of new erosion.

West 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 rocks of the underlying formations. The latter consist largely of shales, limestones, and sandstones, which dip to the northwest at a very low angle. From such a structure is derived the 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 is very frequent alternation of limestones with shale, and the resultant surface is more rolling or undulating. In the remainder of the prairie region, wide, gentle sloped valleys, streams with gentle grades and broad flood plains, and broad, rounded divides are characteristic. The main streams have few laterals, and have not extended their tributaries to drain the entire surface of the flat divides. In short, it is a mature topography,--a smoothness of long continued erosion.(8)

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 Western Prairie and Eastern Lowland regions. Its boundaries on the south, east, and north are the Arkansas State line, the Mississippi and the Missouri Rivers respectively. The western boundary extends from near the northwestern corner of Cooper County in a southwesterly direction to the southwest corner of Jasper County.

The region as a whole is higher and more dissected than the adjoining prairies to the north and west. It has been subjected to erosion for a long period of time, and has reached the mature stage of topographic development. 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. (Plate IV).

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 geographic center but the geologic 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 mere gorges, and few of them have alluvial belts wide enough for even small farms. 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 tend 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.

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 intrestream 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 becomes 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, Christian, 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 hilly to rolling. The former prevails along the streams and rivers, while the latter includes the broad divides and plateaus. Probably the most extensive area of rough land is in the extreme southwest corner of the State, in the drainage region of the White River. The surface everywhere is hilly, but the valleys are not so deep and have more gradual slopes than those of the region to the east. 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 of the Ozark border along the Missouri and Mississippi Rivers is rolling to hilly, but by far the greater part of it is not too steep for cultivation. The hilly areas are most extensive in Osage, Jefferson, and Ste Genevieve Counties, where the belt is crossed by the Gasconade, Meramec 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. It is set off from the Ozark region by a distinct bluff line,

varying from 25 to 150 feet in height, and extending from Cape Girardeau southwestward to the State line in southeastern Ripley County. The lowland region as a whole is a broad flat plain, with a gentle slope to the south. With few exception the surface variations are not more than ten feet, which explains why large areas have poor surface drainage. The two prominent features of the Lowland are Crowleys Ridge and Commerce Hills, remnants of an old upland, that stand 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. Crowleys 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 extends 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 (500 to 700 feet) in altitude for a given area. In general, the average altitude of the Ozark region as a whole, is about the same as the average altitude of northern Missouri (Plate V).

The highest portion of 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 flat 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 and Taney Counties 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 the elevation northwestward. The central part of the region lies near the 900 and 1000 feet contour levels. The west 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 southeast Lowlands varies from 300 to 350 feet, the higher areas occurring in the northern part of the region.

SOILS

General Description

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 only the surface portion of this material that concerns the agriculturist most, 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 small grains penetrate marks the depth of the soil or surface soil. In the case of many alluvial soils the surface soil may extend to a depth of two, three, or more feet, but on the uplands it will probably not average over twelve inches in depth. The subsoil is usually lighter in color and more compact than the surface soil. This is primarily due to a lack of organic matter and to filtration of clay. An increase of the surface soil may be secured by gradually increasing the depth of plowing, thus permitting the deeper incorporation of organic matter and the action of air.

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 below. This

layer is called subsurface. 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. In such cases where the lower subsoil consists of gravel or coarse stone, the finer material above is frequently considered as subsurface, but unless this material differs from the fine material in the lower stratum it is usually classed as subsoil. At some experiment stations it has been customary in sampling soils to consider the top 7 or 8 inches as soil, the layer from this so-called soil down to 20 inches as subsurface soil, and from 20 to 40 inches 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 change in color to 36 inches as subsoil.

All soil descriptions in this thesis 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. This arbitrary depth of three feet is adopted because the substratum is usually similar in its characteristics to the lower subsoil, at a depth of 36 inches, and a description of the latter also will apply to the former.

Soil Classification

By virtue of the great variation in geological formations and conditions, and the resultant variable topographic features, the soils of Missouri present extreme variations in their various characteristics. However, a study of these variations will show that certain regions possess certain similarities and when such similarities have a well defined relation they form a basis for grouping the soils. In general, the nature of the soils of a given region is intimately related to the kind of bedrock from which they have been derived and to the particular processes by which the rock has been disintegrated and deposited in its present position. Thus the soils of the Ozark region have relationship in that they are derived from limestones, and almost universally contain more or less gravel; the soils of northern Missouri have the common characteristic of being glacial in origin or the result of glacial action. In brief, similar geological causes will result in the soils having marked peculiarities. 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 it was 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 glacial deposition. It has been found that by this grouping soils closely related from a geologic standpoint also have close relation from an agricultural standpoint.

Based on the physical properties of the soil, such as color, texture, content of organic matter, etc., 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 are added the descriptive terms of the soil class, such as Shelby loam, Bates fine sandy loam. The soil unit is the soil type. It is uniform in all the above characteristics in all places where it is found. This classification of soils is according to that in use by the U. S. Bureau of Soils.

All soil areas that are essentially the same in their characteristics and properties have been included in the same soil type. It is to be remembered, however, that variations in the productiveness due to different treatments are not a basis for separating soils into types. It is only the inherent or static fertility, or the characteristics that do not undergo great changes that are considered in soil differentiation.

In a reconnaissance it is not possible to make as fine separations as in a detailed survey, and the material mapped

as a type must necessarily often include wider variations in character, and many small areas of other types have to be shown in one color on the map. In general, the soil types in the northern and western part 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 region.

The change from one soil type to another is usually a gradual one, and frequently extends over a considerable distance. Bottomland types are set off from upland types by distinct change in topography, but division between upland types is not so apparent. It is to be remembered, further, that in a reconnaissance survey the soil boundaries can not be as accurately drawn as in a detailed survey. In using a soil map these, as well as other limitations, should be understood and due allowances made.

Classification of Missouri Soils

<u>Soil Province</u>	<u>Soil Groups and Types</u>
	Soils from loessal deposits
	Knox silt loam
	Marshall silt loam
Loessal and	Grundy silt loam
Glacial	Putnam silt loam
	Soils from glacial deposits
	Shelby loam
	Lindley loam
	Alluvial soils
	Wabash loam and clay loam
	Soils from limestone and shale
	Summit silt loam
Residual Plains	Soils from shale
Soils of	Oswego silt loam
West Missouri	Cherokee silt loam
	Soils from sandstone and shale
	Bates fine sandy loam
	Alluvial soils
	Osage silt loam

Soil ProvinceSoil Groups and Types

	Soils from pure limestone
	Hagerstown silt loam
	Soils from moderately cherty limestone
	Union silt loam
	Crawford gravelly loam
	Lebanon silt loam
	Soils from limestone, sandstone, and shale
	Tilsit silt loam
Ozark Region	Boone loam
	Soils from cherty limestone
	Clarksville gravelly loam
	Clarkeville stony loam
	Soils from granite
	Ashe stony loam
	Alluvial soils
	Huntington loam
	Alluvial soils
	Sarpy fine sandy loam
	Lintonia silt loam
Southeast	Lintonia fine sandy loam
Missouri	Sharkey clay loam
Lowlands	Waverly silt loam
	Waverly fine sandy loam

Glacial and Loessal Soils

The glacial and loessal 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 bordering the valley of the Missouri and Mississippi Rivers. In total area, the glacial and loessal 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. The latter is represented in general by the Putnam, Grundy, and Marshall soils. Excepting a very narrow belt forming the bluffs or river hills bordering the Missouri and Mississippi Rivers, the topography nowhere can be described as hilly. In general, the surface is level to gently rolling, and practically everywhere permits of the development of the highest type of agriculture. Non-agricultural land in this province is so small in extent as to be of negligible importance.

In their original condition the glacial and loessal soils of northern Missouri formed a vast prairie, broken only 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. The trees were large, and were not so close as to exclude the growth of grasses between them. Practically all of the original prairie grass has long since disappeared, and only small areas of timberland remain.

In general, the glacial and loessal soils of northern Missouri are characterized by their remarkable uniformity over large areas, by high fertility and prevailing dark color.

Loessal Soils

In the chapter on geology is described the origin of the extensive areas of aeolian soils commonly known as Loess. After the deposition of the till by the glaciers, there was spread over the entire 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 those soils are classified as loessal which are derived from material that is generally accepted as aeolian in origin.

It is a significant fact, and is indicative of its origin, that the loess soils in Missouri occur only along the Missouri and Mississippi Rivers, and have their greatest distribution where the flood plain of these streams is widest. The largest areas of loess soil occur in the northwestern part of the State, where the maximum width of the belt is

approximately fifty miles. To the east of Kansas City the belt gradually widens, attaining its greatest width near the longitude of the west line of Saline County, when it again rapidly 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. 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 forty-five counties, and cover approximately ten thousand square miles, or thirteen per cent of the State.

Loess rarely or never 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, and this character is the one to which the loess really owes its value as a soil. It is an almost ideal texture, the porosity of which is such that it easily rids itself of excess water and yet it is enabled to hold sufficient moisture for growing crops.

The soil particles are coated, more or less, with oxide of iron and calcic carbonate. The amount of the former gives color to the soil which, in the typical form, is usually a

light buff or dull reddish brown; when absent the color is grayish, sometimes approaching white. The removal of the iron oxide probably results from the oxidation of decayed vegetation which changes it to a carbonate, in which form it leaches out, or collects in the form of concretions in the subsoil. This phenomenon is especially marked near the margin of the loess where it is shallow, or in places where it has been reworked by water.

The presence of the calcium carbonate together with the clay appear to constitute a cement which holds the soil particles firmly together so that the loess stands firm like indurated rock, unless softened by moisture. The presence of the lime also tends to make the soil retentive of organic matter, and explains why the loess soils under favorable conditions usually contain a large per cent of this material. Lime concretions and calcarious fossils are scattered thru the soil where the deposit is thick.

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 organic matter. In general, too, the eroded portion has a somewhat coarser texture than the more level areas. Based on these characteristics, 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 eroded portion of the 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 ten to fifteen inches is a brown to yellowish-gray silt loam. The color is variable, and is usually a brown or dark gray on the well drained areas where erosion is not excessive. On areas deficient in organic matter as on steep slopes and poorly drained flats the lighter shades of gray and yellow prevail. The subsoil is a light brown or pale yellow silt loam, usually becoming more clayey in the regions farthest away from the river bluffs, and extending to the bottom of the loess material without any appreciable change. It can be said that the soil of the Knox silt loam has no true subsoil; the former is merely the upper part of the loess deposit more or less darkened by organic matter. In the lower substratum fossil snail shells and potato shaped 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. This condition may be explained by the fact that the prevailing winds in the northwestern part of Missouri are stronger than in the eastern part and can there-

fore carry coarser material. Coffey⁽⁹⁾ found that the soil grains of the Missouri loess are mostly angular, with some fairly well rounded, while in the Mississippi loess the grains are mostly well rounded, with a few angular. The latter represents material which was transported much farther and has therefore been subjected to more abrasion and decomposition. Along with this fact it is interesting to note that the Knox silt loam in the western part of the State is more calcareous than along the Mississippi River, which in turn probably explains the greater amount of organic matter in the soil of the former region than in the soil of the latter region. Assuming that the loessal soil was taken from the valley of the large rivers, this variation in the composition of the Knox silt loam can be explained as follows: The Missouri River, flowing at a rather steep gradient and draining a semi-arid region, will naturally carry rather coarse and only partially leached material. The soil derived from this material which indirectly gave rise to the loess in the western part of the State will therefore possess many of the characteristics of the parent material. The Mississippi River flows at low gradient thru a region of fine earth and relatively high humidity. Its sediment therefore will consist of fine material more or less leached. The loess soil formed along this stream will therefore be of corresponding fine and leached material and thus differ from the Missouri River loess. Again, the Knox silt loam in the southeastern part of the State is heavier in texture, lighter in color, and has a more leached appearance

than along the upper Mississippi. This condition, in addition to the facts above explained, may be due to the greater age and to the more active agencies of weathering that prevail in this part of the State.

The Knox silt loam possesses a high degree of potential fertility with regard to the mineral elements. Its physical properties also are highly favorable. The internal drainage is good, and aeration and capillarity are effective thruout the soil section--three feet--and to a depth in the underlying strata. This must appreciably improve the conditions in the surface layer in which the roots of plants find nourishment.

In general, the Knox silt loam is deficient in organic matter. This is especially true on the eroded areas and in old fields that have received insufficient care. If it is not properly handled it deteriorates. On the other hand, it is readily susceptible of permanent improvement, enabling it to produce large crops.

The topography of the Knox silt loam varies from hilly to rolling. The former 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

without any areas of level land. The total area of the type that is too broken to permit cultivation is very small. The silty texture of the soil aided by the rolling surface causes erosion to be rapid and very destructive. Gullies formed are usually deep with perpendicular walls. Cuts fifteen to thirty feet deep are common near the rivers, and frequently are made in one season. In brief, the rolling surface and excessive erosion are the limitations in the use of this soil. (Plate VI).

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 unexcelled. Where the surface is not too rolling most of the type is used for corn and wheat. Yields of from forty to sixty bushels of the former and of twenty to twenty-five bushels of the latter per acre are common. Clover and alfalfa thrive exceedingly well, which is resulting in the more widespread occupation of the type for the production of these crops. The steeply rolling land is largely used for grass and pasture. In the southeastern part of the State cotton is grown on the Knox silt loam*. In St. Louis and Jackson Counties large areas are used for trucking. Large commercial orchards have also been set upon this soil. The trees make good growth, and come into bearing at an early date. An excellent quality of fruit is produced.

*The loess in southeastern Missouri has been correlated with Memphis silt loam by U. S. Bureau of Soils.

Soil Erosion Map of Missouri

Chemical analysis^(a)--Knox silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement ^(b)
Missouri River Area				
Soil	2660 ^(c)	1206	33,373	0
Subsoil	1506	1113	27,710	960
Mississippi River Area				
Soil	1894	1268	34,006	1036
Subsoil	896	1540	33,146	2615

This data does not permit the drawing of any definite conclusions, but it seems to agree with the statement previously made that the Knox silt loam is more calcareous and contains more organic matter in the western part of the State than in the eastern part.

Marshall Silt Loam

The marshall silt loam constitutes the most important and probably the most extensive single soil type found within Missouri. Like the Knox silt loam, it is of loessal origin,

(a) All chemical analyses included in this thesis were made by the Department of Agricultural Chemistry, University of Missouri. The soil samples used were the official samples taken in connection with the soil survey field work.

(b) Veitch Method.

(c) Results are given as pounds per acre in 2,000,000 pounds of soil.

and has its widest distribution in the western and central part of the State. Thruout the region of its occurrence it occupies practically all of the upland soil.

The surface soil of the Marshall silt loam consists of a dark brown to black, mellow, silty loam, containing a large amount of organic matter. In depth it ranges from ten to twenty inches, the shallower soil prevailing on the rolling areas and the deeper soil on the more level prairies. The subsoil from twenty to thirty-six inches 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 fifty or one hundred feet over wide areas. Frequently in the lower portion of the three-foot section there is present less clay and more silt than in the upper subsoil, and the structure is more friable. In many cases the surface soil feels slightly heavier than the subsoil, but this is due to humus rather than to a higher content of clay. In general, the soil and especially the subsoil are heavier near the outer margin of the type, and lighter where the type borders on the Knox silt loam. In the subsoil are found concretions and accumulations of lime carbonate and calcareous remains of shells.

On the whole, the Marshall silt loam represents a thinner deposit of loess than does the Knox silt loam. On the steeper slopes, especially toward the outer margin, outcrops of the underlying till are much in evidence, and a part of the soil is undoubtedly of glacial origin, altho it was not

possible to show the areas as such on the map.

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 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 all of its physical properties the Marshall silt loam is almost an ideal soil. The gentle slopes, the excellent 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. Moreover, the soil is well supplied with lime. The lower subsoil and the substratum are calcareous and effervesce with acid. In fact, many borings in this type give an effervescence with acid within three feet of the surface, but seldom nearer the surface than eighteen inches. Considerable of the surface soil is, however, beginning to develop acidity as shown by lime requirement determinations, altho the relatively high content of lime no doubt accounts for the high per

cent of humus in the soil. Moreover, the presence of considerable organic matter indicates that the soil is pretty well supplied with readily soluble plant food constituents. The importance of these characteristics can not be overestimated, since they are largely responsible for the high fertility of this soil type.

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 35 to 90 bushels per acre. All the crops suited to the climate and to a silty soil grow well. Thus 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, and range from 40 to 80 bushels. Wheat is not quite so well adapted to this land as are corn and oats, but when properly handled it yields very good crops.

The prevailing type of farming is that of corn growing and the feeding of cattle and swine. Practically all the grain raised is fed to beef cattle. The mixed timothy and clover hay is utilized as roughage in the feeding ration, and frequently the areas in grass are pastured during the final year before the sod is ultimately plowed for corn production. Commercial fertilizers as yet are little used.

Probably no other soil in the State bears such a high proportion of tilled and cultivated crops. / ^(Plate VII) Practically all

of the type may be classed as highly improved land. Farm buildings are characteristically substantial and well kept. The farm units are relatively large, probably averaging 150 acres. A larger per cent of the farms are operated by tenants than on any other soil type (8 per cent more than on glacial soils).

Chemical composition--Marshall silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	3611	1822	33,774	3646
Subsoil	1914	1794	31,394	1938

As has been previously stated, a silt covering was spread over the glacial till after its deposition. This covering has not been recognized universally as a geological equivalent of the loess, altho careful study fails to find a clear demarcation between the typical loess near the large rivers, and the heavy silt more remote from the streams. Probably the most pronounced difference is the finer character of the silt deposit, or "loamy clay" as it is frequently called. In the western and northeastern part of the region of its occurrence this material is universally of a dark color at the surface, and ranges from three to eight or more feet in depth. In the eastern part of the State it usually has a gray surface color, and rarely exceeds three or four feet in depth.

Based on these two important differences, it gives rise to two soil types--Grundy silt loam and Putnam silt loam.

Grundy Silt Loam

The surface soil of the Grundy silt loam consists of a black to dark brown mellow silt loam to an average depth of twelve inches. When dry the soil has a somewhat lighter color and has a dark gray cast. In general, the level areas, and that part of the type found in the northeastern corner of the State are distinctly lighter in color than the main body of the soil in western Missouri.

The upper zone of the subsoil, extending to an average depth of about eighteen inches, is a dark gray to gray-brown friable, heavy silt loam or light silty clay loam. Below this stratum is found the dark drab or yellowish brown heavy tenacious silty clay or clay. The deeper subsoil from about thirty to thirty-six inches is a moderately friable silty clay loam predominantly yellowish gray in color, with brown, gray, and yellow mottlings. Brown iron stains and small iron concretions are present in small number thruout the subsoil. Occasionally lime concretions are present. However, they are not as numerous as in the corresponding strata of the Marshall silt loam.

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 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 gray or light gray, mealy material, varying in thickness from two to six inches, and is essentially the same as the gray layer in the Putnam soil. In its agricultural value this phase is almost equal to the Grundy silt loam and has therefore been included in the latter.

The Grundy silt loam very closely resembles the residuary Summit silt loam of the lower Carboniferous areas. It also closely resembles the Marshall silt loam. Altho the Grundy and Putnam silt loams are of the same origin, the former shows much better evidence of being of loessal origin. The fact that the loamy clay, of which the Grundy silt loam is the surface expression, is of great thickness like the loess deposits, and the fact that the main body of this material lies adjacent to the loess, and like the latter is more or less calcareous in the subsoil, points strongly that it is similar also in origin. On account of the greater depth of the deposit it has not been leached to as great an extent as the Putnam silt loam, and therefore contains a relatively larger amount of plant food and lime than does the latter type.

Originally the Grundy silt loam was covered with a rank growth of wild 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 great depth.

Topographically, the type occupies the broad almost level

divides and the gentle slopes. In general, the surface averages smoother than for the Marshall silt loam, altho this difference is of no appreciable importance. There is usually sufficient slope to carry away the rainfall, even on the more level areas.

In every respect except the matter of underdrainage, the better phases of Grundy silt loam is a nearly perfect soil for general farming. It is friable, well drained and contains a large amount of organic matter. The heavy subsoil rarely has any injurious effect on plant growth.

All of the type is in a high state of cultivation, and is used for the production of all the staple crops common to the region. Corn is the most extensively grown cereal, and yields of 30 to 70 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 soils. Much of the type is in sod, and the excellence of the blue grass pastures is not excelled in any part of the State. Highly improved farms and farm equipment are characteristic of the regions where this soil occurs extensively.

Chemical analysis--Grundy silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	4205	1806	28,290	5215
Subsurface	2068	1734	27,340	4540
Subsoil	1694	1874	27,530	1864

The content of nitrogen in the surface soil is high, but decreases rapidly downward. The supply of phosphorus is about the same as in the Marshall silt loam. The total amount of potassium is rather low in comparison to the other elements, and when the fineness of the soil material is considered. The high lime requirement is indicated also by the consistent, tho not large, returns obtained from the use of ground limestone⁽¹⁰⁾.

Putnam Silt Loam

The Putnam silt loam is represented by the extensive areas of level prairie land in the eastern part of North Missouri.

The silty surface soil to a depth of eight to twelve inches varies in color from light ashy 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 deep soil and good drainage the color is darker, due to the presence of a larger accumulation of organic matter. The texture is uniformly a silt loam, which normally consists of seventy to eighty per cent of silt.

The surface soil is underlain by a layer of gray to almost white, powdery, siliceous silt loam containing (especially in lower portion) numerous small concretions of hydrated iron oxide. In some instances this layer is almost a foot thick, but occasionally it is only faintly developed. The

deeper subsoil, beginning abruptly at about eighteen inches, consists of a grayish brown or dark brown stiff, impervious clay, which grades at about twenty-four to thirty inches into yellowish gray or drab friable silty clay, mottled red, brown, and gray. These layers, altho differing in thickness, are invariably encountered in this type, in the order given. In general the subsoil is darker in color and more intractable on the poorly drained areas.

The Putnam silt loam is 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 stiff clay or 'hardpan' subsoil. It differs from the Grundy silt loam in the more level topography, lighter colored surface soil and the more abrupt change from the surface silt layer to the clay subsoil. Also, the light colored, friable lower subsoil extends higher in the Putnam soil.

It has already been pointed out that both the Grundy and Putnam types are derived from the silty layer over till, and that this layer is thinner in the Putnam soil than in the Grundy soil. This fact may partially explain why there is a greater accumulation of clay in the subsoil of the Putnam than in the subsoil of the Grundy type. However, the differences between these two types are due largely to a difference in drainage. The water, standing on the level Putnam silt loam sometimes for several days after a rain, prevents aeration, so that the natural processes are entirely differ-

ent from those which are active where the surface is rolling and the soil aerated. Under these intermittent wet and dry conditions there is always a tendency for soils to assume a gray color. According to Hilgard⁽¹¹⁾ this is due to organic acids which "reduce the ferric hydrate to ferrous salts, oxidizing away the humus, and accumulating in the form of inert concretions most or all of the lime, iron, and phosphoric acid of the soil mass". While this may not be the true explanation it is observed that on the outer margin of the type, where the drainage is good, the soil is dominantly darker in color and contains a larger per cent of organic matter. The soil on which the experimental fields at Columbia are located is representative of this dark soil phase. The light colored phase is represented by that vast shallow basin or flat extending from Randolph County to the western part of Pike County.

In general, the Putnam 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 loessal deposits. In all its physical characters the type resembles the Oswego silt loam of the residual plains in the western part of the State.

Owing to the level character of the surface and the more or less impervious nature of the subsoil, natural drainage is deficient and artificial drainage is somewhat difficult.

Many farmers consider that drainage is not practicable, but the results obtained on a few farms where tile drains have been installed indicate that it can be satisfactorily established⁽¹²⁾. Altho the surface is practically level, there is usually enough slope to give sufficient fall, or it is usually possible to lead the drains into one of the deep gullies which have been cut back into the upland, without having to go any great distance. To insure perfect drainage, it is necessary to lay the tile lines rather close together and to exercise care not to lay them too deep.

All of the Putnam silt loam is in cultivation. Corn, grass, wheat, and oats are the most important crops grown in the order named. A few areas of wild prairie grass remain. Clover makes a fair growth where the soil is well drained and contains a large supply of organic matter, but most of this prairie is not well adapted to the crop. Bluegrass occupies the soil naturally, and all forage crops thrive exceedingly well.

The prevailing type of agriculture is that of general farming combined with livestock raising and feeding. Commercial fertilizers are extensively used in connection with wheat and corn. The Missouri Agricultural Experiment Station⁽¹³⁾ has found by extensive tests at various places on this soil type that the soil responds to all three fertilizing elements, as well as to lime and organic matter, but that greater returns are obtained from phosphorus than from either nitrogen or potassium. Applications of lime

have returned a fair profit, and on much of the worn land its use is essential if clover is to be grown. The use of barnyard manure and of green manures is also highly recommended.

Chemical composition--Putnam silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	2771	894	38,926	2608
Subsurface	1430	827	25,730	3260
Subsoil	1187	1124	26,780	3134

This data shows a rather low amount of nitrogen and phosphorus in the soil. The reaction in every case is acid, the subsoil being more acid than the surface soil, differing in this respect very strikingly from the Grundy silt loam.

Glacial Till Soils

Continued study of the glacial deposits in the northern part of the State makes it increasingly evident that this material is largely derived from the ground up country rock. This fact is of great significance, because it has influenced the character of the soil 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 on these differences in origin and composition, the glacial soils have been divided into two types--the loamy calcareous material giving rise to the Shelby loam, and the more clayey material forming the Lindley loam.

Shelby Loam

The Shelby loam is extensively developed in the northern and western part of north Missouri, and occupies practically all the rolling land of that region.

Where typically developed the Shelby loam consists of six to twelve inches of a friable, dark brown to yellowish brown loam, which gradually changes to a light brown, heavy loam to a depth of about fifteen inches, below which is a yellow or yellowish brown tenaceous sandy clay. The latter is mottled brown, red and gray, the color usually becoming lighter 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 small gravel thruout 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, and occasionally fragments of limestone and chart. This coarse material does not

hinder cultivation, but tends to give the soil a loamy structure. Occasionally the gravel is stratified as thin lenses, but as a rule it is thoroly disseminated thruout the soil section. Such an arrangement of widely differing materials could result only thru the grinding and mixing of an ice sheet. 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 limy 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, the greater productivity of the glacial limestone soil as compared with that of shale and sandstone origin.

It is thus easy to distinguish between the Shelby loam from the adjoining loess soils. The latter never contain gravel or stones, while the former is partly made up of such material. 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 thoroly 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 some-

times sufficiently steep to offer considerable difficulty to 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 washed 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 sod.

The greater part of the Shelby loam was prairie, and it was only along the streams and the more rolling areas that timber occurred. The latter consisted largely of oaks, hickory, elm, cherry, and walnut. The treeless areas were covered with prairie grass, hazel brush 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 nitrogen as the loess 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 an excellent grass and clover soil, and under proper conditions will grow alfalfa well. Blue grass is indigenous to it, and the acreage devoted to this crop exceeds the total area devoted to small grains.

The soil responds more readily to manure than do the level prairie lands. Commercial fertilizers are not used, but the Experiment Station⁽¹⁴⁾ has found that phosphatic fertilizers on wheat, to be followed by clover, are profitable. Systematic

crop rotations under systems of live stock farming or general farming, together with the careful using of all manure, are recommended.

Chemical analysis--Shelby loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	3005	1070	24,727	3645
Subsurface	2555	1020	----	6400
Subsoil	1138	1156	28,412	3070

Lindley Loam

The Lindley loam includes practically all of the rolling glacial land in the northeastern part of the State. It represents also much of the timber land of this region, and thus is in striking contrast to the adjoining prairie land.

In comparison to the other soil types of the glacial region, the Lindley loam is the most variable, both in its physical properties and agricultural importance. The surface soil to an average depth of five to ten 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 gentle slopes 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 twelve to sixteen inches is a light yellowish brown granular loam, which grades into a tenaceous,

gritty, silty clay, 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 or shale and rarely 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 influences is the occasional occurrence of a foreign gravel in the residuary material. Sand, gravel, and chert fragments in small quantities are scattered thru the soil and subsoil.

The Lindley loam is characteristically low in organic matter, due to excessive erosion and the small amount of lime in the soil. The surface soil therefore is shallow, and is not markedly different from the subsoil. In fact, on some of the uncultivated areas and where erosion is severe the unproductive 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 till, a large part of it consists of modified local 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 especially numerous around Columbia. In general, the Lindley loam in the northern part of the State is more nearly derived from true till, and in these areas closely resembles the Shelby loam.

In addition to the differences already pointed out, it may be added that the Lindley loam is siltier, contains less sand and gravel, and sand of a finer texture than the Shelby loam. Lime concretions are rarely present in the subsoil, and oxidation has not penetrated far below the surface, due to greater compaction than in the more loamy Shelby soil. Both soil and subsoil are lacking in lime carbonate, with a consequent lower productivity.

Altho the material from which the Lindley loam is derived is closely related to the underlying rocks, it has been re-worked by ice, and this type is therefore of glacial origin. As the underlying rocks are usually not very far beneath the surface, the drift is composed largely of local material. However, the imbedding in the drift of crystalline rocks, which must be foreign, shows that there has been a thoro mingling of the material by the ice.

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 is too broken for profitable cultivation. Such areas are most extensive in Adair, Putnam, and Randolph Counties. Erosion is excessive, and this constitutes one of the most difficult problems in the management of the type. The necessity of adding large amounts of organic matter, and of keeping the steep slopes sodded with grass is therefore apparent. A large part of the more rolling land remains timbered with white and post oak, and hickory. All of the very rolling land is used for permanent pasture.

In general, the Lindley loam is not as highly esteemed as the Shelby loam. The cultivated areas are used for corn and oats; in fact the acreage of the former seems disproportionately large when the topography and the quality of the soil is considered. The addition of lime, the checking of erosion, the incorporation of organic matter and the use of fertilizer containing a relatively high percentage of phosphoric acid, particularly on the wheat crop, are needed in the building up of this soil. By such treatment clover could be made to grow successfully on most of the type, and the quality of the pastures greatly improved. Stock farming is the type of agriculture best suited to this soil, for by this system the grass producing qualities of the soil are utilized to the most efficient degree, and soil loss due to erosion reduced to a minimum.

Chemical analysis--Lindley loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1580	746	25,030	1295
Subsurface	1350	---	-----	---
Subsoil	845	933	21,960	2530

In both the Lindley and Shelby soils the phosphorus varies in harmony with the variation in nitrogen. The supply of potassium is rather low when the texture of the soil is considered. The acidity is evidently very largely inorganic in character. This is indicated by the fact that the organic matter decreases whereas the acidity increases with depth.

Alluvial Soils

One of the most striking features of the glacial and loessal 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 hard 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 bordered by a comparatively wide lowland plain. Associated with the wide floodplains is the comparatively fine texture of all these alluvial soils. This character is due to both 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 that might be made to this statement occur along the Missouri and Mississippi Rivers, for the soils along these streams 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 due to 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, and 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 prevailingly a black or dark brown silt loam. In depth it is rarely less than twelve to fifteen inches, but 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 being associated with the heavier texture. In general, the lower subsoil is a drab or yellowish gray clay loam with few brown mottlings. At this depth there are frequently encountered veins or pockets of sand, especially near the stream bed.

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 is 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 large tributaries, Chariton and Platte Rivers, and in large isolated areas along the Missouri 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.

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 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 wonderful 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, probably more than twenty-five per cent of this valuable type is as 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 investment profitable.

Corn is the one universal crop for which the areas of the Wabash silt loam are especially sought out wherever it occurs. The yields obtained are relatively higher than for upland soils, and frequently the crop is grown many years in succession without any 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 the growing of potatoes, and the possibilities along this line have not as yet been fully appreciated. It is only in the loamy alluvial lands in Ray, Carroll, and Osage Counties that potatoes are commercially grown. In brief, the Wabash silt loam represents one of the most valuable soils in the State.

Chemical analysis--Wabash soils

Wabash Silt Loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	3989	1558	30,867	1442
Subsurface	2460	----	-----	----
Subsoil	1989	1382	31,827	1802

Wabash Silty Clay, and Clay Loam

Soil	4898	2348	31,378	3547
Subsurface	4255	----	-----	-----
Subsoil	2496	1768	29,106	665

Residual Prairie Soils of West Missouri

The residual prairie soils of west Missouri occupy a triangular shaped area, covering about seventeen counties, or an area about one-third the size of the glacial and loessal soil province. On the north they blend imperceptibly into the soils of the latter region; the eastern boundary is irregular, but is everywhere rather clearly defined by the presence of the cherty and hilly soils of the Ozark region. In general, these 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 in the State.

It is interesting to note that the rocks from which the residual prairie soils are derived also form the basal structure in the northern part of the State, and it can readily be assumed that were it not for the glacial covering the soil of this region would be similar to those south of the river. Such areas of residual soil as do occur north of the river (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 is no doubt in a large measure due to the partial derivation of the former from the country rock. This is further emphasized by the occurrence in zones or belts of similar types, and the conformity of these zones to the related basal rocks. Thus the gray prairie soils in both the glacial and residual

region (Putnam, Oswego, Cherokee) conform in general to the distribution of the shale horizons; the black prairie soils (Summit, Grundy) overlie in zones the limestone-shale horizons. In this consideration it would have to be assumed that the glacial prairie soils (Putnam, Grundy) are not of aeolian origin, but that they are largely of local material, the latter assumption being very unlikely.

The character and distribution of the residual prairie soils presents some very interesting considerations, and illustrates in a remarkable way how soils are affected by the mother 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 former occurs in the northwestern part of the area, the latter 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 only 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 soils and the corresponding higher content of organic matter thus seems to be associated with an abundance of limestone or calcium carbonate in the soil. Further illustration of this con-

dition are the isolated mounds and ridges capped with limestone, so numerous in Bates, Vernon, and Henry Counties. The weathering of the limestone keeps the lower lying soil supplied with calcium carbonate. The soil on the slopes of these mounds would normally be of a light color and contain little organic matter due to the excessive erosion, but strangely enough 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, the consequent greater leaching they have undergone, and the stratification of the soil material. This latter character is especially pronounced in this region, and is even present in the sandy loams, soils which normally do not readily become stratified. It is to be noted, however, that those soils with a high content of organic matter do not possess this characteristic or if so only to a modified degree. Thus, the Summit silt loam shows much less stratification than the Oswego or Cherokee types. This characteristic seems to hold true for all soils, even those of alluvial origin, but, to our knowledge, has never before received recognition. It can not be attributed to a difference in age, origin, or moisture content, for all these soils were formed simultaneously under similar conditions. Evidence indicates that it is due to a difference in content of calcium carbonate, or possibly of organic matter.

The power of lime to flocculate soil particles is well known. An abundance of this material, especially in the presence of organic matter, seems to retard the downward filtration of the clay particles and the translocation of the iron and other semi-soluble constituents of the soil mass. This whole matter of lime, organic matter, and the stratification in soils, suggests an interesting problem for future investigation. Russian investigators have done much along this line⁽¹⁵⁾.

Topographically, the region of the western 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 almost ideal, and permit of the highest type of agriculture.

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 prevaillingly 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, ten to eighteen 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 twenty-four 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 eighteen inches, where the soil material becomes compact and waxy and the content of organic matter quickly decreases. Lime concretions and calcareous streaks are found in the subsoil and indicate that it is fairly well supplied with lime. A peculiar characteristic of both soil and subsoil, especially where the type occurs near limestone outcrops, is that it has a tendency to granulate or break up into cubes, with the result that it does not puddle readily. The Summit silt loam as a whole is rather uniform, such variations as occur being of minor importance and need to be considered only briefly.

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 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 to 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. The latter occupy the isolated hills, 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 and make 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. Most of the Summit soil in Clay, Ray, and Carroll Counties belongs to this phase.

Thruout its entire extent the Summit silt loam has a level to gently rolling surface admirably adapted to a heavy type of farming. The undulating swell of the surface everywhere is 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 or 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 type 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 loessal soils of northern Missouri. All of the type is highly improved, and is used for general farm crops, such as corn, wheat, grass and oats. Yields range as follows: corn, 30 to 75 bushels; hay, one to two tons per acre, on the better farms, the higher figures being approached more frequently than the lower. In Cass County tobacco is grown on a commercial scale, with yields of 1000 to 1600 pounds per acre. Clover and alfalfa thrive on all of the type.

Commercial fertilizers are not used, but applications of phosphatic materials would probably prove profitable. Applications of ground limestone would be beneficial on the poorer drained areas. In the management of this type, the most important consideration is the maintenance of the organic matter supply, for besides adding fertility, it tends to keep the rather heavy soil in a loamy condition.

Chemical analysis--Summit silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	3477	1626	28,435	3884
Subsurface	2713	1530	---	3833
Subsoil	1926	1857	25,140	1650

In the total amount of plant food the Summit silt loam compares favorably with the loessal soils of northern Missouri. Even the subsoil is well supplied with nitrogen. The rather high lime requirement is undoubtedly due largely to organic acids, as is indicated by the decrease of acidity with a decrease in the organic matter.

Oswego Silt Loam

The Oswego silt loam, like the Summit silt loam, forms part of the black prairie soils of western Missouri. In fact, the separation of these two types is extremely difficult where they come in contact, and the boundaries therefore are in some places more or less arbitrary lines. 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 silty surface soil, nearly level topography, and a stiff clayey subsoil.

Typically, the surface soil is a dark gray, grayish brown to black mellow silt loam, becoming somewhat lighter in color at about ten to twelve inches, or in the lower six inches of the top silty layer. This light colored subsurface is not always present, and can not be considered a characteristic of the type, altho in general it holds true that 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 sixteen to eighteen inches is a dark drab to yellowish gray, stiff, tenaceous clay, passing gradually at about twenty-six to thirty inches into a more friable silty clay, mottled 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. They are most common in Bates and Morgan Counties. This hardpan seems to be due to a compact structure of the clay rather than to lime or iron cementation.

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 favorably with the Summit silt loam,

altho the average yields are somewhat lower than on the latter. Corn is the chief and probably the most profitable crop. Wheat and oats are extensively grown, with average yields of 15 and 35 bushels respectively. Clover is grown to a limited extent. In recent years cowpeas and soja beans have come into wide use. In general, a larger per cent of the Oswego silt loam is used for grass and small grains than of the Summit silt loam, and this fact would indicate the relative adaptability of the two types.

Commercial fertilizer is used on much of the type on wheat land with good results. The soil uniformly shows a high lime requirement, and heavy applications of ground limestone are recommended.

Chemical analysis--Oswego silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	3166	1583	27,500	6000
Subsurface	2466	1700	----	6250
Subsoil	1949	1751	23,840	1211

Cherokee Silt Loam

The Cherokee silt loam is locally known as "white ashy land" owing to its light color and ashy texture, or "hardpan land" because of its tough, impervious subsoil. It is closely related to the Oswego silt loam, but has undergone more weathering and leaching, with a resultant loss in plant food

and change in soil structure. The soil particles have disintegrated so as to be of a clayey texture, and have been washed down and accumulated in the subsoil, giving the latter a close and compact structure. The numerous iron concretions indicate poor drainage and the lack of mineral plant food. These conditions, no doubt, are the result of the absence of calcium carbonate in the soil, for without this element flocculation of the soil particles and accumulation of organic matter is retarded.

The surface soil of the Cherokee silt loam is a gray or brownish gray silt loam to a depth of about ten inches, and is underlain by a light 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 sixteen to eighteen inches, consists of a brown, dark drab or 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, and 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 slowly. Iron concretions are numerous thruout the soil section. Fine argillaceous shale is the origin of the soil material.

The topography is level, and averages smoother than any other upland type in the State. Any change in elevation from that of the given area of the type means the passing into a different soil, usually the Bates fine sandy loam. The type is frequently surrounded by soils of a more rolling topography, thus giving it a basin-like appearance; other areas occur along streams, and resemble high flat terraces.

The surface drainage 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 only be improved by open ditches and tile drains. The soil is not drought resistant and frequent shallow cultivation is of special importance during dry periods.

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 the former range from 20 to 35 bushels, but in 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 due to fertilization. Commercial fertilizers are extensively used on corn and wheat with good results.

Chemical analysis--Cherokee silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	2580	712	20,320	2948
Subsurface	1680	927	22,300	3126
Subsoil	1688	880	18,720	4652

The soil is markedly deficient in phosphorus, potash, and organic matter, and the need of stable manure, legume manure crops, and phosphatic fertilizers is apparent. Numerous tests show the soil and especially the subsoil to be acid, and heavy applications of ground limestone are recommended(16).

Bates Fine Sandy Loam

The Bates fine sandy loam has a wide distribution in the southwestern 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 than the surface soils, but a friable structure is maintained in every condition. The surface soils range in color from brown, dark brown to yellowish gray, the darker shades predominating on the smoother areas, especially in the northern areas of the type. The subsoils are some shade of brown and show bright mottlings of red, brown, and yellow. Sandstone 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 eight to twelve inches into light brown friable silt loam, which is underlain at about eighteen to twenty 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 of a somewhat heavier texture than the surface material. In general, any increase in the unevenness of the surface is accompanied by an increase in the coarseness of the soil material, and this in turn is accompanied by an increase in the mottling of the subsoil. Associated with the more rolling areas is a larger 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 the Bates soils is the bright red mottlings of the subsoil, frequently so intense as to give the lower subsoil a red color. This condition indicates a very thorough oxidation of the soil material to a great depth. The soil contains a relatively high per cent of iron, but due to its complete weathering it is granular, and rarely imparts any objectionable character to the soil. Unlike most upland soils, the Bates fine sandy loam becomes coarser downward, especially when the underlying sandrock is not more

than three to four feet below the surface. 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 type 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 (of level surface) are included small patches of Cherokee silt loam, which are usually only a few acres in extent and therefore too small to be indicated. Near the eastern edge of the type there are included areas of stony loam that probably 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 large 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 re-

quires fertilization to produce profitable crops. Cowpeas and kafir thrive remarkably well. The lighter textured soil is highly prized for small fruits and truck. Alfalfa has been tried with some success, but, owing to the deficiency in both soil and subsoil of lime carbonate, this type is not particularly adapted to this crop.

While the Bates fine sandy loam is not naturally considered a strong soil, and while it quickly deteriorates under bad management, it can, by the use of proper rotations and treatment, be brought up to a rather high state of productivity. Chemical analysis shows it to be low in all three fertilizing elements, as well as in lime and organic matter. The presence of the latter is especially important, as it is only when the soil is well supplied with this material that it will lose its droughty tendency and be less subject to erosion.

Chemical composition--Bates soils

Bates Silt Loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	3187	1436	21,873	5673
Subsurface	2733	1653	-----	7666
Subsoil	1660	1083	18,807	2863

Bates Soils--Coarser than Silt

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	2336	763	14,904	2353
Subsurface	2740	---	-----	----
Subsoil	1310	650	17,060	2550

Osage Silt Loam

The Osage silt loam represents the alluvial soils within the residual prairie region. The type 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 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 prevaillingly a light ashy colored material carrying many iron concretions, underlain at about twenty-four inches by a gray 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 highly productive. The greater part of it is used for corn, and yields of 35 to 75 bushels are obtained. Areas not subject to overflow and that have good internal drainage are well suited to alfalfa. The greatest need of the soil is good drainage and liberal quantities of organic matter.

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 ten to fifteen 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 Barton and Vernon Counties. It is highly prized as a corn, clover, alfalfa and truck soil.

The areas of heavy clay soil within the Osage silt loam are locally known as "gumbo". It consists of a black, heavy, silty clay eight to twelve inches in depth, and underlain by bluish black or drab heavy, 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 conditions as regards moisture.

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. Tile draining, liming, fall plowing, and turning under coarse organic matter are some of the factors essential to improve the efficiency of the soil.

Chemical analysis--Osage silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	2976	1312	26,160	1220
Subsurface	2100	1750	-----	1500
<u>Subsoil</u>	1474	1343	28,986	2800

In composition this soil is fairly well supplied with all the essential plant food elements, if we consider the very deep feeding range afforded to plant roots.

Soils of the Ozark Region

General Description

The soils of the Ozark region as a whole possess characteristics that distinguish them from all others in the State. In general, they are light in color, comparatively low in organic matter, and are more or less 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, however, apply only in part to the region. The prevailing colors are gray, brown, and red with an almost total absence of black. The subsoils are gray, yellow, and red, the brighter colors 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 clays do not occur in the entire Ozark region. The fine material of the surface soil 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 the 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 surround 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 siliceous 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 washed 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 limestone soils, and if found are present only in such soils as are thoroly leached to considerable depth.

The Ozark soils are the oldest in the State and have therefore become thoroly leached. Moreover, the hardness of the rocks from which they are derived has required a long time for weathering. Not enough lime is left to make the surface soil truly alkaline, and organic matter has not accumulated in sufficient amount and in proper form to give

it a dark color. Even the areas overlying the pure carbonate stones usually show an acid reaction, and only the lower subsoil overlying the parent rock shows effervescence with acid. The Crawford gravelly loam being the youngest of the Ozark soils and coming from a rather pure limestone frequently shows alkaline properties, and contains a relatively high per cent of organic matter. 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 prevailing low content of phosphorus would indicate that this element has been removed together with the calcium and other minerals. The effects of weathering extend to a depth of forty or more feet, as is indicated by the discolored material found at such depths when digging wells.

Thru the erosive action of water the Ozark soils are continually losing their finer silt and clay-like 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. Glinka⁽¹⁵⁾ states that soils derived from rocks rich in calcium carbonate do not podzolize readily. 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 remo-

al of the clay and the leaching away of the soluble material tends to make the soil of all formations alike. The matter of the geological age of the rocks and to a large extent the character of the rocks is 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 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 eight hundred square miles.

Thruout the region of its occurrence the Hagerstown silt loam is characterized by a brown or a yellowish-brown silty loam surface soil which varies in depth from eight to fourteen 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 thirty inches. On the relatively smooth areas, especially in St. Francois County, the immediate surface soil is a light gray, and the lower subsoil is mottled brown and yellow and is of a very friable structure. Near limestone outcrops the soil has a bright reddish brown color, grading into a dark brown or almost black in areas where 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, 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 clay 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, and the subsoil more of a reddish brown. The content of organic matter seems to be lower, blue grass 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, it is in many respects 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, being 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, and practically all of the calcium carbonate has been removed. The subsoil rarely shows effervescence when treated with acid, differing thus from the Crawford subsoil which usually effervesces freely. Associated with a lower lime content is a lower humus content, in spite of the fact that the heavier soil is favorable to formation of a large amount of this material. It is more than probable that the difference in lime content accounts for the greater productivity of the Crawford soil. The need of lime on much of this soil is indicated by the better stand of clover when lime is applied to the land. 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 determines the character of the soil.

The Hagerstown silt loam was one of the first soils in Missouri to be farmed, and much of the type has been in continuous cultivation for more than one hundred years. The superior productiveness of the red soil above all others in the eastern Ozark region was early recognized. As a result very little land of this character remains uncleared and untilled, and practically every available acre in all localities where this soil type is found is used to maintain 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 20 to 35 bushels of wheat, 40 to 65 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 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 yields. In order to maintain the higher yields the use of commercial fertilizers on all small grain has become general. The need of making and using more manure and the necessity of growing green manure crops is apparent, for by such practices the soil can be restored to a much higher productiveness. Alfalfa can be grown with proper management, but it is for clover that this soil is

especially well suited.

On the whole, the Hagerstown silt loam offers splendid opportunities for profitable improvement, for the potential productiveness of much of this type has not as yet been fully appreciated.

Chemical analysis-Hagerstown silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1340	1035	31,600	1320
Subsoil	765	1225	33,635	1765

These figures show a rather low content of nitrogen--less than half as much as in the Crawford soil--but a rather high per cent of potassium. Fertilizer applications show good returns from phosphates, while potash gives slightly increased yields, but it is probable that the liberal use of organic matter would tend to make available the soil potash in sufficient amounts for normal crop needs.

Soils from Moderately Cherty Limestone

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, but are in both cases greatest on the smoother land and in the northern part of the type. 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 of 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. 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 red 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 or clay subsoil. The country rock, a thin bedded argillaceous to finely crystalline 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. Due to erosion and weathering the surface soil near the top of the hills is shallow and contains little organic matter. The lower slopes therefore constitute the tilled land, while the higher ground is largely used for pasture. Much of it remains timbered.

The topography varies from rolling to hilly, with practically no smooth land. As a rule the hills are rounded with long slopes, but bordering all the large 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 fifty 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, tho not to such an extent as is common on the rolling glacial soils. This, no doubt, is due to the porous subsoil which permits the rapid absorption of water and thus reduces the amount of run-off.

The origin of the Union silt loam is not perfectly understood. That portion of the type bordering the Missouri River is essentially the same as the Knox silt loam, and is undoubtedly of loessal origin, in part or wholly. The greater depth of the soil mantle and the almost complete concealment of all rock outcrops and the "rounded" topography are very suggestive of loess instead of residual material. To the south or away from the Missouri River the soil is undoubtedly residual, and is derived largely from the Jefferson City limestones, a series of moderately cherty argillaceous and more or less shaly and thin bedded magnesian 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. Of the remainder of the type, probably less than one-half is cleared. Thruout the extent of the type, wheat is by far the most important cultivated 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 on account of the erosion that frequent cultivation encourages. Red clover makes an excellent growth and is profitable both as a forage and as a seed crop. Blue grass thrives fairly well, but does not form as good a sod as on the other red limestone soils of the Ozark region. In fact, good blue grass 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 hilltops are capped with Burlington limestone and the soil largely derived from this formation. It was observed that in all these places the blue grass made a luxuriant growth, but farther down the slope where the magnesian limestone occurs only a sparse growth was noted. In fact, it is not incorrect to say that thruout the Ozark region where the magnesian limestones prevail blue grass does not "take" the land or make a profitable crop. Apples, small fruits, and vegetables all do well, tho 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 live stock raising. The soil is not strong enough and washes too easily 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 railroads and to the St. Louis market. The possibilities of the soil are many, and have been only partially realized.

Chemical analysis--Union silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1353	750	34,583	1457
Subsoil	1606	703	36,666	460

Crawford Gravelly Loam

The Crawford gravelly loam nearly everywhere in the region of its occurrence is known as 'red land' or 'red limestone land', 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 were mapped in Cass, Jackson, Pettis, and Cooper Counties and

in Cape Girardeau County. The total area is approximately one thousand square miles. Altho the soil has been called a gravelly loam there are included large bodies of land that are a silt loam in texture as will be subsequently pointed out.

In its typical development the Crawford gravelly loam consists of a brown, reddish brown, or grayish brown mellow silt loam, grading at about eight to fifteen inches into a reddish brown friable silty clay loam which becomes redder and more gravelly with depth, passing below into red crumbly clay generally carrying an impenetrable mass of angular chert fragments. The latter are distributed thruout the soil section, but are much more abundant in the lower strata. The soil contains approximately ten to thirty per cent, and the subsoil twenty to seventy 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, and limestone fragments are scattered thru the soil. Such areas are not very drought resistant, and are therefore used largely for pasture land. In general, the southern border of the type in Christian County is 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 that is essentially the same as the Bates soil of the residual prairie region. They are derived from coal-measure shales and sandstones which have escaped complete erosion.

Near Springfield, in fact thruout the central part of Greene County, the soil is a silt loam, even the subsoil being 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, but especially well suited for such deep rooting plants as alfalfa, clover, and also fruit trees.

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 bedrock is usually encountered within the three foot section. In Jackson County, especially, rock outcrops occur along most of the drainage ways, which tends 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 in the areas to the west.

In general, the topography of the Crawford gravelly loam is smooth to gently rolling. There are belts of moderately hilly country along both sides of the main streams, but when not too stony are rarely too steep for cultivation. In fact, the surface features of this soil type are not as

broken as of the glacial lands in the northern part of the State.

It is the typical soil of the coarsely crystalline, pure, moderately cherty, massive bedded, fossiliferous Burlington limestone. Altho much of the soil in southwestern 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 Crawford soils. Where the rock is more cherty the soils contain more chert and have therefore been thoroly leached and are of a lighter color. The two characteristics of a fair amount of chert and a relatively larger amount of fine material prevented excessive leaching, yet permitted thoro oxidation to a great depth. The relatively small amount of soil material from the pure limestone caused a greater concentration of the iron material, 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, were 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 color. It is thus probable that the native vegetation is largely responsible for the difference between the Crawford and Hagerstown soils since both are derived from similar material and existed under similar climatic conditions. The small area of Crawford soil in Cape Girardeau County, derived from Burlington lime-

stone, is a timber soil, and is lighter in color than the main areas in the western part of the State.

Practically all of the Crawford gravelly loam is under cultivation and is probably the most productive of all the Ozark soils. It is an excellent grain and clover soil, a large part of it being sown to wheat every year. Yields of the latter range from 10 to 25 bushels per acre. Where the soil is fairly well supplied with organic matter alfalfa does remarkably well. Next to the loess in the northern part of the State, the Crawford gravelly loam is the best fruit soil in Missouri. Apples, peaches, and all kinds of bush fruits make a strong growth and produce fruit of good flavor and coloration. General farming, supplemented by stock raising, dairying, and fruit growing, is the prevailing type of agriculture. Phosphatic fertilizer is extensively used in connection with wheat growing. No soil responds more readily to applications of manure than does this red limestone soil. The many substantial farmhouses, thrifty orchards, and well tilled fields indicate a general condition of prosperity thruout this type.

Chemical analysis--Crawford silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	2748	1404	29,510	3222
Subsurface	3400	1400	-----	6500
Subsoil	1720	1340	26925	4055

Crawford stony loam

Soil	2173	746	27,926	0
Subsoil	620	920	31,560	0

Lebanon Silt Loam

The Lebanon silt loam represents the relatively smooth, stone-free plateau or ridge top soil of the Ozark region. The most extensive areas 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 has been included in this type.

In its general characteristics the soil is a gray silt loam low in organic matter, and underlain by yellowish gray rather heavy silty clay subsoil. Typically, the surface soil to a depth of six to eight inches is a gray to grayish brown silt loam grading into a pale yellow silt loam, which in turn changes to yellow or gray, hard, friable silty clay or clay loam. The lower subsoil is invariably a crumbly silty clay mottled gray, brown, and drab, and usually contains some chert fragments. 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. Level areas with poor drainage have a light gray surface soil and a drab, heavy plastic clay subsoil. As soon as the topography becomes more rolling the subsoil is more friable, and of a brown or yellowish color.

That portion of the Lebanon silt loam occurring in Lawrence, Newton, Jasper, and parts of Polk County is similar in many respects to the Cherokee silt loam in Barton and Vernon Counties. The surface soil is dark gray or brownish gray, and the subsoil a drab to brownish very heavy plastic clay loam or silty clay. The lower stratum shows the usual friable structure and bright mottlings, but rarely contains chert gravel. It is a rather cold soil, difficult to handle, and not very productive. The areas of Lebanon silt loam in the eastern part of the State, notably in Ripley and Carter Counties, are locally known as ''Flatwoods''. It differs from the typical soil in that it has a more reddish or yellowish brown color and more friable structure in the subsoil. At a depth of thirty to forty inches chert gravel is frequently encountered, as well as a cementation of clay and iron which forms an almost impenetrable mass.

It is generally supposed that the Lebanon silt loam is largely derived from rocks which originally lay over the whole western and northern half of the Ozark region. In the western part of the region there is but little doubt that it is a remnant of the Coal Measure shales and clays that originally extended farther east. In the northern part of the region it seems to be either a remnant of Coal measure shales or of glacial clays. In Ripley County the soil is undoubtedly residual of limestone, the latter containing little or no chert. It is probable therefore that the parent

material in every case contained a relatively high per cent of clay which has become more or less mixed with the debris of the typical cherty Ozark rocks.

The Lebanon silt loam is probably the oldest soil in the State, and has become thoroly leached. Most of the lime and iron has been removed, much of the latter having accumulated as concretions in the lower subsoil. Moreover, there has been a translocation of much of the finer material from the surface downward into the substratum, which makes the latter heavy and compact. The content of organic matter is low, and the soil is only moderately productive. It has, however, a good physical character and with the comparatively smooth topography can be easily cultivated.

Originally the greater part of the Lebanon silt loam, particularly in the western part of the State, was prairie or open timber land with blue-stem grass. With the cessation of the forest fires, a scrub growth of oak quickly grew up, so that now all the noncultivated areas are covered with post oak and brush. In the eastern part of the State red oak is the characteristic timber growth. Probably not more than fifty per cent of the type is in cultivation.

Drainage is inadequate, particularly in the southwestern areas, and the soil remains cold and wet until late in spring. It readily becomes saturated in wet weather, but also dries out quickly as the supply of moisture from below is brought up extremely slowly.

Corn, hay, and wheat are the principal crops. Corn yields from 10 to 30 bushels per acre, altho occasionally higher yields may be obtained under exceptionally good treatment. As a rule the yields of wheat are not profitable unless fertilizer is used. Hay yields from one-half to one ton per acre. Meadows quickly deteriorate, become infested with sedge-grass and briars, and must be renewed about every three years. There is no doubt that the most profitable use of this soil type is for livestock farming, probably growing some corn, wheat, and oats with fertilization, followed by grass and possibly clover. As a cultivated crop, cowpeas might be included in the rotation.

Chemical analysis--Lebanon silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1957	793	26,233	2031
Subsoil	1367	785	22,977	2829

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 show on the soil map occur in all the adjoining counties. In general, the northern areas of the type differ in topography and composition from the southern areas, as will be pointed out in the following paragraphs.

In Cape Girardeau, Perry and St. Francois Counties the typical Tilsit silt loam consists of pale yellowish brown silt loam, grading at about six to eight 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 sandstone comes 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 distinct 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, largely because of this fact,

it is easily eroded.

Practically all of the southern half of the type is in cultivation, and is used for corn, wheat, clover, and cow-peas. 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 of 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 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. It formerly extended farther west than it does now, but has been placed in its present position by the wear and tear of the elements, leaving a great deal of its material in the soil as it weathered back. The farther from its 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 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 whose distribution and character are determined by the parent rock (Plate VIII). Since the sandstone from which it is derived weathers at about the same rate as the surrounding limestones the surface features are the same, but the soil from the former containing less humus and being more porous has been eroded and leached to a greater degree.

Thru a proper rotation with the growing and plowing under of leguminous crops and the use of manure this soil can be kept in a fairly good state of productivity. The growing of winter cover crops is important in checking erosion on all sloping land. Wheat is extensively grown, but the yields average smaller than on the adjoining Hagerstown soil. Clover does not make a good growth unless the land is well supplied with organic matter.

Chemical Analysis--Tilsit silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1560	820	29,240	240
Subsoil	800	1180	32,880	4200

Diagram Showing Variations in
the Soils Due to Weathering of
Rocks (*Angle of Dip Greatly Magnified*)

The above table indicates that the soil contains a rather high per cent of potassium. The high lime requirement of the subsoil is a characteristic of nearly all soils derived from sandstone.

Boone Loam

The main area of the Boone loam lies in Dent County, but numerous areas, either too small in extent or whose boundaries have not been 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 clay or sandy loam prevails, but where limestone is the most important parent material the subsoil is generally a stony clay. This latter phase occurs around the northeastern and southern borders of the type and along some of the larger valleys. The former occurs in the interior of the area. There is an apparent increase in sandy character southward and eastward. The stones scattered thru the soil and subsoil are never present in sufficient quantity to seriously interfere with cultivation.

The main area of the Boone loam lies on and near the

Ozark Divide, and in a locality where the surface has not as yet been deeply dissected. The topography therefore is level to gently rolling and is essentially the same as that of the Lebanon silt loam. 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 into another type of soil. All of the surface, therefore, is of such character as to permit of 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 Boone loam is derived from a medium to coarse grained brown to 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 is separated into two beds by an interbedded limestone.

Black jack and post oak is the prevailing timber growth, altho black oak occurs on the more clayey phase, especially if it has a reddish color. Originally the greater part of the type was prairie or 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 brush.

The greater part of the Boone loam is still in timber. 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, and probably more 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. It has not been abandoned on account of its being worn out, but because the natural fertility of the soil is so extremely low that farming is not profitable.

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

Soils from Cherty Limestone and Granite

Clarksville Gravelly Loam

The Clarksville gravelly loam is one of the most extensive of the Ozark soils, 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 is not as cherty and the topography less rugged.

The surface soil to an average depth of eight inches consists of a gray or pale yellow gravelly loam or silt loam. The immediate subsoil from a depth of eight inches to about twenty-four inches is a heavy yellowish or grayish brown silt loam which grades downward into a stiff, friable, reddish brown silty clay. 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, the amount usually increasing with depth. The chert-free or moderately cherty areas border the Lebanon 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 is that of the Crawford soil, but it is not as quartzitic in character as that of the Clarksville stony loam.

The surface features of the Clarksville gravelly loam vary from almost level to hilly. Where the type surrounds

the Lebanon 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 prevailingly hilly. The several areas occurring in St. Francois and the surrounding counties are sharply rolling, but rarely are the slopes too steep to make cultivation possible. In general, it can safely be said that the content of rock in the soil rather than the topography is the limiting factor in the utilization for agriculture of the Clarksville gravelly loam.

The rocks underlying are cherty limestones and magnesian limestones, the latter being 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, there 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 Lebanon silt loam. 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 consisted of the various oaks, with some hickory and walnut. Probably more than fifty per cent of the type is now cleared and in cultivation. Much of the timbered portion is too stony to permit of profitable agriculture, but can be used as woods

pasture. By removing the brush the pasturage on much of such land could be greatly improved. 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 good growth if the soil is fairly well supplied with organic matter. As a rule, the best results are obtained on new land, on north slopes, and on the moderately gravelly areas. Of the grasses, orchard grass is by far the most successful.

Apple trees do fairly well, especially on such area as have a deep red subsoil. Strawberries and other small fruits are commercially grown in the southwestern counties. Peach growing is an important industry in Howell County. 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 great.

Chemical analysis--Clarksville gravelly loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1013	393	22,313	1733
Subsoil	495	600	25,395	1265

Analysis of the Clarksville gravelly loam shows the subsoil to be extremely low in nitrogen, due largely to the high per cent of gravel. The content of phosphorus also is

very low, lower than of any other soil type in the State.

Clarksville Stony Loam

The Clarksville stony loam is the most extensive soil type in the State, and includes approximately one-third of the Ozark region. The main area occurs in the east-central part of the region, with minor areas bordering all the streams, but in every case this soil type represents rough and stony land, only a very small per cent of which can be utilized for agricultural purposes.

The greater part of the soil 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. From twenty-five to ninety-nine per cent of the soil mass consists of chert fragments ranging in size from small particles to pieces several feet in diameter. Frequently the surface is so thickly strewn with these fragments that fine soil material is not visible. Rock outcrops are numerous.

On the narrow ridges and on many of the north slopes the soil is a gravelly loam and can be cultivated fairly easily. At the base of long slopes bordering the larger valleys there frequently occur small patches of silty or moderately gravelly soil, representing the wash from the hills. Such areas are rather productive and are cultivated,

but in total area they are of negligible importance. That part of the Clarksville stony loam bordering the White River in Taney and Barry Counties contains comparatively very little chert, and correspondingly more soil material, but rock outcrops are so numerous and the surface so broken that the land is 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. The occurrence of even small areas of smooth land is so infrequent as to be practically negligible. The tillable area is small and will always remain so, not only on account of the roughness of the topography but also on account of the large amount of stone in the soil.

The rocks giving rise to the Clarksville stony loam consist mainly of very cherty limestones. 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 siliceous than in the northern part. The soil in the former region therefore contains more stone, is more porous and drier. It is the region of pine timber.

In general, the Clarksville stony loam is non-agricultural land. It is, and should remain, a forest area mainly. Such small farms as have been established within the type represent the valleys or ridges where the stone content is

small. The crops grown are the same as those on the other Ozark soils.(Plate IX).

Ashe Stony Loam

The Ashe stony loam probably has the least agricultural value of any soil type in the State. 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 gray, usually very stony silt loam or silty clay with a yellowish gray clay subsoil, the latter being full of stones also. The heavier phase as a rule occupies the more level granite areas. It contains comparatively few stones but is difficult to work. In general, the soil mantle in all this type is very shallow, frequently only a few inches in depth or it may be entirely absent. Cultivation is practically impossible. Moreover, such small areas as are smooth enough and stone-free enough to be plowed are not sufficiently productive to make their cultivation profitable.

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.

Topographically the Ashe stony loam is the roughest land in the State. Only a very small part of it is smooth

enough to cultivate. The greater part of it consists of steep mountain sides, the tops of the peaks being from two hundred to seven hundred feet higher than the adjacent lower country. The valleys are mere gorges, usually too narrow for even small fields. As a whole, this type must be considered practically non-agricultural.

The whole area, except the small patches that are cultivated, is covered with a growth of black, white, and red oak. Post oak occurs with the others on the smooth areas underlain by granite.

Alluvial Soils

Huntington Loam

The alluvial soils of the Ozark region make up a relatively small but nevertheless an important part of the area. It has been estimated⁽⁶⁾ that one-fourth of the grain produced is grown on the alluvial soils. In the economy of the region they are therefore of the highest 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 the belt of alluvial land does not average more than one-fourth mile in width, and usually much less than this.

The Huntington loam has been made to include all the

alluvial land, since the latter is predominantly a loam in texture altho it also includes gravelly loams and silt loams. In color it is brown, reddish brown to dark brown, but gray to nearly white soil occurs, the latter representing terraces of limited distribution. In the region of the Clarksville stony loam, and along many of the small streams, it is gravelly as a rule, the gravel consisting wholly of chert. Bordering the stream the soil is almost universally a loam or fine sandy loam. In the wide valleys and back from the stream the texture is usually a silt loam.

There is usually very little difference in the physical properties of soil and subsoil. The latter is invariably of a light texture, and frequently is sandy or gravelly in the lower portion. This is but natural, since all the streams flow at rather steep gradient and deposit only coarse material. Taken as a whole, the Huntington loam does not stand drought very well, especially in areas coarser than a loam. However, the water table usually lies sufficiently near to the surface to be in reach of deep-rooting crops, and total crop failures are of rare occurrence.

The Huntington loam is alluvial in origin except in the narrow valleys where it is partly colluvial. The material is derived from the cherty limestone soils with an admixture of more or less sand from the thin sandstone beds. The surface is level, altho there are many shallow depressions

and abandoned channels that are frequently deep enough to limit the size of the fields. 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 the high average yields obtained attest to the high fertility of this type. Wheat, clover, alfalfa, and grasses all thrive exceedingly well. A very small acreage is used for pasture purposes, as the less fertile hills adjoining supply sufficient grass for this purpose. Rarely is an attempt made to build up the land by the use of manures or fertilizers, since these materials bring larger returns when applied to the upland soils.

Chemical analysis--Huntington silt loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1820	1176	24,875	782
Subsoil	1400	1135	25,580	1437

Southeast Lowland Soils

General Description

The Southeast Lowlands present one of the most varied and interesting soil areas in Missouri. Altho all the soils are of alluvial origin, they are unlike the alluvial soils in other parts of the State. The latter receive new soil material at each overflow, and are therefore still in the process of formation. Their characteristics are not fixed, but are subject to change. The soils of the Lowlands, altho for the most part subject to overflow, do not--excepting along the Mississippi River--receive new soil deposits. The overflow water consists of local rainfall, and of water from the upland streams. The latter, as a rule, has lost its load before entering the Lowland or immediately after doing so, and thus adds no new soil material. The Lowland soils may therefore be said to be static in their characteristics, and in this respect are like upland soils.

The deposits from which the Lowland soils are derived have been 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 Loessal Prairies, and residual uplands together with varying amounts of organic matter. It is only along the edge of the uplands and at the debouche of the small streams that the soil is largely of local origin. It is more than probable that the

alluvial lands between Crowley's Ridge and the main upland consists largely of loessal material washed down from the adjoining uplands (particularly Crowley's Ridge) and is therefore more homogenous in source than are the alluvial lands east of the Ridge. The rather remarkable uniformity and fine texture of the soil indicate strongly that it consists of reworked loess. Moreover, the similarity of the alluvial soil along the streams within Crowley's Ridge to 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 swift current consist of sandy soils, while areas of slow flowing or standing water consist of silt and clay loams. This is due to the checking of the current upon leaving the main channel, which causes the coarser particles to be deposited first, while the clay, silt and finer sand are carried farther back and laid down in the more quiet waters. The occurrence of the extensive area of sandy soil bordering the Mississippi river is therefore easily explained. This area in the northern part, within the bend of the river, is much wider than in the southern part where the river flows in an almost straight line.

The belt of heavy soils extending from near Cape Girar-

deau to the Arkansas State line represents the old river channel.⁽¹⁷⁾ 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 a slow one, and ample time 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 similar causes now acting along the present banks of the Mississippi River.

The pronounced color differences of the several Low-land soils is of interest not only to the student of soils, but also to the farmer who uses it as a basis for determining the relative 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 referred to. 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 such a degree that most of the humates have disappeared, and 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 due to the organic matter. Weathering has been more complete than on better 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.

Coffey⁽⁹⁾ states that "If a soil is low in lime, intermittent wet and dry conditions will cause it to turn white and markedly decrease in productiveness, while if lime is present it will become much darker and an increase in productiveness will take place."

The removal of the iron, or at least the leaching of it from the upper soil to the lower strata, is cause also for the gray color of the soil, and for the presence of the numerous concretions in the subsoil. Moreover, on account of age and leaching and the low lime and organic content, there has been a greater translocation of the finer particles from the surface downward. As a matter of fact, these gray soils are the only alluvial soils that show stratification, altho they are replenished in the surface by additions of material to a greater extent than the other Lowland types. The color of these Lowland soils is therefore of great sig-

nificance, as it indicates their age, drainage condition, and relative amount of leaching and loss of fertility they have undergone.

In general, 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 nearly inexhaustible fertility, but their total area is small..

On the basis of color and textural differences, the soils of the Lowlands 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 innumerable. Moreover, they are not as important agriculturally as in upland soils, owing principally to the much shallower depth of the water table and 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 the soil.

Sarpy Fine Sandy Loam

The Sarpy fine sandy loam represents the extensive frontal land along the Mississippi River in the Lowland region. It includes all of Mississippi County, and the eastern part

of Scott, New Madrid, and Pemiscot Counties.

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 clay, but prevailing is a fine sandy loam or loam to the extent of more than eighty per cent of the type. The color varies from brown, thru gray to black, with all intermediate shades. Probably the most persistent and distinguishing characteristic of the type is the texture of the subsoil, the latter being almost without exception a grayish brown fine sandy loam. The depth of the surface soil is about twelve to eighteen inches. In general, there is no line of demarcation between soil and subsoil, and the only apparent difference is the somewhat lighter color and texture of the latter. It is of special interest to note that while all 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 seasons. This condition has been aggravated in recent years due to the continued cultivation of the land and the consequent burning out of the organic matter which acts as a soil binder.

Thruout the area of the Sarpy fine 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 8 or 10 to 50 feet or more, and in height from only a few inches to thirty-six inches or more. They are elongated, and have a northeast-southwest trend, which indicates their origin from swift flowing water in time of high overflow. The material of these mounds is largely quartz sand, medium to coarse in texture, and averaging coarser and sharper than that of the surrounding soil. They probably result from the gathering of the sand in clumps of bushes or trees.

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, account for the greater accumulation of fine material on the lower ground. This, in part, explains the variability in texture and color of this soil type. 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 seriously affect crops. With the exceptions 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, doubtless, more or less capillarity between the root bearing layer and the permanently saturated substratum of sand, so that droughty conditions in a properly tilled field are rarely serious.

In general, the whole of the Sarpy fine sandy loam is under cultivation and includes some of the most improved land in the Lowland region. Various reasons may be given for this. Bordering the river, it was the first to be settled by the early immigrants, who did not venture far inland from the large streams. In general, drainage conditions are better than on the soils to the west, and the construction of costly drainage channels was not necessary before the land could be cultivated. The light texture

and high fertility of the soil made cultivation easy and profitable.

All of the crops common to the region are successfully grown on the Sarpy fine sandy loam. In Scott and Mississippi Counties corn, wheat, cowpeas and alfalfa are the staples, while 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 are especially well adapted to alfalfa. The deep, porous subsoils permit of 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 value of all farm property in Pemiscot County from 1900 to 1910 increased more than 263 per cent. The influx of farmers has been mostly from the northern states. These men have brought with them the most improved type of agriculture which is rapidly replacing the indifferent and extravagant methods of the early settlers.

Lintonia Series

Lintonia Silt Loam

The area of Lintonia silt loam forms one of the most pronounced physiographic divisions of the Lowland region--Sikeston Ridge. The latter, extending from near the center

of Scott County to New Madrid in the same 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 offset of twenty to thirty feet to the bottoms, but on the east it grades rather gradually into the Sarpy soils.

The surface soil of the Lintonia silt loam in general consists of a brown, dark brown or grayish brown silt loam to fine sandy loam to an average 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. The lower subsoil is nearly always a silty clay with some sand. In general, the soil on the west side of the ridge is siltier than on the east side. Numerous areas of sandy soil, in some respects resembling the "sand blows" of the Sarpy soils, and varying in extent from a few square rods to several acres, are found thruout the ridge. The sandy surface soil is usually associated with a sandy subsoil, but in many places the latter is almost sand free. The occasional shallowpond-like depressions, and shallow swails and abundant bayous, have light gray surface soils with gray or drab clay subsoils. The light color of the soil is due to inadequate aeration and almost constant saturation during rainy seasons. These areas are much inferior to the main type, and resemble the Waverly soils.

The Lintonia silt loam is alluvial in origin, having

been deposited by streams when flowing at higher levels. The soil material 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 evidences 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 under-drainage are good. Aeration is effective to great depths, and this is doubtless the chief cause of the high degree of oxidation of the ferruginous minerals, and the rapid decay and rather slight accumulation of organic matter in the soil.

The Lintonia silt loam is one of the oldest, if not the oldest, settled soil in the State. New Madrid, founded in 1764, is located on it. 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 the principal crops, but of these cotton is no longer grown. With the decrease in the fertility of the soil there has been a reduction in the acreage of corn, and small grains, clover, cowpeas, and grass are now the most important crops. In general, the Lintonia silt loam is a highly desirable soil

for general farming, but its efficiency could be greatly increased by addition of organic matter of which it is greatly in need.

It represents the highest priced land in the Lowland region. The prevailing price is \$100 to \$150 per acre, but sales at \$250 per acre have been made. These high values are due not only to the desirable physical properties of the soil, good drainage, and transportation facilities, but because much of the land is held by wealthy owners who have given it a high social value.

Lintonia Fine Sandy Loam

The Lintonia fine sandy loam, like the Lintonia silt loam, represents a distinct physiographic area of the Lowland region--Dunklin sand ridge. The latter begins near Dexter in Stoddard County and extends south thru Dunklin County to the Arkansas State line. In the northern part it varies from four to six miles in width, 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 of the type occur in Ripley County and the northern part of Stoddard County, but only those in the latter location are of sufficient extent to show on the soil map.

The Lintonia fine sandy loam is dominantly a fine sandy loam, altho included in it are 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 usually is somewhat lighter in color and 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 thruout 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 comparatively 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 soil material associated with good aeration and drainage. For the same reasons the content of organic matter is not very large and is not present in sufficient quantity to conceal the brown coloration of the soil particles. 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 existing under poorer drainage conditions, contains a much larger amount of organic matter, and is not as thoroly oxidized as the former. It is possible, too, that this difference is aggravated somewhat by the greater age of the Lintonia soil.

The surface of the Lintonia fine sandy loam is nearly level with the exception of faint undulations which are hardly noticeable in perspective. Slight mounds and low ridges from a few inches to several feet in height occur, as well as slight depressions, generally 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 type.

Like the Sikeston Ridge, the Dunklin sand 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 of high grade. Corn, cowpeas, clover,

and melons are extensively grown. Alfalfa thrives where drainage conditions are good and the soil not too coarse in texture. Potatoes, peanuts, truck, and other crops which require a warm light soil are successfully grown.

Chemical analysis--Lintonia sandy loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1791	1054	----	858
Subsurface	1190	1065	----	1562
Subsoil	960	1012	-----	1080

The soil has lost much of its original fertility, especially where cotton has been grown many years in succession and no organic matter supplied. The necessity of growing legumes and winter cover crops for green manures is being realized. Commercial fertilizers are used to some extent--usually for melons. The very sandy areas are not drought resistant, and frequently crops suffer.

Sharkey Clay Loam

The Sharkey clay loam forms the belt of heavy soil extending from the southern part of Cape Girardeau County to the State line along the south side of Pemiscot and Dunklin Counties. This area is frequently known as the Little River Valley. It undoubtedly represents the old channel of the Mississippi River before this stream shifted its course to the present position.⁽¹⁷⁾ It is but to be ex-

pected that the soils of such a large area have considerable variation, and only the main 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 thruout the soil section. The surface soil contains a rather large amount of organic matter, which makes it fairly friable. The immediate 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 subsoil in general is quite uniform, altho sand or sandy clay is encountered in places. Such areas represent an approach to the Waverly soils. 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 outer border 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 from 50 to 65 per cent of clay and from 30 to 40 per cent of silt. The content of organic matter is considerably higher than for the type as a whole, and in restricted areas--along east side of Dunklin sand ridge, west side of Sikeston ridge, and northern part of Stoddard County--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 and even serve as natural drainage ways. The timber growth consists of cypress, ash, and tupelo gum almost exclusively. Such areas as have been drained have proven exceedingly productive, and are used for corn almost exclusively.

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 clay 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 a much easier cultivated soil than the Wabash clay loam. As a rule the soil loses much of its "stickyness" after being cultivated a few years, due to a decrease or at least a change in the organic matter. 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 much wider range of moisture conditions than on most soils of 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 no trouble will ordinarily be had 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 in the depressions. Locally the Sharkey clay loam is termed "'swamp'" because most of it is subject to annual overflow from water which comes in from the Ozark streams. Drainage is necessary before the land

can be cultivated. Many ditches have already been constructed, and with the completion of all the proposed drainage all of the type can be utilized. There is no doubt but that in time this vast area of heavy soil will be as valuable and as productive as any part of the Lowland region.

In its natural fertility the Sharkey clay loam is probably on a par with 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. Portions of the type are well adapted to the production of rice.

Land values are determined largely by the moisture 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.

Chemical analysis--Sharkey clay loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	4355	2855	36,820	1750
Subsurface	1753	1826	-----	116
Subsoil	1600	1620	39,460	0

From this table it will be seen that the total amount of plant food in this soil is as high as in the alluvial soil of north Missouri. The content of potassium is especially high. The greater lime requirement of the surface soil would indicate that the acidity is due to organic material.

Waverly Soils

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 light color and silty texture of the soil, and the smaller timber growth. 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 in 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, faintly mottled with rusty brown colors, which grades at a depth of six to ten inches into a light gray to white silt loam also mottled and containing small iron concretions. The subsoil below fifteen to eighteen inches is almost uniformly a 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 twenty-four inches, but where the surface averages a silty clay the subsoil is correspondingly heavier, and generally lies within fifteen inches of the surface. The gray subsurface layer is always present and is most highly developed in the silty soil, but 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 a large amount of organic matter, and in general does not have the weathered appearance of the older soils to the south. Much of this area possesses almost true swamp characteristics, having a light floating soil or mud from a few inches to several feet in depth. The outer edge of these bogs is covered with cypress and ash, but in the center they are either open water or are covered with flags and water loving grasses. When drained the soil will be the same as the surrounding Waverly silt loam, but will contain a much higher percentage of organic matter.

Thruout the Waverly silt loam, particularly near Crowley's Ridge, there are places where the surface soil to varying depth 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 on the surface and thruout 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 identically the same way, at the same altitude, 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 it existed. There is no question but that the Waverly silt loam is largely of local origin, washed down from the adjoining uplands, and therefore consists of reworked loess. This explains the uniformly fine texture of the soil, and the relatively higher altitude of the land near Crowley's Ridge. It is also correct to assume that the alluvial deposits and especially the wash from the upland did not have the characteristics that the soil now has.

These changes were brought about by poor drainage and the consequent leaching and filtration of the clay particles in the lower subsoil. The alternate wetting and drying of the soil in the presence of decaying organic matter is directly the cause of the gray color and the abundance of iron oxide concretions, normal oxidation, which in this re-

gion gives a uniform brown color to a soil, having been inhibited 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 cemented the soil particles and formed a hardpan. Probably no other soil in the State has so well developed a tendency toward hardpan as does the Waverly silt loam, and the only plausible reason for this is that described above.

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.

It is but 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 as 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 can not be considered a good corn soil, but is best adapted to wheat, peas, and grass, and it is on these crops that the future agriculture of the type will probably depend. A very small acreage of cotton and clover is grown. Attempts at growing rice have been successful, and it is probable that this industry can be extended with profit.

Chemical AnalysisWaverly Silt Loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	1764	1556	24,520	4088
Subsurface	1013	1800	-----	3166
Subsoil	956	1360	26,700	2408

Waverly Clay Loam

Soil	2588	1040	25,780	2740
Subsurface	1150	680	-----	0
Subsoil	908	1024	23,400	288

Calhoun Clay Loam

Soil	1980	1032	27,180	5020
Subsurface	1246	1020	-----	6000
Subsoil	1780	955	24,940	5344

Waverly Fine Sandy Loam

The Waverly fine sandy loam is found in Stoddard County east of Crowley's Ridge, and 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 eight to twelve inches into yellowish brown, compact, fine sandy loam. The subsoil from eighteen to thirty-six inches

is fine 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 thoroly leached. Most of this area is subject to annual overflow which comes in from Black River.

In Stoddard County all 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 thoroly 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 and the very acid condition of the soil. The hardpan in the lower subsoil tends to keep the soil saturated with water and thus makes it cold and difficult to handle.

Chemical analysis--Waverly loam and fine sandy loam

	Total Nitrogen	Total Phosphorus	Total Potassium	Lime Requirement
Soil	2026	1813	22,250	3216
Subsurface	1393	2126	-----	833
Subsoil	803	1610	22,253	656

General Consideration

The discussion of the Soils of Missouri has been confined in this thesis to twenty-eight types, each of which represents as nearly as possible uniform conditions as to its origin, physical properties and agricultural value. It is obvious that in an area so large as Missouri, with a great complexity of soil conditions, each type must include variations, but in general these have no special importance in determining the adaptation or utilization of the soil as a whole. Because of the great area of these few types, because each soil is preeminently adapted to the production of some great staple crop or group of such crops, and because each soil possesses particular problems in its management, the agriculture of the State is influenced more by such homogeneous soil areas than by a diversity of minor types.

Agriculture is still a generalized business, altho its specialization into horticulture, market gardening, and other subdivisions has begun. With increasing population, with greater intensity of cultivation, greater demands will continually be made upon the soil and greater precision and skill in the selection and handling of soils for special crops will be required. The soil factor which governs plant and crop growth must therefore be understood and appreciated. The fact

that each crop has varieties suited to different soils must receive more recognition. The problems of maintaining and ever increasing the producing capacity of the agricultural lands, while they are probably economic and farm management problems to a certain extent, are only capable of solution after a thoro study of soil conditions in the field. Moreover, such studies can not be confined to small areas of only a few acres in extent, but must cover the entire region under consideration.

In general, the soils of Missouri are capable to a greater or less degree of further extension either of cultivated area or of more diversified, more intensive, and more profitable agricultural occupation. Of the Ozark soils, less than one-fourth the total area is in cultivation. However, further development waits upon the solution of economic problems rather than upon the discovery of suitable methods of their utilization. It is primarily upon the soils that are now in cultivation that the future agricultural development of the State depends. This will be made possible by accurate and detailed knowledge concerning the character, varieties, adaptations, and capabilities of each of the twenty-eight soil types that have been established.

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Bureau of Soils.

Soil Map of Missouri.

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