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The Brown Loess Soils of Missouri and Their Utilization

Fig. 1.—The brown loess soils are adapted to a great variety of crops. Among these, fruit is becoming steadily more important.

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MISSOURI'S WEALTH OF BROWN LOESS

1. The loess soils represent the most valuable single soil resource of Missouri. They cover approximately one-eighth the area of the State, but in their relation to the agriculture of the State they occupy first place. Their utilization for successful crop production has made it increasingly evident that they are capable of a much greater development, and this fact has prompted the publication of this report.

2. Loess soils have characteristics of origin and structure that not only are of interest to the student of soils, but also explain their desirability for crop production.

3. Loess is generally considered to be wind-deposited soil material. Within the confines of Missouri it forms an almost unbroken belt of upland soils along the Missouri and Mississippi rivers.

4. The brown loess soils with which this report is concerned, are commonly known as "river hill lands". They represent the brown colored, timbered soils, as distinguished from the dark colored prairie soils of the loess deposits. They are generally characterized by deep, mellow, silty surface soils and open, friable, silty clay subsoils.

5. The very favorable physical properties of these soils, and a rather high degree of fertility bring about marked productivity and an adaptation to a great variety of crops, especially deep rooting crops such as legumes and fruits.

6. The limitations in the utilization of the brown loess soils are primarily those of topography. Practically all of them have a rolling or hilly surface. The stronger relief predominates in the eastern part of the State, so that in places as much as 25 per cent of the land is non-arable. Soil erosion is everywhere a serious problem.

7. General farming is the prevailing type of agriculture, but near the towns more intensive practices based on dairying, fruit growing and trucking, prevail. Soil, market and transportation conditions are especially favorable for an extension of the fruit growing industry. As a whole, the brown loess soils possess superior advantages for a "small farm" type of agriculture.

The Brown Loess Soils of Missouri and Their Utilization

H. H. KRUSEKOPF

Abstract.—In this publication are reported some of the results of a reconnaissance survey of the brown loess soils of Missouri. This survey was made in 1921-22 for the purpose of obtaining information concerning the extent, general character and the possibilities of these soils to serve as a practical guide toward their best utilization. The origin and structure of the loess soils are explained and their extent and location are shown on a specially prepared map. The adaptability of these soils to a great variety of crops is noted, with special emphasis on their utilization for fruit growing. The report recognizes the chief limitation of the loess soil—their susceptibility to erosion—and describes systems of management to avoid losses from this source. The report ends with an analysis of the factors that fit the loess soils primarily for a "small farm" type of agriculture.

Along the Missouri and Mississippi Rivers in Missouri is an extensive belt of upland commonly known as "bluff land," or "river hill land." The soil material distinguishing this bluff land is known as loess. Soils derived from loessal deposits always have attracted much interest because of their wide distribution and high agricultural value. In Missouri they constitute one of the most extensive and important soil groups, and have a significant relation to the agricultural development of the State. In the diversity of the agricultural products, in the intensity of the cultural methods practiced, and in the high average yields of all crops grown, the loess soils are not excelled by any other group of upland soils.

In order to secure information on the extent, general character, utilization, and possibilities of the loess soils the Missouri College of Agriculture in 1921-22 made a reconnaissance survey of the brown loess soils in the State. Some of the results of this study are included in this report.

Farms of small size are in steadily increasing demand among farmers of small means and those who wish to operate only on a modest scale. Farms of this type to be most successful must fulfill several requirements. They must be favorably located with reference to towns and transportation facilities. They must offer favorable home sites. They must have a soil that is of rather high productivity, that is easily handled,

NOTE.—This report has been prepared largely for the use of those interested in the utilization of the brown loess soils of Missouri. It is proposed to publish at a later date a more technical report dealing with the detailed characteristics of these soils.

and that is suited to the growing of a wide range of crops. No other group of upland soils possesses all these characteristics to so marked a degree as do the brown loess soils.

The adaptability of the brown loess soils for fruit production, particularly orchard fruits, and for the production of a great variety of small fruits and general crops, has long been recognized. No other soil in Missouri will grow so many crops with success as the brown loess. While there are other soils better adapted to corn and other general farm crops, the brown loess soils grow them all with fair to good yields. Orcharding and small fruit growing have attained their greatest success on these farms. The need for and the possibility of the extension of these industries seems to be closely related to their development on favorable soil conditions. The brown loess soils are the only ones on which tobacco is grown to any extent. They are in most cases well suited to alfalfa. They grow excellent grass, clover, and grain crops. It is the purpose of this report to point out the relation of the various phases of the brown loess soils to their agricultural utilization.

It is important to note that this report is confined to the *brown* loess soils, so named because of the predominating color. It does not include the dark prairie lands which are generally considered as being derived from loessal deposits. Neither does it include other upland soils which contain an admixture of loessal material, but have been modified appreciably by the latter. In brief, this report is confined to those brown soils derived entirely from loessal deposits.

It can be assumed that with these limitations, the brown loess soils comprise less than one-third of the State's total loessal area. It must be apparent also, that the limits of the brown loess soils in relation to the other loess types, as well as to the soils of residual or glacial origin, cannot always be definitely established. Probably in no other general soil group do variations and differences blend so gradually or extend over such wide areas as in the loessal group; and in some places a change of one or more miles in the soil boundary indicated on the map would not appreciably affect its accuracy.

The classification of the brown loess soils into various types is according to the method used in all detailed soil mapping, and it is based primarily on such factors as color, depth of soil, character of subsoil, and surface features. It is important to remember that there are included in each type numerous small areas of non-loessal soils, consisting largely of small alluvial valleys and soils from glacial and residual deposits. However, within the indicated areas on the map, the loess soils form the predominating surface covering.

The method of naming the soils is the same as that used by Federal and state departments of soils. Several apparent inconsistencies be-

tween this report and some of the county reports are due to a greater refinement in soil mapping. Thus in the early county reports, prior to 1913, all brown loess soil was called Knox silt loam. With the adoption of more detail in soil differentiation, the Knox silt loam is confined to the deep, rich-brown loess soils, while the light-brown silt with heavy subsoil is now called Memphis silt loam. For detailed maps and descriptions of the various loess soils, the reader is referred to the following county soil survey reports: Atchison, Andrew, Buchanan, Platte, Jackson, Ray, Lafayette, Carroll, Chariton, Cooper, Boone, Cole, Callaway, Franklin, St. Louis, Lincoln, Pike, Ralls, Marion, Perry, Cape Girardeau, Stoddard, and Ripley.

DEFINITION OF LOESS

The word loess (commonly pronounced lo-es) means loose, and is of German derivation. Loess is soil material deposited by the wind. It is the accumulated dust laid down in favorable localities during long periods of time. These deposits, no doubt, were centuries in formation, beginning during the glacial period. The melting ice gave rise to large volumes of water which flooded the streams and dropped much sediment. The latter, after becoming dry, was picked up by the strong winds and deposited to form the present loess. These processes are active at the present time, although probably to a lesser extent. The dense clouds of dust that may be seen over the Missouri River valley during windy days in dry weather illustrate the strong lifting and carrying power of the wind.

DISTRIBUTION

The brown loess soils in Missouri are locally known as "bluff land" because of their occurrence along the large river valleys. They form an almost unbroken belt of upland soils bordering the Missouri and Mississippi Rivers—from the northwest corner of the State to St. Louis along the Missouri, and from Lewis County to the Arkansas state line along the Mississippi valley.

In the northwestern part of the State the loessal soils including the black or prairie division, attain a width of 50 or more miles. East from Kansas City as far as Boone and Moniteau Counties, the belt on either side of the river rarely exceeds 12 to 15 miles in width. East from Boone County the belt narrows sharply, and along the lower Missouri as well as along the Mississippi, with exceptions in St. Louis and Cape Girardeau Counties, the loess soils rarely extend more than 4 to 6 miles back from the river valley. In general, it can be said that the area of brown loess soils with which this report is concerned, will average from 6 to 20 miles in width throughout the extent of their occurrence.

In the eastern half of the State it includes the entire area of loessal deposits, while in Northwest Missouri it includes only the hills and rolling land adjacent to the river. It is peculiar, therefore, in that it occupies the uplands bordering the large rivers. This is suggestive of the origin of the loess material and indicates its source as the river plain deposits.

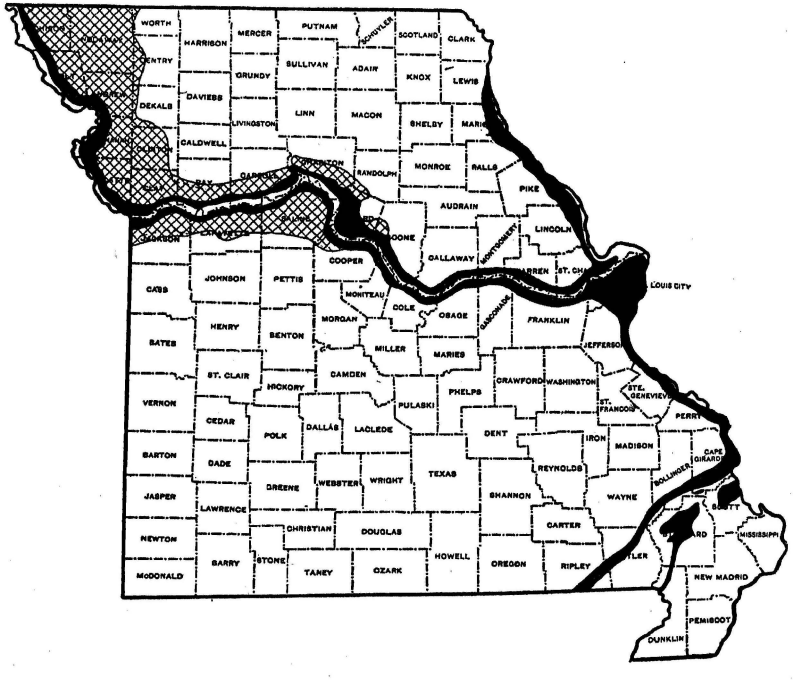

Fig. 2.—Map showing general distribution of loess soils in Missouri. Shaded areas represent brown loess soils; cross-lined areas represent dark-colored, prairie loess soils.

The brown loess soils in the western part of the State, as far east as Howard and Cooper Counties, are bordered nearly everywhere by dark colored prairie soils. They form, therefore, a rather distinct soil division on account of their characteristic color and also because of their more broken surface. Throughout the eastern half of the State, the brown loess soils are bordered by residual soils from limestone, and to a lesser extent from the shales and glacial till which are predominantly brown, yellow, or gray in color. They thus show a resemblance to the loess soils and are not always easily distinguished from the latter. Factors other than color are therefore used in identifying the loess soils in the eastern part of the State. Such factors as depth of soil material, absence of

stone, clay content, character of forest vegetation, quality of soil and topography are taken into consideration.

The total area of brown loess soils in Missouri is estimated at approximately 1,500,000 acres, or 2,300 square miles. They occur in 41 of the 114 counties in the State. It is probable that no other state in the Union contains so large an area of these soils or has them so widely distributed.

DEPTH OF LOESS

In thickness the brown loess deposits vary greatly both locally and regionally. Local variations are, no doubt, largely the result of erosion which has acted with varying intensity. Regional variations are due to the amount of deposit in different regions. In general, the loess is thickest in the western part of the State, particularly in the region between Kansas City and the Iowa state line, and averages thinnest along the Mississippi River.

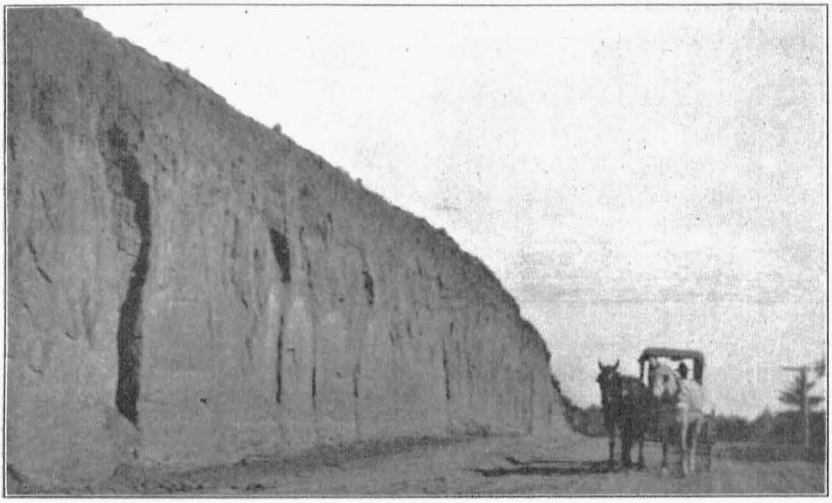

Fig. 3.—This 30-foot bank represents less than one half of the thickness of the loess deposit in Northwest Missouri. Soil type, Knox silt loam.

The extreme thickness of loess is always found within a mile from the edge of the bluff, and it thins with increasing distance from the bluff. This feature is especially apparent where the deposits are relatively thick and in places gives to the upland surface a slope away from the river within the first mile. In the northwestern part of the State the loess mantle may exceed 150 feet in thickness, and over considerable areas may average more than 100 feet. Its thickness is greatest in Atchison, Holt, Buchanan, Howard and Cooper Counties. East of Boone and

Cooper Counties the maximum thickness probably does not exceed 40 to 50 feet. Along the Mississippi River, Marion, St. Louis, Cape Girardeau, and Scott Counties have the greatest deposits. East from Kansas City and excluding the bluffs for a mile back from the river valley, it probably does not average more than 10 feet in depth.

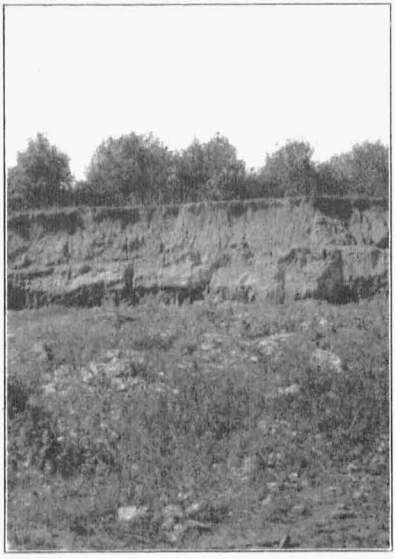

Fig. 4.—Twenty feet of apple orchard, 15 feet of brown loess, 5 feet of limestone. Found along bluff line in Pike County.

TOPOGRAPHY

The brown loess throughout the State has a rolling to hilly surface, and nowhere are there level areas of any considerable extent. This is due to its geographic position, and the severe erosion to which the soft soil material has been subjected. Because of its position high above the river valley, there is a steep gradient, and because all lateral streams draining into the rivers must pass through the loess area, it is inevitable that the surface be broken and dissected. The bluff line and the land for a considerable distance back of it, is broken at frequent intervals by deep V-shaped valleys, through which the short tributary streams flow down to the larger valley. Away from the bluff line the surface of the country is usually less broken, the slopes are more gradual, the ridges become wider, and a more rolling topography develops. Where the underlying rock consists of limestone, the surface is more deeply broken than in regions of soft rocks such as shales.

In general, the belt of brown loess between Howard and Cooper Counties on the west, and St. Charles and St. Louis Counties on the east, and the belt along the Mississippi River south from St. Louis, is the most completely and deeply dissected portion. In these regions the surface everywhere is hilly and even precipitous in places. Away from the bluff line the surface consists of ridges and cross ridges separated from one another by narrow, steep-sided valleys. With every heavy rainstorm each of these valleys cuts deeper into the loess material and removes more and more soft earth from the upland area. The largest areas with undulating surface occur in St. Louis and St. Charles counties. Along the Mississippi north of St. Charles, the surface is moderately hilly.

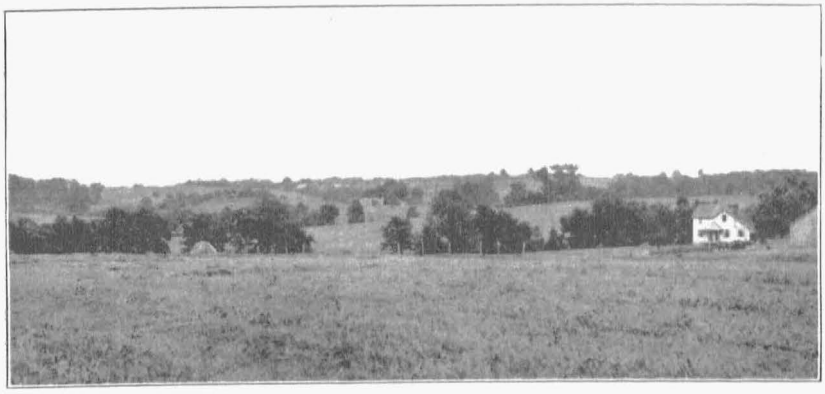

Fig. 5.—The scattered trees and the narrow belts of timber along the branches give to the loess region a pleasing landscape. Memphis silt loam in St. Charles County.

In the western half of the State the surface of the brown loess is predominantly rolling, except along the immediate bluffs which usually consist of steep slopes. Probably less than 10 per cent of the total area is such that it cannot be farmed. A small but broken area occurs north of Kansas City in Platte and Clay Counties. Here the loess occurs mainly on the ridges, and the steep slopes are covered with residual clays. It is only where the loess deposits are of great depth, as in the western part of the State, that the material has obliterated the original surface features, and where the relief is entirely a post-loessal development.

Fig. 6.—A landscape of the gently rolling phase of the Memphis silt loam in Lincoln County. General farming is the prevailing type of agriculture.

There is a wide range in the altitudes at which the brown loess is found. Along the Mississippi the altitude of its surface ranges from 400 to 800 feet above sea level, or from 50 to 300 feet above adjoining river bottoms. Along the Missouri as far west as Boonville its altitude is usually from 550 to 900 feet above sea level, with the same general relationship to the streams as already described. In the western part of the State, its altitude ranges from 700 to 1000 feet above the sea level, and from 50 to 150 feet above the major streams.

The natural drainage is everywhere good. In the smoother country somewhat remote from the streams, there are occasional low slopes where the drainage is deficient because of the seep water from the higher lying land. Such areas are always marked by a light gray surface soil, and by the presence of small iron concretions, locally known as "buck-shot." Aside from these very minor gray spots, the natural drainage is adequate.

EROSION

It is apparent that erosion should be a very serious problem on the brown loess soils. The difficulty of its control is due primarily to the naturally steep gradient, and to the character of the soft, non-cohesive material which is easily carried away by water. However, careless cultivation without any regard to checking erosion has been the rule throughout the loess area. Many slopes have been brought under cultivation that should have remained forested. In other places the continued growing of cultivated crops on land that should be kept in

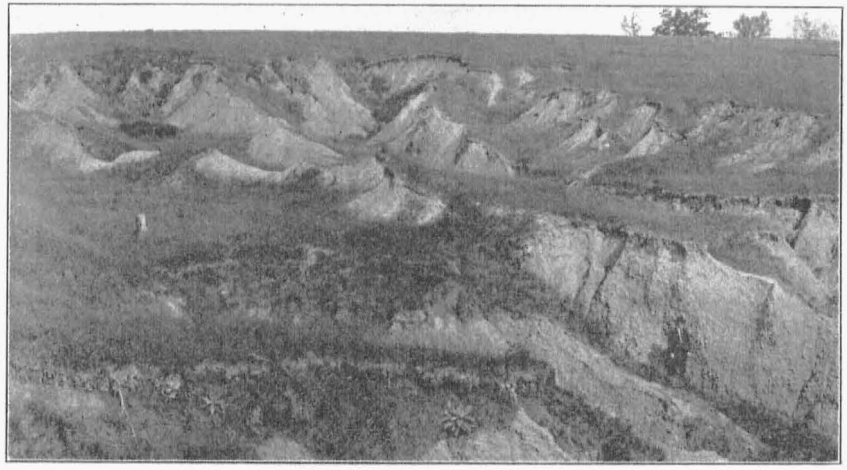

Fig. 7.—Characteristic erosion of brown loess soil. Such gulches frequently form on rather gentle slopes—if carelessly farmed.

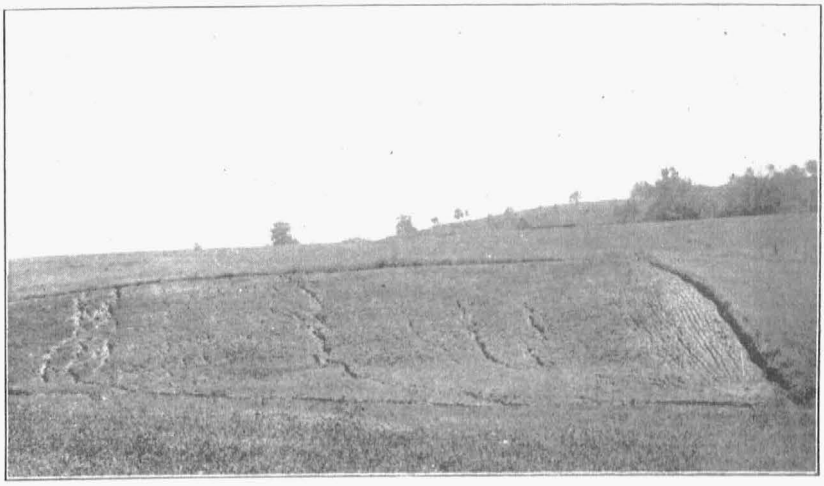

Fig. 8.—Memphis silt loam. Erosion is a constant menace to steep slopes. Such washes should be stopped while small, or the land, if very steep, should be left in grass.

grass has caused disastrous results. That erosion has increased enormously due to the action of man, is evidenced by the comparatively recent development of great alluvial deposits at the mouths of the many short streams flowing from the loess hills. A single freshet may add as much as 3 to 6 inches of sediment brought down from the hills and spread over the valley. Throughout the hilly regions there are many places where the loess mantle has been entirely removed from the slopes and the bare, red clay or bedrock are exposed at the surface. The extensive areas of gullied waste land along the lower Mississippi may be looked upon as the end to which all erosion in the loess soils is tending unless better conservation practices are adopted.

Much of the brown loess soils in steep, hilly areas can only be maintained against ruinous washing by allowing the land to remain forested. Other areas should be used only for pasture and kept permanently in sod. The need of terracing, contour cultivation, the immediate checking of incipient gullies, and the construction of soil saving dams, as remedial measures, must find a more general adoption. Without such practices the arable land will not only be seriously damaged but will actually decline in extent. If wisely handled, the brown loess soils will support safely and permanently a very much greater population than now inhabits them.

It is extremely fortunate under these circumstances of excessive erosion that the subsoil material and the parent loess are capable of becoming transformed into fertile and productive soil within a very

brief period of time, provided proper care is taken to incorporate organic matter for the formation of a complete soil. There is probably no other soil material which recovers so speedily from excessive erosion.

VEGETATION

The original vegetation of the brown loess soils in Missouri was timber. In the western part of the State, west of Howard and Cooper Counties, these soils comprised the principal forested area of the uplands near the river. In this region also, the tree growth was varied, consisting largely of elm, walnut, burr oak, white oak, linn, hickory, poplar, hackberry, cherry, ash, locust and many smaller species such as pawpaw, redbud, hawthorn, wild grape, etc. It is evident that in parts of Atchison,

Fig. 9.—A pasture like this is a joy to man and beast. An open, mixed timber growth originally covered much of the brown loess in prairie regions.

Holt, and Buchanan Counties the timber was open, or consisted of scattered trees which permitted a rank growth of wild grasses similar to that on the adjacent prairies. In such places the soil averages darker in color due to a greater accumulation or organic matter.

In the eastern half of the State white oak and red oak formed the predominating tree growth, although elm, walnut, sugar maple, hickory, and poplar were abundant. In fact such terms as "hackberry land," "elmwoods land," "sugar-tree land," etc., were used by the early settlers to designate the loess soil areas, which were held in high esteem. In general, the timber growth on the loess soils in its abundance and rank growth shows a close relation to the forest growth on the adjacent river

and creek bottoms. Along the lower Missouri and the lower Mississippi the strong forest growth on the river hills and bluffs is frequently in striking contrast to the smaller and purer growth on the residual upland soils. The significance of this fact is that it indicates a soil condition favorable to deep root growth and to a great variety of species. It is a common observance that the roots are long, smooth and slender with straight downward growth. It can be assumed that vegetation on loess soils has a zone of root action that is much greater than in most upland soils of fine texture.

MECHANICAL COMPOSITION

The brown loess soils in Missouri are predominantly silt loams, i. e. the great bulk of the soil particles are intermediate in size between very fine sand and clay. Probably no other extensive soil group is so largely made up of soil particles of about the same size. There are, however, variations in texture in different parts of the State. In general, the brown loess in the western part of the State averages coarser than along the Mississippi in the eastern part of the State. In fact, much of the bluff land between Kansas City, and the Iowa line averages a very fine sandy loam. On the slopes in the hilly sections where much of the top soil has been washed off, the clay content of the surface soil may exceed 30 per cent, although 10 to 25 per cent is the range for most loess soils.

The loess material is always coarsest on the bluffs, and gradually becomes finer with increasing distance from the river. This range in textural change is most pronounced where the belt is wide, and reaches its maximum within 3 to 5 miles from the edge of the deposit. There is also considerable textural range in a vertical section to a depth of about 4 feet. Nearly everywhere the silty surface soil is underlaid by a silty clay subsoil, that contains more of the fine particles than does the surface. This is the result of the normal processes of weathering. The soil particles break down to form clay, and this is carried down and accumulates in the subsoil through the action of percolating water. The general structure and mechanical composition of the brown loess is especially favorable to the movement of the soil moisture and to the easy penetration of plant roots. The soils are usually porous enough to allow a ready downward movement of gravitational water, and on the other hand, they are retentive of moisture and are thus quite drought resistant. These factors are of great significance in the agricultural value, and in the wide adaptability of the loess soils. They have an especial relation to the growing of deep rooting crops, including fruit trees.

SOIL COMPOSITION

Chemical analysis of a great many brown loess soils indicates that they are only fairly well supplied with nitrogen and phosphorus, two of the essential plant food elements, but that they are especially rich in potash or potassium. Organic matter, which includes the nitrogen, has not accumulated in the surface soil because of the forest covering and because of the severe erosion on all the brown loess. The need of growing legumes, such as clover to supply nitrogen, is apparent. The high agricultural value of the dark colored prairie lands must be attributed to the high content of nitrogen and humus.

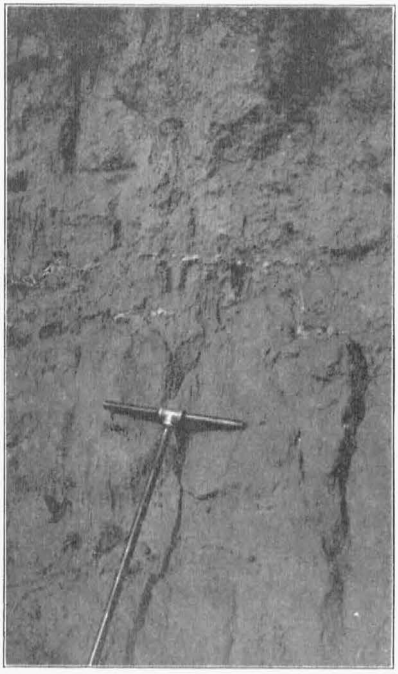

Fig. 10.—The white spots are lime concretions, generally occurring 3 to 4 feet below the surface.

The Knox silt loam is better supplied with both nitrogen and phosphorus than the Memphis silt loam, and this is reflected by the higher productiveness of the former. The rather low supply of phosphorus particularly in the eastern half of the State suggests strongly the need of phosphate fertilizers on much of the land. Wherever such fertilizers have been used they have given good returns. The greater use of phosphates on the thinner lands in truck and vegetable growing is especially recommended. The use of nitrates on apple orchards is growing in favor. There are few upland soils that are as well supplied with potassium as is the brown loess. The use of mixed fertilizers containing this element is not generally recommended. The success of tobacco, alfalfa, and other plants that are heavy feeders on potassium, indicates the abundance of this element in the soil.

As a whole the loess soils are well supplied with lime, although it is only in the western part of the State that the subsoil occasionally has a calcareous reaction. A medium to low acidity characterizes most of the surface soils. The need of applying lime to promote crop growth is not yet apparent, although such treatment has given very satisfactory returns in some places, particularly on the moderately rolling land of St. Charles and St. Louis Counties.

COLOR OF LOESS SOILS

Brown is the dominating color of the loess soils under consideration. There are, however, many variations in color, as might be expected of a group of soils existing under such a wide range of conditions; but these will always come within the range of brown, yellow or buff with their various shades and tints. In general, the loess soils of the western half of the State average somewhat darker than those in the eastern half. This difference must be attributed in part to the more active agencies of weathering and erosion in the latter region. On all the hilly land erosion has retarded the accumulation of organic matter in the surface soil.

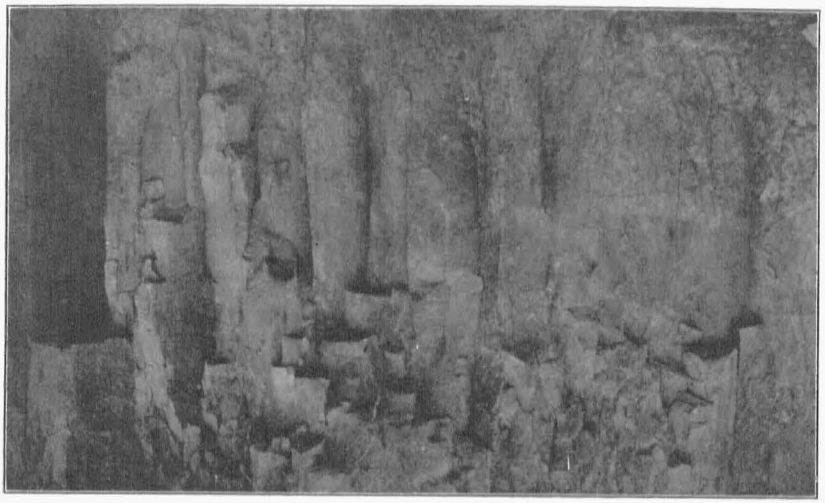

Fig. 11.—A close-up view of a deep loess cut, showing the peculiar columnar structure most commonly found in the cuts near the river bluffs, where the texture is somewhat coarser than the average.

On the level or very gently sloping areas as in parts of St. Louis and St. Charles Counties, weathering has reached a more advanced state, and here the gray or light yellow color is dominant over the brown.

In general, the more characteristic brown color prevails on the bluffs, but becomes either lighter or darker more remote from river. The change in color from brown to black is quite rapid where the dark prairies occur.

The organic matter content of the brown loess soils is only medium and averages less than half of that for most of the black prairie lands. Most of the land was forested, which did not favor the accumulation of organic matter in the soil. However, the deficiency of this material is of less importance in the loess soils than in most other soils, because of their depth and very desirable physical properties.

CHARACTER OF THE SOIL PROFILE*

The general character of the soil profile is remarkably uniform for all the brown loess soils. The surface and subsoil horizons do not show distinct stratification, and nearly everywhere the gradation from one horizon to another extends through a zone several inches in thickness. The surface soil is always a mellow, porous silt loam. There is not a well defined subsurface horizon, as this portion of the profile closely resembles the surface material. The upper limit of the subsoil usually occurs at a depth of 16 to 20 inches. The predominating subsoil is a yellowish-brown silty clay, friable in structure, uniformly oxidized, and without evidence of deficient drainage. In the lower part of the subsoil there may appear gray streaks and spots, or cracks filled with a thin layer of gray silty material. This is essentially a part of the substratum, which for the majority of the brown loess soils is a gray brown silty loam. In general, the color is lighter and mottlings are more abundant where the subsoil is rather heavy. On the bluffs the substratum usually is a rather uniform brown, friable silt loam and consists of the slightly weathered loess deposit. Where the brown loess soils border on the dark prairie lands, the subsoil and substratum take on more of the character of the latter which usually is a gray or drab silty clay which has brown and yellow mottlings.

RELATION OF SOIL CHARACTER TO CROP PRODUCTION

The wide versatility of the brown loess soils for crop production is one of their peculiar characteristics. They have long been recognized as superior fruit soils, but they also hold a high rank for the production of grain and leguminous hay crops. There are several factors that are responsible for this.

First among these is the generally high fertility of the soils. It has already been stated that the loess is a comparatively recent formation, and therefore has not been weathered and leached to the same extent as older soil material. It contains a relatively higher content of the mineral plant foods, and moreover, these seem to be in a more available form for plant use. The inherent fertility of the brown loess soils must be considered one of the prime reasons for a vigorous and varied plant growth.

The second reason for the superiority of these soils is that the high percentage of silt results in great capacity for holding water and yet retaining a porous and open structure. The brown loess soils are uniformly silty in texture. They are everywhere sufficiently fine to meet the best requirements of such crops as timothy and bluegrass, and also open

*A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called a horizon. The term *profile* refers to the number, arrangement and character of the various horizons to a depth of about 4 or 5 feet. These variations are distinguishing features in the separation of soils into types.

enough for such crops as corn and potatoes which do best in a mellow porous soil.

In the third place, the subsoil is rarely so heavy or compact as to interfere with the root action of the deepest rooting crops. Excepting on the occasional level and light colored soil areas, the subsoil is porous; in fact, this is probably the most outstanding characteristic of the loess soils as compared to residual and glacial soils.

The depth uniformity and permeability of the substratum also, is an especially important factor for fruit trees, alfalfa, and other deep rooting crops. The feeding area, and the water supply are thus greatly increased. It is a common observance in road cuts, ditch banks and other exposed places that tree roots grow straight down, are slender, and have few large laterals. Even the fibrous roots are long, slender, and straight. Alfalfa roots have frequently been observed 15 feet in length. Likewise tree roots, 20 to 40 feet in length, are often exposed in hillside cuts. With such a large zone of root action, plants are less subject to injury from dry weather, and it is not possible for the soil to retain an excess of water for long periods of time.

RELATION OF SURFACE TO LAND UTILIZATION

The prevailing hilly to rolling surface of the brown loess soils is of tremendous importance in the economic handling of the soils, and is the main limiting factor in the utilization of much of the land. While much of the brown loess is well adapted to corn and all the staple crops, other parts of it are fit only for pasture. Some of this land in the past has not been valued at more than $20 an acre for ordinary types of farming, but may be worth $100 or more an acre for apples. The fact that lands are valued at much higher prices when adapted to fruits has led to the placing upon the market of much of the rough hilly land as fruit land, although it may be suited only for pasture. In many places attempts have been made to farm steep hill land that is not suited to any of the cultivated crops. Land that is good only for pasture normally cannot attain as high a value as alfalfa or fruit land. The sale of land at prices which its adaptability does not justify has caused great losses and many disappointments.

In the eastern half of the State, excepting in St. Louis, St. Charles and Marion Counties, the majority of the brown loess soils are too rolling and hilly to be well suited for corn. However, most of them are used for wheat and other small grains, and for clover and pasture. In the loess soils, land that is relatively more rolling than either the glacial or residual uplands is used for cultivated crops. This is because of its higher average productivity. It should be remembered, however, that the majority of the brown loess soils are not well adapted to a heavy or extensive type of

farming. The size and shape of the fields are usually irregular and more or less limited because of ravines and ditches. This makes the use of heavy farming tools impractical. However, the crops grown in the rotation must be adjusted in such a way that erosion will be best controlled.

In general it can be assumed that where the surface is not too sloping to permit the practical growing of corn and wheat, orchard trees may be grown. In fact, orchards are frequently placed on slopes that are normally considered too steep for ordinary cultivation. With the smaller fruits, such as grapes and berries, even the steepest slopes can be utilized if ordinary precautions against washing are used. The practice of terracing has not yet become common, although its success frequently has been demonstrated. Wherever possible the rows should be along the contour of the slope so as to reduce the chances for erosion. At the end of the rows sod strips can be left, and over these the water can move down the hill without damage to the field.

The grape thrives exceedingly well on the steepest bluff soil and can be grown commercially where other fruits might be a failure. Many such slopes are too steep to permit cultivation excepting by hand, but because of the mellow character of the soil this is rather easily performed.

CLIMATE

(With Special Reference to Fruit Growing)

The brown loess soils on account of their wide distribution exist under the full range of climatic conditions common to Missouri. However, this range is of little or no significance in the growing of fruit trees. Both the mean of temperature and the mean of rainfall are characteristics of the Corn Belt, and therefore most favorable for a wide range of plant growth. The annual mean temperature ranges from about 50° F. in the northwestern counties to about 58°F. and in the southeastern counties. The mean temperature in January is about 26° in the northwestern, 30° in the central, and 36° in the southeastern counties. Periods of extreme cold are of short duration, and the temperature seldom falls lower than 5° to 10° below zero.

The average annual precipitation ranges from 34 inches in the northwestern to nearly 50 inches in the southeastern counties, the average for the State being 39 inches. In general, the precipitation increases from north to south and from west to east, but this is not sufficient to have any marked influence on the fruit tree growth.

Probably of chief consideration is the occasional injury caused by late spring frosts. This is particularly true for peach growing, as well as for plum, apricot, and cherry. No section is immune from occasional winter killing of fruit buds, and injury from spring frosts. In general, it is probable that the southern half of the State, because of its slightly

TABLE 1.—MEAN ANNUAL TEMPERATURE AND PRECIPITATION AT ST. JOSEPH, COLUMBIA, HANNIBAL AND JACKSON

Month	Temperature				Precipitation			
	St. Joseph	Columbia	Hannibal	Jackson	St. Joseph	Columbia	Hannibal	Jackson
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	28.5	32.9	31	36.7	1.25	1.70	1.3	3.34
January	23.4	27.2	23	33.7	1.21	2.46	2.2	3.80
February	27.9	30.1	27	33.9	2.20	2.18	2.0	3.15
Winter	26.6	30.0	27	34.7	4.66	6.34	5.5	10.29
March	38.7	41.4	42	46.6	2.08	2.91	2.5	5.06
April	52.6	54.3	53	56.4	3.38	3.88	3.3	4.40
May	63.4	64.5	64	65.3	4.81	4.83	5.0	4.42
Spring	51.6	53.4	53	56.1	10.27	11.62	10.8	13.88
June	72.4	74.5	73	73.5	4.84	4.86	3.6	4.45
July	75.2	77.4	76	76.2	4.52	4.08	4.0	3.39
August	75.1	74.7	75	75.5	4.37	3.58	3.3	3.12
Summer	74.2	75.5	75	75.0	13.74	12.52	10.9	10.96
September	67.0	67.8	68	69.2	3.42	3.84	3.5	3.40
October	54.9	54.8	56	56.6	2.64	2.16	1.7	2.77
November	39.7	42.4	43	45.5	1.66	2.15	2.0	3.65
Fall	53.9	55.0	56	57.1	7.72	8.15	7.2	9.82
Year	51.5	53.5	54	55.7	36.53	38.46	34.4	44.90

TABLE 2.—NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION, AT KANSAS CITY, MO.

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year	Total amount for the wettest year	Snow average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	34	70	−13	1.4	1.7	1.4	4.7
January	30	69	−17	1.3	0.4	4.1	5.6
February	29	76	−22	1.8	1.4	1.1	8.0
Winter	31	---	----	4.5	3.5	6.6	18.3
March	41	88	2	2.5	3.7	4.5	4.1
April	56	90	22	3.0	4.2	3.8	1.0
May	65	90	36	5.1	0.8	7.7	0.0
Spring	54	---	----	10.6	8.7	16.0	5.1
June	74	100	48	4.4	2.5	6.0	0.0
July	78	106	54	5.0	2.8	4.9	0.0
August	76	103	46	4.0	2.6	5.0	0.0
Summer	76	----	----	13.4	7.9	15.9	.0
September	69	101	35	3.9	1.8	4.5	0.0
October	58	91	26	2.3	2.2	4.4	0.4
November	43	79	4	1.7	0.6	2.7	1.3
Fall	57	---	---	7.9	4.6	11.6	1.7
Year	54	106	−22	36.4	24.7	50.1	25.1

milder winters, is more favorable to peach growing than the northern half. This difference does not apply to apples. However, weather conditions are not the determining factor in the location of the peach industry, and the distribution of the orchards of the State are not governed by climate.

TABLE 3.—NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT ST. LOUIS

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1871)	Total amount for the wettest year (1858)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	35.5	74	−14	2.23	1.17	8.52
January	31.0	77	−22	2.27	2.53	3.42
February	33.5	84	−18	2.75	2.92	2.12
Winter	33.3	84	−22	7.25	6.62	14.06
March	43.5	90	3	3.43	1.27	3.96
April	56.1	91	22	3.52	0.49	6.07
May	66.5	94	32	4.24	3.15	10.64
Spring	55.4	94	3	11.19	4.91	20.67
June	75.1	102	44	4.47	2.51	6.69
July	77.7	107	55	3.43	1.64	8.03
August	77.2	106	52	2.06	3.55	2.87
Summer	76.7	107	44	10.56	7.70	17.59
September	70.0	102	37	2.91	0.25	3.86
October	58.4	94	24	2.41	2.07	7.73
November	43.4	85	5	2.88	1.83	4.92
Fall	57.2	102	5	8.20	4.15	16.51
Year	55.6	107	−22	37.20	23.38	68.83

TABLE 4.—KILLING FROSTS AS RECORDED AT KANSAS CITY AND ST. LOUIS
(Data from U. S. Weather Bureau, Columbia, Mo., George Reeder, Sec. Dir.)

Year	Kansas City		St. Louis	
	Last in Spring	First in Autumn	Last in Spring	First in Autumn
1908	April 30	November 5	March 9	November 5
1909	May 1	October 12	April 10	October 12
1910	April 24	October 22	April 24	October 28
1911	April 9	October 27	April 7	November 2
1912	March 27	November 1	March 25	November 2
1913	March 28	October 20	March 28	October 21
1914	April 9	October 27	April 9	October 27
1915	April 1	November 14	April 3	October 9
1916	April 9	October 19	April 9	October 21
1917	April 9	October 12	April 9	October 12
1918	April 21	November 1	April 10	November 1
1919	April 1	October 17	April 1	November 5
1920	April 13	October 29	April 13	October 29
1921	April 17	November 10	April 17	November 10
1922	March 28	October 17	March 8	November 16
1923	April 8	October 21	April 8	October 31
1924	April 1	November 8	April 2	November 8

Fruit growing is sufficiently developed in all parts of the State to prove that no one section or region holds a distinct climatic advantage over any other section. If there is any difference it has not as yet been indicated by any reliable experimental evidence. The occasional late summer drought sometimes affects orchard trees by causing the fruit to drop off before maturity. Similarly, bush fruits such as the blackberry are occasionally damaged by dry hot weather so that the fruit cannot mature. This difficulty can be overcome to a large extent by mulching, and by proper cultivation. Wet spring weather sometimes damages strawberries by causing the fruit to rot, but such losses are less serious when the fruit is on well drained land.

A climatic feature, the real significance of which is not well known, is the modifying influence of the rivers themselves on the temperature of the adjacent territory. It is well known that large bodies of water have a tempering effect on extremes of heat or cold. It has frequently been observed that vegetation makes an earlier and quicker start in early spring on the river bluffs than in the interior regions. Whether or not this is due to the influence of the river has not been determined. It is evident that the greater heat absorption on south slopes, and the early warming of the porous well drained soil has much to do with giving vegetation an early spring start.

The varied topography of the loess soils may have an important influence on the local climate or local temperature. Thus it is well known that north and east slopes produce more vigorous tree growth because of the greater abundance of moisture in the soil. South slopes, however, usually produce a more highly colored fruit, due to the greater amount of sunshine. The varied surface provides good air drainage, and may assure a limited immunity from frost. In the spring, if warm weather has advanced vegetation sufficiently to start the trees into blossom, untimely frosts may kill the blossoms on trees in the valley and on the lower parts of the hillside, while those on the higher elevations escape.

AGRICULTURAL CONDITIONS

Most of the brown loess soils are used for general or mixed farming. It is only in a few areas near the larger towns, as in St. Louis County, that a specialized or intensive agriculture prevails. Corn and wheat are the two great staples, although clover, alfalfa, and oats are extensively grown. A considerable proportion of the land is in pasture and meadow. Cotton takes an important place in five or six of the counties in the southeastern part of the State. In conjunction with the general field crops, more or less livestock is raised and fed. In general, the type of agriculture is not much different from that on other soils in the various parts of the State.

Corn is the most important crop. In fact, it is grown more extensively on the brown loess than on any other soil of similar topography. However, the cultivation of the steeper slopes has in many places been accompanied by destructive erosion. Yields averaging from 40 to 60 bushels an acre are obtained, and compare favorably with those of the adjacent bottom and prairie lands. In the counties to the north of Buchanan, probably 50 per cent of the loess area is devoted to corn.

The brown loess soils have long been held in high esteem for wheat production, both on account of the high yields and the superior quality of the grain. Much of the hilly land particularly in the eastern part of the State that is not well suited to corn, is used extensively for wheat.

Fig. 12.—Sweet clover on brown loess soil. Few other soils grow this valuable crop so well.

It is evident that these two great staples will continue to be the principal crops on all farms where a general system of farming will be practiced.

The growing of red clover in Missouri has reached its greatest extent on the brown loess soils, largely because these soils are especially well adapted to this valuable legume. Except in unfavorable seasons, there is rarely any difficulty in getting a stand even without fertilization. Yields of 1 to 2 tons an acre are obtained. The production of clover seed is important in some sections and is a source of income on many farms.

Nowhere in the uplands of Missouri are conditions more favorable to the production of alfalfa than on the better phases of the brown loess soil. An appreciation of this fact is indicated by the increasing average devoted to the crop. The requirements of a deep, well drained and fer-

tile soil are usually found on the better lands. In many sections alfalfa is a potent factor in the prosperity of the farming industry.

Other legume crops grown on the loess soils are sweet clover, cowpeas and soybeans. The former is being grown mainly on the better soils of the northwestern part of the State. Cowpeas are grown extensively in the southeastern counties, and to a large extent take the place of clover. Soybeans are steadily growing in favor and are extensively grown either as a single crop or in combination with corn.

Tobacco growing in Missouri is confined almost entirely to the brown loess soils. At present the industry is commercially important in Platte County, but is extending to Boone, Howard and other river counties. White Burley is grown almost exclusively. Yields average from 1,200 to 1,800 pounds an acre. The quality is good and competes with the tobacco grown in Kentucky and other important tobacco centers. It does best on new ground. The fields usually are small, rarely exceeding 5 to 10 acres in size.

Cotton is grown successfully on the loess soils in the southeastern part of the State. Where the land has been kept up in fertility, yields of 500 to 1,200 pounds of seed cotton an acre are obtained.

It is becoming increasingly evident that the general or extensive type of farming as it has prevailed on the brown loess soils in the past is gradually undergoing modification with a trend toward more diversified and intensive practices. Under the extensive system the fertility of the soil cannot be so well maintained and in many instances erosion cannot be controlled. Because of the prevailing hilly surface, much of the land is not well suited to a heavy type of farm implements. The fields are relatively small and irregular in shape, and the control of soil washing must receive constant attention. The soils respond readily to good treatment and the returns from efforts expended can be measured by increased yields.

LIVESTOCK

The raising of livestock is an important industry throughout the extent of the brown loess soils. This is necessary in order to utilize the rougher land that is suited mainly for pasture. In some sections particularly in the western part of the State, the livestock industry takes the form of cattle feeding. Most of the grain used is produced on the adjacent river bottom farms, and the loess uplands are used as feeding ground. By this method the pasture is used in the most effective way, and at the same time the fertility of the soil is maintained.

Dairying is carried on in connection with general farming, or as a specialty, in all parts of the brown loess soils. Like the fruit industry, it has reached its highest development near the larger towns. No other

group of soils offers more favorable conditions for the dairy industry. Not only do the pasture grasses thrive, but the legume crops such as clover and alfalfa are well suited to most of this land. This is an important factor in the economical production of feed.

The loess counties are among the leading poultry counties in the State. The factors that are favorable to dairying also in a large measure are favorable to poultry production. It is one of the side lines of farming that fits in particularly well on the smaller farms where somewhat more intensive practices prevail.

SIZE OF FARM UNITS

The average size of the farms on the brown loess soils is smaller than for any other group of upland soils in the State. It is estimated that it does not exceed 100 acres as compared to 132.2 for the State. The smaller size is explained in part by the inclusion of the small farm areas surrounding St. Louis and Kansas City and other towns, but the primary cause is unquestionably that the surface features do not favor an extensive type of farming. The loess soils as a group are the oldest soils in point of settlement in the State. The early holdings were relatively large, but have been subdivided through several generations. Then too, the relatively large number of towns and villages bordering the river has had a further tendency to divide adjacent upland into small units and garden tracts. Because of the extensive trucking interests in St. Louis and Jackson Counties, the farms here average smallest. In general, the larger units occur in the counties to the northwest of Kansas City. In the very hilly sections, as along the lower Mississippi, some of the farms are large because they include much hilly land that is not suited for cultivation.

Crop specialization has not characterized the agricultural development, primarily because of the wide adaptability of the soils and because the demands of the local markets do not favor the production of one crop as a specialized industry. This has a profound effect on the size of the farms because in a diversified agriculture fewer acres often give as large return as larger areas under a more restricted cropping system. The possibilities for intensive farming are well illustrated in the well established and prosperous trucking areas of St. Louis and Jackson Counties, and to a lesser extent in Buchanan County. In the first named county about 60 per cent of the farms contain less than 50 acres, although there are several hundred farms that contain less than 10 acres each.

Excepting near the large cities, most of the small farms are as yet farmed in a similar manner to the larger farms. The land is used for the staple crops and for pasture and is not intensively farmed. This is

mainly due to a lack of knowedge regarding fruit and vegetable products and their production. Another reason is that the land owners are not interested in and have not learned to practice intensive methods. Many of the small farms cannot be made economically profitable without the adoption of such methods.

The question presented to those who contemplate purchasing a farm on the brown loess soil, is, how large must a farm be to furnish a satisfactory living. Probably the best practical measure with which to answer this question is the gross income. The area of land necessary to obtain a gross income of $3,000 will depend upon the crops grown. Thus, if the land were all put into general crops such as corn, wheat, and clover, from 120 to 160 acres would be required. On the other hand, a fruit farm of under 20 acres might be expected to produce a similar income. Under intensive truck growing five acres might provide this gross income. Similar estimates can be made concerning other systems of farming such as dairying. The size of farm must therefore be governed by the type of farming adopted. In general, the smaller the acreage, the more intensive must be the practices and the more valuable the crops produced in order to obtain a given income.

The loess soils, because of their wide adaptability, lend themselves to use for successful small farms better than almost any other upland soils. Moreover the character of the surface which requires careful handling to avoid excessive erosion, and the relatively small size of any of the fields are further factors favoring small unit areas. Under a condition of farming where dependence is placed on fruit or vegetables, frequently in combination with dairying and poultry raising, a farm of 20 acres will provide as much as one man can properly care for. A smaller acreage should suffice where vegetables only are grown. A combination of apples and general farm crops will necessitate from 60 to 100 acres for normal requirements.

It is not the purpose of this bulletin to advocate the small farm. In fact, under a general system of farming it seems necessary that the average farm should contain 100 or more acres in order to be economically profitable. It is intended to show, however, that most of the brown loess soils because of their high average productivity and wide adaptability are suited under right conditions to small farms and an intensive agriculture.

The size of the farm and the type of farming for the most successful operation must depend on the desires and capabilities of the individual and the character of the land. The farm should not be so small that an economical use cannot be made of the equipment. It is a mistake to attempt to handle too small a farm to afford sufficient work for the stock and implements. Experienced men on small tracts (10 to 40 acres)

of good soil may make a living by a diversified and intensive system of farming, i. e., by the production of enough vegetables and fruits to supply the wants of the family as nearly as possible and by making something out of chickens, cows, bees, small fruits and vegetables. A man to succeed at this work must be careful in details, industrious and a good farmer. It is usually not possible to maintain the same standard of living on such a farm as on a larger farm with more capital invested. Usually farms where livestock or field crops are the principal sources of income require larger areas for equivalent labor incomes than those where fruits or vegetables are the main lines of production. Size should be thought of only in relation to financial returns.

The type of farming should be governed, first, by the preference of the farmer. The truck gardener should not attempt general farming and vice versa. The greatest probability of success will be attained where the individual can follow his preferred methods. Markets and transportation are vital factors in any specialized and intensive farm practice, and must be considered when selecting a location. The character of the land also is an important factor in determining location. Thus the fruit grower can utilize more rolling land than the truck farmer. In all cases, it is essential that a considerable portion, probably 50 or more per cent of the farm, be made up of easily tillable land.

An important consideration throughout the brown loess soils area is the amount of waste land included in the majority of farms. Here again the western part of the State appears much more favorable than the eastern part. Thus in Boone, Callaway, Montgomery, Moniteau, Cole, Osage, Gasconade, and Jefferson Counties, from 20 to 40 per cent of the brown loess soils area is practically non-arable. In other places it is impractical to farm land unless most careful attention be given to it. Without such care it would rapidly deteriorate under cultivation. In hilly regions a certain amount of waste land must be assumed on every farm. It might be said in general, that for grain raising, 100 acres will be required to secure a gross income of $3,000 per year; 60 acres may be required for orchard fruits or dairying; small fruits and vegetables may require 40 acres or less. Ten acres appears to be about the smallest area which can be expected to return a gross income of $3,000 a year under average conditions even in truck farming. This does not mean that a smaller area will not produce that amount, in fact it is repeatedly done, particularly in the trucking districts near the large cities. However, such cases are not a proper guide for the new settler or the beginner in agriculture. It is merely a goal for which one may strive. It is an indication of the possibilities under the most careful and intensive practices in crop production.

For large returns there are required the most favorable conditions and much ability at farming. If one is content with a smaller gross income, a smaller area may satisfy the needs. It is fairly obvious, however, that statements of satisfactory income on less than 10 acres, which undoubtedly do occur, do not represent normal conditions and are not safe guides for those who desire to make a home in the open country. Such small areas may, and in many cases do, furnish delightful homes for those who have other sources of income, and it is apparent that this type of population is destined to increase.

LOESS SOILS NOT SUITED TO TENANT FARMING

From what has been said as to size of farms and care in cultural practices, it is evident that the loess soils as a group are not well suited to tenant farming. The vast majority of the farms are of such size that they will not produce enough profit for both land owner and tenant in proportion to the money and labor invested. Furthermore, the average tenant is not disposed or does not feel justified in putting forth much effort to maintain or improve the land. To prevent soil washing, keep up fencing, etc., is relatively a more serious problem on the brown loess soils than on prairie lands. Moreover, an intensive system of agriculture rarely is profitable under a tenant system of farming. The hill land requires more labor in cultivation than smoother land since it does not admit so readily of the use of heavy machinery. Census figures show that the loess counties along the lower Missouri River east from Saline County, and south along the Mississippi River, have as low a percentage of tenants as any region of the State. The counties west of Saline do not make such a favorable showing, but if only the brown loess soils area could be considered, the percentage of tenants would be much lower than for a county as a whole.

CLASSIFICATION OF LOESS SOILS

It has already been stated that the loess material was uniform in character at the time of deposition. The uniform character was not maintained, however, since the action of rain and weather during long periods of time has so modified the material that the resulting soil differences have given rise to several soil types. Thus the brown loess in the eastern part of the State, because it originally contained less lime, and because of the greater rainfall in this region, apparently has weathered more than the loess in the western half of the State. The former has lost more of its soluble constituents through leaching and has acquired a heavier subsoil. It is classed as the Memphis silt loam. The loess in the western part of the State shows less modification through weathering and gives rise to the Knox silt loam.

The loess areas more remote from the bluffs have eroded less, because of the smoother surface. This condition, together with a grass vegetation in the open timber, favored the accumulation of organic matter in the soil and gave to the latter a dark color. The Marshall silt loam represents the dark loess soil, although this report includes only a small portion of this extensive soil type. The bluff land in the northwestern part of State that probably represents the most recent loess deposits and that shows least change due to weathering is classed as Hamburg very fine sandy loam. On the other hand the Clinton silt loam which is a light-colored soil with heavy subsoil represents the greatest modification from the original material.

The Knox and Memphis types at various places have a distinct variation from the prevailing character of the land. These areas have been indicated on the soil map, and are referred to as phases of the typical soil. Thus the hilly phase of the Memphis silt loam is more broken, has steeper slopes, and includes more stony and clay outcrops than the main soil. Phase differences may also indicate considerable differences in the agricultural value of the land.

No attempt has been made to give a detailed classification of the brown loess soil. On the accompanying soil maps their general distribution is indicated. The location of the boundaries is based on actual field observations and on data obtained from the several county soil survey reports. The general character of the various soil types and their agricultural development are briefly described in the following pages.

LIST OF TYPES

Knox silt loam	Memphis silt loam
Knox silt loam, dark phase	Memphis silt loam, hilly phase
Knox silt loam, heavy phase	Memphis silt loam, Brickey Hills area
Hamburg very fine sandy loam	Memphis silt loam, gray phase
Marshall silt loam	Clinton silt loam.

Knox Silt Loam.—The most extensive and important of the brown loess soil types is the Knox silt loam. It extends along the Missouri River from Holt County in the northwestern to Howard and Cooper Counties in the central part of the State, and includes practically all of the hilly land extending back from one to four or more miles on both sides of the river valley.

In its general characteristics the Knox silt loam is a brown, mellow soil, with a light brown silty clay subsoil. In the hilly areas, especially on the bluffs adjacent to the river bottom, where erosion is active, the soil averages lighter in color, usually a light brown to gray brown; while on the gently rolling areas and near the prairie lands the soil is darker in

color and averages a brown to dark brown. The depth of the surface soil ranges from 9 to 15 or more inches. The change from surface to subsoil is marked only by the gradual increase in clay content. The subsoil almost uniformly is a brown, silty clay that is friable and open. The lower subsoil below 30 inches usually is somewhat lighter in color and texture, and on level areas near the typical prairie land, frequently is mottled yellow and gray. The subsoil of some of the bluff land is a coarse silt loam similar to the surface soil, and in places is calcareous or contains lime concretions.

There are occasional variations in the soil from those described above, but in general the Knox silt loam is remarkably uniform in the brown color, silty texture and other physical properties. Because of its great depth, and the open, porous character of the soil, the Knox silt loam has almost ideal properties for absorbing and holding moisture and for deep and easy root penetration. It is easily cultivated and early to warm in spring—factors that are especially important in truck farming.

The surface varies from hilly to rolling. The roughest areas include the bluffs or hills along the river bottom, where some of the land is so steep as to be unsuited for cultivation. Rather steep slopes, however are successfully farmed since the porous soil eliminates some of the danger of surface washing. The greatest danger is from gullying. Gullies should be stopped when they are small. When allowed to develop they deepen rapidly with perpendicular walls. One of the safeguards against erosion is the more extensive use of winter cover crops such as rye.

Practically all of the Knox silt loam is in cultivation. The majority of it is used for general field crops such as corn, wheat and clover and the yields obtained compare with those of the black prairie soils. As a clover and alfalfa soil it is not excelled by any upland soil in the State. The acreage of the legume crops is proportionally larger than for any other soil type.

TABLE 5.—COMPOSITION OF KNOX SILT LOAM

County	Location			In 2,000,000 pounds of Surface Soil		
	Tp.	R.	Sec.	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
Buchanan	55	36	5	2,160	1,540	39,100
Buchanan	56	34	7	2,220	1,100	32,960
Buchanan	57	35	28	3,680	1,120	32,760
Platte	52	35	27	2,540	1,480	33,400
Lafayette	49	29	24	2,380	1,060	38,300
Lafayette	57	25	13	1,820	820	36,420
Carroll	53	23	36	3,140	1,420	33,940
Carroll	53	21	14	2,300	720	32,780
Howard	51	16	23	1,640	1,020	35,280

Table 5 gives the composition of the surface soil of the Knox silt loam from various places. These figures indicate that the soil is fairly well supplied with both nitrogen and phosphorus, and that it has a high content of potassium. The lime requirement is low. The problem of soil management is principally one of maintaining the supply of organic matter and nitrogen through proper systems of rotation and the return of organic matter in manure or green manures. Under a system of intensive farming, the use of phosphate fertilizer should be adopted.

Fig. 13.—Apple trees bowing low with fruitfulness. Brown loess soil is the cause of it.

Pomological Features.—As a fruit soil, the Knox silt loam holds first place in acreage and in production. Apples are the most important in acreage and value, but peaches, grapes, strawberries and bush fruits are extensively grown. Many of the most successful commercial orchards are located on this type. The high fertility of the soil and its great depth and open structure cause the trees to make strong growth. Excellent orchard sites with good locations are available everywhere. Commercial fertilizers are little used and apparently are little needed. However, the growing of legume crops such as clover or alfalfa in the young orchard is a common practice. On the steep slopes, a narrow strip between the tree rows is left in sod so as to retard erosion.

At the present time orcharding has its greatest development in Buchanan, Andrew and Jackson Counties, with smaller developments in Holt, Lafayette and Howard Counties. Fall and winter varieties of apples are grown almost exclusively. Some peach orchards, chiefly of the

early ripening varieties, are scattered throughout this region. Strawberries, grapes and bush fruits are extensively grown in Andrew, Buchanan and Jackson Counties. In these areas, too, the commercial growing of vegetable crops has reached considerable importance.

In general, only a slight beginning has been made at developing the possibilities of fruit growing on the Knox silt loam. Market demands would seem to be the only limiting factor in the area to be planted. Much of the land will always be used for general field crops because of its desirability as a general farming soil.

Knox Silt Loam, Dark Phase. (Elmwoods or Hackberry land).—Within the regional belt of the Knox silt loam there are areas of dark soil that deserve special consideration and have been correlated in this report as Knox silt loam, dark phase. In some of the county soil reports this dark soil has been classed as Marshall silt loam, but for this report it seemed desirable to include it with the Knox series because of the soil properties in relation to fruit growing. The most extensive area occurs in the western part of Atchison and Holt Counties, and smaller areas in Andrew, Carroll and Ray Counties.

The soil is a rich dark brown, mellow-silt loam from 15 to 24 inches deep. The content of organic matter is high, and this in addition to the characteristic silty texture of the loess gives to the soil an almost ideal open, granular structure. The subsoil differs from the surface soil in that it is lighter in color—usually a dull brown, friable, silty loam. There are a few mottlings or brown stains, and lime concretions and lime streaks are sometimes present in the lower subsoil. There is a perceptible downward gradation in the size of the soil particles composing the type as the distance from the bluffs increases. On the bluffs where the coarser texture prevails, the soil is lighter in color and the surface and subsoil are nearly alike—a dull brown, coarse silt loam. At the eastern and northern edge the dark phase grades into Marshall silt loam. The transition is a gradual one, and the boundary is more or less an arbitrary line. That part of the dark phase occurring in Ray and Carroll Counties averages heavier in the subsoil than in Atchison County and has more of the characteristics of the Marshall silt loam. The latter type is distinguished by a darker surface soil and a heavier subsoil. The dark phase is distinguished from the typical Knox silt loam by the distinctly darker and deeper soil of the former.

The surface is moderately hilly to rolling and averages smoother than for most of the brown colored Knox silt loam. All of it can be farmed without difficulty. The dark color of the soil would indicate that the land was prairie. However, there are present large trees that are remnants of the former forest covering. It is evident that the tree growth

was scattered so that a prairie-like covering of grass grew beneath the trees and supplied the abundant organic matter. The timber growth consisted mainly of elm, hackberry, walnut and oak. The term "hackberry land" is frequently applied to this dark brown soil.

TABLE 6.—COMPOSITION OF KNOX SILT LOAM, DARK PHASE

County	Location			In 2,000,000 pounds of Surface Soil		
	Tp.	R.	Sec.	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
Andrew	58	35	21	3,600	1,040	33,180
Holt	61	38	16	4,100	1,680	34,940

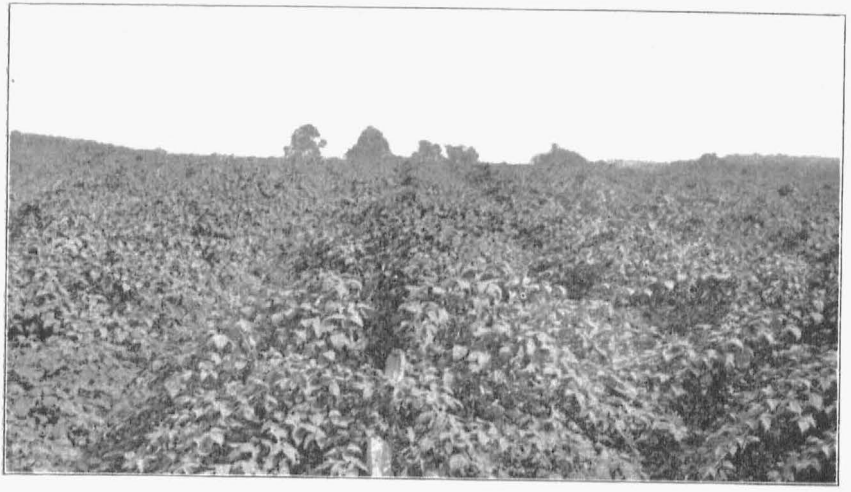

Fig. 14.—Raspberries on brown loess soil near St. Joseph, Missouri. The heavy growth of vines make possible the production of large yields.

Agriculturally, the dark phase of the Knox silt loam is one of the most productive upland soils in the State. It is largely used for corn and yields of 50 to 80 bushels an acre are obtained. As a clover and alfalfa soil it is equal to the best bottom lands. The deep, rich, mellow soil is ideally suited to a wide range of crops. Its desirability as a fruit soil is well established. It is superior even to the brown Knox for this purpose because of the higher average fertility. That portion of the phase in southern Andrew County is now largely used for fruit and berries. At various places tobacco is grown in a small way. Yields of 1,000 to 2,000 pounds an acre are obtained. All vegetation makes a rank growth. Apple trees attain large size, and sometimes require severe pruning. The desirability of the land for corn, and the fact that most of

it is held in rather large farms, has probably retarded the development of fruit growing.

Knox Silt Loam, Heavy Phase.—In parts of Buchanan, Platte, and Holt Counties, the brown loess varies in its properties from the typical Knox silt loam in that it is heavier and contains many patches of residual soil derived from the underlying shales and limestones. This variation has been classed as Knox silt loam, heavy phase.

The surface soil is a silt loam that varies from light brown to dark brown in color, and from 8 to 12 inches in depth. The subsoil is a gray brown to yellowish gray silty clay or clay loam, usually mottled gray and brown. The lower subsoil below about 3 feet, is a gray or yellow friable silty clay. In general, the heavy phase has a darker surface soil and a heavier subsoil than the typical Knox silt loam. It has fewer of the brown loess characteristics, and in its appearance closely resembles the residual shale soils in this region.

The heavy phase of the Knox silt loam is not a uniform soil. This is because the loess mantle is relatively thin, and has been entirely removed on many of the steep slopes. There are thus included in the phase, areas of soil consisting entirely of residual material that normally contains more clay than the brown loess. There are also included steep slopes with rock outcrops. In fact, a considerable portion of the land is not suited to farming or fruit growing because of the broken, hilly surface. The southern part of Platte County and the small area in the southeastern edge of Holt County are thus characterized. In the southern part of Buchanan County and the northern part of Platte County, the soil has a rolling surface, and the majority of it is used for general farming.

As far as the soil is concerned, there is no difference in crop adaptation between the typical Knox silt loam and its heavy phase. The yields of hay and grain crops are about the same on the two soils. The latter, because of its heavier subsoil, is in general not quite so well suited to orchard fruits as the typical Knox silt loam. Small fruits and bush fruits thrive. The use of manure or fertilizer is frequently necessary on eroded land for the best results.

Marshall Silt Loam, Brown Phase.—It has already been pointed out that the loess soil, other than the brown loess, occupies extensive areas in the western part of the State. The great majority of this belongs to the black soil type classed as Marshall silt loam. In this report only that small portion of the Marshall is considered that borders on the brown loess types, and that in some of its characteristics resembles the latter. It is the transition zone between the lighter colored, timbered hill hand, and the dark soil of the undulating prairie. This zone also is

characterized by a subsoil that averages heavier than for the brown soils, but lighter than for the dark prairie soils. It is apparent that the distribution and the limits of such an intermediate soil type cannot be definitely determined, and that the general boundary indicated on the map merely marks in an arbitrary way the assumed limits of the type. In some of the county soil reports, soil of this character is classed as Marshall silt loam, brown phase.

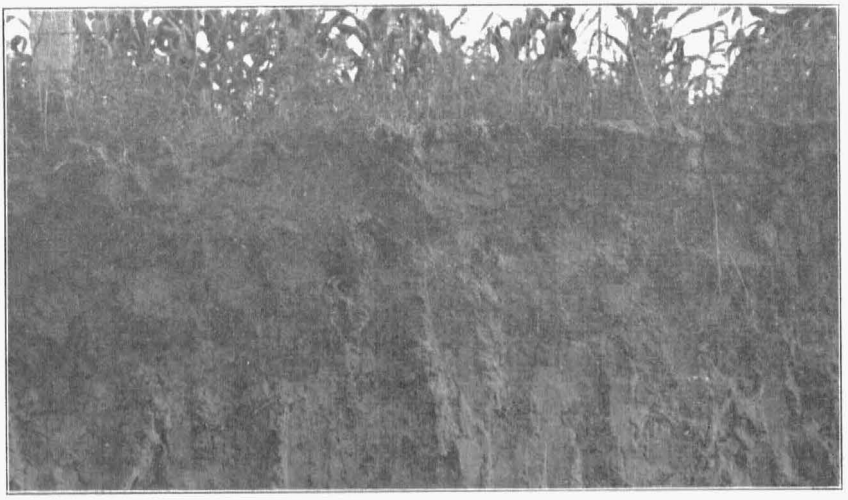

Fig. 15.—The prairie loess, or Marshall silt loam, brown phase, has deep, dark surface soil resting on a brown, friable subsoil.

The Marshall included in this report is predominantly a dark brown to almost black, mellow silt loam, varying in depth from 10 to 18 or more inches. The subsoil from most of the type is a dull brown to yellowish-brown heavy silt loam to silty clay. It is friable and permits water to pass through readily. Adjacent to the Knox soils, the subsoil of the Marshall partakes more of the character of the former and usually is a friable, dull brown silty clay. Approaching the darker prairie lands of the typical Marshall silt loam, the subsoil becomes heavier and frequently is mottled with yellow and gray.

The surface of the Marshall silt loam varies from undulating to rolling, thus averaging smoother than the brown loess types. The structure of the soil and the topography are favorable to thorough drainage. Erosion is severe and causes great damage by removing the rich surface soil and by the formation of gullies. The development of clay points on slopes is evidence of the severe washing, particularly on fields that are repeatedly used for corn. There is need for the more extensive use of winter cover crops, and the greater use of terraces and soil saving dams.

The Marshall silt loam is regarded as one of the best upland corn soils in the Mississippi Valley. Yields of 60 to 75 bushels are obtained under good farming conditions. The yields of wheat and oats are in about the same proportion. Clover, alfalfa and bluegrass are especially well adapted to the soil. Liming is not necessary as a rule, except for alfalfa on land which has been heavily cropped to grain without proper provision for maintaining the organic matter supply.

TABLE 7.—COMPOSITION OF MARSHALL SILT LOAM, BROWN PHASE

County	Location			In 2,000,000 pounds of Surface Soil		
	Tp.	R.	Sec.	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
Andrew	58	35	3	3,220	1,180	35,720
Lafayette	50	28	28	3,220	1,080	36,000
Lafayette	51	24	28	3,440	1,040	34,740

In its content of the three important plant food elements, the brown Marshall silt loam is similar to the dark phase of the Knox silt loam. Of the brown loess soils these two phases have the highest content of nitrogen.

Fig. 16.—Corn belt landscape on the dark, prairie loess. Marshall silt loam, brown phase, in western Missouri. Here soil, topography and climate are at their best for live-stock, grain and fruit production.

Pomological Features.—All of this soil is adapted to fruit growing and also to general farming. Because of its value for corn and other grain crops, commercial orcharding is not as extensively developed as on the Knox soils. Orchards near the larger towns supply the local

markets, but in Buchanan County there are many commercial orchards in which fall and winter apples are grown almost exclusively.

Because of the higher average fertility and because of the smoother surface, the Marshall has greater adaptability for fruit growing than most of the brown loess types. It is claimed also, that the former is less affected by dry weather than the latter. Peaches, strawberries, grapes and small fruits are successfully grown. Fertilization is not practiced, as all trees and small bushes make a strong growth without such treatment. The desirability of the Marshall silt loam for fruit production is equal or superior to that of the brown loess types, but its utilization for this purpose will be limited because of the desirability of the land for grain production.

Hamburg Very Fine Sandy Loam.—The narrow belt of high, broken hills representing the bluff lines in portions of Atchison, Holt, Buchanan and Platte Counties, has been classed as Hamburg very fine sandy loam. The soil is a gray-brown, very fine sand to coarse silt loam that usually extends to a depth of many feet without any appreciable change in color or texture. On the ridges the subsoil may average a friable silt loam. The substratum is a yellowish brown, loose, incoherent, very fine sand that may extend to a depth of 100 or more feet. There are scattered through the soil mass, but most abundant in the subsoil, small shells and thin calcareous seams. The presence of these indicates that the soil has been weathered to only a slight extent. The content of organic matter is low. Its accumulation is retarded by erosion and by rapid decay in the open soil.

All of the Hamburg type is very hilly. The slopes, particularly on the river side, are very steep, but rarely precipitous. The narrow ridges, however, are all rounded and nowhere does the contour have a sharp, angular appearance. This is because the soft materials weather readily, and sharp edges will not persist. Much of the land has an almost dune-like appearance, and is suggestive of the wind-blown origin. Many of the virgin bluff slopes are minutely terraced, the height of the terraces varying from one to three feet. It seems probable that they are formed by land slides of small extent.

Originally most of the Hamburg very fine sandy loam was covered with mixed hardwood forests consisting largely of elm, basswood, walnut, hackberry, etc. Many of the western slopes were treeless, but were covered with coarse bunch grasses and other prairie vegetation characteristic of semi-arid regions. Because of the deep, loose, porous nature of the soil it will take up water readily, but it is not drought resistant. During prolonged dry spells in late summer the soil may become dry to a depth of several feet. This is a limiting factor in the utilization of the land. Only deep rooting crops should be used.

Only a very small per cent of the Hamburg soil is cultivated. Much of it is used for rough pasture and woodland, but in contrast to the surrounding soils it is generally considered as waste land. Probably 50 per cent of the type is non-arable because of the broken, hilly surface, but the droughty condition and the liability to wash are other reasons why the land is not all utilized. A sample of surface soil from Section 21, Township 64, Range 41, Atchison County, contained 2,860 pounds of nitrogen, 1,640 pounds of phosphorus and 35,200 pounds of potassium. It is inherently a very productive soil. By incorporating in it more organic matter the moisture conditions could be improved. It is naturally adapted to deep rooting crops. Alfalfa does well, although it sometimes is difficult to get the young plants established on account of dry weather.

The greatest value of the land is for growing fruit. Under an intensive cropping system, much of the land that is now considered non-arable can be utilized, and the attempt will be made on account of the high fertility of the soil. Apple and peach trees thrive remarkably well and produce large yields. The fruit is characterized by its high color and flavor. Orchard sites are numerous on the low and gentler slopes. By terracing, many of the steep slopes could be used for grapes. Similar land near Council Bluffs, Iowa, is successfully used for grape production. Because of better moisture conditions small fruits should be placed on east and north slopes.

Memphis Silt Loam.—Most of the brown loess soil in the eastern part of the State, east of Howard and Cooper Counties, has been classified under the general type name of Memphis silt loam. It is to be expected that soil of such wide distribution and existing under varied conditions, should have considerable variation. In this report minor variations are not considered, but those that are more or less regional in extent, and that affect the economic utilization of the land, have been recognized, and are classed as phases of the predominating soil type. Thus has been established in addition to the typical soil type the "hilly phase" and the "gray phase" of the Memphis silt loam. Within the area of the type, as indicated on the soil map, there are included numerous small areas of soils of different origin. For a consideration of these the reader is referred to the several county soil maps of this region.

In its general characteristics the Memphis silt loam is a light brown to gray brown soil, ranging from 8 to 15 inches in depth. It is mellow, stone-free, easy to cultivate, but contains only a moderate amount of organic matter. The subsoil is brown to yellow-brown, fairly heavy silty clay. It is not compact, but is less granular and friable than the corresponding horizon of the Knox silt loam. The subsoil below 30 inches is sometimes mottled yellow and gray. This coloration is most

abundant on gently rolling land and where the surface soil is light in color. In general, mottling has a rather close relation to the degree of weathering the soil has undergone, and is generally associated with the less productive portion of the type. The substratum is a light brown, granular, silty clay. It is rarely calcareous.

Cultivated fields of the Memphis generally have a spotted appearance because of the surface washing. Where the top soil is largely removed and the subsoil exposed, the color is yellow in contrast to the gray-brown of the less eroded areas.

TABLE 8.—COMPOSITION OF MEMPHIS SILT LOAM

County	Location			In 2,000,000 pounds of Surface Soil		
	Tp.	R.	Sec.	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
Warren	45	1	19	1,780	380	35,540
Franklin	54	2E	30	2,260	1,760	42,600
Frankl n	44	1W	20	1,640	600	39,460
Ma:i›n	57	5	9	2,620	960	32,060
Marion	58	5	20	2,540	1,020	36,460
Marion	59	6	25	2,600	1,100	34,400
Pike	¾ Mi E. Turpin and 4 Mi. South of Clarksville			2,340	720	33,220
St. Charles	3½ Mi. E. of St. Peters			2,040	1,160	33,620
St. Louis	¾ Mi. W of Pattonville			2,140	1,280	36,640
St. Louis	1 Mi. W. of Spanish Lake			1,480	1,120	35,460
St. Louis	46	5	34	1,320	1,000	39,060
St. Louis	44	6	28	1,540	1,140	37,880
Jefferson	42	6	19	1,840	860	34,380
St. Genev.	38	9	20	1,480	680	39,340

The surface of the Memphis silt loam is prevailingly hilly, and averages more broken than the Knox soils. Extensive areas with a rolling surface occur in St. Louis and St. Charles Counties. Much of the steep bluff land cannot be farmed with ordinary implements. Probably 20 per cent of the type is not suited to cultivated crops. Soil washing is more severe, because of the lower porosity and stronger relief than on the Knox soils. Numerous analyses of Memphis silt loam indicate that it contains only about one-third the amount of nitrogen that a normal fertile soil should contain. It averages lower in this constituent than does the Knox silt loam. Moreover, phosphorus is also deficient and the use of phosphate fertilizer can be depended on to give profitable returns. Clover can generally be grown without difficulty, although lime is often very beneficial. In order to build up the nitrogen supply in this soil, it is important that clover or other legume crops be grown more extensively and used as a green manure.

All but the most broken areas of the Memphis silt loam are improved and a considerable portion of it includes some of the most intensely farmed land in the State. In the general farming sections, wheat, corn,

and clover are the principal crops. A larger percentage of the type is used for wheat than of the Knox soil. This is due in part to the more broken surface and also to the type of farmers. Nearly all of the Memphis is settled by Germans.

Pomological Features.—Over most of the Memphis silt loam the fruit industry is only slightly developed, but on part of the type it is highly developed. The majority of the Memphis in St. Louis County and in parts of St. Charles and Jefferson Counties is devoted to truck and vegetable crops. The soil from a physical standpoint is well suited to intensive farming, but heavy applications of manure and fertilizer must be used for best results. In general the Memphis silt loam is too deficient in nitrogen and phosphorus to give as rapid and strong growth as is desired in most garden crops. It is in the region of truck farming that most of the fruit is grown. Most of the orchards are comparatively small and few exceed 20 or 40 acres in size. The total volume of fruit produced, however, is large. In the production of apples, peaches, grapes and bush fruits, St. Louis County leads.

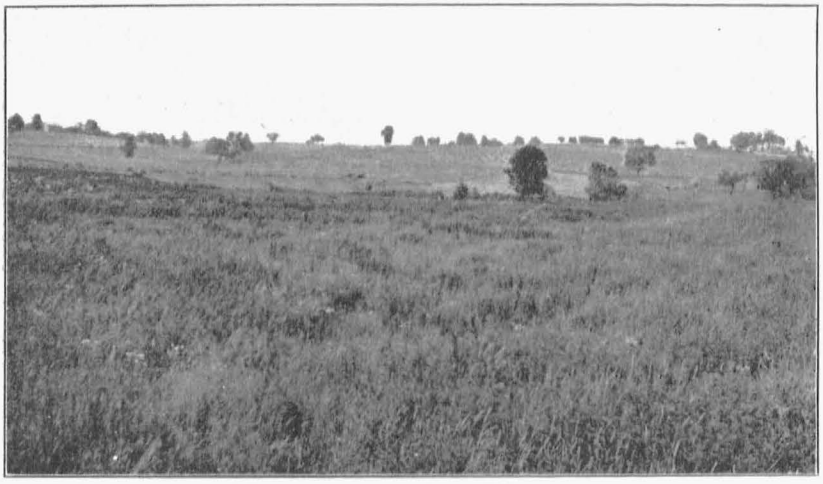

Fig. 17.—Memphis silt loam, St. Louis County. Wherever the surface is favorable to cultivation, wheat is extensively grown.

There are commercial orchards in Franklin, Pike and Marion Counties. Orchards of family size are numerous throughout the loess belt. In general, however, the Memphis silt loam is not as desirable for orcharding as the Knox soils because of the more broken surface and lower average fertility. More attention must be given to maintaining the productivity of the soil by the use of manure and by growing clover. The latter crop thrives on all of the land. Excellent orchard sites exist

everywhere except on the steepest slopes. The trees make good growth and come into bearing at the age of 7 to 10 years depending primarily upon the care they receive. St. Louis is the principal market for all fruit and vegetable products. Along the Mississippi River much of the apple crop is shipped by boat. The local markets and shipping facilities are good throughout the extent of the Memphis silt loam. Practically all of the type, because of its superior soil conditions and because of its market and transportation advantages, offers excellent opportunities for the extension of fruit growing and, in general, a more intensive system of farming.

Fig. 18.—A very deep gulley like this will form in 4 to 5 years, but it may take 40 to 50 years to reclaim it.

Memphis Silt Loam, Hilly Phase.—The areas of Memphis soil that have a broken, hilly surface with a considerable percentage of the land non-arable have been classed as the hilly phase. It is a separation based primarily on a difference in topography and not on soil character. The surface soil, like that of the typical Memphis silt loam, is a brown to gray brown silt loam. At the immediate surface it is gray to yellow, which tends to give uncultivated fields a gray color. In depth the soil is generally quite shallow on account of severe washing. The subsoil is yellow-brown silty clay, frequently mottled yellow and gray below 24 to 30 inches.

Within the area of the hilly phase of the Memphis soil there are many slopes from which the loess has been removed, and the residual clay lies at the surface. The latter may include only a few square yards

or it may include the whole hillside. South slopes more often have clay points. Where these conditions exist the land is not well suited to cultivation. The soil is shallow and not resistant to drought. Slopes of this character generally are timbered or covered with brush.

The surface everywhere is hilly. The general feature of the topography is that of narrow ridges, steep slopes and ravine-like valleys. Probably more than 30 per cent of the land is too broken for cultivation. Even a large percentage of the arable portion is not well suited to crops that require frequent cultivation of the land. Wheat and grass therefore are the important crops.

In general, the hilly phase of the Memphis silt loam is as productive as the main type, but a much smaller percentage of it is farmed. Corn yields average 35 to 40 bushels an acre and wheat yields 15 to 20 bushels an acre. It is a good clover soil and alfalfa is grown successfully on the deeper soil on the bluffs; but manuring, phosphating, and sometimes liming, are necessary for best results. To control soil washing and to increase the supply of organic matter are the great problems in handling this hill land. It gives good response to manurial and phosphate treatment. Lime is not generally needed. The present system of grain farming is destructive and rarely profitable. Much of the steep land now cultivated ought to be kept in grass so as to check soil washing.

TABLE 9.—COMPOSITION OF MEMPHIS SILT LOAM, HILLY PHASE

County	Location			In 2,000,000 pounds of Surface Soil		
	Tp.	R.	Sec.	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
Cole	44	10	10	1,800	660	35,360
Cole	45	12	20	2,040	760	37,060
Ralls	56	3	29	1,620	520	31,280
Perry	34	13	1	1,760	920	33,540
Perry	36	11	20	1,540	880	37,000
Perry	5 Mi. W. of Belgique and 1 Mi. N. E. Serens			1,080	1,380	36,400

The soil is well suited to apples, small fruits and gardening wher-ever the surface features are favorable. Orcharding is carried on in a small way at several places and is generally successful where good methods are used. It has already been pointed out that at one time grape culture was extensive particularly in Gasconade and St. Charles Counties. The industry has declined largely on account of vine diseases. Under favorable price conditions, the extensive development of grape growing can be recommended. It is an industry by means of which many of the steep hills can be made as economically productive as the lands that have more favorable surface features.

For orchard trees, the hilly phase as a whole is not as desirable as the main type The greater difficulty of cultivating, spraying and harvesting on the steep lands increases the cost of production. There are, however, numerous good orchard sites, and even a partial development of these would be of great importance to the fruit industry of the State. The transportation facilities and the local markets are as good as for any of the other loess types.

The hill land is well suited to dairying also. Since clover and grasses thrive everywhere abundant pasture is easily supplied. The nearby bottom lands can be depended on to supply the necessary grain crops. In general, the hilly phase of the Memphis silt loam requires careful handling, but is well suited to fruit growing or intensive farmin gwhere the surface conditions are favorable.

Memphis Silt Loam—Brickey Hills Area.—The river hill land in the southwestern part of Jefferson County and the northern part of Ste. Genevieve County, between Crystal City and White Sands station, is characterized by its extremely hilly and broken surface, and is locally known as "Bricky Hills". The entire area consists of a series of sharp ridges, steep slopes and gorge-like valleys, with a northeast-southwest trend. The range in altitude from valley floor to ridge crest is about 250 feet. It is the most completely and deeply dissected area of river hill land in the State.

All of the area probably at one time was covered by loess soil similar to that of the loess belts to the north and south. However, through the action of erosion, much of the soil mantle has been removed from the slopes, particularly the south slopes. On all the steeper slopes limestone outcrops and rock-strewn surfaces are frequent. It is only on the narrow ridge tops and at the bases of slopes that loess material remains and gives character to the soil. In its characteristics the soil is the same as the Memphis silt loam elsewhere.

Practically the entire Brickley Hills area is timbered and contains only a few small cultivated areas. Various kinds of oaks, elm, walnut, and hickory are the predominating forest growth. Because of the hilly surface it is not probable that any considerable portion of the area ever will be farmed. Most of the ridges and valleys are to narrow to make farming practicable. The growing of grapes on favorable locations probably offers the best opportunities of success. In general, the Brickley Hills area is essentially forest land and should be so used.

Memphis Silt Loam—Gray Phase.—The loess soil in the southeastern part of the State to the south of Perry County, has been classified as Memphis silt loam, gray phase, because of uniformly lighter color and lower productivity than the typical Memphis silt loam farther

The gray phase of the Memphis silt loam should be devoted more largely to livestock farming, preferably dairying, than to grain farming. Bluegrass and clover thrive but the superior pasture grass for this region, particularly to the south, is Bermuda. It is especially effective in preventing soil washing, and produces a larger amount of forage than the other pasture grasses. All farming systems should be so planned as to increase the supply of organic matter in the soil. The use of phosphate fertilizer, particularly on wheat, should be more generally practiced. Where difficulty is experienced in growing clover, applications of lime are often necessary.

Pomological Features.—The fruit industry is practically undeveloped on this soil and has received less attention than on any of the other loess soils. In recent years a few commercial orchards have been planted in Cape Girardeau and Scott Counties. All orchard and small fruits do well. Apples when well cared for bear regular crops. Peaches in particular thrive well, and are less frequently injured by frosts than in most other parts of the State. Orchard diseases are rather prevalent but can be controlled by proper spraying. Conditions are especially favorable for the production of strawberries and other small fruits. The fruit ripens from one to three weeks earlier than in other parts of the State. In addition to the favorable soil and climatic conditions, the populous lowland region to the south, with its good transportation facilities, provides large and convenient markets that will favor the development of a varied fruit industry. The whole lower Mississippi Valley could be supplied from this region. With the present tendency from extensive to a more intensive system of farming, the planting of orchards is receiving a great stimulus.

Clinton Silt Loam.—The brown loess soil in parts of St. Louis and St. Charles Counties possesses characteristics somewhat different from that elsewhere, and has been classified as Clinton silt loam. It represents that portion of the loess material that apparently has undergone the greatest weathering and modification. In point of development it might be considered the oldest of the loess types.

The surface soil of the Clinton is a gray-brown to pale yellow silt loam averaging about 10 inches in depth. When moist, the color is brown, but when dry the cultivated fields have a distinct gray appearance. The light color is indicative of the low content of organic matter. The transition into the subsoil is accompanied by an increase in clay. The lower subsoil normally is a yellowish gray friable silty clay, mottled brown and gray. Small iron concretions are sometimes present, and in general the soil shows a rather advanced stage of leaching and weathering.

The surface features vary from gently rolling to undulating, and average smoother than for any other brown loess type. The slopes are short, and erosion is not generally severe. The natural drainage is good and the subsoil is rarely sufficiently compact to retard the downward percolation of water.

Because of its location near a populous center and because of its favorable surface features, all of the Clinton is highly improved. A considerable portion of the St. Louis County area is used for town and residence sites. The St. Charles area is devoted to general farming. The type is not as productive as the Memphis or any of the other loess soils. Because of the slight compaction in the subsoil it is not as well suited to deep rooting crops such as alfalfa. As a fruit soil also it must be considered inferior, since trees and bush fruits do not make as vigorous a growth as on the other loess soil types. However, by the use of manure and fertilizers, small fruits and vegetables are grown successfully. Strawberries and truck crops are extensively grown in St. Louis County.

Fig. 19.—Clinton silt loam, St. Louis County. This type has smoother surface features than any other of the brown loess soils.

TABLE 11.—COMPOSITION OF CLINTON SILT LOAM

Church	Location			In 2,000,000 pounds of Surface Soil		
	Tp.	R.	Sec.	Lbs. Nitrogen	Lbs. Phosphorus	Lbs. Potassium
St. Louis	45	5	22	1,720	940	34,840
St. Louis	45	6	5	1,580	1,300	35,400
St. Louis	45	5	25	1,220	540	36,240
St. Charles	Near Harvester			1,680	720	35,760

In general the Clinton silt loam is only moderately fertile, and is rather low in organic matter. There is need of more extensive growing of clover and other legumes as green manure to supplement the stable manure. The phosphorus content of the soil is low, and the use of phosphatic fertilizers gives good returns, particularly on wheat. Most of the soil is acid and liming is usually essential to satisfactory stands of clover or alfalfa. High grade mixed fertilizers should be used on truck crops. Building up the soil is essential for profitable yields either in general or intensive farming.

CONDITIONS AND POSSIBILITIES OF FRUIT GROWING*

Missouri is generally recognized as one of the leading fruit states in the Mississippi Valley. However, in common with nearly every other state, there was a great decline in the number of fruit trees in the decade from 1910 to 1920. The census for 1910 gives 14,359,673 apple trees as compared to 6,748,682 in 1920, a decrease of over 53 per cent. Peaches suffered even a greater percentage loss. The primary cause for the rapid disappearance of so many fruit trees must be attributed to the errors in planting poor varieties, in the selecting of soils and sites unsuited to fruit growing and to the lack of care. Much of the fruit produced was of inferior quality and as a result the industry in many cases was unprofitable. Through the costly experience of the past it has been learned that apple growing is a specialized industry and that it requires the highest skill and the greatest care.

The decrease in the number of fruit trees has not been accompanied by a decrease in consumption. In fact, the demand for fruit is steadily increasing. More orchards are needed. The population is growing and orchards are declining. There is still a need for well cared for home orchards, but there is a greater need for commercial orchards. The Middle West has not been holding its own against the competition of the Pacific Coast. The excellent Western fruit not only captured the market but held it. With approved methods, orcharding in Missouri has tremendous advantages over the commercial orchards of the West. Because of its central location, because of its favorable climate, because of its markets and transportation facilities, but primarily because of its loess soil, Missouri should be the leading fruit state in the Central West.

Orchard fruits, particularly apples, are grown throughout the extent of the brown loess soils, although the localities where they are grown commercially are rather limited. One of the most important fruit regions in the State is the group of northwest counties with Buchanan County as

*Because of the excellent adaptation of these soils to fruit, the possibilities of fruit growing have been rather strongly emphasized in this report.

a center. Not only is the acreage large, but the production is heavy. Other orchard centers of importance are St. Louis, Carroll, Howard, Pike, and St. Charles Counties. Extensive plantings have been made in recent years in Lafayette, Boone and Jackson Counties, so that in time the commercial producing region will be greatly enlarged. The great majority of the market apples of Missouri are produced on the brown loess soils.

It cannot be said that any one region possesses special advantages from a soils standpoint over any other region within the brown loess soils area. There is, however, a tendency for the orchard industry to develop more rapidly near established orchard centers. Such centers usually have advantages for fruit production as compared to other locations even on similar soil. The concentration of orchards in certain sections has the advantage of facilitating the sale of the fruit, either through cooperative methods or by attracting a larger number of buyers.

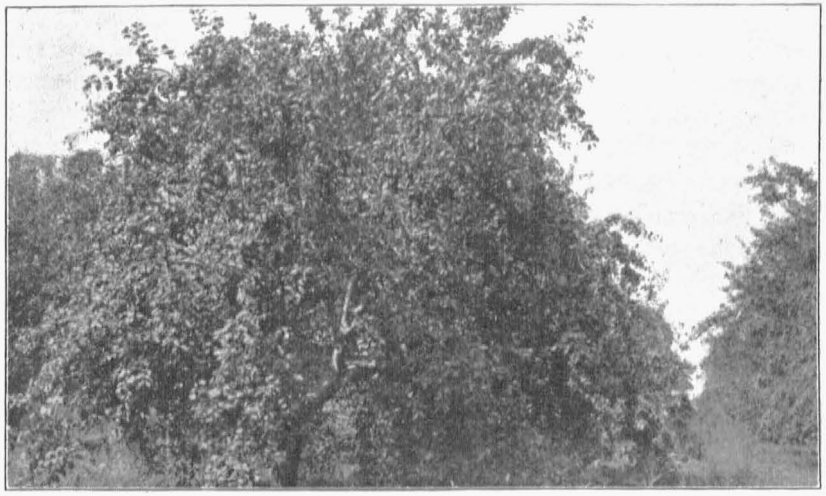

Fig. 20.—The superiority of the brown loess for apples is indicated by the vigorous, healthy and heavy bearing trees.

Probably the most important limitation in the utilization of the loess soils for apple production is the topography. Much of the brown loess land particularly in the eastern half of the State is so hilly as to be unsuited for tree planting. The problem of cultivating, spraying and harvesting is largely governed by the character of the land. In general it can be assumed that land not too steep for corn is suited for orchards. Occasional areas of light-colored or grayish brown loess soil, having a tight clay subsoil, and those areas where the surface soil is shallow are not so well suited for orchard trees. Land of this type occurs mainly

in the eastern half of the State and is most extensive in St. Louis and St. Charles Counties. In general, the brown loess along the Mississippi River, especially south from St. Louis, because of its average lower fertility does not produce as vigorous trees as the loess in other parts of the State.

The varieties of fall apples now bearing in the approximate order of their importance, are as follows:

Ben Davis	Grimes	Arkansas Black
Gano	York	Huntsman
Jonathan	Stayman Winesap	Ingram
Winesap	Willow Twig	

Non-bearing young orchards have been planted largely to varieties of higher quality like Jonathan, Grimes, Delicious, King David, Stayman and Winesap.

The most important summer and early fall varieties are Transparent, Duchess and Wealthy. In the commercial orchards, summer apples probably represent less than one per cent of the bearing trees. In all new plantings the tendency is toward fall and early winter varieties. At the present time, about three-fourths of the bearing trees are winter varieties, and the majority of the remainder are fall varieties.

Other orchard fruits grown with success on the brown loess soils are peaches, pears, cherries, and plums. The acreage of these is largest in Buchanan, St. Louis, Clay and Jackson Counties, and is due to the proximity to the large city markets. Peaches are frequently damaged by late spring frosts. Pears are subject to injury from blight, but this can largely be controlled by proper care. The supply of the various fruits is rarely sufficient to supply even the local demand. Some of the varieties adapted to Missouri conditions are as follows:

Cherries: Early Richmond and Montmorency
Pears: Keiffer, Garber, and Seckel
Plums: Wild goose, Greengage, and Shropshire Damson
Peaches: Greensboro, Early Champion, Elberta, Salway, and Krummel.

The growing of small fruits such as grapes, blackberries, raspberries, gooseberries, currants, and strawberries is carried on in a small way near many of the towns, but has reached most extensive proportions in Buchanan and St. Louis Counties. Frequently young orchards are interplanted with berry fruits to provide an income until the trees are of bearing age. In general, the bush fruits such as the raspberry and blackberry require a rich, moist soil and are more restricted in their adaptation

than fruit trees. On hilly land north and east slopes usually give better results than the drier south slopes, although the latter favor earliness.

TABLE 12.—PRINCIPLE FRUIT CROPS IN COUNTIES HAVING BROWN LOESS SOILS U. S. CENSUS FOR 1920.

County	Strawberries	Black and Dew Berries	Apples		Peaches		Pears		Cherries		Grapes	
			Bearing	Not bearing	Bearing	Not bearing	Bearing	Not bearing	Bearing	Not bearing	Bearing	Not bearing
	A.	*A.*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Vines*	*Vines*
Atchison	42	15	29,148	9,335	2,430	731	1,238	744	2,365	933	10,027	1,996
Holt	32	24	60,647	36,321	8,067	2,194	3,792	1,465	3,772	2,236	10,301	2,439
Andrew	43	20	66,824	23,131	15,600	4,306	6,759	2,159	7,871	3,078	129,828	3,789
Buchanan	59	40	101,045	20,325	12,540	4,038	7,484	2,226	17,441	4,563	147,986	11,263
Platte	26	5	59,197	20,089	3,643	2,028	2,427	669	5,760	2,902	7,267	1,671
Ray	37	38	18,064	7,878	8,739	3,921	2,791	1,300	5,076	4,319	22,032	12,492
Clay	39	25	33,853	6,895	5,672	2,749	3,908	958	9,370	3,363	21,194	3,498
Jackson	72	56	10,263	23,735	11,971	6,103	8,581	1,621	15,177	6,394	54,470	11,219
Lafayette	32	26	93,659	42,657	9,401	5,021	4,297	1,307	6,072	3,412	12,738	1,257
Saline	48	21	32,725	13,768	8,914	3,431	1,833	755	4,698	2,552	12,683	1,286
Carroll	28	20	62,845	11,910	8,047	3,896	2,137	644	5,412	2,968	15,604	2,068
Chariton	32	17	39,158	10,041	5,383	4,985	2,399	561	5,484	4,280	18,231	2,259
Howard	8	2	38,869	5,055	4,818	2,547	1,269	278	2,175	7,106	4,521	278
Boone	35	101	47,841	18,643	18,303	5,678	3,447	859	4,974	3,907	13,730	2,904
Moniteau	14	42	20,127	8,804	12,144	4,864	2,243	1,082	2,533	18,210	13,663	1,299
Cooper	23	32	30,992	12,816	13,055	3,841	1,553	760	5,353	2,636	16,492	1,544
Cole	12	43	24,725	14,840	15,620	5,070	4,260	1,251	3,506	2,080	46,285	2,718
Callaway	29	76	57,616	9,551	24,161	4,568	3,891	770	4,722	2,488	13,112	2,016
Osage	13	68	22,844	15,215	28,910	8,075	2,322	1,128	2,881	2,477	20,802	2,436
Gasconade	17	44	47,501	9,786	33,167	5,683	2,999	648	3,461	2,929	113,453	1,470
Franklin	33	61	66,866	29,106	34,918	14,594	4,404	1,686	6,567	4,261	52,169	5,960
Montgomery	12	48	30,659	8,126	15,118	2,952	2,502	328	4,705	1,940	14,821	1,299
Warren	4	11	22,941	4,761	9,603	2,014	2,558	285	2,154	874	9,044	987
St. Charles	4	20	53,640	12,077	13,121	6,288	4,267	1,035	3,279	2,169	23,146	1,604
St. Louis	745	548	77,716	39,405	74,867	49,384	30,255	5,598	18,118	19,280	418,064	62,763

Practically all of the brown loess soils because of their deep, porous subsoils are particularly well adapted to all the small fruits. The commercial growers generally plant a number of kinds because this admits of a better distribution of labor. Of the various small fruits the strawberry is most extensively grown. It is particularly well adapted to the loess soils and a high quality fruit is produced. The yields average higher than in other parts of the State. The majority of the product is marketed locally.

In general, the brown loess soils offer great possibilities for the extension of the orchard and small fruit industry. The profitableness of the industry will, of course, depend somewhat on market conditions. For the more perishable fruits chief dependence must be placed on the nearby markets, since long-distance shipping renders the results very uncertain. Thus far, however, the local demand to a large extent has

been left unsupplied, and the existing markets in the populous regions to the north can absorb a vast amount of fruit products that are not now produced. The production of winter apples for shipment to the large markets has proved in the main a profitable industry. Wherever the adaptation of soil and market are satisfactory, the fruit grower may improve his labor conditions and stabilize his income by planting two or more kinds of fruit

GRAPES

The peculiar adaptation of the loess soils for grape production has long been known. The famous vineyards along the Rhine and Moselle Rivers in Germany are located on a soil similar in origin and nature. Grape growing on a commercial scale in Missouri had its beginning about 1850. It developed mainly as a home vineyard proposition with the exception of Gasconade County where commercial grape growing for wine was extensively carried on for many years. Since 1918, there has been a great decline in this locality and many of the vines have been destroyed. The development of grape growing near Hermann in Gasconade County cannot be attributed to any special soil and climatic conditions, since these are essentially the same as elsewhere on the brown loess soils. It was due primarily to the type of people, who were Germans, many of them having come from the wine growing regions of the old country.

Grapes are grown throughout the loess area, but are most extensive in St. Louis County, the 1920 census reporting 480,827 vines. Andrew, Buchanan, Jackson, and Jefferson Counties also have a considerable acreage. The vineyards are found in all positions on the tops of ridges or hills, on slopes and on alluvial valleys. In all these locations the plants do well. Southern and eastern slopes are sometimes preferred because of the better exposure to sunlight which favors early ripening. As far as soil and climatic conditions are concerned, practically all of the brown loess soils are well suited to grape production. Steep slopes not suited for general farm crops or even to orchard fruits can be utilized for grapes. On account of the soil, and the long seasons with an abundance of sunlight, a high quality of fruit is produced. With the steadily increasing demand for grapes, both as table grapes and for the manufacture of grape juice, there are possibilities for an extension in vineyard acreage.

Injury due to extreme cold in winter is uncommon, and the vines are never removed from the trellis and covered for winter protection. Injury from late spring frost is rare. In general, the uncertainties due to climate are less destructive to grapes than to other fruits.

The Concord is by far the most common variety. Moore's Early is also commonly grown in this region. The Concord should produce with

good care 2 to 4 tons an acre. The harvesting season usually occurs between the middle of August and the end of September.

TRUCK FARMING

The geographical position of Missouri is such that most of the common vegetables grown in the far South can be produced here. Also, practically all of those grown in the Northern States can be grown satisfactorily. The wide range of crops and the favorable soil conditions as offered by the brown loess make truck farming profitable. It has its greatest development in St. Louis County where approximately 25,000 acres are devoted to commercial fruit and vegetable growing. As a rule a wide diversity of crops is grown on each farm. This permits a more equitable distribution of labor and income, and makes possible a succession of crops so that the land is used throughout the growing season.

Fig. 21.—When more of Missouri's loess soil is farmed in this way, we shall no longer be dependent on California for canned fruits.

The physical characteristics of the brown loess soils are especially favorable for vegetable growing. The mellow, silty nature of the soils, their absorptive capacity for moisture and their generally well drained condition are the essentials. They also are stone-free and are easily maintained in good tilth. Because of the large amount of labor required, vegetable growing must be confined to the relatively smooth land. Vegetables as a class require much richer soil than farm crops. Only the better lands should be used, and the necessity of applying large and frequent additions of manure is apparent. Applications of 10 to 20 tons to the acre are not at all uncommon. Except on the very rich soils, the use of commercial fertilizers should have a more extended application. The use of acid phosphate is even more profitable in vegetable

growing than in general farming. For quick results it is superior to bone-meal. Not only does it increase yields, but hastens maturity which is such a valuable feature for the market gardener.

In general, truck farming as an industry on the brown loess soils will doubtless be confined to a relatively small area because of the limitations of market demands. However, it is possible for every farm to have a garden which will produce such vegetables and fruits as are needed for home use. In the vicinity of every city or large town there is room for a number of truck farms to supply local markets. This is the safest form of trucking and it is to be preferred to the commercial growing of vegetables for shipment to distant markets. The crops to be grown must therefore be determined by soil and market demand. The great diversity of truck crops that can be produced on these soils is indicated by the following partial list:

Irish potatoes, sweet potatoes, tomatoes, peppers, asparagus, sweet corn, egg-plant, peas, beans, onions, parsley, leek spinach, okra, (gumbo) rhubarb, lettuce, celery, beets, carrots, radishes, horse-radish, turnips, salsify, cabbage, cauliflower, kale, collards, kohl-rabi; musk-melons, watermelons, cucumbers, and squash.

EXTENT OF OCCUPATION

Practically all of the brown loess soils are in farms. However, probably 20 or more per cent of the land remains timbered or is essentially idle land in that it is not utilized except for woods pasture. The greater part of the unimproved land consists of the steep slopes and bluffs, and is most extensive along the lower Missouri and Mississippi rivers. In many places a small part of this land can be cleared and farmed; however, the total is small and most of it should remain as timber and pasture. Even some of the land now classed as improved should never have been cleared, and should be considered as pasture land because of its broken surface. It is therefore scarcely probable that a much larger percentage of the loess soils will be successfully tilled than at present, although the utilization of some of the pasture lands for fruit crops is possible. As a whole, the farm practices on the brown loess soils permit of more intensive methods and greater diversification. The more intensive occupation of the land will result in an increased production and is entirely practical under the existing soil and market conditions.

POPULATION AND TRANSPORTATION

The brown loess soils were the first soils in Missouri to be settled and farmed. Because of their location along the large rivers, which in early times were the routes of transportation, many towns were es-

tablished on or at the edge of these uplands. Many of the oldest and most prosperous towns in the State are thus located. This is of significance in the development of the agriculture, particularly under fruit or truck farming, in that there are many local markets and shipping points. More than 2,000,000 of the state's population live in the loess counties, and considerable more than 70 per cent of this number are city dwellers. St. Louis, Kansas City, and St. Joseph are located on brown loess soils. Other important towns similarly located are Hannibal, Cape Girardeau, Jefferson City, Boonville, and Lexington. Throughout the eastern half of the State, and along the south side of the Missouri River, as far west as Kansas City, most of the brown loess soils are settled by people of German descent.

Fig. 22.—Brown loess landscape in Howard County. Steep slopes and ravines are timbered. The gentler slopes provide excellent orchard sites and represent good general farming land.

An important factor in the economic utilization of any soil is transportation. An examination of the map indicates the relation of railroad lines to the distribution of the loess soils. With a few minor exceptions, practically all of the brown loess soil is within five or six miles of a railroad, and the majority of it is less than four miles from a railroad town or shipping station. There is thus provided direct access to all the market centers. With the ultimate development of river traffic, the facilities for marketing bulky products, such as apples, will be greatly improved. The construction of several state and transcontinental highways that are within or adjacent to the belt of brown loess soils will further improve the local shipping facilities by means of trucks.

LAND VALUES

Land values for the brown loess soils range from near the lowest to the highest in the State. The lower values prevail in the broken, hilly sections in the southeastern part of the State, south from St. Louis. Much of the bluff land that is not suited to farming is held at $10 to $25 an acre. Part of this value can be generally attributed to the timber. Along the lower Missouri east from Boonville and along the Mississippi north of St. Louis values range from $30 to $100 an acre, with higher values near the larger towns. In the western part of the State, where practically all of the loess soil is arable, prices range from $50 to $125 an acre. Near the cities values always range much higher than for the more distant areas, although the quality of the soil may be essentially the

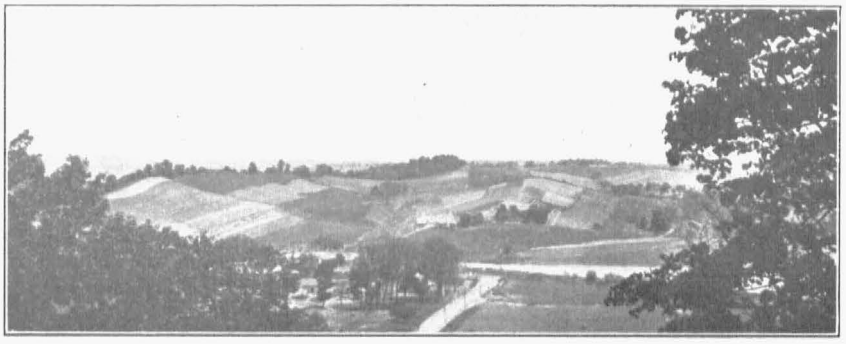

Fig. 23.—A landscape in a region of rather intensive farming in Andrew County. All of the land, to the brink of the bluff, is utilized for the growing of a large variety of crops. Knox silt loam.

same. In St. Louis, Jackson and Buchanan Counties near the larger cities the highest prices prevail, and here some of the land is held as high as $300 or even much more per acre. The price of land is, however, not a criterion of its value or productivity. In general, land values of the brown loess soils are relatively lower than those of other soils of equal productivity because of the hilly surface and the greater difficulty of farming the land. For the farmer of small means, there is still much opportunity on these soils since very satisfactory land, fairly well located, may be had at prices ranging from $40 to $100 per acre.

SUMMARY

1. The loess soils represent the most valuable single soil resource of Missouri. They cover approximately one-eighth the area of the State, but in their relation to the agriculture of the State they occupy first place. Their utilization for successful crop production has made it increasingly

evident that they are capable of a much greater development, and this fact has prompted the publication of this report.

2. Loess soils have characteristics of origin and structure that not only are of interest to the student of soils, but that add also to their desirability for crop production.

3. Loess is generally considered to be wind-deposited soil material. Within the confines of Missouri it forms an almost unbroken belt of upland soils along the Missouri and Mississippi Rivers.

4. The brown loess soils with which this report is concerned, are commonly known as "river hill lands." They represent the brown-colored, timbered soils, as distinguished from the dark colored prairie soils of the loess deposits. They are generally characterized by deep, mellow, silty surface soils and open, friable, silty clay subsoils.

5. The very favorable physical properties of these soils, and a rather high degree of fertility bring about a marked productivity and an adaptation to a great variety of crops, especially deep rooting crops such as legumes and fruits.

6. The limitations in the utilization of the brown loess soils are primarily those of topography. Practically all of them have a rolling or hilly surface. The stronger relief predominates in the eastern part of the State, so that in places as much as 25 per cent of the land is non-arable. Soil erosion is everywhere a serious problem.

7. General farming is the prevailing type of agriculture, but near the towns more intensive practices based on dairying, fruit growing and trucking prevail. Soil, market and transportation conditions are especially favorable for an extension of the fruit growing industry. As a whole, the brown loess soils possess superior advantages for a "small farm" type of agriculture.