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Forest Soil Areas in the Ozark Region of Missouri

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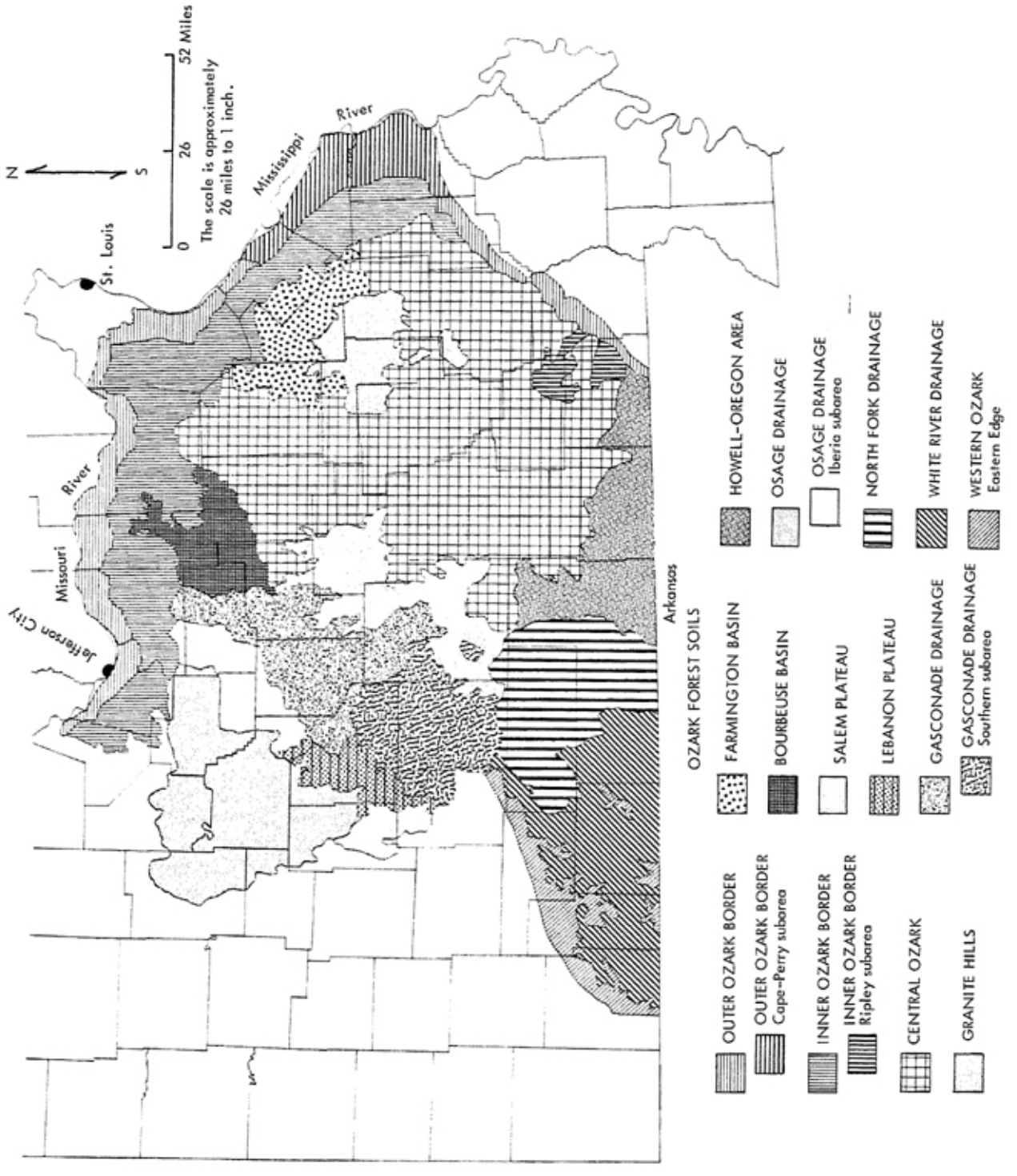
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INNER OZARK BORDER
INNER OZARK BORDER
Ripley subarea
CENTRAL OZARK
GRANITE HILLS
FARMINGTON BASIN
BOURBEUSE BASIN
SALEM PLATEAU
LEBANON PLATEAU
GASCONADE DRAINAGE
GASCONADE DRAINAGE
Southern subarea
HOWELL-OREGON AREA
OSAGE DRAINAGE
OSAGE DRAINAGE
Iberia subarea
NORTH FORK DRAINAGE
WHITE RIVER DRAINAGE
WESTERN OZARK
Eastern Edge

Forest Soil Areas in the Ozark Region of Missouri

H. H. KRUSEKOPF

The interrelation of the forests and soils in the Missouri Ozark region is of interest to both foresters and pedologists. In modern forest management, greater emphasis is being given to the soil factors as they affect the potential for increased production of usable products or services. Whether certain marginal forest land should be retained for timber production or converted to some alternate use is a problem facing both public agencies and private individuals engaged in land management. A classification of the forest soils to help delineate areas suitable for permanent forest production is essential for land-use planning and adjustment.

In general, there is need for a basic understanding of the soil factors that influence the variations and the occurrence of different forest types. Some broad soil-plant relationships have been recognized for a long time, but these have not been well defined. That white oak[1] develops better on deep, moist, soils than on shallow, dry, sites is well established. Poor sites usually support only blackjack or post oak. This survey was made to delineate the major soil areas and to identify the forest types characteristic of each area.

The Missouri Ozark region considered in this report includes all the land in the State south of the Missouri River and west of the Mississippi River to the prairie region (Fig. 1). The western boundary is irregular and extends roughly from Moniteau County on the north to Stone County on the south, along the eastern edge of the prairie region. About 27,000 square miles are involved in this geologic and geographic region which contains several physiographic subdivisions.

Except for a few small spots on the Salem and Lebanon plateaus, the entire Ozark region was originally forested. Approximately half of the total land area remains forested.[2] This represents almost 60 percent of all the forested land in Missouri. The forests are unevenly distributed over the region, occupying from 20 percent of the total land area in some counties to over 85 percent in others. Forests are most extensive where the topography is hilly and steep.

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[1]See Appendix A—Common Forest Species.

[2]Missouri Soil and Water Conservation Needs Inventory. February 1962. University of Missouri Agricultural Experiment Station Publication.

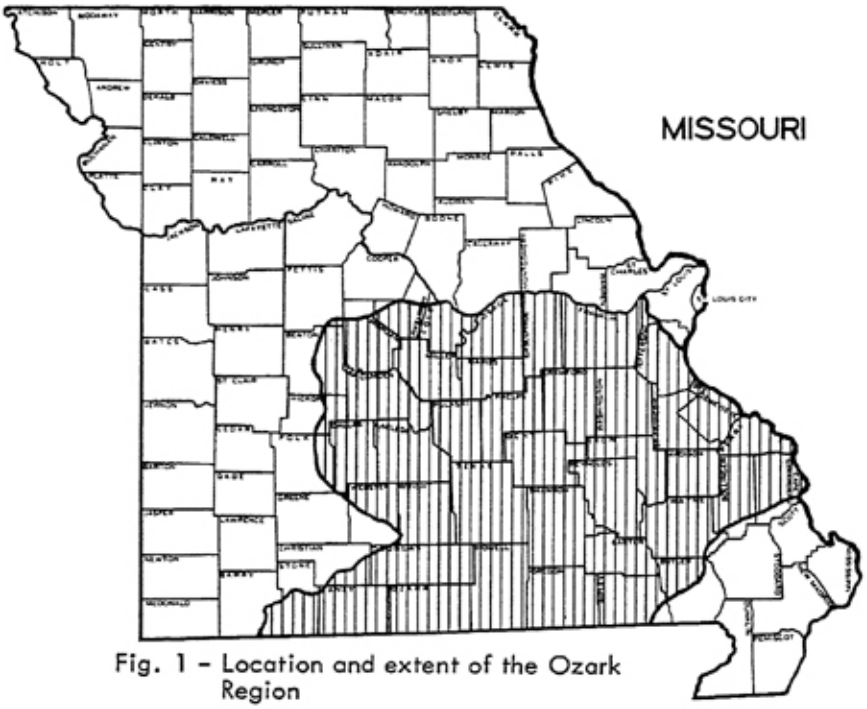


Fig. 1 – Location and extent of the Ozark Region

WHAT WAS DONE

A reconnaissance survey of the entire Ozark region was made in 1959 to map the major forest and soil areas.[3] Survey data were supplemented by numerous soil studies and field observations made during the past 25 years. Additional information was obtained from county and state soil reports, geologic, topographic and road maps, publications on forest and vegetation of the region by foresters, ecologists, geographers and explorers. Thirteen major and four minor soil areas are recognized.

The six broad forest types used are an elementary grouping of the forest species. There are wide variations in both forests and soils within each soil area. No attempt was made to delineate minor soil or forest variations or to make precise site classifications. Soil description and classification on a *series* level will be required for more specific correlation with forest cover. This survey can be considered as laying the groundwork for such an evaluation of the site potential of the larger soil areas.

General Considerations of Forests and of Soils

In their main physical features, both the forests and the soils of the Ozark region are characterized by their sameness. The upland oak forest type prevails over the entire region, but shortleaf pine and redcedar sometimes are the most important species. Within the oak forests are many local variations in predomi-

[3]University of Missouri Agricultural Experiment Station in cooperation with Central States Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Columbia, Missouri.

nance of species, stocking and growth rate, which often are related to variations in both soil and climate. Specific forest-soil areas are described in another part of this report.

The sameness of the forest type is paralleled by the sameness of the soils in their main morphological features. Soils are consistently light in color—either gray or brown, shallow in thickness of surface soil, of medium (silt loam) texture, and of relatively low fertility. Varying amounts of chert stone characterize nearly all the soils except in the Ozark Border region. The soils belong to two Great Soil Groups—Gray-Brown Podzolic and Red-Yellow Podzolic. The former includes the essentially stone-free soils of the Ozark Border, and the latter includes the soils derived from residuum of the various rock strata.

The Red-Yellow Podzolic soils have a profile morphologically similar to the Gray-Brown Podzolic but tend to have a friable and brittle consistency throughout the profile. This unfavorable structure may be attributed to the low content of organic matter and the severe weathering of the material. The lower subsoil tends to have a brown or reddish-brown color and is consistently acid—a pH value of less than 5. The percent of base saturation is low.

Both forests and soils are characterized by maturity in development. This is a highly significant consideration. There are no sharp contrasts in either forests or soils, and all changes tend to be gradational. In many cases the present forest cover has been modified by past treatments such as cutting, burning, and grazing so that the original soil-site relationships have been obliterated. The maturity of the soils is evidenced by the great depth, 100 or more feet, to which the bedrock has decomposed and the thickness of the residuum, the highly leached soil, and the distinctive soil profile that result from long-time development processes.

Classifying the Forests

In determining the relation of forests to soils, it was necessary to adopt some forest classification scheme and to define grades of forest types. Detailed forest and vegetation maps of the Ozark region are not available. The following criteria or guides were considered in evaluating the forests:

1. Relative prevalence of species
2. Growth rate or relative height of trees
3. Stocking or density of stand
4. Ground cover—mainly grass and shrubs.

The Ozark region is in the western portion of the central hardwood forest zone. Although the broad forest type is classed as *oak-hickory,* the latter species may be rare or absent. The forest is composed principally of several oak species in various combinations. Shortleaf pine often is codominant with the oaks or locally may form pure stands. On the more mesophytic slopes sugar maple, yellow poplar and similar species may be abundant. In contrast, limestone glades and balds that once were grass covered have been invaded by redcedar and other xerophytic trees and shrubs. As a whole, however, variations of the oak-hickory forest prevail over the entire Ozark region.

In this report, six forest types are recognized. These are designated by the major species in accord with the classification of the Society of American Foresters:[4]

1. Post oak-black oak
2. White oak—black oak—hickory
3. White oak
4. Yellow poplar—white oak—red oak
5. Shortleaf pine—oak
6. Eastern redcedar.

The post oak—black oak type commonly occurs on dry ridges and upper south slopes or where frequent fires have eliminated the other oaks. Blackjack oak may be an important constituent on very stony south slopes. Black oak and scarlet oak are varying components of this type, increasing in frequency where the areas have been protected from fire or on the slightly better sites. Post oak usually prevails on the nearly level plateaus.

White oak—black oak—hickory is the most widespread and most important forest type in the Ozark region. Composition varies greatly with more white oak on northerly slopes and more black oak and scarlet oak on the ridges and drier sites. Red oak occurs on the more mesophytic slopes throughout the region.

Pure stands of white oak occur in patches in the white oak—black oak—hickory type. They are found most frequently in the Ozark Border where the soil mantle is deep and stone-free.

In the Ozark region the yellow poplar—white oak—black oak type occurs only on the most mesophytic sites and nearly always is limited to the deep loess soils in the eastern Ozark Border. Associated species are sugar maple and red oak.

Shortleaf pine may occur in pure stands in the pine—oak type, especially in abandoned fields; but it usually grows in a mixture of scarlet oak and black oak. Other associated species are white oak, post oak, hickories and black gum.

The redcedar type generally occupies dry uplands that have shallow soil and numerous limestone outcrops. Although it will grow on good soil sites, redcedar usually is replaced by faster growing species. Red cedar is a common invader of glades and old prairie openings. Associated species include winged elm, post oak, white ash, and xerophytic shrubs.

The six forest types indicate the relative predominance of species, but not necessarily the site potential. Height growth rate probably is more significant than species predominance in site classification. Quality differences and stand composition associated with the soil areas may have been strongly influenced by past fire and cutting history.

Special consideration was given to post oak as a site indicator. This species occurs in all parts of the Ozark region. Its abundance is consistently associated

[4]Society of American Foresters. 1954. Forest cover types of North America (exclusive of Mexico). Washington, D. C.

with some unfavorable soil feature, mainly in the subsoil, that affects root growth. Post oak apparently has acquired a greater or more consistent adjustment to the edaphic environment than any other forest species and therefore is considered a good indicator of certain sites. Although pure stands of any species are not extensive, post oak occurs in such stands more often than any other species. Forests of varied composition usually are associated with the deeper and more productive soils.

Shortleaf pine has a wide distribution, being most abundant in the east-central Ozark region (Fig. 2). Although most prevalent on the drier, well-drained sites that it tolerates better than the oaks, the *occurrence* of pine is independent of any special soil condition.[5] Pine grows on thick loess, alluvial bottoms, sandy and stony slopes, soils with pans, and on soils derived from granite or limestone.

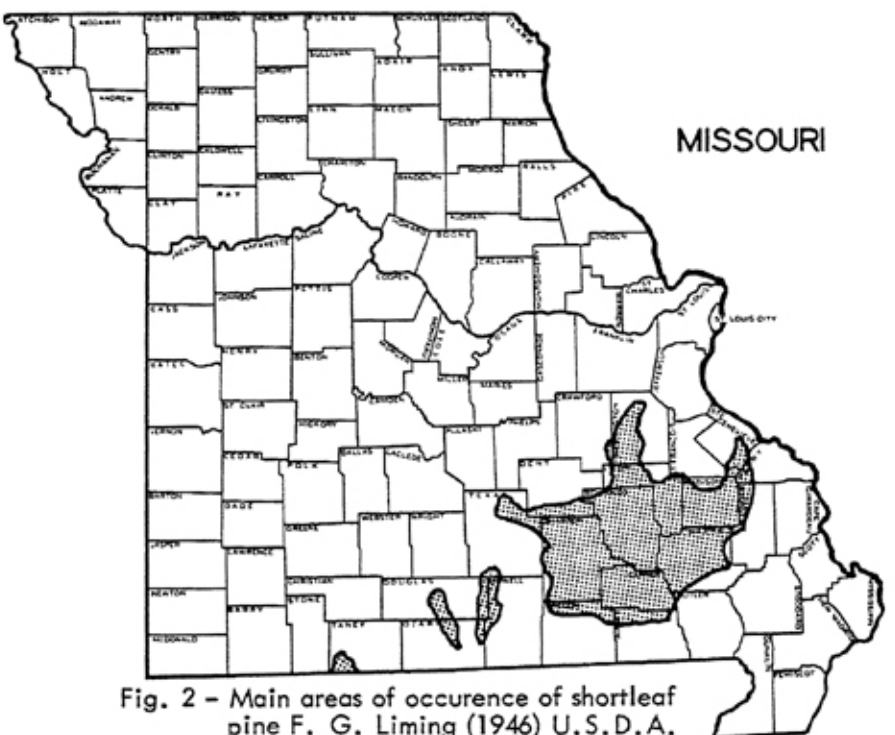


Fig. 2 – Main areas of occurence of shortleaf pine F. G. Liming (1946) U.S.D.A. Cent. States Forest Ext. Sta.

Criteria for Classifying the Forest Soils

The term "forest soil" as used in this report does not refer to a specific soil condition or have a meaning other than that at some time the land has been covered with trees. In soil classification a basic distinction is made between soils formed under forest cover and under grass cover. Pedologists consider all soils developed under forest as forest soils. Morphological features once acquired persist almost indefinitely. In general, it is assumed that weathering processes are more intense under forest than under grass vegetation.

[5]Fletcher, P. W. and McDermott, Influence of Geologic Parent Material and Climate on distribution of shortleaf pine in Missouri. Research Bul. 625, Mo. Agri. Exp. Sta. 1957.

In establishing a classification or grouping of the forest soils primary consideration was given to those physical features that affect moisture properties and root penetration. The Ozark region has a dry physiography. Although the average annual rainfall is about 40 inches, summer drouths are frequent. The soils have only limited capacity to retain moisture because of dense structure and generally high stone centent. Measurements indicate that more than 25 percent of the rainfall is lost almost immediately to the streams as runoff. The permeable structure of the lower substrata also favors loss by deep percolation. A water table within the range of root penetration is non-existent. All soil features must be considered in classification, but features related to profile and texture are most significant.

The upland soils throughout the entire Ozark region have a distinctive profile. In general the A_1 horizon consists of a gray to pale brown silt loam, rarely more than 6 to 7 inches in depth and generally darkened by organic matter in the upper 2 or 3 inches. The subsurface (A_2) is gray-brown in color, slightly more compact, and 6 inches in thickness. The subsoil (B_1) below 12 to 14 inches is a friable silty clay, uniform yellow-brown when dry, reddish brown when moist, that rarely extends below a depth of 24 inches. This sequence of horizons is best developed in stone-free and moderately stony soils.

From a forestry standpoint, the lower subsoil (B_2) is both the most significant and the most variable part of the profile, and provides the main basis for soil area differentiation. Variations in the forest cannot be correlated with depth or thickness of the surface soil because the latter is remarkably uniform throughout the region. The lower subsoil may vary from gray to red, stone-free to stony, and from partly weathered clay to a leached pan. These variations are largely dependent on the topography and character of the soil-forming rock.

Soils and Geology

A distinctive feature of forest soils of the Ozark region is the chert stone which is almost universally present in the residuum soil material. The amount of chert is determined mainly by the soil-forming rock; chert is most abundant over the Eminence and Gasconade limestone in the eastern Ozarks (Fig. 3, "Geologic Map of the Ozarks"). The Roubidoux formation is the source of most of the chert and sandstone in the Osage, Gasconade and Meramec drainage areas. Chert is less abundant in the Cotter-Jefferson City dolomite, and some strata are chert-free. This formation forms the surface rock in the northern and western Ozarks. The extensive areas of glades—bedrock with a veneer of soil—in the White River drainage are peculiar to the upper strata of this limestone formation.

The chert content of stony soils may vary from a few fragments up to 75 percent of the soil mass to a depth of three or more feet. Probably more than one-half of these soils consist of 30 percent or more of stones (Fig. 4, A, B, C). The chert may be most abundant at the surface or in the subsoil or evenly distributed through the profile. A high content of stones in the subsoil usually is an unfavorable condition for tree growth, particularly where the chert is more

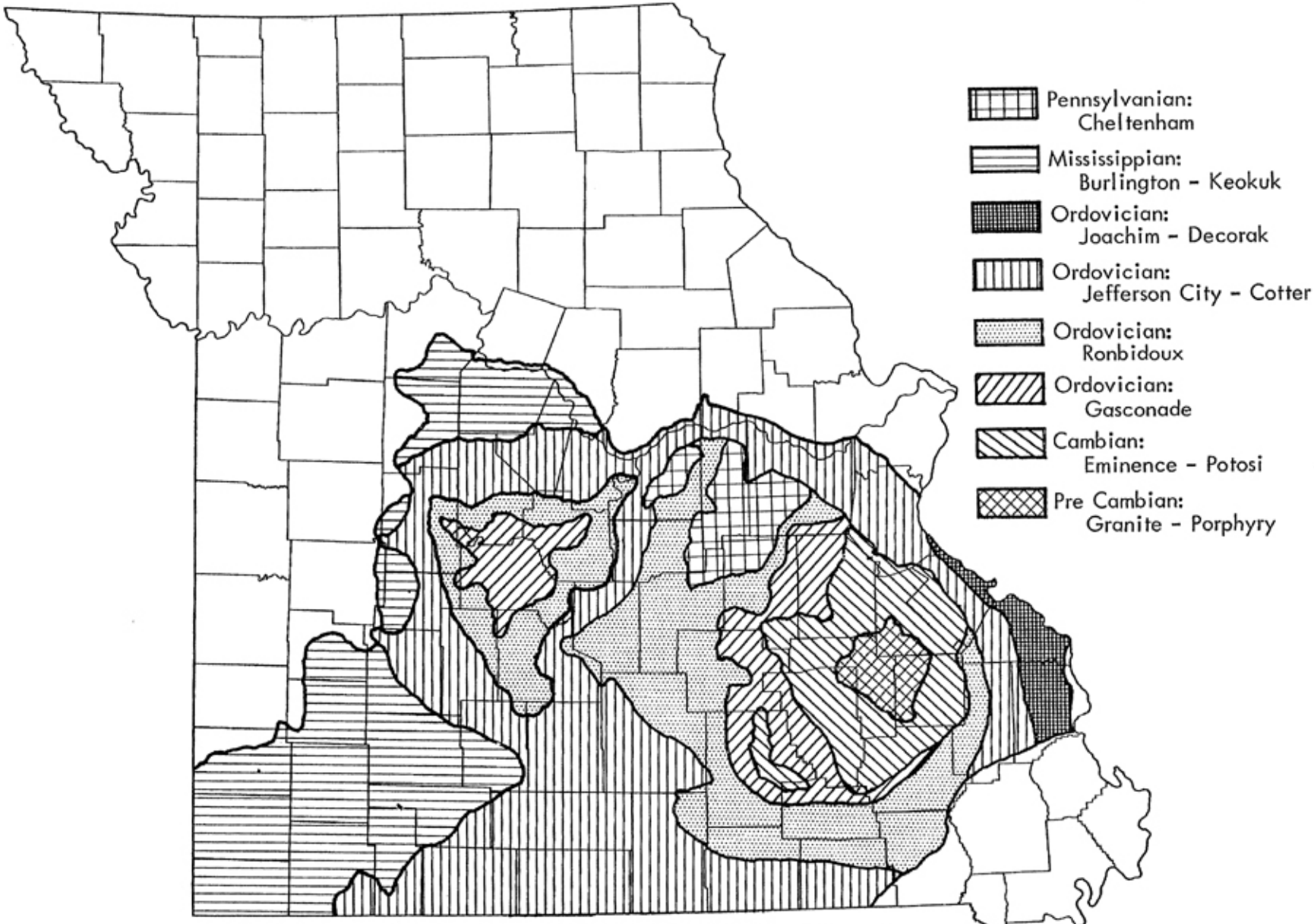
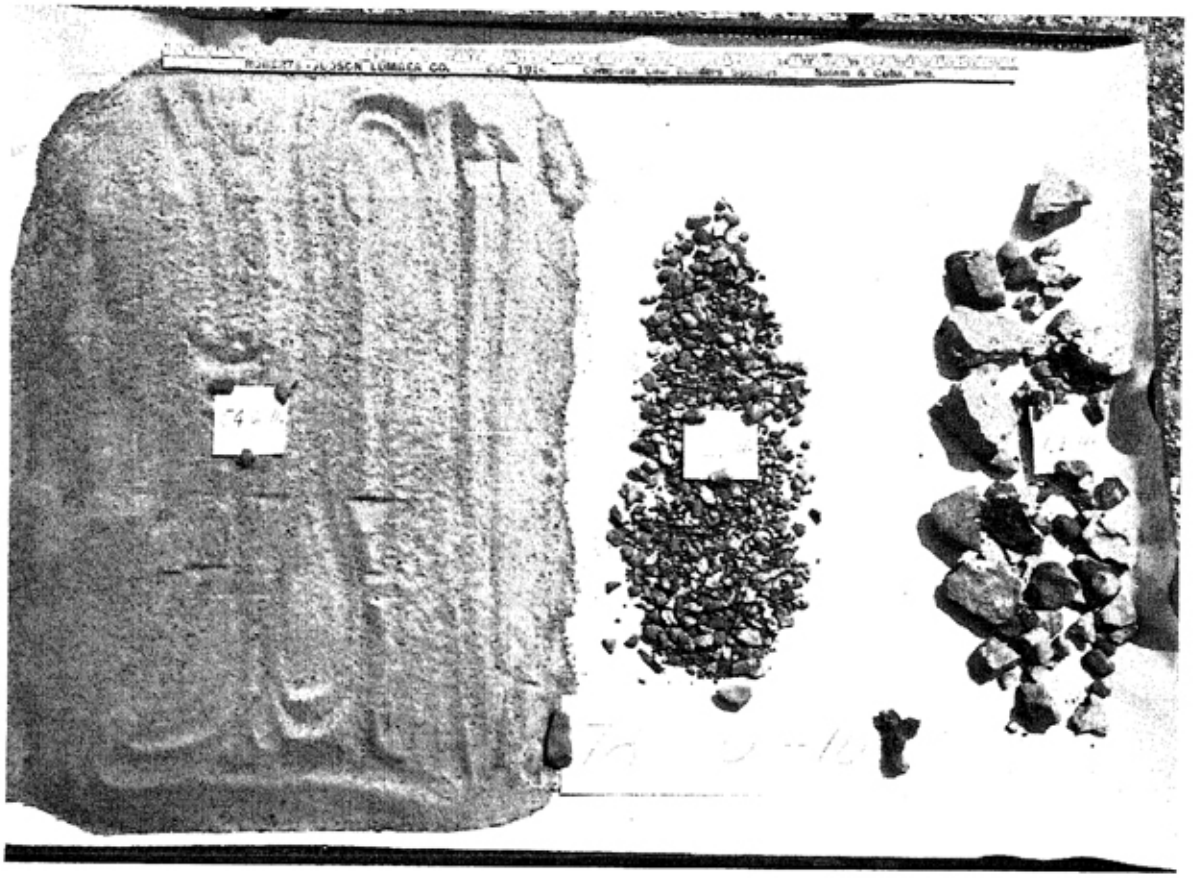
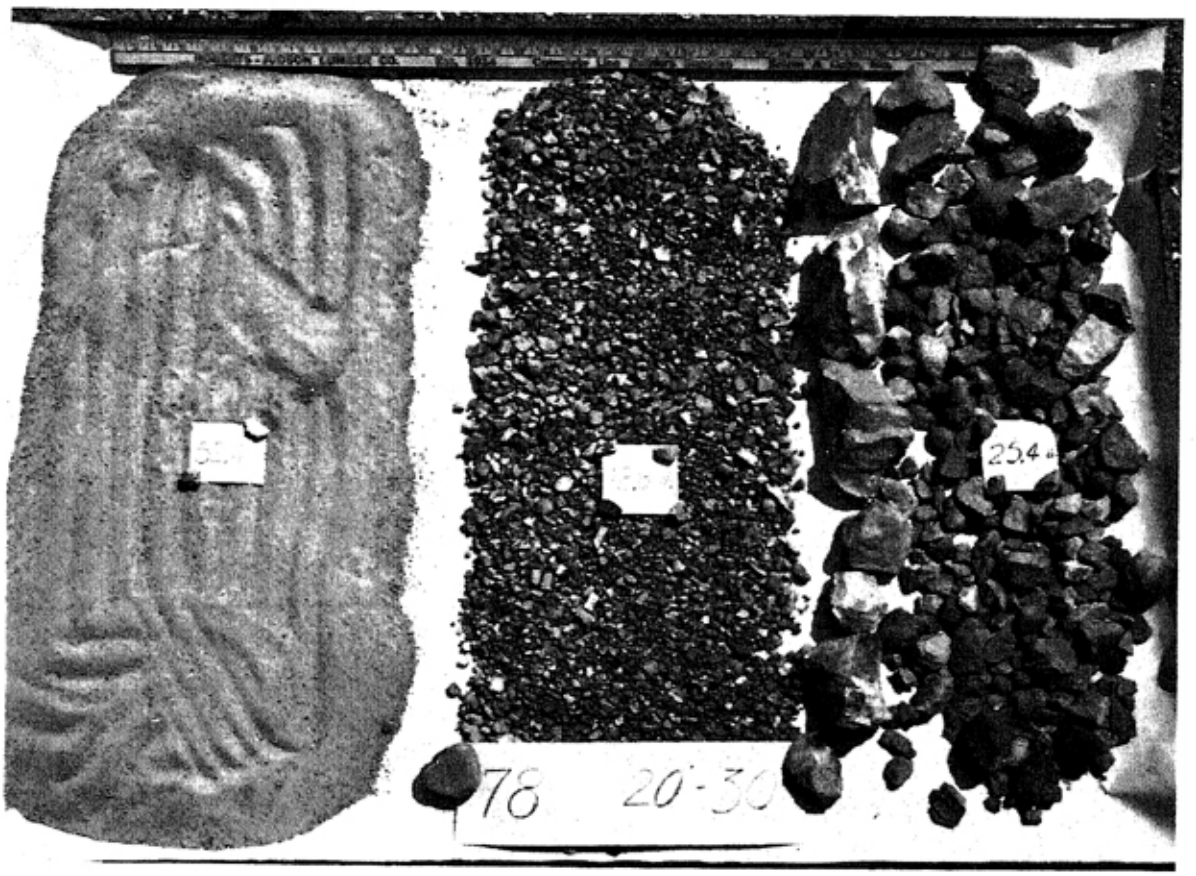


Fig. 3 - Generalized geologic map of the Ozark Region Derived from Geologic Map of Missouri, 1961 Missouri Geological Survey.

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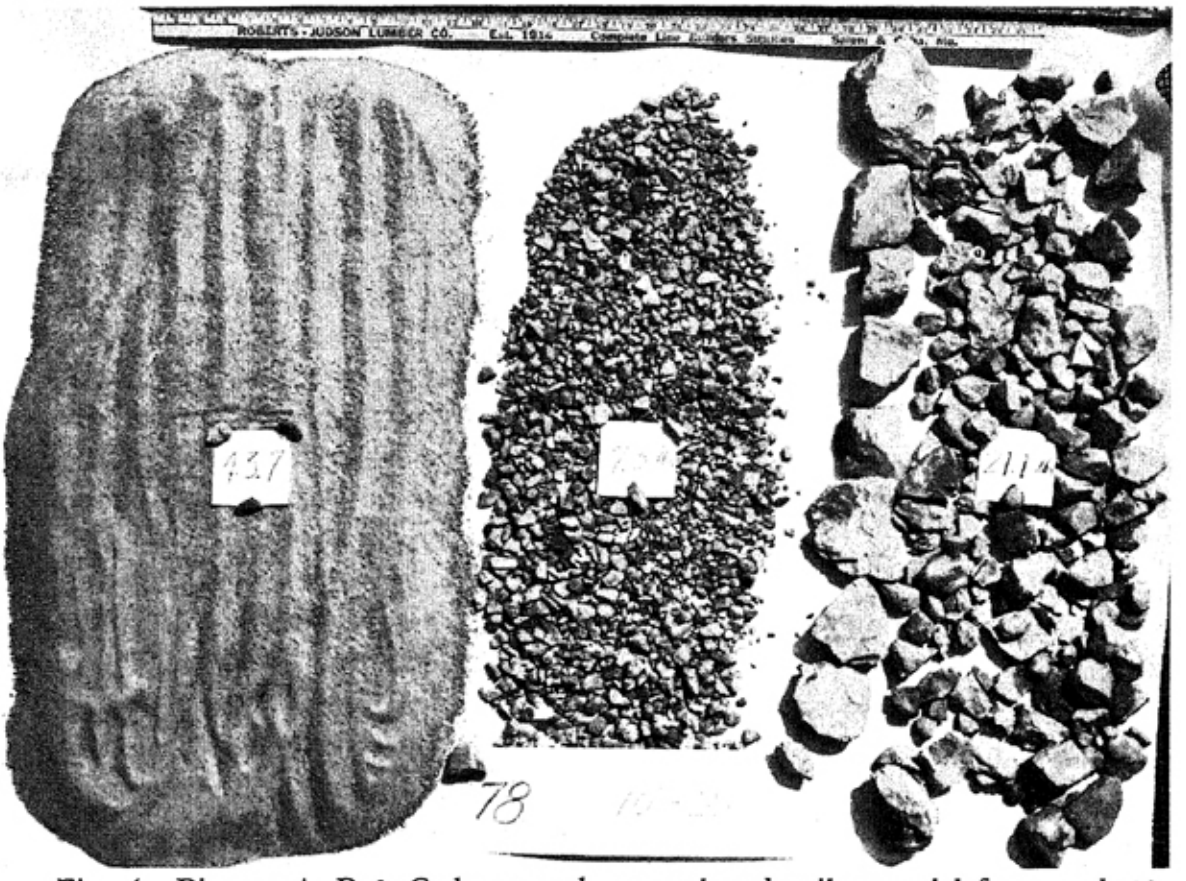

Fig. 4—Picture A, B & C show rock, gravel and soil material from each 10 inch layer in the profile of a moderately stony soil. Size of fractions—rock > 16 mm., gravel 2-16 mm., soil < 2 mm. Sample site on U. S. Sinkin Experimental Forest, southeastern part of Dent county. Number in middle of the 3 fractions is the weight of that material in the sample. From unpublished Master Thesis, 1958, by George S. Carter, University of Missouri.

or less banded or stratified as it was in the original form in the bedrock. The size of the stones also is a factor in site quality. Large stones, four or more inches in diameter, are much more undesirable than smaller fragments. Chert from the Cotter-Jefferson City formations apparently averages larger than that from other or lower limestones. Steep slopes, glades and south exposures generally have the highest stone content; and it is on these sites that moisture capacity is lowest.

Plates A. B, and C show the rocks, gravel and soil from successive 10 inch layers in the soil profile. Moderate stony site on Sinkin Experimental Forest, Dent County, Mo.[6]

Soils derived from rock residuum always are more variable in profile features than soils derived from unconsolidated and more uniform parent material such as loess or glacial till. The loess soils of the Ozark Border are more uni-

[6]George S. Carter. The determination of Moisture in Rocky Soils. Unpublished Masters Thesis, University of Missouri, 1958.

form in physical properties than the soils of the central Ozark region. The chert content from limestone residuum may vary from a few fragments to 50 percent of the soil mass within a distance of 100 feet. These variations may not be obvious on the surface, but they apparently are responsible for local or "spot" variations in the forest—especially the growth rate of individual trees.

Subsoil Characteristics

On ridges and on slopes of less than 10 percent, most Ozark soils have a fragipan (Fig. 5). This is a hard, dense layer in the lower subsoil, usually at a depth of about 24 to 30 inches. It varies in thickness from 6 to 12 inches and in degree of hardness or development. Occurring in both stone-free and stony soils, the pan is most common on ridges that are capped by stone-free material. Fragipans do not occur in very stony soils, on steep slopes, or in soils that have a reddish clay subsoil.

When a pan occurs at the top of the chert layer in the subsoil, it is extremely dense. Fragipans are slowly permeable to water but not to tree roots. The soil material is very acid and highly weathered.

A fragipan formation is considered the most significant single feature of the forest soils. The pan limits root penetration and therefore restricts the zone for obtaining moisture and nutrients to the surface horizons. There is a direct and consistent correlation between the abundance and height of post oak and the presence and degree of development of the pan horizon. When this is thick and near the surface, post oak is the dominant species and the trees are relatively short. Where the pan occurs at greater depth, other oak species tend to be more abundant.

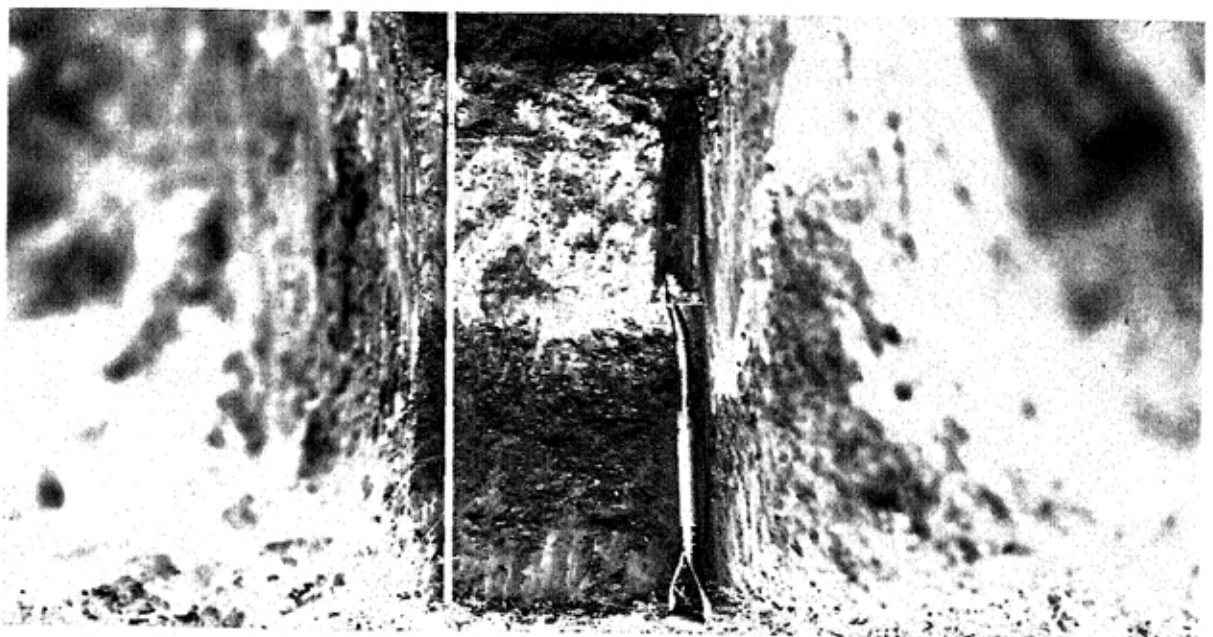

Fig. 5—Profile of a stone-free, ridgetop soil with highly developed fragipan. Thickness and depth of the dense, light colored pan horizon is indicated by the spade. Soil material below the pan is a mass of red-yellow clay and chert stones. —Photo is by C. L. Scrivner.

Other criteria considered in evaluating the forest soils are the color and clay content of the subsoil and substratum. Fragipans do not develop in red subsoils; thus, soils with a red or reddish-brown subsoil and substratum are associated with the more productive forests. Such soils are most extensive in the eastern Ozarks where the Gasconade, Eminence, and Potosi limestones are the surface rocks. Smaller areas occur in Howell and Oregon counties, and detailed soil classification no doubt would reveal numerous other tracts. Although the majority of the Ozark soils have reddish substratum, only when this color extends upward to include the subsoil does it indicate a good forest site.

The Cotter-Jefferson City limestone is the predominant surface rock over the southwestern and southern part of the Ozark region. Within this area many soils have a yellowish-gray plastic clay lower subsoil that apparently is derived from clay horizons in the limestone. Although not uniformly present, this clay layer may occur in both stony and stone-free soils. Where present it is associated with an inferior forest growth—mainly post oak and blackjack oak.

Soils with true claypan subsoil occur in the drainage area of Bourbeuse River—in Gasconade and the surrounding counties. The highest upland in this area is capped by clays of Pennsylvanian age. The soils developed from this material have a dense clay subsoil that is unfavorable for deep root penetration. Post oak is the predominant forest type.

The stone-free soils of the northern and eastern Ozark border are largely derived from *loess*. As a soil-forming material, loess is geologically young in contrast to the older residuum from the limestones and other rocks. Loess derived soils are not as highly weathered and have a much more complex mineral composition. The distinct silty texture of loess is retentive of moisture. These are significant factors that are reflected in the greater variety, more rapid diameter growth and greater height of the trees. The loess soils of the Ozark border thus form some of the most productive forest soils of the entire Ozark region.

Forest soils of the Ozark region have a thin cover of litter, consisting of partially decomposed leaves rarely more than 2 or 3 years old. The litter may cover the entire surface under dense stands of trees, but sites subject to wind action generally are bare. The greatest accumulation is in ravines and depressions and on north slopes. In general, the litter is thicker on the loess soils of the Ozark border than elsewhere in the Ozark region. The rapid decomposition is attributed to the warm climate and the tree species involved. Although not important as a moisture reservoir, litter serves as a protective mulch that reduces evaporation and runoff. A correlation between litter abundance, forest type, and stone content of soils has not been established, so litter depth was not considered in soil classification.

Other Soil-Site Factors

In evaluating the forest-soil relationship, other factors affecting soil formation also were considered. These include geology, degree of soil weathering, and topography. Geology largely determines the physiographic areas and the stone content of the soils. Long-time weathering has reduced soil differences that may

have existed because of different geologic formations, thus geologic boundaries and soil boundaries rarely conform. One exception to this is the St. Francois basin where granite, sandstone, and limestone, are associated with rather specific soil conditions and forest types. In another sense, the soils associated with the Cotter-Jefferson City limestones generally contain more clay, less chert and lower relief, but in spite of these apparently favorable characteristics, the soils are not as productive as those derived from the lower or older limestone formations.

The correlation of topography with specific soils and forests is one of the most evident and significant features of the Ozark region. Topography as such is not a soil feature, but it is associated with stone centent and the profile development of the soils. Except where deep loess is present, steep slopes consistently are stony. Gently sloping ridges and interstream divides contain fewer stones or may be stone-free. Although the boundary between forested and cleared land frequently coincides with a change in slope, the determining factor in land use usually is the stone content.

Exposure or direction of slope may have an important influence on forest soil productivity. North slopes generally are steeper and have deeper soils than south and west slopes. The latter tend to have shallower and more stony soils and a xerophytic type of vegetation consisting of blackjack oak, post oak, cedar and various shrubs. In extreme cases, as on glades, only redcedar and grasses may be able to survive. In the northern and eastern Ozark border zone where the soil mantle is thick and stone-free, slope and exposure are of much less significance than elsewhere in the Ozark region. In general, the effect of exposure is not significant on slopes of less than 15 percent and is most apparent on very stony soils.

Erosion: Soil erosion is not a serious problem in most of the Ozark region. The forest cover itself provides almost complete protection, but even the non-forested soils are not very erosive. This is attributed to the soil structure which favors high runoff, but with little soil removal.

Erosion conditions are entirely different in the Ozark border region, however. Here the loess soils are more permeable and very erosive. These steep slopes include some of the most severely eroded land in Missouri.

Soil Fertility: Most Ozark soils are derived from sedimentary rocks that are low in minerals containing phosphorus and potassium and, therefore, are inherently low in these constituents. Long-time weathering and solution also have removed much of the original basic marerial. The degree of weathering is indicated by the great thickness (50 to 100 feet) of the residuum or the depth to which the bedrock has been decomposed. Outcrops of bedrock are rare except in bluff and glade areas. Further evidence of solution is the complete removal of free carbonates to great depth, the weathered surfaces of chert rocks, the dissection of the land surfaces, and the maturity of the topography. The soils are acid to a depth of many feet. Acidity may not have an injurious effect on forest trees, but it is associated with poor structure and density of the soils and low content of organic matter. It reduces the availability of plant nutrients. These conditions in

turn affect the retention of moisture. The tendency of the soils to be "droughty" has long been recognized.

Over-all Effects

In evaluating the forest soils as a site factor, it is necessary to consider the interrelation of all the different soil conditions as they affect tree growth. There is no simple relationship between landscape, vegetation, and soil. One factor or condition may compensate for the deficiency of another. Thus, the generally low inherent fertility may be offset by the medium texture of the soil material and the basence of an excess of either sand or clay. A medium texture is most favorable for moisture retention, aeration, root penetration, and fertility release.

The interpretation of the soil features in this report is entirely observational and needs to be verified by quantitative field and laboratory studies. For example, the true effect of chert stones on tree growth rate has not been evaluated. It is generally assumed that the moisture retention and the volume of the nutrient-supplying soil is inversely related to the stone content. There is little evidence that forest growth in the Ozarks is adversely affected when the stone content is less than 40 percent of the soil mass. The size and arrangement of stones in the subsoil apparently is more significant than the abundance of stones in the surface soil. These are conditions that require quantitative measurement.

There is greater diversity in the soils of the Ozark region than in the diversity in the forest types. This implies that different soil areas may support similar forest types. Soil boundaries are too rigid to serve as forest type boundaries, especially over large areas. Precise forest type boundaries are difficult to establish because the forest is a continuum. In general similar vegetation over an area of uniform topography usually indicates uniformity of sites. This applies especially where both vegetation and land form have reached maturity as in the Ozark region. The kind of vegetation also may be indicative of certain soil characteristics. Thus blackjack oak is associated with dry, shallow sites, and elm with wet sites. Site quality is reflected in tree growth with height growth usually being more significant than species prevalence. In general, moisture appears to be the most important soil factor that can be consistently related to forest type distribution and then only as the extreme of soil moisure condition is reached.

In this preliminary attempt to correlate the forests and soils of the Ozark region 13 major soil areas and four sub-areas are recognized. These areas are not of equal significance—i.e., the differences in soil and forest among areas are not always of equal magnitude. But each area is characterized by certain forest, soil, and topographic features (page 4).

It should be recognized that within each large soil area there are many variations both in soil quality and forest composition. Further surveys are needed to delineate small sub-areas that are more uniform in soil characteristics and cover type. A better understanding of the various physical features and their effect on tree growth is required. In general, a classification is needed that more nearly indicates the basic site potential for any given location.

In the following pages, the soil areas and their subdivisions are described briefly. The special features that characterize each are interpreted in relation to the forest cover. Each area is named for its physiographic location or the river basin in which it occurs.

FOREST SOIL AREAS AND FOREST TYPES

The northern and eastern border of the Missouri Ozark region is a broad bank of hilly land, varying from 18 to 30 miles in width, that extends along the Missouri and Mississippi Rivers from the eastern edge of the prairie in Moniteau County to the Arkansas state line about 20 miles southwest of Poplar Bluff. It is not a distinct geographical or physiographical area, but it has certain soil and forest features that distinguish it from all other sections of the Ozark region. On the basis of soil and forest differences, the border has been divided into two major soil areas designated as:

1.—Outer Ozark border (Missouri-Mississippi River hills)
2.—Inner Ozark border

Each of these is further divided into a sub-area to show differences in soil depth and topography.

Outer Ozark Border (River Hills)

The Outer Border or River Hills soil area forms a continuous band 5 to 12 miles wide of steep hill land bordering the Missouri and Mississippi rivers. The entire area is covered with loess that ranges from 10 to 30 feet in thickness. The soils derived from the loess are stone-free, brown silt loams with yellow-brown silty clay loam subsoil that is permeable to deep root penetration. Soil fertility is relatively high, but gully erosion is severe. The forest mull layer is thicker, and the soils are less acid than in other soil areas.

Although less than 40 percent of the land is forested, the northern Outer Border area contains the best forest soils in the state. This is evidenced by the variety of species, relative height of trees, and growth rate. White oak is the predominant species and probably forms more than 40 percent of the stand. Sugar maple, elm, white ash, black walnut, and basswood are abundant; and there is practically no post oak. Tulip poplar occurs as far north as St. Louis. Understory growth frequently is dense. The basic forest type is white oak—red oak—hickory.

The southeastern portion of the Outer Border area extends from the southwestern corner of Cape Girardeau County through Bollinger, Wayne, Butler, and Ripley Counties to the Arkansas state line. This section of the Ozark border has low relief and consists of a comparatively narrow band of loess-derived soils bordering the Mississippi lowland. The loess material here is comparatively thin, less than 10 feet in thickness, and the stony substrata are exposed on the steeper slopes along the streams. The soil is pale brown silt loam. The subsoil is yellow silty clay. On the level area the lower subsoil below 24 inches grades into a compact gray silty clay or fragipan. The highly weathered soil is not as produc-

tive as that in the northern portion of the Outer border area but rates high as a forest site. There is less white oak and more black oak, southern red oak, and hickory. Sweetgum is abundant in the valleys. Most of the land has been cleared for cultivation.

Cape-Perry Sub-area

The eastern part of Cape Girardeau and Perry Counties and the southeastern corner of Ste. Genevieve County have been designated a sub-area of the Outer Border area because of more gently rolling topography and a higher percent of land in cultivation. Forest composition also differs in that it originally included much yellow poplar which has been largely eliminated by cutting. The loess deposit is thicker here than elsewhere along the Mississippi River. Although most of the land has been cleared, some forests still are maintained as permanent woodlots. Because of excellent growth rates and the prevalence of the more desirable species, the Cape-Perry sub-area potentially is the most productive forest land in the Ozark region. The basic forest type is yellow poplar—white oak—red oak.

Inner Ozark Border

This extensive soil area is closely related to and borders the Outer Border area. The delineation between the two is an arbitrary line. Although soils of the Inner Border area also are mainly derived from loess, the material is much thinner and stony slopes are frequent. The stone-free soils are light brown in color. The subsoils are gray-brown and contain more clay, indicating more advanced profile development than the subsoil in the Outer Border area. Moderately developed fragipans may occur in nearly level areas. In general, although these loess soils are not as productive as those in the Outer Border, they still are considered very good for growing forests.

The stony soils of the Inner Border include many outcrops of bedrock, especially in areas where the Cotter-Jefferson City limestones are the underlying formations. Small, gladey, shallow soil areas occur on south slopes but rarely exceed two to three acres in extent. They are more frequent in Jefferson County than elsewhere. Stony soils generally contain fewer but larger size stone fragments than is characteristic of the stony soils in the Central Ozark area. Forest quality on the stony sites is much poorer than that on surrounding deeper soils.

White oak is less numerous here than in the Outer Border area but more abundant than in the Central Ozark area. Post oak may occur on the ridges and drier sites with the black oaks generally predominant elsewhere. Less than 50 percent of the total area now is forested. The major forest type is white oak—black oak—hickory with some pure white oak stands.

Ripley Flatwoods Sub-area

This small but distinct section of the Inner Border area is found in Ripley, Carter, and Butler Counties. The surface is level to gently rolling. The loess-derived, stone-free soil is characterized by a thick fragipan layer in the lower

subsoil. The soil is similar to the stone-free soil on the ridges in the Central Ozark area, but sites are more productive because of a thicker topsoil. This subarea is inferior to the Inner Ozark Border area as a whole for growing trees. The general forest type is post oak—black oak, but pine also is becoming locally abundant. Most of the land is cleared.

Central Ozarks

Reynolds and Shannon Counties form the center of this large and important forest soil area. Except on silt-capped ridges and in the valleys, the stony soils contain chert material that may comprise from 20 to 75 percent of the soil mass. The surface soil is gray to light brown in color. The subsoil is almost uniformly a yellow-brown silt clay. The lower subsoil varies from reddish brown to yellowish gray silt clay with varying amounts of chert. A fragipan occurs on practically all ridges and gentle slopes of less than six percent.

The entire area is characterized by a hilly to deeply dissected surface. Local variations in the topography are attributed to solution valleys and slumped slopes. Because of the stony texture and the hilly terrain, soils with fragipan are less extensive here than in the northern and western parts of the Ozark region. In this large area, there are many minor variations in both forest and soils that are associated with topography and the stone content in the soil. One example is the soil with red clay subsoil in Iron and the southern part of Washington counties. The greater diversity of forest species and the abundance of undergrowth indicate the superiority of this soil variation.

Forest soils in the Central Ozark area are among the most productive in the main Ozark region. Growth rate and composition are reasonably good. White oak, black oak, and scarlet oak are the predominant species although post oak is abundant on the ridges. It should be noted that the main area where shortleaf pine is a component of the forest coincides almost exactly with this soil area (Fig. 2). Pine occurs on all sites and soils, whether ridges, stream valleys, stony or stone-free slopes, but predominates on the dried sites.

Granite Hills

The Granite Hills area—known also as St. Francois Mountains—is more specifically a geographical unit than a soil area because of the diversity of its physical features. It has greater relief and different topography than other parts of the state. High rounded hills or knobs are interspersed with almost level basins or valleys. The soil over the granite is shallow and of low fertility. It may be stone-free or contain large boulders. Glade-like areas occur on the higher slopes. Poor quality black, post, and blackjack oak predominates and may be interspersed with redcedar. It is estimated that approximately 50 percent of the total land area is of the granite soil type.

On the lower slopes where the soil is deep and in those places where the soil is derived from limestone residuum the forest type is white oak, black oak, and hickory and similar in quality to that on the better soil areas. In the alluvial

valleys and terraces the soil varies from gray clay to brown loams, with a corresponding range in forest type. Almost pure stands of post oak characterize the gray clay soils. The better soils are cleared. In general, the Granite Hills area has less uniformity in soils and forest than any other major area.

Farmington Basin

The Farmington Basin is not important as a forest soil area because practically all of the land is farmed. The western and southern boundaries of the basin are marked by an irregular but distinct escarpment. The eastern boundary grades into the Inner Ozark Border. The stone-free soils are variable, mainly red, brown, and gray silt loams. The red and brown soils are very productive for grain and forage crops and originally were forested with maple, walnut, elm, and hackberry. Redcedar occurs where limestone outcrops near streams. The poorly drained gray soils have a clay subsoil and a low site value. In the eastern part of St. Francois County and the western part of Ste. Genevieve County some of the soils are moderately sandy and on level areas have a fragipan subsoil.

Bourbeuse Drainage

This probably is the most distinct forest soil area in the Ozark region. It is a high plateau with a gently rolling surface. The sharp boundaries are marked by the Rock Island Railroad on the north, Highways 28 and 63 on the west, and the Frisco Railroad on the south. Unlike those of other parts of the Ozark region, the soils are derived from shale and sandstone of Pennsylvania Age. As a result, the soils are stone-free and have a gray clay subsoil (claypan) that is unfavorable for root penetration. Most of the land is farmed. Level areas near Owensville and St. James originally were prairie. Post oak is the predominant tree species.

Salem Plateau

This is a broad, gently rolling interstream divide between the Gasconade, Meramec, Current, and North Fork drainage basins. In general, it can be considered the divide between the eastern and western parts of the Ozark region. The light colored soils are stone free to moderately stone, but the subsoil is almost uniformly stony. The chert fragments are larger than those found further east in the region. A characteristic of most soils is the highly developed fragipan horizon in the lower subsoil. In Dent County and the northern part of Texas County most of the soils are moderately sandy. Sandstone fragments and outcrops occur on the slopes. Near Licking some of the soils are reddish-brown in color with few stones and generally are more productive than elsewhere on the plateau. Many small glades occur in the drainage area of Piney River in the southern part of Texas County. In general, these soils contain more stones than those in the sandstone section.

Except in the deeply dissected portions, the Salem Plateau is an inferior forest soil area because of the low fertility, low moisture-holding capacity, and unfavorable subsoil structure. Post oak is the prevailing forest type with black-

jack oak abounding on sandy sites. Much of the land is cleared. Schoolcraft[7] and other early explorers noted the open and "scrub" timber in this section of the Ozark region.

Howell-Oregon

Although not a distinct physical unit, this area has been delineated from the soil areas to the north and west on the basis of lower relief, less deep dissection, soils not as stony, and the presence of reddish clay in the lower subsoil. All these features are attributed to the Jefferson City limestone which is the underlying bedrock. The general boundary is gradational.

The stony soils are gray and have a yellow-gray silty clay subsoil. Their most distinguishing feature is the prevalence of a red or yellow stiff clay lower subsoil. When the clay is exposed, as in roadcuts, it tends to acquire a red color. When the clay is near the surface, it forms glade-like conditions. Such sites are most frequent in Ripley County, and are characterized by post oak—blackjack oak forest.

The topography of the Howell-Oregon area ranges from nearly level to hilly. The most extensive level areas are to the south of West Plains and near Rover in western Oregon County. There is evidence that some of the level land originally was prairie. Large shallow sinks southwest of West Plains and flatwoods areas near the Arkansas state line are occupied by post oak stands. Soils with a bright red subsoil occur in basin-like valleys to the south of Alton and east of West Plains.

There is much variation in the soils, especially in stone content, and this is reflected in the variation in the quality of the forest. The better forests occur on the stony soils that have a reddish lower subsoil. Although the general forest type is white oak—black oak—hickory, post oak may be abundant on sites that have shallow soils or compact subsoils.

Gasconade Drainage

The Gasconade drainage basin has been divided into two parts—southern and northern. The approximate boundary between the two parts is near Highway 32 from Lebanon to Licking. This conforms closely to the contact line between the Cotter-Jefferson City limestones and the underlying Roubidoux formation. Different topographic features and soil conditions associated with these formations are reflected in modifications of the basic white oak—black oak—hickory forest type. The Roubidoux and the underlying Gasconade limestone contain much chert and tend to form deeply entrenched solution valleys.

Northern Sub-area

The northern section of the Gasconade is very hilly and deeply dissected. High cliffs border the larger streams. The soils are very stony, and bedrock outcrops are numerous. Stony slopes on south and west exposures are generally

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[7]Schoolcraft, H. R. 1821. Journal of a tour into the interior of Missouri and Arkansas . . . in 1818-1819. (Rare book collection, Missouri State Historical Society).

characterized by poor quality timber. Where the soil mantle is thick, especially on lower slopes, this sub-area is very favorable for tree production. The composition of the forest is fairly uniform, but there are many variations in timber growth rates. This applies especially to the rugged upland along the Gasconade River. Pine occurs on all topographic positions in the Big Piney drainage area.

Southern Sub-area

This section, which includes the headwater drainage area of the Gasconade, Roubidoux and Big Piney Rivers, has a rolling to moderately hilly topography. The soils are moderately stony. Because of the sloping surface, relatively few soils have a hardpan, but nearly all have a stony subsoil. The forest includes many white oaks which are associated with soils that contain more than average amounts of clay. Probably more than 50 percent of the land is cleared.

Lebanon Plateau

The Lebanon plateau is a broad divide between the Gasconade and Osage drainage areas. The surface is level to gently rolling. The soils are stone-free or moderately stony. Broad, shallow solution basins or sinks occur south of Lebanon; these soils usually are gray and have a gray clay subsoil. The Lebanon plateau resembles the Salem plateau; but in general the soil mantle over the cherty substratum is thicker, the hardpan horizon is not as universally present, there is no sandstone, and over much of the area the soils are light brown in color. For these reasons, the forest is somewhat varied. There are many pure stands of post oak on the undissected portions, but the more mesophytic sites support better quality stands. Most of the plateau area is farmed.

Osage Drainage

Geologically, topographically, and pedologically the Osage drainage area is similar to the northern part of the Gasconade area, but the forest cover is generally inferior. Almost the entire Osage area is underlain by the cherty Roubidoux and Gasconade limestones which determine the general character of the landscape. The northern boundary is a sharp line and closely parallels the Rock Island Railroad from Freeburg west to Highway 65. The western boundary is at the edge of the prairie or the occurrence of the Burlington limestone. The entire Osage area is hilly and the soils very stony. Bedrock outcrops on many slopes, and small glades (less than 20 acres in extent) are frequent in Miller County. The moist sites in the coves and lower slopes bordering the Lake of the Ozarks have good timber, but the ridges and especially the south slopes are inferior sites.

The Osage forest soil area as a whole is characterized by poorer quality trees than the rest of the Ozark region. Although the forest type is white oak—black oak—hickory, post oaks are abundant. Forests in the Osage basin have been burned repeatedly for years. This, no doubt, has reduced the quality and growth rate of the present trees.

The effect of south and west slopes on the forest is very evident. The high

content of chert stones in the soil and the generally steep slopes are unfavorable for the accumulation of forest litter or conservation of soil moisture. The vegetation indicates a drier site and a gradation to the forest-prairie transition zone. Prairie grasses are more frequent here than in any other major soil area.

Iberia-Buffalo Sub-areas

The Iberia sub-area in the western part of Maries County and the Buffalo in the southeastern part of Camden County are a part of the broad interstream divide between the Gasconade and Osage drainage basins. The surface is moderately hilly and the soils not as stony as in the main Osage area. Soils are light brown in color and have a characteristic yellow-brown silty clay subsoil. The lower part of the profile is a stony clay. The nearly level ridges are stone-free and generally have a fragipan in the lower subsoil. On these sites post oak predominates. Elsewhere white oak is abundant. More than 50 percent of the land has been cleared.

The headwater drainage area of the Niangua River in Webster County and the southern part of Dallas County have been classified with the Iberia sub-area because of similar soil and forest conditions. Much of the land is stone-free, and most of it has been cleared. The forests contain many post oak and white oak. Black oak is most abundant on the stony slopes. Bluestem grass in the open forest area indicates the proximity of the prairie.

North Fork Drainage

This area is very hilly with very stony soils. Steep, stony bluffs boarder the larger streams. A red silty clay subsoil characterizes most of the soils except on the higher ridges. The red coloration apparently extends higher in the profile than in other areas where the Cotter-Jefferson City limestones are the soil-forming material. The soil variations are associated with different limestones that vary in chert and clay content and in rate of weathering.

The area contains some of the better forest soils but includes many inferior sites or glades, particularly in the Bryant Creek basin. Blackjack and post oaks often are the largest trees on these gladey areas. Pine occurs on the slopes bordering the large streams, but the general forest type is black oak—white oak—hickory. More than 75 percent of the land is forested. In general, the forest is better in composition and height in the North Fork than in the Bryant Creek drainage area.

White River Drainage

The White River drainage area is sometimes designated as the "gladeland" of Missouri. The area is sharply defined on the north and west by a serrated, steep escarpment at the contact of the Burlington and Cotter-Jefferson City limestones. The eastern boundary is not as definite, but the indicated lime is the eastern limit of prominent areas of gladeland.

Glades include the barren bedrock slopes and bedrock areas covered with a thin mantle of soil mixed with partly weathered limestone and chert fragments.

The "bare glades" occur mainly on south and west slopes. The veneer of soil that may remain is a dark clay loam, usually calcarious. That portion of the gladeland in Ozark County generally has a thicker soil mantle and fewer balds. The xerophytic vegetation includes eastern redcedar, winged elm, blackjack oak, yellow wood, prairie grasses, and numerous shrubs.

On the lower slopes and in the valleys between the glades the soil mantle is thicker but usually very stony. Post oak predominates on the light colored soils that have a clay subsoil. White oak and black oak are abundant on terraces and occasional low slopes that have a red clay subsoil. Winged elm often dominates on the moist sites caused by seep water from the gladey slopes.

A distinct soil and forest feature in the White River area is the occurrence of high, narrow ridges capped by Burlington limestone. The residuum from this limestone is a reddish clay containing a very high percent of chert rock. These ridges are the most productive forest sites of the surrounding area. Black oak is the predominant forest type. Pine occurs in places and grows rapidly.

Approximately 60 percent of the total land area consists of actual glades or very shallow soils. The unfavorable effect of south and west exposure is very evident throughout the area. In general, the White River area has a low potential for forest production.

SOIL AREA GROUPING

The recognition of specific forest soil areas is not intended to be a forest productivity rating. An attempt has been made, however, to rank the unit areas in accord with their comparative desirableness on the basis of the criteria used for forest production. For this purpose the units have been classed in three general groups designated as: A—good; B—medium; C—inferior. Such a grouping should be used with care because of the variations within each soil unit. Only the combined effect of the total environment of each unit should be considered.

Group A

Outer Ozark Border
Inner Ozark Border
Central Ozark Area
Farmington Basin

Group B

Howell-Oregon Area
North Fork Drainage Area
Gasconade Drainage Area
Osage Drainage Area

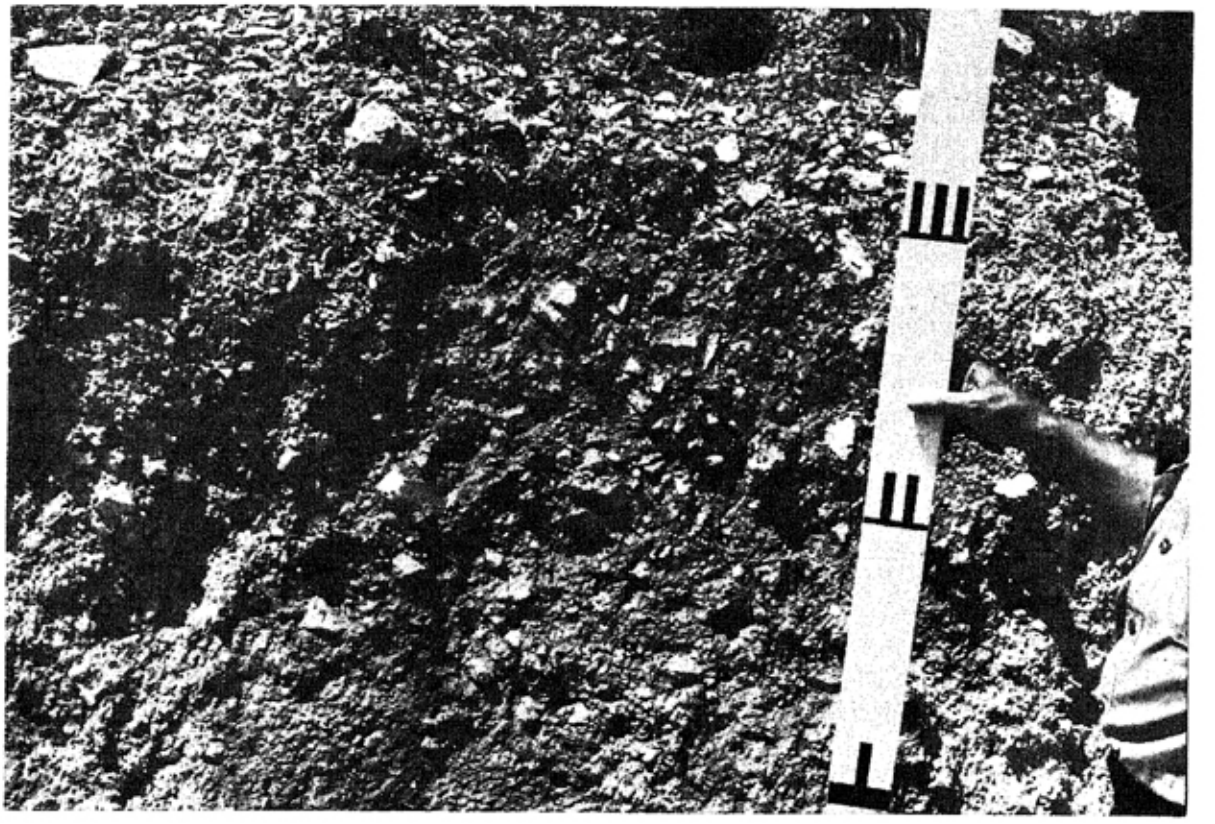
Group C

Granite Hills
Lebanon Plateau
Salem Plateau
Bourbeuse Drainage Area
White River Drainage Area

APPENDIX

Forest Species

White oak	*Quercus alba* L.
Post oak	*Quercus stellata* Wangenh.
Black oak	*Quercus velutina* Lam.
Scarlet oak	*Quercus coccinea* Muenchh.
Blackjack oak	*Quercus marilandica* Muenchh.
Sugar maple	*Acer saccharum* Marsh.
Black walnut	*Juglans nigra* L.
Ash	*Fraxinus* species
Elm, American	*Ulmus americana* L.
Elm, winged	*Ulmus alata* Michx.
Sweetgum	*Liquidambar styraciflua* L.
Yellow poplar	*Liriodendron tulipifera* L.
Hackberry	*Celtis occidentalis* L.
Black hickory	*Carya texana* Buckl.
Mockernut hickory	*Carya tomentosa* Nutt.
Shortleaf pine	*Pinus echinata* Mil.
Eastern redcedar	*Juniperus virginiana* L.

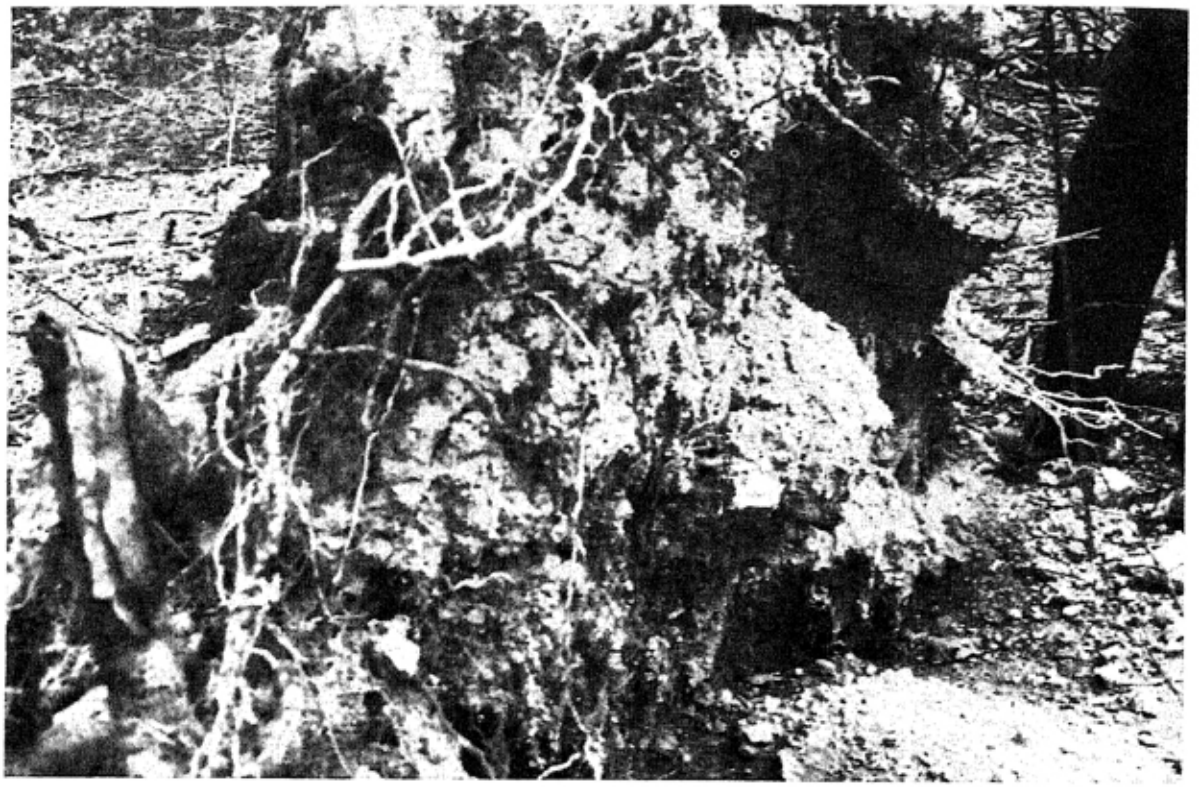


U.S. FOREST SERVICE PHOTO

N.O. 1988. Profile of a rocky forest soil with "A-C" horizons developed. Trees were mostly black oak on steep southeast exposure. Note high percentage of rock in upper 25-30 inches of soil and dense "C" horizon.

U.S. FOREST SERVICE PHOTO

N.O. 10,063. Flat bottom of soil mass exposed by wind-thrown 18-inch white oak. Zone occupied by roots is about 25-30 inches thick, and most feeding roots are in upper half of soil mass. Tree grew in mid position on moderate slope in southeastern Shannon County.



U.S. FOREST SERVICE PHOTO

N.O. 10,066. Wind-thrown 16-inch black oak shows shallow (12-14 inch) root zone over fragipan formation on ridgetop. An occasional cluster of roots may grow deeper into cracks of the fragipan layer.

U.S. FOREST SERVICE PHOTO

N.O. 10,070. Shortleaf pine root system usually is confined to upper two feet of the soil, with fine feeder roots close to the surface. Taproot may grow several feet deeper in permeable soils.