A PHYTOSOCIOLOGICAL AND MICROCLIMATOLOGICAL ANALYSIS OF A SELECT ECOSITE IN CHRISTIAN COUNTY, MISSOURI

By

LAWRENCE N. STAUFFER

Bachelor of Science
Northwestern State College
Alva, Oklahoma
1952

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1961

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
August, 1969

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Thesis Approved:

Kenneth E Wiggins
Thesis Adviser

John E Thomas

Roy W. Jones

J. J. Crockett

D. D. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

The writer extends sincere appreciation to Dr. Jerry J. Crockett and Dr. Kenneth S. Wiggins under whose guidance and encouragement this study was undertaken and to the other committee members, Dr. Roy W. Jones and Dr. John E. Thomas for their assistance.

Appreciation is also extended to the personnel of the Mark Twain National Forest--Ava District, especially Mr. Roger Kirkman, for their aid and cooperation.

Special recognition is made in honor of the late Major Albert E. Chaney for his invaluable aid in the completion of this study. Also recognized is the service of Mr. J. Terry Thompson, Mr. James S. Wright and Mr. William Vernon.

Acknowledgment is made of Drury College for financial assistance which aided in the implementation and completion of this study.

Special thanks is extended to the members of my family for their encouragement, understanding and sacrifices through the duration of this endeavor.

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CHAPTER I

INTRODUCTION

Although one of the oldest geological regions of the world, the boundaries of the Ozark "Mountain" area are rather ill defined. They lie, in general, south of the Missouri, west of the Mississippi, and north of the Arkansas rivers, extending west briefly into Oklahoma. This vast area is historically a plateau which includes the Boston Mountains of Arkansas and the Salem Plateau and Springfield Plateau of the "Ozark Plateau" (Figure 1).

This study is concerned primarily with an analysis of the present vegetation and microenvironmental factors within a very limited area of this region. It is, however, necessary to have the historical viewpoint, both vegetational and geological, in attempting to determine how this stand was initiated and why it now supports some dominant species rather than others.

The Ozark region, according to Steyermark (1959), is one of the oldest geological regions of the world and occupies southern Missouri to the Missouri River, northern Arkansas and parts of southeast Kansas, northeast Oklahoma, and southern Illinois. This region has been a continuous land area since the end of the Paleozoic Era. After at least two uplifts, the Ozarks were worn down by peneplanation to produce the present-day topography. The flora currently present represents a climax that can be correlated with past geological

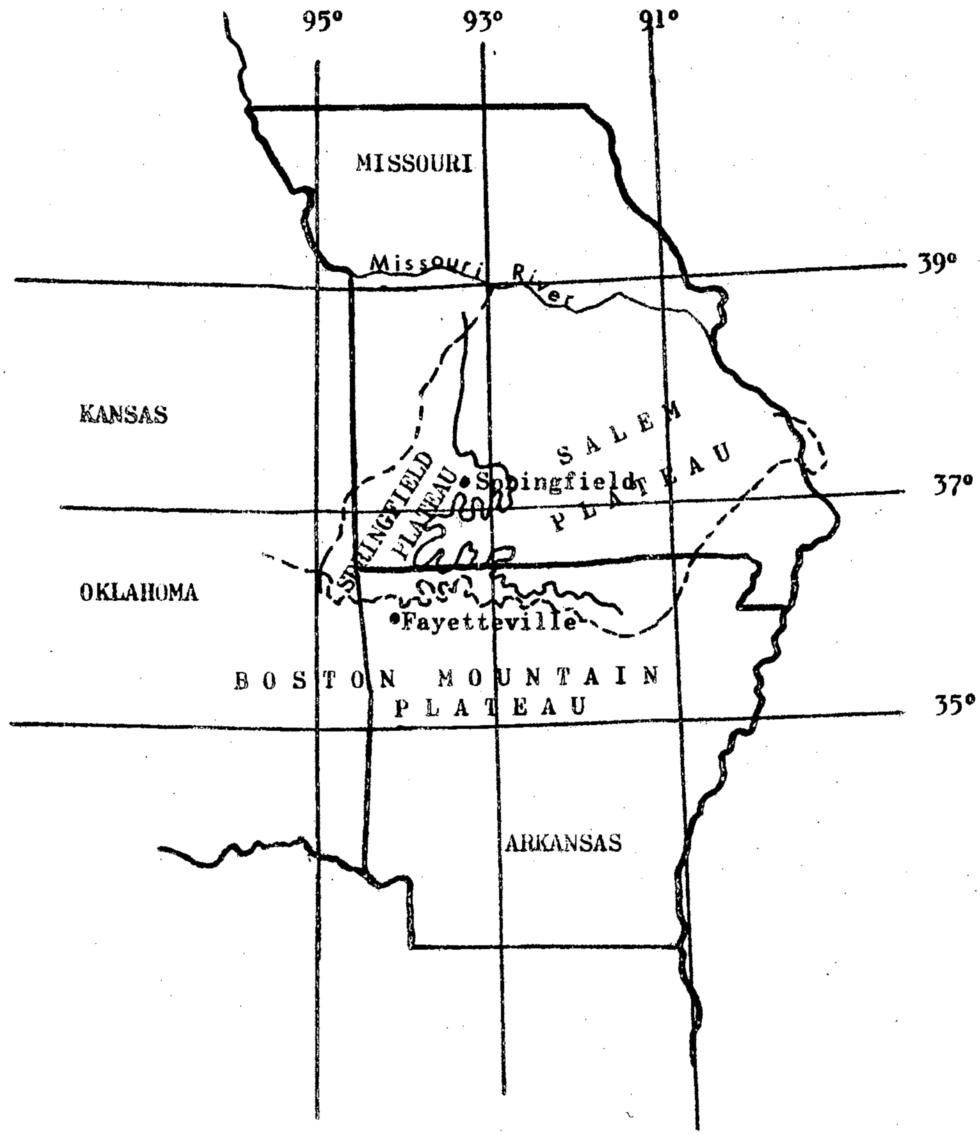

Figure 1. A Map of Missouri and Adjoining States Showing Boundaries of the Springfield and Salem Plateaus[1]

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[1]Fenneman, Nevin M. Physiography of Eastern United States, First Edition. McGraw-Hill Book Co. Inc., New York. 1938

events, indicating great age. The Ozarks have been above sea level since Carboniferous times and subject to many changing conditions. As each change left its imprint on the changing landscape, fragments of a variety of different floras remained throughout the area.

Today the Ozark region is an area where east meets west and north meets south as species from the southern coastal plains, the present Appalachian flora, the Great Plains flora and remnants of a boreal flora are all a part of the local vegetation. It is likely that the Ozarks served as a center of origin and dispersal of plant life.

As stated by Steyermark (1959) "the Ozark forest manifests a climax forest represented by a climatic-edaphic adaptation of the flora as expressed by the development of five major plant associations conditioned by the local nature of the soils, their exposures and moisture content." This passage is a generalization but typical of Steyermark's argument to support his theory of long established climax forest regions of the Ozarks. This is contrary to the opinions set forth by Beilmann and Brenner (1951) who conclude that the Ozark forest area is of an immature type and lacks any definite climax. Steyermark (1959) points out falacies in the Beilmann-Brenner concept and suggests their misinformation is due in part to a short study period (of about twenty years) and misinterpretation of previous authors on the subject who influenced their opinions. Steyermark (1940) suggests transition (from prairie to forest) of the Ozarks area but admits his studies to that point were inconclusive and that he was influenced by previous writers who he now believes are in error.

Upon comparing present-day conditions with the original land surveys of the early 1800's (about 1816 to as late as 1848 in Taney

County), Steyermark (1959) concludes that: (1) there has been no obvious change in the composition of the dominant forest cover since the time of the original land survey, (2) specific areas he surveyed in the National Forests of the Ozarks in 1936 and 1937 have the same dominant forest cover as during the original land survey and (3) areas reported as heavily or densely forested at the time of the original land survey are today heavily forested while those considered to be prairie areas during the survey are today prairies.

Although application of the maturity index as suggested by Pichi-Sermolli (1948) indicates an immature stand in the study area there is no evidence to indicate anything other than re-establishment of the original climax community after possible logging and severe land abuse of the mid-nineteenth century. Writings of early travelers and botanists of this area indicate the same type of edaphic and climatic conditions existed in the past as prevail today. Steyermark (1959) and Braun (1950) agree that the Ozarkian oak-hickory association had its origin in the late Tertiary time when it was derived from the mixed Tertiary forest due to the increased xeric conditions that resulted from the uplifting of the Ozark Plateau. This presumedly eliminated the species with higher mositure requirements. No exact records of this precise area are available but word of mouth accounts of the area would indicate that the region was used as open range and possibly suffered abuse due to overgrazing as forage was undoubtedly scarce in the forest.

According to Steyermark (1951) botanical records of Missouri are incomplete. Early botanical explorers such as Bradbury, Schoolcraft, Shumard, Swallow and Broadhead made only random and scattered studies.

Although a few counties in the state have been studied intensively (St. Louis, Boone, Jackson, Greene, and Jasper), most have been botanized little so that information is fragmentary.

The precise history of the area included in this study is unknown by the author, although attempts to uncover the exact history have proven fruitless, the concensus of the forestry personnel currently working the area is that it has been logged to some extent in the past and the climax vegetation is now being re-established.

The question of the past history and development of the Ozark forests may never be resolved but the fundamental premise--that the forest and its very existence was determined by climate, soil and sub-soil of the locality--is without question. Research by Read (1952), Kucera and Martin (1959), Burk (1964), Dyksterhuis (1948), and Diebold (1935) present interesting evidence for unraveling the cryptic relationships that exist between characteristics of soil and the vegetation it sustains. Climate, according to Bates (1922), affects the region and vegetation in two ways; (1) it is presently the most important factor in the environment of the vegetation, and (2) it has affected the present environment in its historical development.

The determination of the important features of a climate is not a simple matter. It must rest upon a sufficiently long series of observations at well-equipped meteorological stations. However, much can be accomplished by comparatively short-term studies of individual investigators who may uncover some fundamental facts which alter the conception of a given problem and therefore lead to a more productive effort by a permanent organization for long-term study. In the words of Bates (1922) "substantial progress in forest investigation can be only by recognizing the principle of supplemental effort of individuals on a limited, short-term basis. There should be no attempt to delimit the work of any organization or individual."

With this advice in mind, the investigator undertook the following study. The underlying theme is an analytic study of a delineated region of the forested area of southwestern Missouri. This region will hereafter be referred to as Peckout Hollow. The specific objectives of this study are; (1) to determine the exact floral composition of three different microsites (each on a different aspect) within the general ecosite of Peckout Hollow, (2) to analyze the microclimatic and edaphic conditions of the three aspects, and (3) to attempt to correlate this information in order to better understand the interrelationships that exist between the biotic and the physical elements of the environment.

Although much research of this nature has been conducted--Oosting (1942), Ayyad and Dix (1964), Penfound (1945), Cantlon (1953), Cooper (1961), MacHattie and McCormack (1961), and Longerheim (1962)--nothing has been done in this particular vegetational zone. Kucera (1957) conducted a study in the "glades" region of Taney County, some thirty miles southeast of Peckout Hollow. This was, however, concerned primarily with grasslands.

The information presented herein may contribute in some way to a better understanding of the interrelationships that exist between vegetational environment and physical environment. It is a recognized fact that the knowledge and skills of contemporary man have brought us to greater dependence upon our natural environment than has heretofore been realized. Understanding our environment is necessary to our surviving in it. Each particle of evidence, however small, contributes to this understanding. In the words of Commoner (1969), "unless we begin to match our technological power with a deeper understanding of the balance of nature, we run the risk of destroying this planet as a suitable place for human habitation."

CHAPTER II

DESCRIPTION OF STUDY AREA

Peckout Hollow is a region of the Mark Twain National Forest set aside by the Forest Service as an outdoor laboratory. It includes 3500 acres within the Ava District of the National Forest. This particular district is located in the southeast corner of Christian County, Missouri T25N, R20W. Access to the area is by way of Missouri State Highway 125 south of Chadwick, Missouri to the junction of Highway "C," south on "C" to the entrance of the forest, then via forest road atop the crest of Flyblow Ridge to its termination (see Figure 2).

An important feature of the area is the ecological diversity found within a relatively limited area. There are eight major soil types, a wide range of plant associations, a steep and varied topography plus a complex forest cover condition. The climate is variable from day to day and season to season and characterized by a precipitation range of 27 to 58 inches per year with an average of 42 inches per year. Snow usually accounts for less than 2 inches of the annual total. Seasonal droughts are common and extended droughts occur periodically. The average maximum temperture is 77.6°F, and an average minimum is 33.9°F. Extremes range from below zero, at times during the winter to 100+ degrees occasionally during the summer months. The last killing frost of the spring occurs, on the average, about April 1st and the first killing frost of the fall about November 1st. The

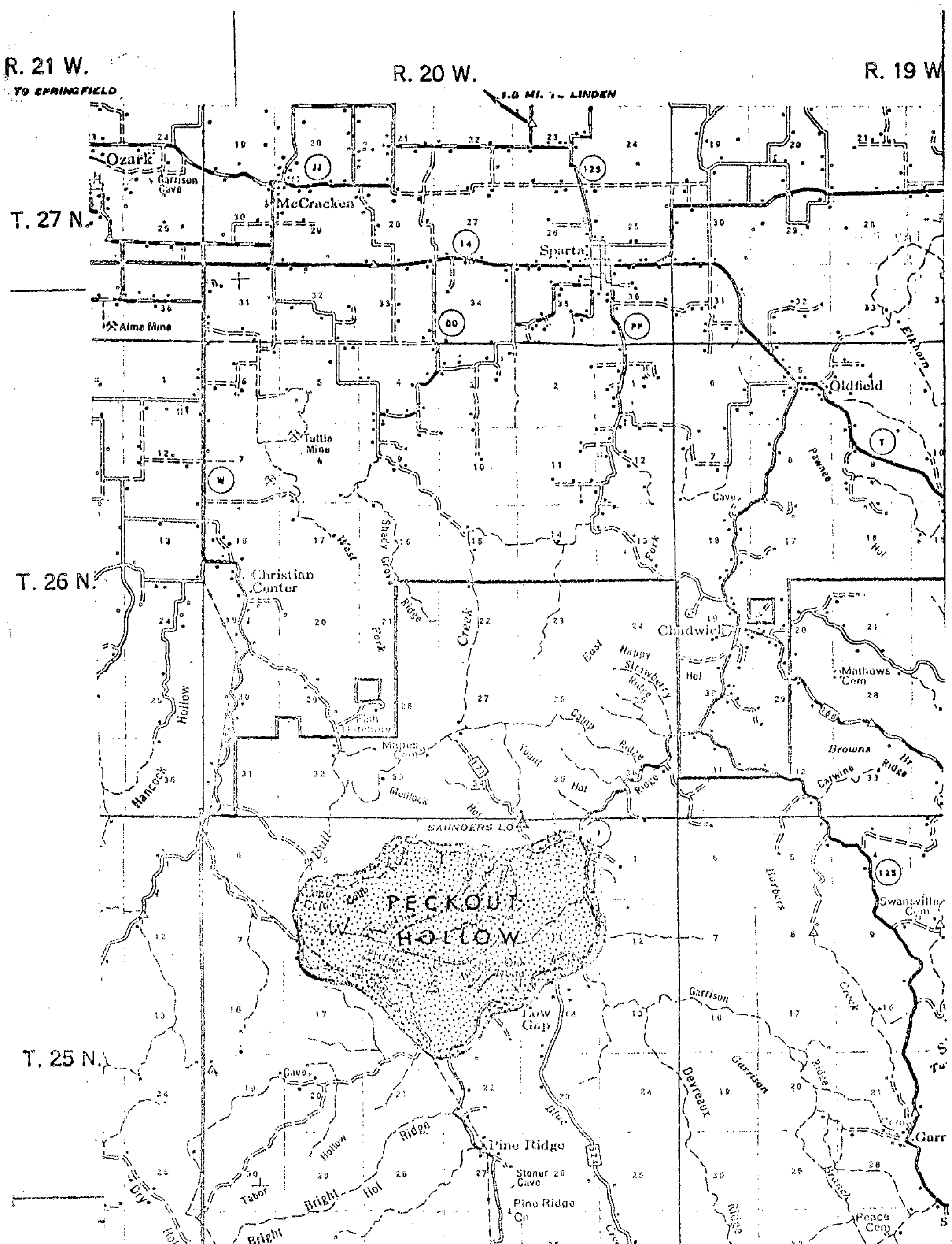

Figure 2. A Map of Southeastern Christian County, Missouri Showing Peckout Hollow and Access to the Study Area

average growing season, according to these limiting extremes, is approximately 178 days in length.[1]

Tributaries of Bull Creek, which drains approximately 100 square miles of this region, have cut downward into nearly flat-lying sedimentary rock formations and have formed valleys, one of which is Peckout Hollow. Seven formations, ranging in age from Ordovician to Mississippian, are present at or within a few feet of the surface. Generalized descriptions of the seven formations are included in Table I.

These rock formations are almost horizontal and are normally arranged with the oldest on the bottom and progressively younger ones on top. The Cotter, the oldest formation exposed in this vicinity, crops out low on the hillsides, whereas younger formations crop out higher up. Although the Reeds Spring is the youngest formation in the study area, the Burlington is probably present beneath nearby ridges. Mississippian formations (Bachelor, Compton, Northview, Pierson, Reeds Spring, and Burlington) consist predominantly of limestone, a rock composed largely of the mineral calcite. The chemical composition of limestone is calcium carbonate. The Reeds Spring has a high percentage of chert nodules and beds. Chert, composed of silicon dioxide is harder and more resistant to weathering than is the limestone that surrounds it. The Cottor formation consists predominantly of dolomite, a rock composed largely of the mineral dolomite, the composition of which is calcium-magnesium carbonate. The Cotter also has

[1]United States Weather Bureau. 1968. Climatological data. Missouri. U. S. Dept. of Commerce. Washington, D. C.

TABLE I

GENERAL DESCRIPTION OF ROCK FORMATIONS AT OR NEAR THE SURFACE IN THE PECKOUT HOLLOW AREA[2]

AGE		Formation	Thickness if not eroded	Rock Type
Era	Period			
PALEOZOIC	Mississippian	Burlington	100	Limestone, some chert
		Reeds Spring	60'-70'	Limestone, much chert
		Pierson	16'	Limestone, some chert
		Northview	6'	Siltstone, shale
		Compton	14'	Limestone
		Bachelor	0'4"	Sandstone, shale
	Ordovician	Cotter	150'-200'	Dolomite; some sandstone, chert, shale

[2]L. D. Fellows, "Geology of Peckout Hollow" (unpub. information bulletin, Missouri Geological Survey and Water Resources, Rolla, Missouri, 1964).

some sandstone, shale and scattered chert nodules.

Limestone and dolomite, both carbonate rocks, dissolve rather rapidly in warm, humid climates. Chert, although not insoluble, is much less soluble than either of the former. Throughout this area limestone and dolomite near the surface have been dissolved and all that remains is a residue consisting of clay minerals, iron oxide, and chert fragments. This residuum is the parent material in which soil on the upland has developed. The composition and characteristics of residual soils are directly related to the rock from which the residuum was derived. A mixture of rock fragments, residuum, and organic matter, transported and deposited by streams as alluvium, is the parent material in which soils along streams have developed.

Residuum is generally thickest beneath the crests of hills and thinnest on slopes. As a result there is a general lack of outcrops near the tops of ridges and an abundance of them lower on the hillsides. Residuum from near the tops of the ridges has moved downslope. In certain places Ordovician dolomite crops out but fragments of Mississippian chert are common at the surface. Blocks of sandstone that crop out in other areas are present at the surface for a considerable distance downslope. One significance of this is that soil parent material at any spot might have been derived from rock belonging to several different formations. Thus, one would not expect the boundaries of soil types to coincide exactly with the contacts between rock formations.

A soil survey of Peckout Hollow was begun in March 1964 by the

U. S. Forest Service and is, as yet, unfinished.[3] Publication will be included on the Soil Survey Report of Christian County, Missouri. Since the soil survey is not yet complete, all series names used herein should be considered as tentative and subject to change.

Soils of Peckout Hollow

Soils of this area were mapped by identifying, describing, and classifying them according to the kinds and sequence of the horizons which make up the soil profiles. Differences in the kinds and sequences of these horizons are the results of differences in parent material, climate, living organisms, topographic relief, and time. On the basis of these differences, the soils have been separated into eight soil series designated by Fellows (1964) as: (1) Alluvial, (2) Bodine, (3) Colluvial, (4) Clarksville, (5) Dickson, (6) Fullerton, (7) Gasconade, and (8) Nixa.

In mapping soils, certain combinations or subdivisions of soil series and associated land features such as slope, erosion and stoniness are recognized as being important in determining floristic composition. These units (of combinations or subdivisions) are called soil phases and they form the basis for the soil mapping unit. Soil mapping units are the areas on the landscape which have been delineated to form the soil map (see Fig. 3).

There are eleven mapping units on this soil survey area. These mapping units have been given names taken from the soil series or other units in the classification system which best describes the

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[3] Ibid., p. 11.

CKS Clarksville Slope soil series
NIXR Nixa Ridge soil series
FLL Fullerton Ledgey soil series
GSE Gasconade soil series

Study Area

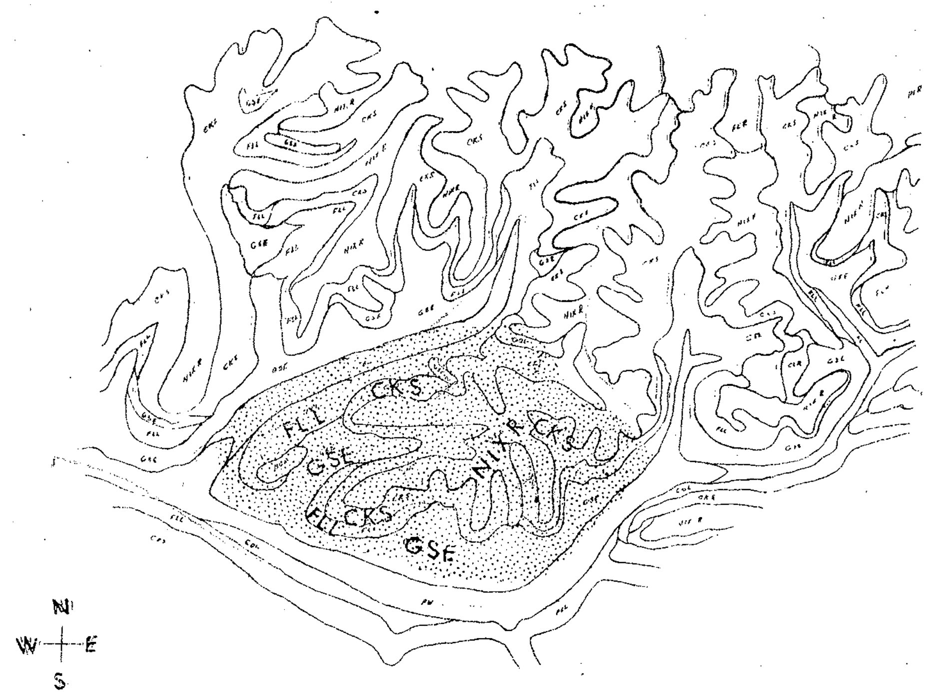

Figure 3. A Map Showing Soil Mapping Units of Peckout Hollow and Limits of the Study Area[4]

[4]Mark Twain National Forest--Ava District Office. 1964. Unpublished information pamphlet. U. S. Dept. of Agriculture. Washington, D. C.

kinds of soil or soils included in the mapping unit. A description of each follows. Three of these soil series are found in each of the microsites where climatic conditions were measured and where vegetation sampling was conducted. These three series will be described in somewhat more detail.

Alluvial Series

Two units, "very gravelly" and "well-drained," occur within the Alluvial series. The gravelly alluvial soils are found on the narrow upstream creek bottoms. The depth of soil material over bedrock ranges from a few inches to five or six feet. These soils are very porous and low in moisture holding capacity. They are important as filters and reservoirs for runoff. The other sub-type of alluvial soils, the "well-drained alluvials," occurs on the wider creek bottoms. The depth of soil material, over gravel as bedrock, ranges from 24 inches to 5 or 6 feet. These soils are high in moisture holding capacity.

Bodine Series

Bodine cherty silt loam is a well-drained soil which occurs at the highest elevations on narrow ridgetops and usually has slopes of 5-51%. This soil has a high chert content of 70-80%. The depth to underlying bedrock is estimated to exceed 10 feet, but shallower areas may occur. Bodine soil has a high infiltration rate and good permeability to a depth of 30 inches. Moisture holding capacity is low because of the high volume of chert in the soil.

Colluvial Series

These soils are moderately drained to well-drained on low slope sites. They are moderately deep and are relatively chert free in the upper 20 to 40 inches. Slopes range from 4-20% and average about 10%. Colluvial soil has a high infiltration rate and good permeability to a depth of three to four feet. Moisture holding capacity is moderate.

Clarksville Series

Clarksville, one of the soils found in the vegetational sampling plots, occur on the steep side slopes in close association with the Fullerton. Slopes are usually 30% or more.

Soil Profile Description

Depth in inches	Description
1 inch - zero	Litter and humus layer, principally leaves and dead plant material.
zero - 4 inches	The A horizon (surface material) is a very dark grayish-brown, cherty silt loam with a chert content of 40 to 50%. The soil bacteria which live in this horizon readily break down the above dead plant materials.
4 - 20 inches	The A_2 horizon is a pale-brown, cherty silt loam with a chert content of 45 to 55%. This horizon has lost many of its plant nutrients. It is very strongly acid and contains lesser amounts of soil bacteria.
20 - 36 inches	The B horizon (subsoil) is a brownish-

yellow, cherty silt loam with a chert content of 60 to 75% and the chert pieces are from 2-5 inches in diameter. This horizon is very strongly acid.

36 + The C horizon (substratum) is a strong reddish-brown, cherty silty clay loam with a chert content of 60 to 70%. This horizon is quite thick and can extend to depths of 10 to 20 feet. It is strongly acid.

Clarksville soil has a high infiltration rate and good permeability. Moisture holding capacity is moderately low because of the high chert volume. Erosion hazard is moderate to low.

Dickson Series

The Dickson series is a moderately well-drained upland soil. It occurs on gently to moderately sloping ridgetops. Normal slope is about 5 to 6% but may range up to 15%. The soil has developed from a layer of silty material about 12 inches to 18 inches thick overlaying residuum from the Grand Falls and Burlington formations. Infiltration rate is medium and moisture holding capacity is good to a depth of about 16 inches. Percolation is severely restricted below 18 inches by the fragipan horizon and lateral seepage can be expected. Runoff is heavy in late winter to late spring. Erosion hazard is high when vegetation is removed.

Fullerton Series

The Fullerton soils are considered to be two phases, a ridgetop phase and a side slope phase. Both are cherty silt loams.

The ridgetop phase is a well-drained soil containing a high percentage of chert fragments. It occurs on narrow ridgetops and on tops of "glades" where soils are deep. It has developed from residuum of the Burlington and Jefferson City formations. This soil differs from Bodine in being less cherty and in having a better developed B horizon. High infiltration rate and good permeability to a depth of about 30 inches is characteristic. Below 30 inches, in the fine textured residual material, permeability is very slow. Moisture holding capacity for plant growth is low.

The side-slope phase, the Fullerton found in the vegetational sampling area, is a well-drained soil containing a high percentage of chert fragments. It occurs on slopes below the ridgetops. Slopes average about 25% and range between 10-40%. It has developed from residuum of the Jefferson City and associated formations.

Soil Profile Description

Depth in Inches	Description
1½ - zero	Litter and F layer.
zero - 3 inches	Surface soil (A_1) is friable, dark grayish brown, cherty silt loam; pH 5.5; and ranges in thickness from 1 to 5 inches. Chert fragments are mostly 8 inches and less in diameter.

3 - 16	Surface soil (A_2) is friable, yellowish-brown, cherty silt loan; pH 5.0; and ranges in thickness from 10 inches to 20 inches.
16 - 30 inches	Subsoil (B_2) is yellowish-red cherty silt loam or clay loam, less friable than above; pH 5.5. Chert content is 20-50%.
30+ inches	Substratum (C) is reddish, residual cherty clay and silty clay; pH 5.0 and 6.0. Dolomitic limestone bedrock occurs below this layer usually at a depth of 5 to 6 feet or more.

There is some variation in thickness of each horizon and in the amount of chert. Depth to the residual clay ranges from 15 inches to three or four feet. Occasionally, bedrock may occur within 3 to 5 feet. This soil has a high infiltration rate and good permeability to a depth of 30 inches. Below this the fine textured residual material are less permeable. Moisture holding capacity is low because of the high volume of chert in the soil. Erosion hazard is moderate to low.

Gasconade Series

The third soil series found in the vegetational sampling area is the Gasconade silty clay loam. This soil is found on side slopes of glade areas. It is shallow to dolomitic limestone bedrock and contains some rock ledge outcrops. Slopes range between 15 - 40% and average about 20%.

Soil Profile Description

Depth in Inches	Description
zero - 6 inches	Surface soil (A_1) is very dark grayish brown or black, friable silty clay loam with good soil structure; pH 7.5.
6+ inches	Dolomitic limestone bedrock, upper part may be broken into thin flat fragments with some soil material in crevices and between rock.

Average depth of soil is 4 to 10 inches but small areas of deeper or shallower soils may be included with this unit. The soil usually has good grass cover. Erosion hazard is moderate. The shallow soil mantle is subject to severe and permenent damage from only a moderate amount of erosion. Storage capacity is very low.

Nixa Series

The Nixa cherty silt loam is somewhat droughty. It developed from risiduum of the Burlington formation. This soil, found on the broader high ridgetops, is moderately well-drained and is characterized by a cherty fragipan. Normal slopes are 2-14%. The droughtiness is due to the high chert content in the soil profile preventing the soil material available from holding and releasing moisture to the plants. The fragipan restricts the depth that plant roots can penetrate which also limits the available moisture for plant growth. Infiltration rate is considered to be moderate and permeability is good to a depth of about 17 inches. Infiltration and permeability are inhibited at this depth by the fragipan. These soils have practically no surface runoff and

and erosion hazard is low.

At the termination of Flyblow Ridge the topography presents a slope off northward into Flyblow Hollow and southward and westward into Peckout Hollow. The south aspect is, on the average, a 21.15° slope with some outcropping of parent limestone. Soils are of the Clarksville type near the crest and either Fullerton or Gasconade in the lower elevations. The west aspect has an average slope of 18°. Soils, as on the south, are of the Clarksville, Fullerton and Gasconade types with Clarksville well defined near the top of the ridge. Fullerton occupying a well defined area mid-way down the slope and the Gasconade in a well defined belt near the lower limits of the slope. Limestone out-croppings are more common on the western slope and relatively large open spaces between more widely spaced trees support a moderately heavy grass cover in places where more xeric conditions prevail.

The north aspect presents a slope of 22.65° on the average. Soils are again of the Clarksville, Fullerton and Gasconade types with the Clarksville forming a narrow band near the crest of the ridge. Fullerton occupies a wide band through the center and Gasconade is at the lower limit. No limestone out-croppings were encountered on this slope and vegetation was considerably denser.

In accordance with Steyermark (1959) it is assumed that the floral composition of the area is essentially of the same type distribution as it has been for the past several hundred years. This natural vegetation includes as dominant species a variety of oaks and hickory. Lesser species such as Cornus florida,[5] Juglans nigra, Juniperus virginiana, Pinus echinata, collectively make up a substantial percentage of the total flora. Pine and oak stands are associated with the ridges in the deep upland soils. The steep sloping uplands are predominately oak and hickory. On shallow upland soils which border limestone ledges Quercus stellata and Juniperus virginiana predominate with a heavy shrub cover. Cornus florida and Juglans nigra prefer the more hydric condition of the north aspects. The shallow "glade" areas support Juniperus virginiana and shrubs, with a wide variety of native herbaceous plants.

The precise area under consideration here is a "point" which provides three forested slopes. It is assumed that the microclimate of the three slopes varies. These variations are reflected in the plant communities supported by each. Because species differ genetically, they exist where they are found because each has certain essential requirements. Each species has a definite potential for growth within a limited range of tolerance to environmental conditions and each has a unique capacity for utilizing the available resources of the community in which it exists. Because the various elements of the physical environment vary from place to place and because plants vary in their innate ability to utilize these varying elements, we may expect diverse populations within a relatively small are. Interaction of the plant members of the community with each other as well as with other biota exerts an influence on the stand of a particular species

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[5]Botanical nomenclature will follow that of Steyermark, Julian A., The Flora of Missouri, The Iowa State Univ. Press. 1963.

within the community.

Three factors of the physical environment are considered here as exerting the controlling influence upon the flora of the area. These are: (1) climatic, (2) edaphic and (3) topographic. Plants respond to a complex of environmental factors impinging upon them simultaneously and it is difficult to segregate particular factors as causing a certain response. Consequently, the total influence of all factors is of paramount concern.

CHAPTER III

METHODS AND MATERIALS

Selection of Sites

As a prerequisite to precise investigation of the Peckout Hollow ecosite a general observation of the area was begun in the spring of 1964 and continued through 1966. Regular trips to the area at about one-month intervals were made throughout the growing seasons to become acquainted with the area, its topography, and general floristic compositional changes throughout the year, and to generally "get the feel" of the area.

In the Peckout Hollow area three rectangular microsites, each approximately 425 feet by 500 feet, were delineated. One in a representative area on each of three slopes, a south facing, a west facing and a north facing aspect. The positioning of each microsite in an area representative of the total aspect was facilitated by use of aerial photographs of the area.

After specific parameters had been decided upon, appropriate instruments for measuring them were assembled from a variety of supply companies. The need for recording equipment in the immediate area was suggested by Rosenbery (1964) as information concerning climatic conditions from a U. S. Weather Bureau, however close, is not necessarily representative of the area. The nearest weather station is fifty miles from Peckout Hollow. Instruments used in the final

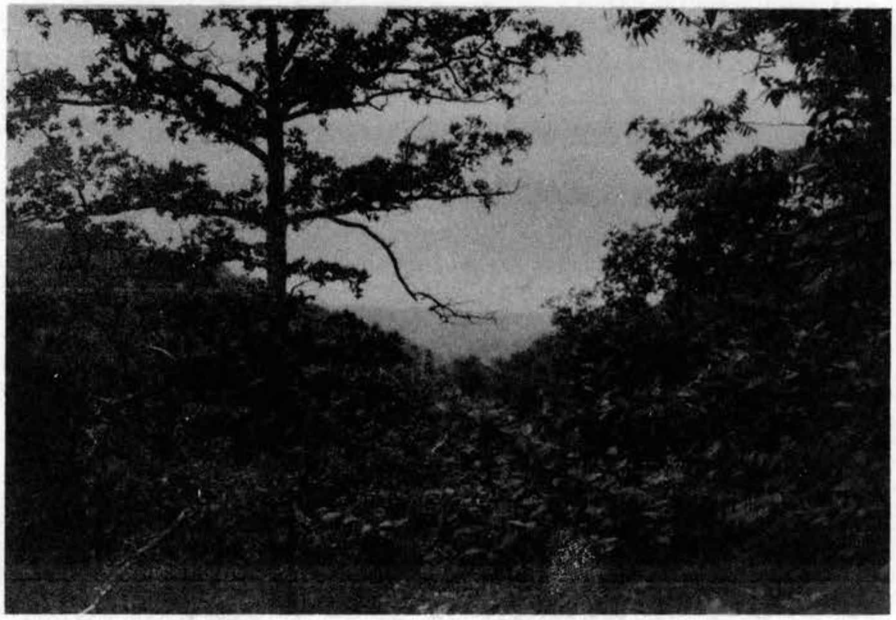

Figure 4. Peckout Hollow. View from North Aspect.

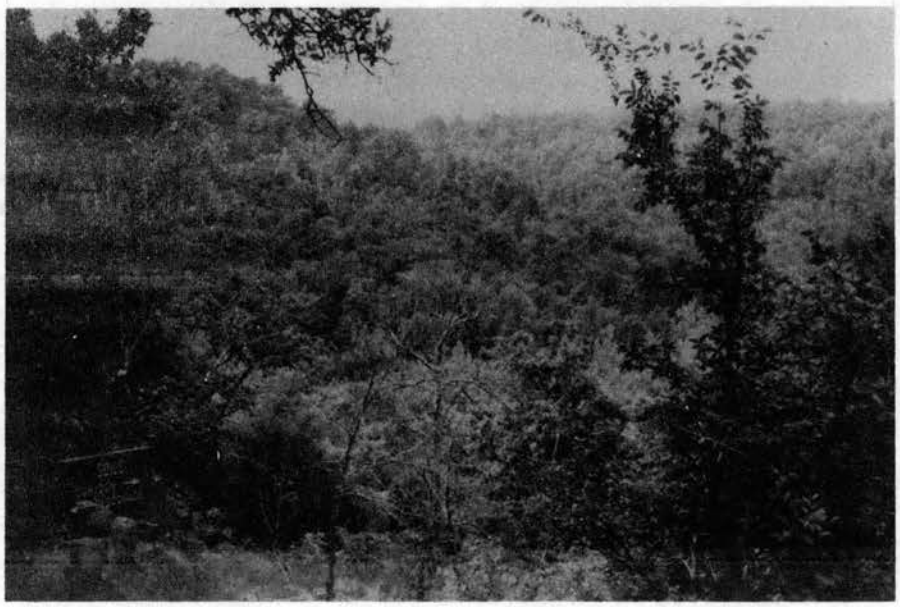

Figure 5. Peckout Hollow. View from South Aspect.

analysis were chosen for their reliability and accuracy. Limited funds prohibited use of more pieces of equipment as well as some more sensitive, and expensive, instruments.

Each recording station, with an instrument shelter as the center, was equipped with instruments for measuring and recording air temperatures, relative humidity, soil temperatures, and rate of evaporation. Soil samples, for determining percent of soil moisture at 0-6 inches and 6-12 inches below surface, were also collected weekly.

Field Vegetational Measurement

A knowledge of the specific plants and their abundance was a prerequisite to analysis of the vegetation at each site. Inasmuch as the area is relatively large and a wide variety of different species is present, a statistically reliable sampling procedure was imperative.

General observation of the area over the previous three-year period (1964-1966) led to the conclusion that the floral stands on each of the slopes were generally uniform. The western aspect may have been the one exception as it possibly constitutes a transition zone between the north and the south slopes.

Determining the size of the microsite to be samples was a problem. Kershaw (1964) states that each case must be decided independently and considered against the amount of sampling involved to reach a certain level of accuracy. Trial sampling runs, using the Bitterlick-angle gauge, were undertaken on each microsite at different seasons. Each sample consisted of at least twenty-four points but the first sample was concentrated within a quadrat of approximately 380 feet by 460 feet. The other sample consisted of 26 points which circumscribed the first. A close correlation of dominant species was presented. From this evidence it was decided that each sampling plot should be approximately five acres in size as this would include most of the area between the top of the ridge and the bottom of the ravine in a vertical belt approximately 500 feet wide. Uniformity and density of the vegetation within this area would be representative of the entire slope. The recording stations, when installed, were located near the center of each of these sampling plots.

The overstory was sampled using the Bitterlick-arms length rectangle method. Grosenbaugh (1952) and Rice and Penfound (1955) described this procedure as being very effective. It incorporates the best features of two sampling methods into one and was found to be very practical for the needs of this study. The sampling plot on each aspect included an area approximately 425 feet by 500 feet with 48 sightings (points) with the angle gauge and 48 arms length rectangles. Basal area was determined by using the angle gauge, frequency and density from the arms length rectangles. The information obtained from the sampling was then used to calculate the following.

Basal Area

Basal area, or number of square feet per acre, is determined by dividing the number of hits by the number of points and then multiplying by 10. The Bitterlick is based upon 0.1 acre quadrats.

Density

Density, or number of trees per acre, is determined by dividing the number of hits in all quadrats by the total number of quadrats and

Figure 6. Sampling Overstory Using the Bitterlick-Angle Gauge.

multiplying by 100. All frequency and density calculations involving measurement from the arms length rectangle are multiplied by 100 as it is based upon 0.01 acre quadrats.

Frequency

Frequency is determined by dividing the total number of quadrats into the number of quadrats in which each species occurs and multiplying by 100.

Relative Basal Area

Basal area for a species divided by the total basal area multiplied by 100 produces a figure representative of the relative basal area.

Relative Density

To determine relative density the species density is divided by the total density and multiplied by 100.

Relative Frequency

Species frequency divided by total frequency multiplied by 100 represents the relative frequency.

Importance Value

The importance value is determined by the summation of relative basal area + relative density + relative frequency. An importance value of 75 or higher indicates a dominant species (Rice 1965).

Those plants which constitute the understory--saplings less than three inches DBH, shade tolerant low-growing trees and shrubby perennials--were sampled using the point-centered quarter method. Originally devised by Curtis and Cottam (1956) for woodlands sampling and modified by Dix (1961) for use in grassland sampling, this procedure proved effective here.

In preparation for sampling, a point-centered quarter was fashioned from a three foot steel shaft of half inch diameter. One end was bent to form a handle, the other sharpened to a point. Four inches above the point two metal fins, each 8 inches long, were welded at their mid-points to the shaft at right angles to each other. The fins served as guides when dividing the area around the shaft into quadrants.

Sampling vegetation by using this method, as with the Bitterlick-arms length rectangle, is random but systematic in that a starting point is established before going into the area and the interval and path of sampling is predetermined. By following this procedure and using a notch in the boot of the operator to guide the shaft into the ground, random sampling is achieved. Each time the shaft is set the area around it is divided by imaginary lines into four quadrants. The species of plant nearest the shaft in each quadrant is recorded and the distance from the shaft is measured to the nearest centimeter. From these measurements, the following information can be calculated.

Distance

Distance represents the sum of measurements for all species.

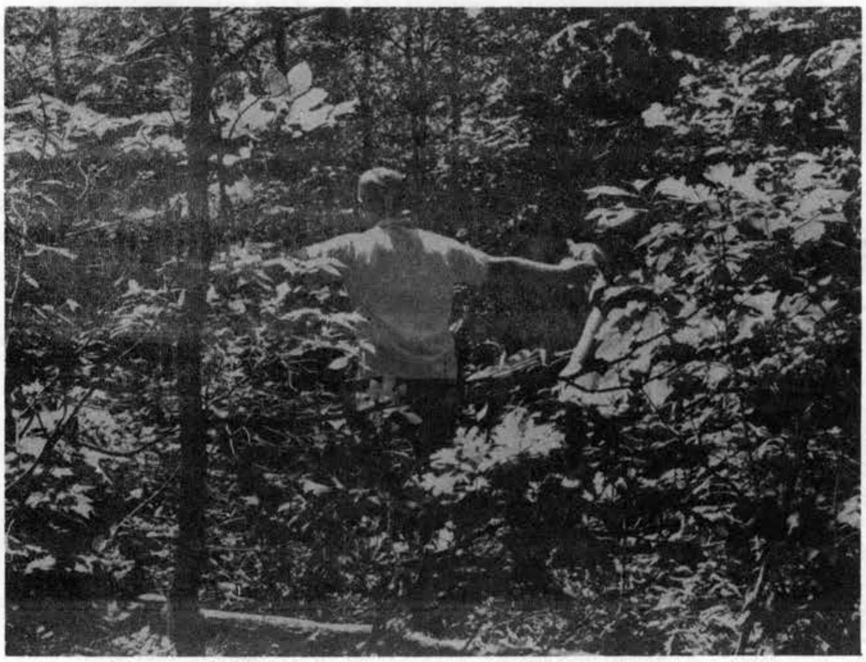

Figure 7. Sampling Overstory Using the Arms Length Rectangle.

Mean Distance

The sum of distances divided by the total number of measurements provides a figure representative of the mean distance.

Mean Area

The mean area is the square of the mean distance.

Total Density

Total density or the number of plants per square meter is determined by dividing the unit area by the mean area.

Relative Density

The number of occurrences of a species divided by the total number of measurements multiplied by 100 produces a percentage which is a figure representative of the relative density.

Absolute Density

Absolute density is determined by multiplying the total density by the relative density.

Frequency

To determine frequency the number of quadrats in which the species occurred is divided by the total number of quadrats and then multiplied by 100 to convert to a percentage.

Relative Frequency

The frequency of species divided by the total frequency and multiplied by 100 is equal to the percent relative frequency.

Environmental and Physiographic Records

Slope Measurement

The angle of slope of each aspect was measured by using an Abney level consisting of a large protractor mounted on a wooden frame with a weighted line attached to the frame at the mid-point of the base of the protractor. In measuring the angle of slope the Abney level was held parallel to the general slope of the terrain as determined by an associate standing some distance from the operator. The angle of slope is then determined by the angle formed where the line falls across the protractor and the perpendicular to the slope. Forty readings were taken in each area by walking a pre-determined path with the instrument shelter serving as the center of the quadrat. The readings were then averaged to produce one figure representative of the general area. Measurements were undertaken during the winter months so that visual sightings would not be obstructed by foliage.

Microclimatic Measurement

Precipitation

A single rain guage was installed for measuring precipitation. A standard rain and snow gauge of the U. S. Weather Bureau type was centrally located between the three microsites. This instrument was the eight inch non-recording type. Care was exercised during installation to insure an open area unobstructed by vegetation.

Instrument Shelters

The center of each sampling plot was indicated with the establishment of an instrument shelter of the standard climatological station type used by the Weather Bureau. Installation of each shelter was in a site representative of the surrounding area. Some leveling was necessary although in choosing the sites care was taken to select a relatively level clearing which would provide an unobstructed flow of air but was still in keeping with the representative terrain. The shelters were so placed that the door opened to the north as a precaution against the sun shining directly on the instruments within when readings were being taken and re-setting was accomplished. A hygrothermograph and one set of maximum-minimum thermometers, described below, were placed in each shelter.

Air Temperature Thermometers

The air thermometers, both maximum and minimum, were of the liquid in glass type and mounted in a Townsend support which facilitated reading and resetting to the current temperature at the time of observation.

Hygrothermograph

A hygrothermograph was housed by each instrument shelter for the purpose of measuring and recording relative humidity as well as air temperatures. These instruments, obtained from Bacharach Industrial Instrument Company, were equipped with a humidity sensitive diaghragm

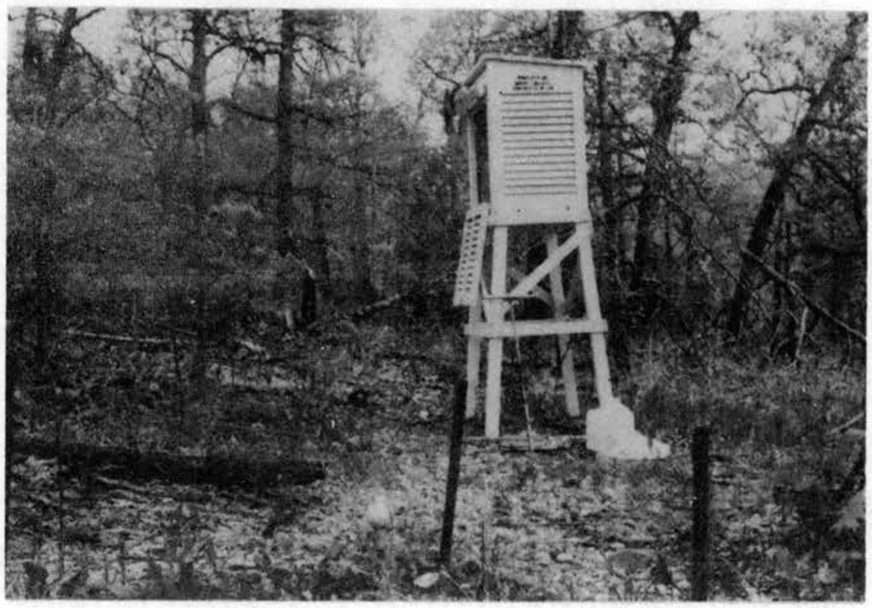

Figure 8. Instrument Shelter in Field Recording Site. Atmometer Bulb with Protective Fence in Foreground.

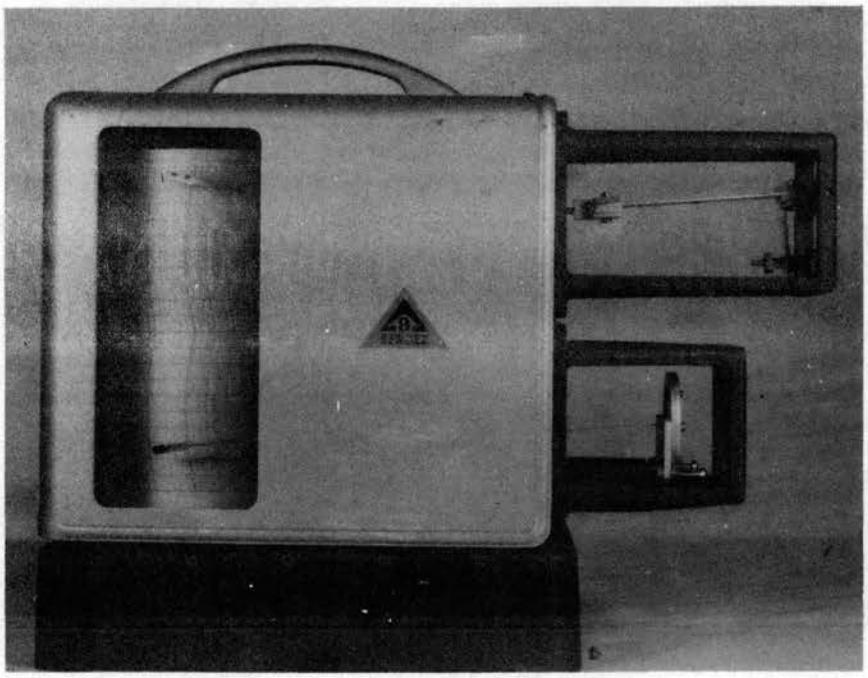

Figure 9. Hygrothermograph Used in Instrument Shelters at each Recording Site.

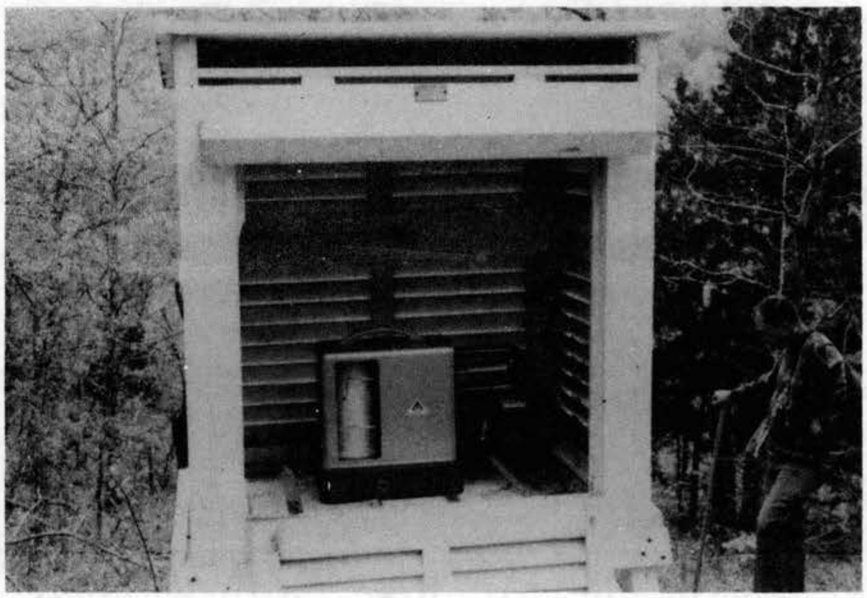

Figure 10. Open Instrument Shelter Showing Position of Hygrothermograph and Maximum-Minimum Thermometers.

for humidity measurement and a temperature sensitive element of the cantilever bimetallic type for measuring temperature. The models used were provided with a seven day clock-work drive which turned a chart drum on which weekly charts were maintained and humidity and temperature readings were recorded.

Soil Temperature Thermometers

For measuring soil temperatures a dial-type maximum-minimum thermometer supplied by Science Associates (model number 117S) was installed at each recording site. This model is equipped with a mercury-activated temperature sensitive bulb on a five-foot flexible capillary. The procedure for installing the soil thermometer necessitated caution so that the sensing element would be located in and under undisturbed soil. The sensing element was placed in close contact with the ambient soil, without the presence of insulating air spaces and without artificial channels for entry of water.

Evaporimeters

For measuring the rate of evaporation, standardized, white, porous-porcelain atmometer spheres five centimeters in diameter were used. The outer surface of these spheres is ground smooth and the neck water-proofed on the outside. Each piece bears, on the water-proofed part, a serial number and its coefficient of correction. Each atmometer bulb was mounted in a one-liter volumetric flask which served as the reservoir (see Figure 12). The supply tube was a straight glass tube approximately 30 cm long with an internal diameter of 6 mm. This tube was inserted through a cylindrical cork which

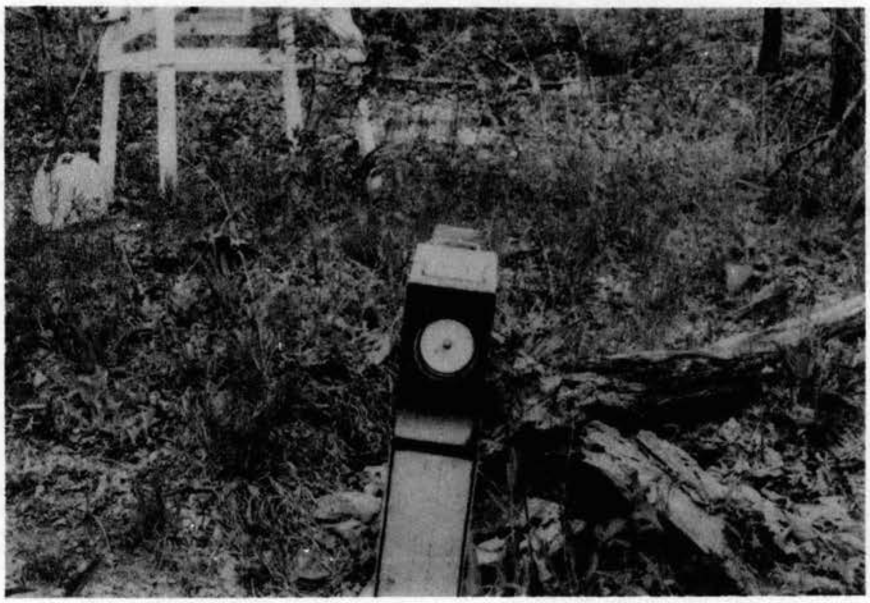

Figure 11. Maximum-Minimum Soil Thermometer Installed in Protective Container.

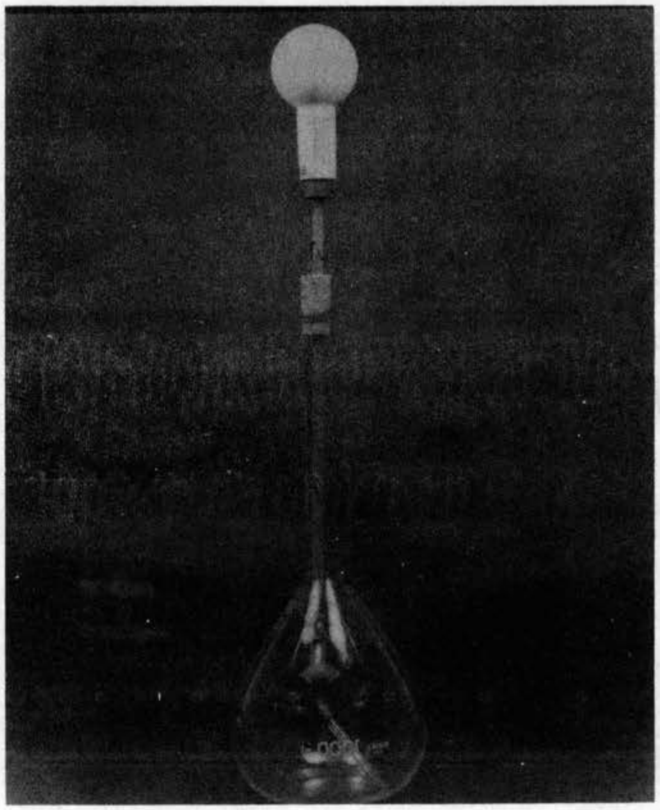

Figure 12. Atmometer Set-up and Reservoir Used at Recording Sites.

was held by the neck of the flask. The supply tube was fitted with a Livingston-Thone (Thone 1924) valve attached to its lower end. This valve, which is designed to prevent downward movement of water through the supply tube was deemed necessary because of the anticipated precipitation in the study area. As water is withdrawn from the reservoir it is necessary that a vent allow entrance of air. This is accomplished by inserting a small J-shaped copper tube through the cork. In final assemblage of the apparatus the cork, when set tightly, projected far enough above the neck of the flask to furnish a firm finger hold. The one-liter mark on the neck of the flask was used as a zero mark when refilling the reservoir. As a convenient aid in refilling the reservoir and, at the same time, measuring the amount of water evaporated, a burette (dispensing type with stopcock) was used.

Prior to field installation all atmometers were soaked in distilled water for several days. Field installation of atmometers, as was true for all instruments, was undertaken one month prior to the beginning of the recording period so as to check out the pieces for proper functioning.

One atnometer set-up was installed at each of the three recording sites. Care was exercised in the installation of each to set the reservoir in the soil at such a depth that the atmometer bulb was approximately twelve inches above the surface of the soil. A triangular guard fence of chicken wire was installed around each with the bulb centered no closer than two feet from any part of the fence. The fence served to protect the atmometers from animals that might inadvertantly step on them.

As a precaution against breakage due to expansion of water upon

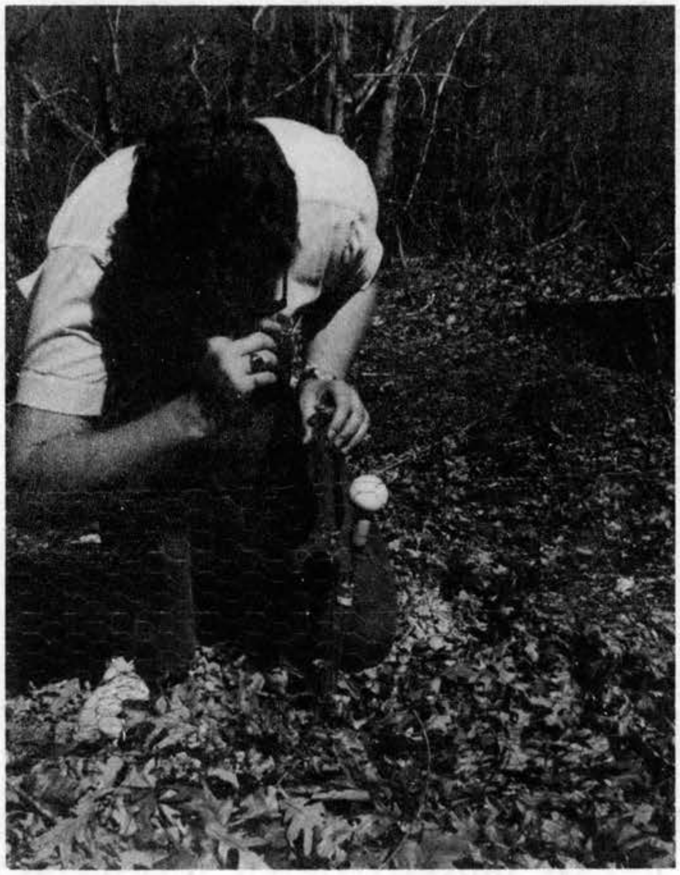

Figure 13. Re-filling the Atmometer Reservoir Using a Graduated Burette

freezing, a device described by Livingston and Hassis (1929) was employed. This consisted essentially of inserting a soft rubber tube, closed at both ends, inside the atmometer bulb. This afforded a "hollow space" which absorbed the expansion and prevented breakage upon several occasions of unexpected freezing temperatures.

As was suggested by Livingston (1935) the growth of algae on the bulbs was inhibited by treatment with a dilute solution of mercuric-chloride. The treatment was employed only when observation of algae growth deemed it necessary.

According to Livingston (1935) restandardization of instruments at regular intervals is a good practice. The need depending upon inherent conditions of each individual site which would affect the time interval in which accurate measurement could be expected. Due to a limited number of atmometer bulbs and the need to replace bulbs after a period of extended use, a standardizing apparatus was necessary. This device, of the rotating table type similar to that described by Nichol(1913), was constructed and used to insure a supply of standardized bulbs.

Soil Moisture

The percentage of moisture in the soil was determined at 0-6 inch depths and at 6-12 inch depths on each microsite. The procedure, as described by Weaver and Clements (1938), is as follows.

Samples of soil were removed with a soil auger and transferred immediately to air tight glass containers. The soil auger was found to be more practical than the geotome due to the rock content of the soil. These samples were then returned to the laboratory where they were weighed, dried in an oven at 80°C for 48 hours (or longer), re-weighed and the moisture content computed by the following formula:

$$\frac{\text{wet weight of soil + can - dry weight of soil + can}}{\text{dry weight of soil + can - can weight}} \times 100 = \text{percent.}$$

CHAPTER IV

RESULTS AND DISCUSSION

Thirty-three different species of trees constituting the overstory were identified in the study area. Not all species, however, were recorded on all three slopes. Based upon their importance value (i.v.) only three species were significant enough to be considered dominants according to Rice (1965), i. e., with an importance value of 75 or more. These three dominant species were present in varying density and frequency on each of the three different aspects. *Quercus velutina* with an i. v. of 95 was the dominant species on the south aspect and *Quercus stellata*, i. v., 75, and *Quercus alba*, i. v., 97, were dominant on the west and north aspects respectively (all figures used herein are rounded to the nearest whole number for clarity.)

The understory, which included saplings of less than three inches DBH, shade tolerant trees, and shrubs, was comprised of thirty-three species. Dominant species on the three aspects--as indicated by a relative frequency of 10% or more--included *Ulmus alata*, *Rosa setigera*, *Quercus alba*, *Quercus velutina* and *Cornus florida*. Only two of these, *Quercus alba* and *Quercus velutina* were dominants on all three aspects.

Precipitation for the growing season, April 1 to November 1, was 25 inches with approximately 60% occurring during the latter half of the growing season. Relative humidity ranged from a low of 12% on the south aspect, to a fairly consistent high of 100% on the north aspect. This consistently high relative humidity record may be questioned: The hygrothermographs were calibrated by the supplier to read accurately (± 3%) within the range of 15% to 95% relative humidity. The possibility of error in the reading over 95%, the microclimatic conditions found in the north aspect, and the density of the vegetation would tend to support this record. The mean low relative humidity on all aspects was 34% and the mean high was 96%. The minimum air temperature recorded on all aspects was 16°F. The mean minimum temperature was 40°F. The maximum air temperature on all aspects was 97°F with a mean high of 85°F. Soil temperature ranged from a low of 40°F on the north aspect to 87°F on the south. Mean low and high for all aspects was 59°F and 71°F, respectively. All temperature readings were taken to the nearest whole number. According to Platt and Griffiths (1964), "in order to know the temperature of something the sensitive element of the measuring device should have exactly the same thermal properties. Since this is rarely, if ever, the case, approximations are made. Consequently, it is useless to attempt to take measurements to a senseless degree of accuracy. A reading to the nearest whole degree will suffice because the microfluctuation of air temperatures are almost continuously of that order of magnitude." As this is undoubtedly true in other climatic measurement all readings are rounded to the nearest whole number.

Evaporation rates were greatest on the south aspect with a maximum of 187 ml for the week of April 26 to May 3 and lowest on the north with the minimum loss for any one-week recording period being 23 ml. Soil moisture at the 0-6 inch depth ranged from a minimal 7%

to a maximum of 48% and at the 6-12 inch depth from 9% to 53%.

Soils in all three study areas included Clarksville, Fullerton, and Gasconade. No attempt was made to confine the vegetational sampling plots to any particular soil series. The sampling procedure, due to the systematic randomness of it, cut across boundaries of all three soil types.

South Aspect

Analysis of overstory

The overstory on the south aspect was dominated by Quercus velutina with a very significant i. v. of 95 (Table II) and a relative basal area of 17%, relative frequency of 36% and relative density of 42% (TableIII). Second in importance value was Quercus stellata with an i. v. of 58. Next in order of abundance were Quercus alba, i. v. 37, Carya ovata, i. v. 19, and Pinus echinata, i. v. 19. Relative basal area, relative frequency and relative density are indicated in Table III. Carya ovata and Pinus echinata were the only species other than oaks that were significant on the south aspect. Carya ovata ranked third in the frequency analysis and Pinus echinata ranked third for basal area. With the exception of Ulmus Thomasi, i. v. 11, all other fifteen species recorded on the south aspect were of rare occurrence with an i. v. of less than 10.

Analysis of understory

The understory vegetation of the south aspect was dominated by Rosa setigera, Ulmus alata, Quercus alba, Quercus velutina, Crataegus spp.,

TABLE II

OVERSTORY VEGETATIONAL ANALYSIS
IMPORTANCE VALUES

Species	South Aspect	West Aspect	North Aspect
Acer rubrum	-	-	1.6
Acer saccharum	t	9.7	4.1
Aesculus glabra	-	4.4	-
Bumelia lanuginosa	-	t	-
Carya cordiformis	2.6	t	8.9
Carya glabra	t	1.2	2.9
Carya laciniosa	-	-	t
Carya ovata	19.0	19.7	5.0
Carya texana	-	-	3.7
Carya tomentosa	t	2.0	3.3
Cornus florida	8.1	8.9	51.9
Fraxinus americana	4.7	2.4	1.2
Fraxinus pennsylvanica	-	4.0	5.4
Juglans nigra	7.6	17.9	7.7
Juniperus virginiana	6.8	22.3	-
Ostrya virginiana	-	3.6	-
Pinus echinata	18.8	t	-
Prunus spp.	-	-	2.9
Quercus alba	37.4	50.0	97.1
Quercus coccinea	1.3	-	-
Quercus marilandica	5.9	4.4	3.3
Quercus Muhlenbergii	2.1	17.0	-
Quercus palustris	3.8	-	t
Quercus rubra	7.3	-	37.7
Quercus Shumardii	-	-	t
Quercus stellata	57.5	75.2	2.9
Quercus velutina	94.7	38.1	46.4
Sassafras albidum	5.1	-	t
Tilia floridana	-	-	3.3
Ulmus alata	t	11.3	-
Ulmus americana	4.3	-	3.7
Ulmus fulva	-	t	-
Ulmus Thomasi	11.1	5.6	3.7

TABLE III

COMPARISON OF DOMINANT SPECIES

Dominant Species of Overstory	Relative Basal Area %			Relative Frequency %			Relative Density %		
	south	west	north	south	west	north	south	west	north
Cornus florida	.4	1.6	9.0	4.5	3.9	21.2	3.2	3.5	21.6
Carya ovata	2.1	5.2	2.1	8.9	7.7	1.6	8.1	6.9	1.3
Juniperus virginiana	1.3	6.0		2.2	7.7		3.2	8.6	
Juglans nigra	3.2	1.6	2.9	2.2	7.7	2.7	2.2	8.6	2.1
Pinus echinata	7.3	.4		6.7			4.8		
Quercus alba	25.8	22.7	39.1	6.7	13.5	27.5	4.8	13.8	50.5
Quercus Muhlenbergii	2.1	4.4			5.8			6.9	
Quercus rubra	3.5		13.2	2.2		13.1	1.6		11.4
Quercus stellata	25.8	37.0		15.6	19.2	1.6	16.1	19.0	1.3
Quercus velutina	17.2	1.2	13.6	35.6	15.4	16.3	41.9	15.5	16.5
Ulmus Thomasi	3.5	2.0	.8	4.5	1.9	1.6	3.2	1.7	1.3

Juniperus virginiana, *Rubus* spp., and *Vaccinum vacillans* (Tables IV and V). The two most abundant species as determined by relative frequency and relative density were *Ulmus alata* and *Rosa setigera*. Although *Rosa setigera* occurred frequently it actually accounted for very little cover. These plants were generally small and often found in any open spaces otherwise occupied by herbaceous dicots and grasses.

The relative frequency of both *Ulmus alata* and *Rosa setigera* on this slope, as well as on the west, and its absence on the north is indicative of their preference for the more xeric conditions associated with openness of the overstory on the south and west aspects.

Sapling *Quercus velutina* and *Quercus alba* were of secondary importance as understory species, each with a relative frequency of 10%. Both of these species appeared as overstory dominants on the south aspect. *Juniperus virginiana* and *Crataegus* spp. are both less important species with a relative frequency of 6%.

West Aspect

Analysis of Overstory

The west aspect is probably a transitional zone, between the south and the north aspects, with a wider range of microclimatic conditions. Assuming this is true, it follows that this transitional zone may then exhibit vegetational characteristics of both south and north aspects. Possibly some species, not prevalent on either of the other slopes, may be found on the west aspect. This was precisely the case. If an observer should walk in an arc around this terminal point of Flyblow Ridge from south to north he would indeed discover a

TABLE IV

RELATIVE FREQUENCY OF UNDERSTORY VEGETATION

Species	South Aspect	West Aspect	North Aspect
	%	%	%
Acer rubrum	-	-	5.5
Acer saccharum	-	5.6	-
Amelanchier canadensis	-	1.4	-
Carya ovata	4.2	5.6	4.1
Carya tomentosa	-	1.4	4.1
Cercis canadensis	-	1.4	-
Cornus florida	2.8	-	11.2
Corylus americana	-	2.8	6.8
Crataegus spp.	5.6	1.4	-
Diospyros virginiana	-	1.4	2.7
Fraxinus americana	-	-	5.5
Juniperus virginiana	5.6	5.6	1.6
Nyssa sylvatica	-	1.4	-
Quercus alba	9.9	5.6	20.6
Quercus marilandica	-	1.4	-
Quercus Muhlenbergii	1.4	2.8	-
Quercus stellata	2.8	4.2	-
Quercus velutina	9.9	9.7	9.6
Parthenocissus quinquefoloa	2.8	-	1.6
Pinus echinata	-	1.4	-
Rhus aromatica	1.4	8.3	-
Rhus glabra	1.4	-	-
Rosa setigera	11.3	11.1	-
Rubus spp.	4.2	-	1.6
Sassafras albidum	1.4	-	8.2
Smilax hispida	-	1.4	1.6
Symphoricarpos orbiculatus	1.4	-	2.7
Toxicondendron radicans	2.8	1.4	2.7
Ulmus alata	14.1	11.1	-
Ulmus Thomasi	-	9.7	1.6
Vaccinium stamineum	4.2	1.4	6.8
Vaccinium vacillans	4.2	-	-
Vitis cordifolia	4.2	2.8	2.7

TABLE V

RELATIVE DENSITY OF UNDERSTORY VEGETATION

Species	South Aspect	West Aspect	North Aspect
	%	%	%
Acer rubrum	-	-	5.2
Acer saccharum	-	5.2	-
Amelanchier canadensis	-	1.0	-
Carya ovata	4.2	5.2	3.1
Carya tomentosa	-	1.0	3.1
Cercis canadensis	-	1.0	-
Cornus florida	3.1	-	12.5
Corylus americana	-	2.1	6.3
Crataegus spp.	4.2	1.0	-
Diospyros virginiana	-	1.0	2.1
Fraxinus americana	-	-	3.1
Juniperus virginiana	4.2	6.3	1.0
Nyssa sylvatica	-	1.0	-
Quercus alba	11.5	4.2	22.9
Quercus marilandica	-	1.0	-
Quercus Muhlenbergii	1.0	2.1	-
Quercus stellata	2.1	4.1	-
Quercus velutina	8.3	7.3	8.3
Parthenocissus quinquefolia	4.2	-	1.0
Pinus echinata	-	1.0	-
Rhus aromatica	1.0	10.4	-
Rhus glabra	1.0	-	-
Rosa setigera	13.5	16.7	-
Rubus spp.	6.3	-	3.1
Sassafras albidum	1.0	-	8.3
Smilax hispida	-	1.0	1.0
Symphoricarpos orbiculatus	1.0	-	4.2
Toxicondendron radicans	2.1	2.1	2.1
Ulmus alata	10.4	12.5	-
Ulmus Thomasi	-	10.4	3.1
Vaccinium stamineum	7.3	1.0	7.3
Vaccinium vacillans	7.3	-	-
Vitis cordifolia	3.1	2.1	2.1

gradual transition in microclimatic conditions and vegetation--a transition that would include, within the west aspect, an area much like the south, a uniquely west microenvironment, and an area much like the north aspect.

The west aspect included Quercus stellata with an i. v. of 75, relative basal area of 37%, relative frequency of 19%, and relative density of 19%. Quercus stellata was by far the dominant tree on the west aspect. Of secondary importance was Quercus alba with an i. v. of 50, followed by Quercus velutina with an i. v. of 38. Of somewhat lesser importance but significant was Juniperus virginiana with an importance value of 22. This species was not encountered on the north aspect and was insignificant (i. v. 7) on the south. Three other species of moderate significance were Carya ovata, i. v. 20, Juglans nigra, i. v. 18, and Quercus Muhlenbergii, i. v. 17. Species tolerant of more xeric conditions were more abundant on this aspect because of the uniqueness of some areas of the western exposure. These areas, obviously much more xeric than any of the others, are not identified by the climatological data because of the location of the recording station.

Analysis of the Understory

Dominant plants of the understory included Rosa setigera and Ulmus alata, both with a relative frequency of 11%. Of secondary importance were Quercus velutina and Ulmus Thomasi, both with a relative frequency of 10% and Rhus aromatica with 8% relative frequency. Of moderate importance were Juniperus virginiana, Carya ovata, Quercus alba and Acer saccharum all with a relative frequency of 6%. Fifteen other species were noted but considered minor because of a relative frequency of less than 5%.

North Aspect

Analysis of Overstory

As will be evident from the microclimatological data, the north aspect provides for a much more mesic environment and consequently supports a vegetation quite unlike the south and west aspects. By far the most important dominant tree of the north aspect was the white oak, *Quercus alba*, with an i. v. of 97. This species was strikingly significant here as compared with its incidence on the west aspect, where it was calculated to have an i. v. of 50, and on the south aspect, where its importance value was 37. *Quercus alba* was calculated to have a relative frequency of 27%, a relative density of 31% and a relative basal area of 39%. Of secondary importance was *Cornus florida* (an insignificant species on the other aspects) with an i. v. of 52, a relative frequency of 21%, a relative density of 22%, and a relative basal area of 9%. Also of secondary importance were *Quercus velutina*, i. v. 46, and *Quercus rubra*, i. v. 38. Thirteen other species were encountered but were insignificant with individual importance values of less than 10.

Analysis of Understory

Dominant species of the understory included sapling *Quercus alba* with a relative frequency of 21%, and *Cornus florida* with a relative frequency of 11%. Of moderate importance were sapling *Quercus* *velutina* with a relative frequency of 10% and *Sassafras albidum*, with a relative frequency of 8%. *Vaccinium stamineun* and *Corylus americana*, each with a relative frequency of 7%, and *Acer rubrum*, with a relative frequency of 5%, were present as minor species. Twelve other species were judged to be insignificant, each with a relative frequency of less than 5%.

Correlation

Sampling a plant community is based in part on the assumption that there will be some degree of association or correlation between the various species present as well as between the species and the environmental factors, both microclimatic and edaphic.

An important factor concerning the structure of a plant community is the relationship between the quantities of species present. An analysis of this factor attempts to show correlation between species comprising the plant communities of the three different aspects. A correlation coefficient based upon basal area (Table VI) and density (Table VII) values was calculated to note the level of correlation between all possible combinations of aspects.

The correlations considered here include all species identified on all aspects although individual species may not be present on all three sites. This should influence any interpretations of the correlations. A similar precaution concerns the importance of quadrat sizes. Quadrat size is important and should be considered.

TABLE VI

OVERSTORY VEGETATIONAL ANALYSIS
BASAL AREA

Species	South Aspect	West Aspect	North Aspect
Acer rubrum	-	-	t
Acer saccharum	t	1.3	t
Aesculus glabra	-	t	-
Bumelia lanuginosa	-	t	-
Carya cordiformis	1.3	t	2.1
Carya glabra	t	t	1.5
Carya laciniosa	-	-	t
Carya ovata	1.0	2.7	1.0
Carya texana	-	-	t
Carya tomentosa	t	1.0	t
Cornus florida	t	t	4.6
Fraxinus americana	t	1.3	t
Fraxinus pennsylvanica	-	t	1.3
Juglans nigra	1.0	t	1.5
Juniperus virginiana	t	3.1	-
Ostrya virginiana	-	t	-
Pinus echinata	3.5	t	-
Prunus spp.	-	-	t
Quercus alba	12.5	11.9	19.8
Quercus coccinea	t	-	-
Quercus marilandica	t	t	t
Quercus Muhlenbergii	1.0	2.3	-
Quercus palustris	-	-	t
Quercus rubra	1.7	-	6.7
Quercus Shumardii	-	-	t
Quercus stellata	12.5	19.4	-
Quercus velutina	8.3	3.8	6.9
Sassafras albidum	t	-	t
Tilia floridana	-	-	t
Ulmus alata	t	t	-
Ulmus americana	t	-	t
Ulmus fulva	-	t	-
Ulmus Thomasii	1.7	1.0	t

TABLE VII

OVERSTORY VEGETATIONAL ANALYSIS
DENSITY

Species	South Aspect	West Aspect	North Aspect
Acer rubrum	-	-	t
Acer saccharum	-	4.2	2.1
Aesculus glabra	-	2.1	-
Bumelia lanuginosa	-	t	-
Carya cordiformis	-	-	6.5
Carya glabra	t	t	t
Carya laciniosa	-	-	t
Carya ovata	10.4	8.3	2.1
Carya texana	-	-	2.1
Carya tomentosa	-	-	2.1
Cornus florida	4.2	4.2	35.4
Fraxinus americana	2.1	-	-
Fraxinus pennsylvanica	-	2.1	2.1
Juglans nigra	2.1	10.4	3.5
Juniperus virginiana	4.2	10.4	-
Ostrya virginiana	-	2.1	-
Pinus echinata	6.3	-	-
Prunus spp.	-	-	2.1
Quercus alba	6.3	16.7	50.0
Quercus coccinea	t	-	-
Quercus marilandica	4.2	2.1	2.1
Quercus Muhlenbergii	-	8.3	-
Quercus palustris	4.2	-	-
Quercus rubra	2.1	-	18.8
Quercus Shumardii	-	-	t
Quercus stellata	20.8	22.9	2.1
Quercus velutina	54.2	18.8	27.1
Sassafras albidum	2.1	-	-
Tilia floridana	-	-	2.1
Ulmus alata	-	6.3	-
Ulmus americana	2.1	-	2.1
Ulmus fulva	-	t	-
Ulmus Thomasi	4.2	2.1	2.1

TABLE VIII

CORRELATION COEFFICIENTS FOR ASPECTS BASED UPON BASAL AREA AND DENSITY VALUES OF ALL SPECIES ON EACH ASPECT[1]

Aspects	Basal Area	Density
West versus North	0.41308	0.45891
South versus West	0.89381	0.68305
North versus South	0.65159	0.39138

As indicated in Table VIII, a high degree of positive correlation is evident between the south and west aspects, especially when using basal area as the criterion rather than density. This would be expected in view of the fact that microclimate records reveal air temperature, soil temperatures, rate of evaporation, and the lower limit of relative humidity on these two slopes to be closely correlated. Inconsistancy of soil moisture data is undoubtedly due to unavoidable error in positioning the recording station such that underlying bedrock and soil in a limited area was not characteristic of the whole western aspect. The lowest correlation value of 0.39138 between communities of the north and the south aspects indicated the dissimilarity of species

[1]Snedecor, George W., 1956. Statistical Methods. The Iowa State College Press, Ames, Iowa.

as a manifestation of the differences in microclimatic and edaphic factors.

Two oaks, Quercus velutina and Quercus stellata, were the most abundant species on both south and west aspects. Quercus velutina was most abundant on the south slope with a density of 54 trees per acre and secondary on the west with a density of 19 trees per acre. A density of 27 as on the north indicates its preference. Quercus stellata ranked second on the south with 21 trees per acre but was the dominant species on the west with 23 trees per acre. The west and north aspects both included Quercus velutina and Quercus alba as dominants with the former being of secondary importance on the west slope having a density of 19 trees per acre. This species ranked third on the north aspect with 27 trees per acre. Quercus alba was by far the most dominant species on the north with a density of 50 trees per acre while it ranked third in line on the west with a density of 17 trees per acre. The only dominant species which occurred on both south and north aspects was Quercus velutina which ranked first in abundance on the south aspects with a density of 54 but only third on the north aspect with 27 trees per acre.

Basal area values substantiated the correlation between south and west but indicate more correlation between north and south in number of square feet per acre than between west and north aspects.

"t" Test for Significance

Just as we assume some correlation between entities in an ecosystem so may we assume a certain amount of error associated with any field observations or experimental results. The source of error lies

lies in the method of sampling and in natural variation of living things. To test for significance of results standard error was computed and a "t" test was used to determine reliability of results (Steel and Torrie, 1960). Density figures, obtained by a sampling procedure which employed the arms length rectangle were used in these calculations. The test for significance was applied only to Quercus alba, Quercus velutina and Quercus stellata. Of the thirty-three species identified in the study area only these three were calculated to have an importance value of 75 or more, consequently, these are considered dominants--as defined by Rice (1965). Based on the mean density of the three dominants of the entire area (three aspects), all slope exposures were found to be significantly different at the 1% level from each other (Table IX).

A correlation can be detected between the "t" values and the abundance of each dominant species. Generally, a larger "t" value indicates a more significant difference between the two aspects. The one obvious exception, Quercus alba on the south and west aspects, can be justified on the basis of the transitional zone of the west aspect. The sampling plot extended into the north aspect where Quercus alba is by far the dominant species.

Analysis of the Microclimate

Microclimatic conditions on the south aspect represent a somewhat xeric environment in contract to the conditions which prevail on the north. The west represents a transitional region, which in some respects reflects the conditions of the south exposure and in others is more nearly like the north.

TABLE IX

SIGNIFICANCE FOR VARIOUS ASPECTS SAMPLED BASED
ON MEAN DENSITY VALUE OF *QUERCUS ALBA*,
QUERCUS STELLATA AND *QUERCUS VELUTINA*

Aspect	Species	Mean Importance Value ± Standard Error	Aspect Tested	"t" Values
	Quercus alba	.0625 ± .25	North	3.339*
South	Quercus stellata	.208 ± .544	North	2.280*
	Quercus velutina	.542 ± .921	North	1.167*
	Quercus alba	.167 ± .429	South	14.718*
West	Quercus stellata	.229 ± .472	South	.202*
	Quercus velutina	.188 ± .445	South	2.392*
	Quercus alba	.500 ± .875	West	2.362*
North	Quercus stellata	.021 ± .145	West	2.889*
	Quercus velutina	.354 ± .636	West	1.482*

*Significantly Different at 1% Level

Relative humidity on the south aspect ranged from a low of 12%, recorded November 1, to a high of 99% in mid-August, a period of abundant precipitation (Figure 14). The rising and falling of the lower limits of the relative humidity range corresponded to periods of precipitation (Figure 15). The upper limits of relative humidity correlated with precipitation generally but there was less fluctuation in favor of a rather consistant upper level of 90-95% relative humidity from late May throughout the remainder of the growing season (Figure 16).

Air temperatures were recorded at all stations by both maximum-minimum thermometers and a hygrothermograph. An average of the two readings was recorded.

Air temperature ranged from a low of 22^{o}F. in late October to a high of 96^{o}F. in mid-July. The weekly fluctuation of air temperatures produced a pattern of negative correlation with precipitation. Periods of precipitation were accompanied by decreased temperatures whereas higher temperatures accompanied dry periods. No extremes in air temperatures were recorded and no extended periods of unusually high or low temperatures were noted. Minimum temperatures consistently increased (with weekly fluctuation) from a low of 23^{o}F. in early April to a high of 65^{o}F. by mid-August. This was followed by consistantly decreasing temperatures (with weekly fluctuations) to a low of 22^{o}F. by early November (Figure 17). Maximum temperatures were more consistant, ranging from 77^{o}F. to 96^{o}F. with greater fluctuation in the first and last eight weeks and fairly even temperature during mid-season (Figure 18).

Soil temperatures, both maximum and minimum, paralleled very

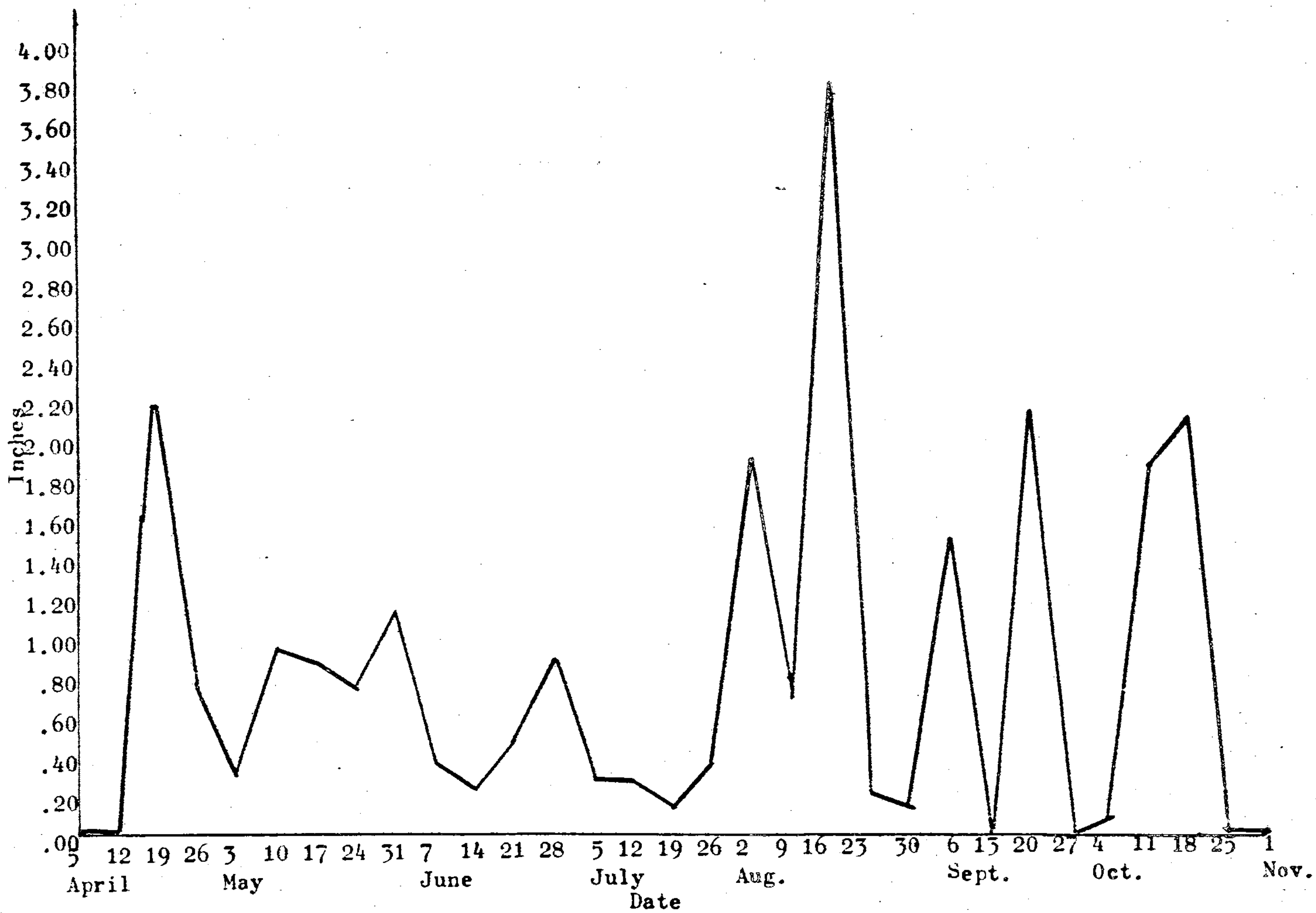

Figure 14. Weekly Precipitation

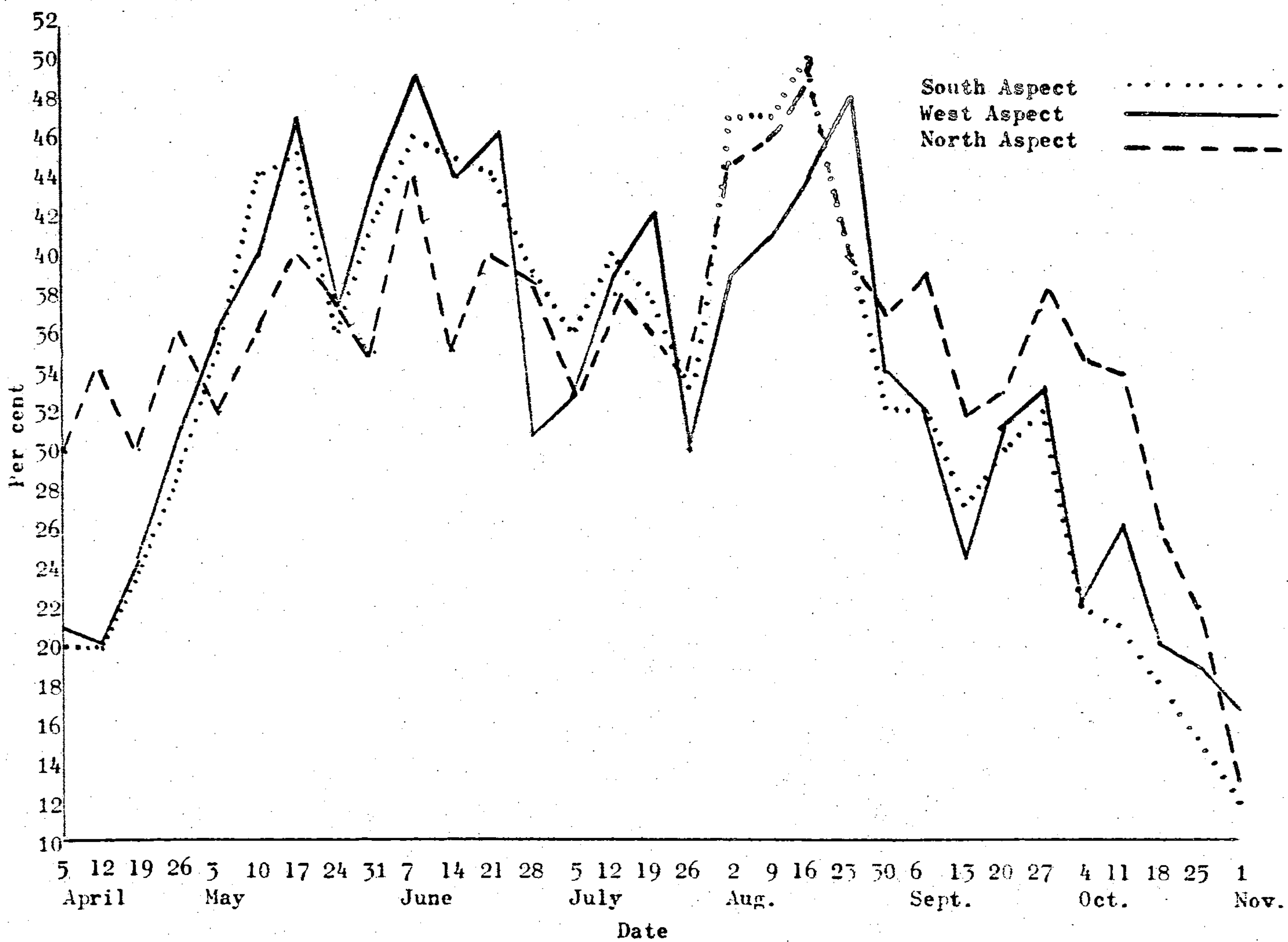

Figure 15. Lower Limits of Relative Humidity

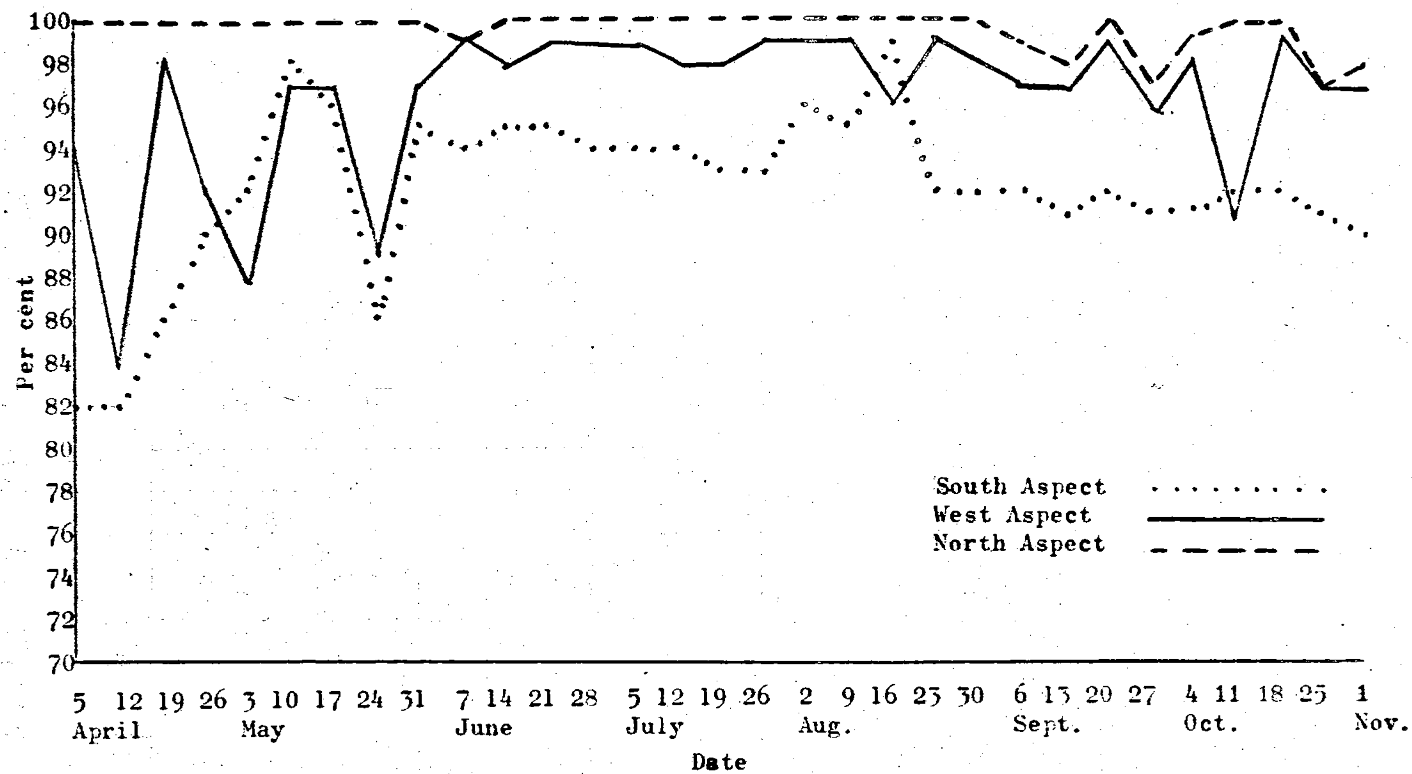

Figure 16. Upper Limits of Relative Humidity

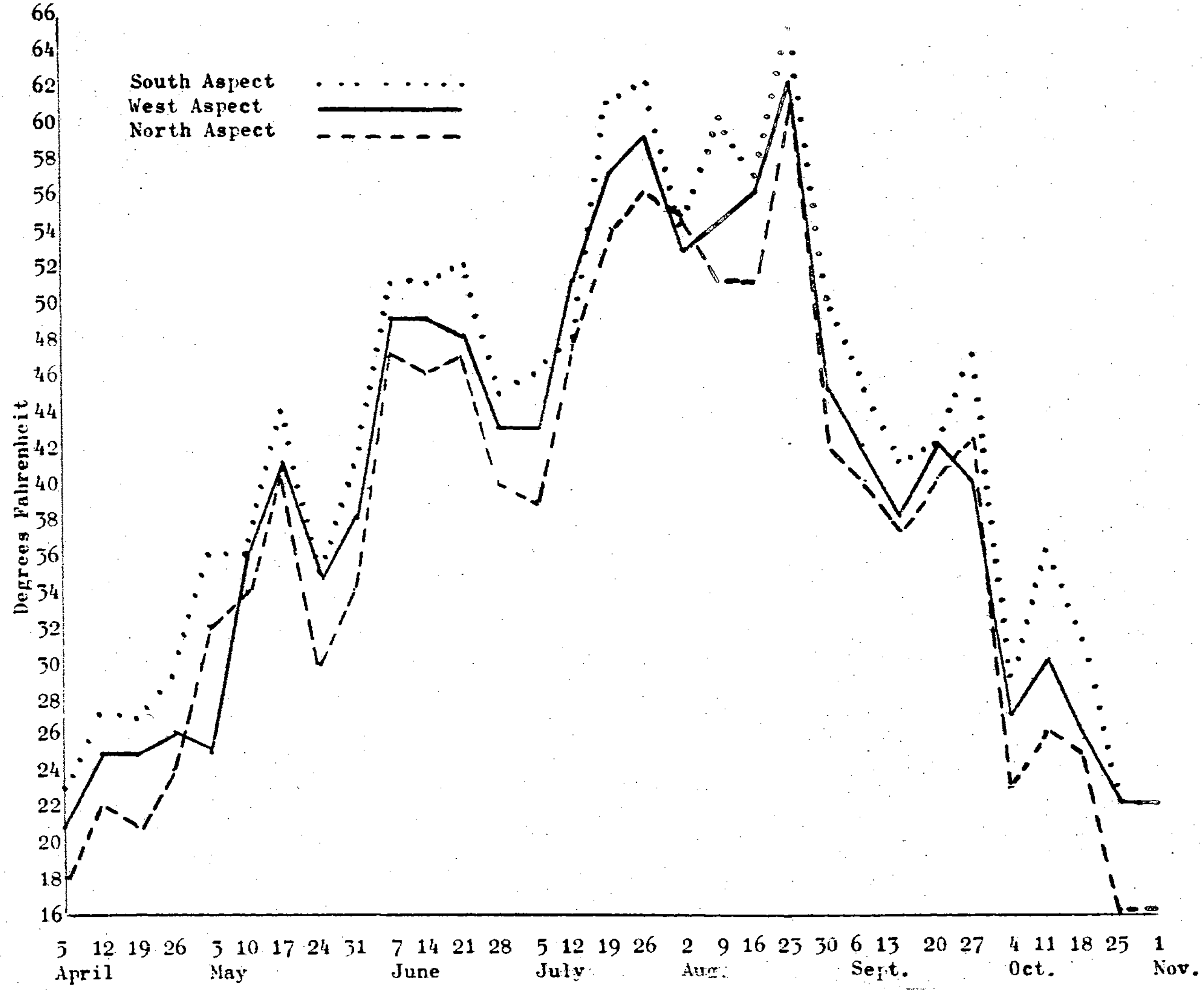

Figure 17. Minimum Air Temperatures

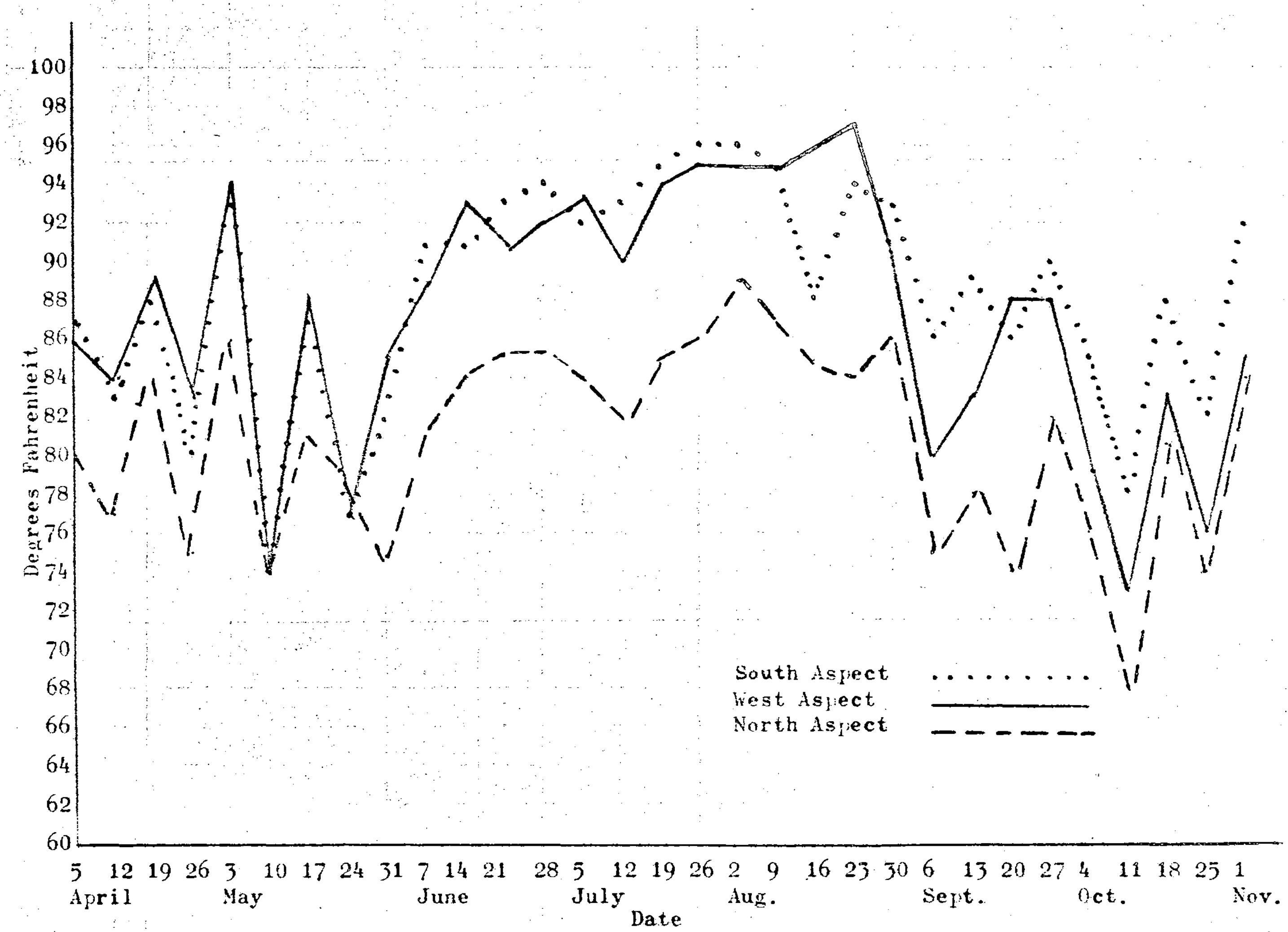

Figure 18. Maximum Air Temperatures

closely their respective counterpart in maximum and minimum air temperature. Minimum soil temperature on the south aspect was 47°F. recorded at the onset of the growing season. Fluctuations in highs and lows paralleled those of the air, all readings being approximately 20°F. higher than air temperatures for any respective date. Minimum soil temperatures increased constantly (with weekly fluctuations), coinciding with air temperatures, until late August at which time a downward trend was continuous to the end of the growing season (Figure 19).

Maximum soil temperatures, too, closely paralleled their counterpart in air temperature (Figure 20). Again, a close correlation was observed between the two but with only approximately ten degrees difference, the air temperature being higher. No extreme temperatures were recorded and no given temperature readings were observed over an extended period of time.

Percent of soil moisture at the 0-6 inch depth ranged from a low of 8% in mid-September to a high of 37% in late May (Figure 21). There appears to be some degree of correlation between percent of soil moisture and precipitation, especially in the later half of the growing season. The early part of the season shows some high readings for percent of moisture but little precipitation. This could be an error explainable only in terms of the collecting technique and the underlying bedrock. Soil samples could not be collected in the same place each time. This necessitated collecting in a variety of places on each aspect. Underlying bedrock and soil conditions may have favored water retention in some areas and not in others.

Soil moisture at the 6-12 inch depth is likewise somewhat inconsistent with precipitation values for the early half of the growing

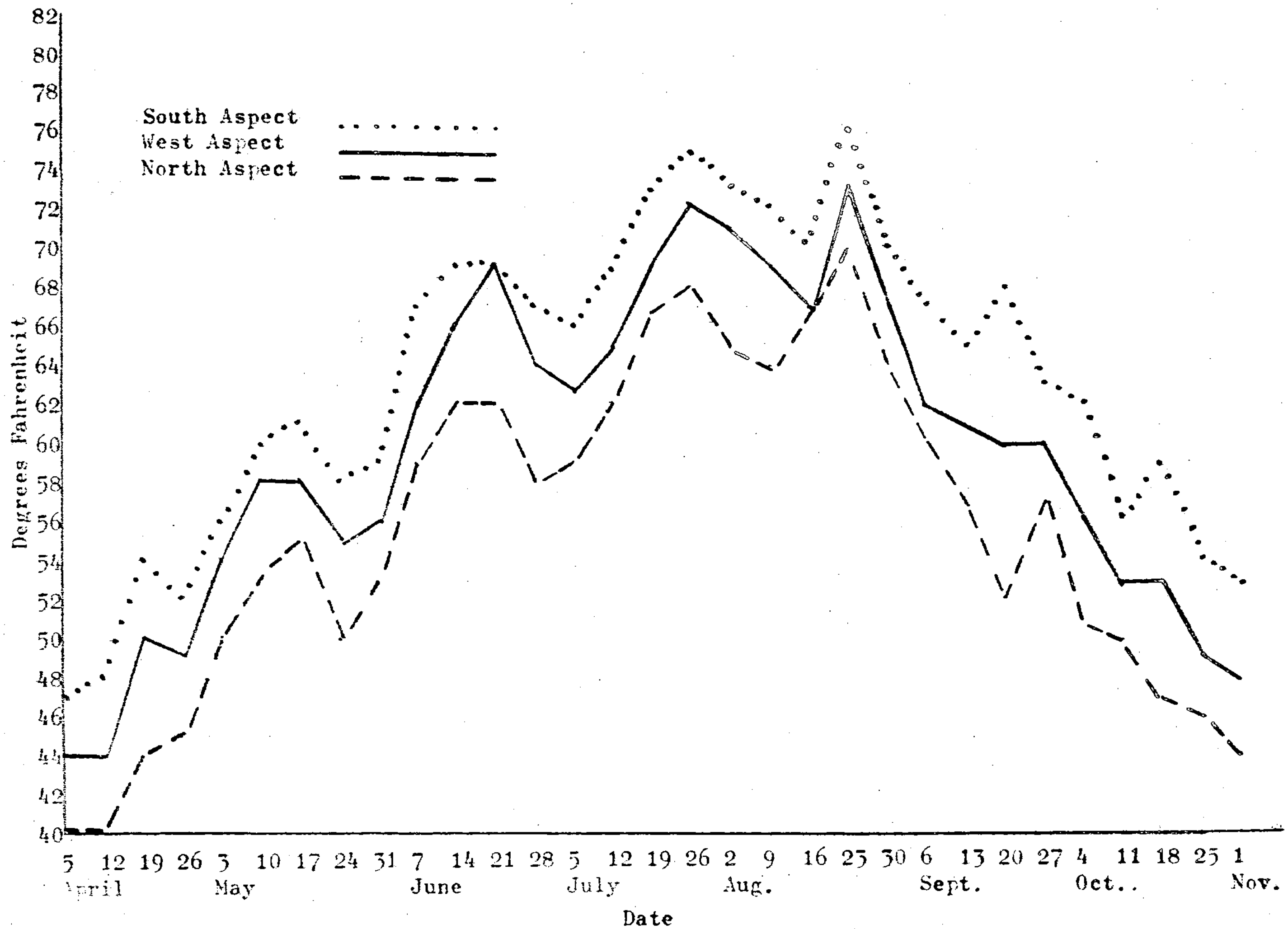

Figure 19. Minimum Soil Temperatures

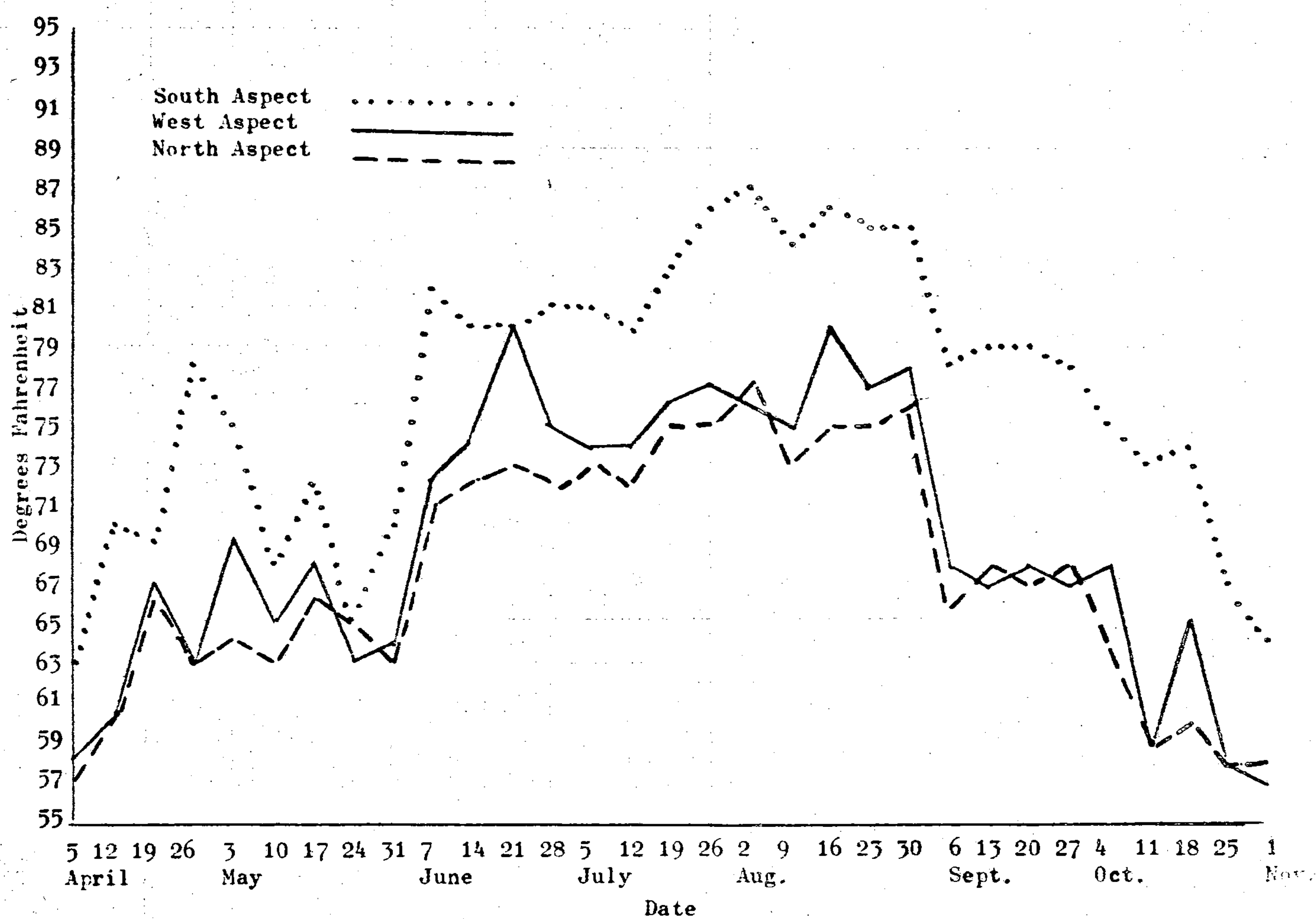

Figure 20. Maximum Soil Temperatures

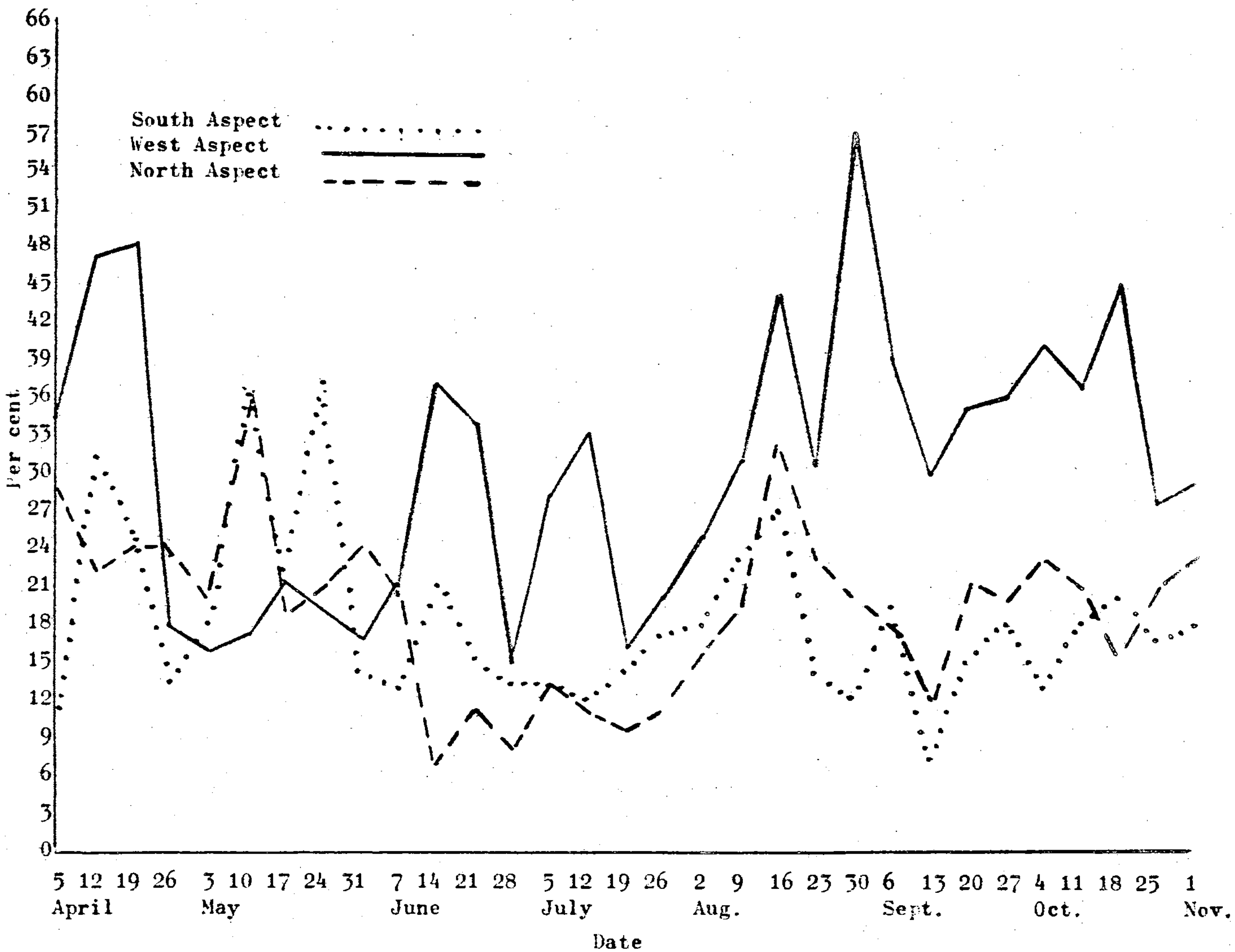

Figure 21. Percent of Soil Moisture at the 0-6 Inch Depth

season. A range of 12% to 49% was recorded (Figure 22). There seems to be some correlation between the percent soil moisture at the two levels with moisture at the 6-12 inch depth being almost always a higher percentage by an average of 8.5%.

The rate of evaporation as determined by use of the Livingston atmometers provided data which indicated a relatively high rate of evaporation early in the season (Figure 23). A reading of 130 ml of water evaporated the first week in April increased to 159 ml by mid-April, falling briefly in late April and then showing a significant rise in early May. This would be expected because of the lack of abundant moisture early in April and May. For the remainder of the season evaporation rates fluctuated between 45 ml and 85 ml with a significant rise to 98.8 ml on October 5 and another significant rise during late October. There was a very close negative correlation between precipitation and rate of evaporation throughout the growing season. Increased precipitation was consistently followed by a period of low evaporation. Negative correlation was also seen between relative humidity and evaporation rate. A striking correlation was obvious during early season. Relative humidity fluctuated rather widely and a corresponding negative effect was evident in the evaporation rate. After June 1, relative humidity seemed more stabilized at a rather high level (90-96% for upper limit). During this same period the rate of evaporation seemed more stable and at a lower level (40-80 ml).

Relative humidity seemed to be of primary importance in determining rate of evaporation. Air temperatures were not significant. Relatively low maximum air temperatures in early season occurred at a time of high evaporation. Consistantly high maximum air temperatures

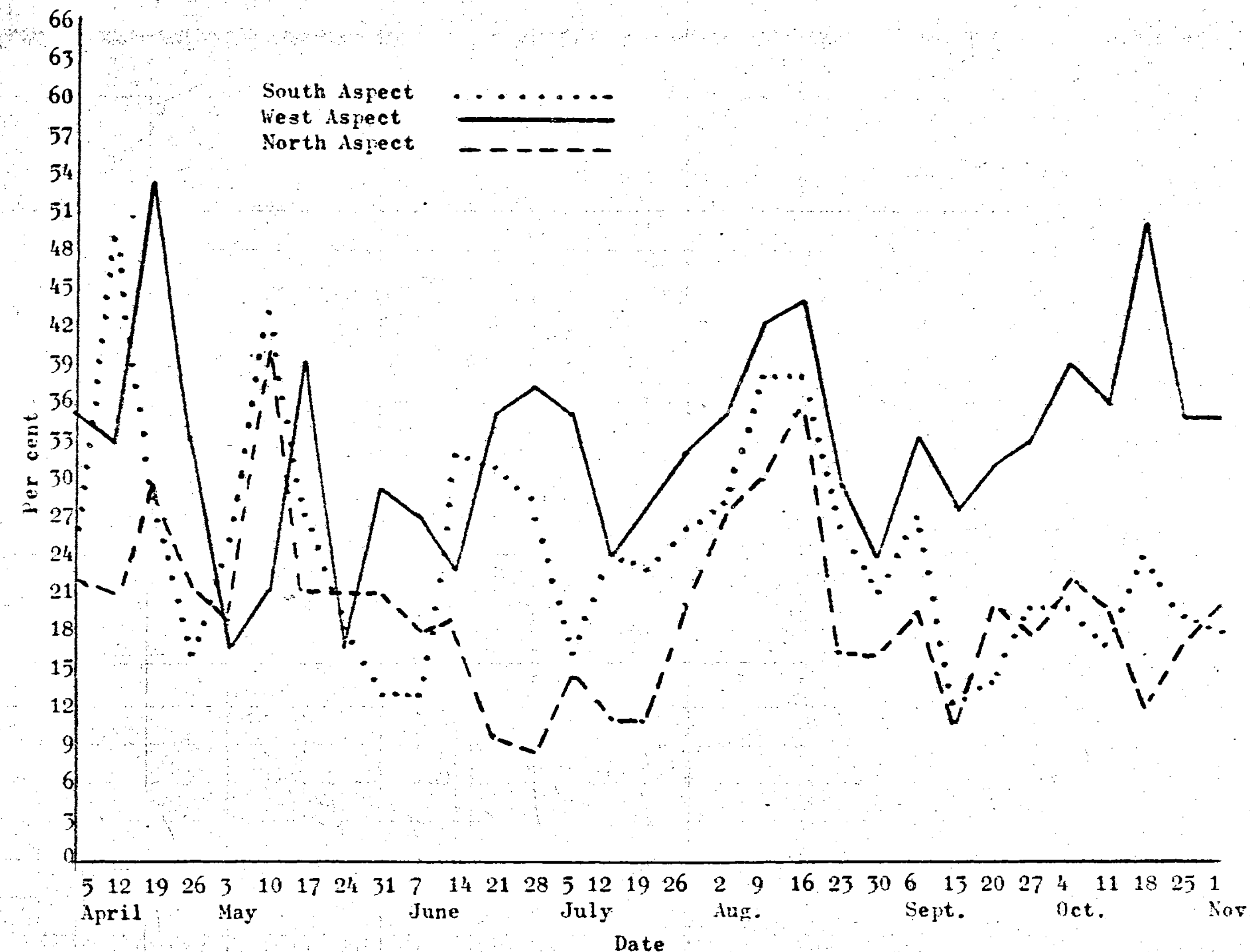

Figure 22. Percent of Soil Moisture at the 6-12 Inch Depth

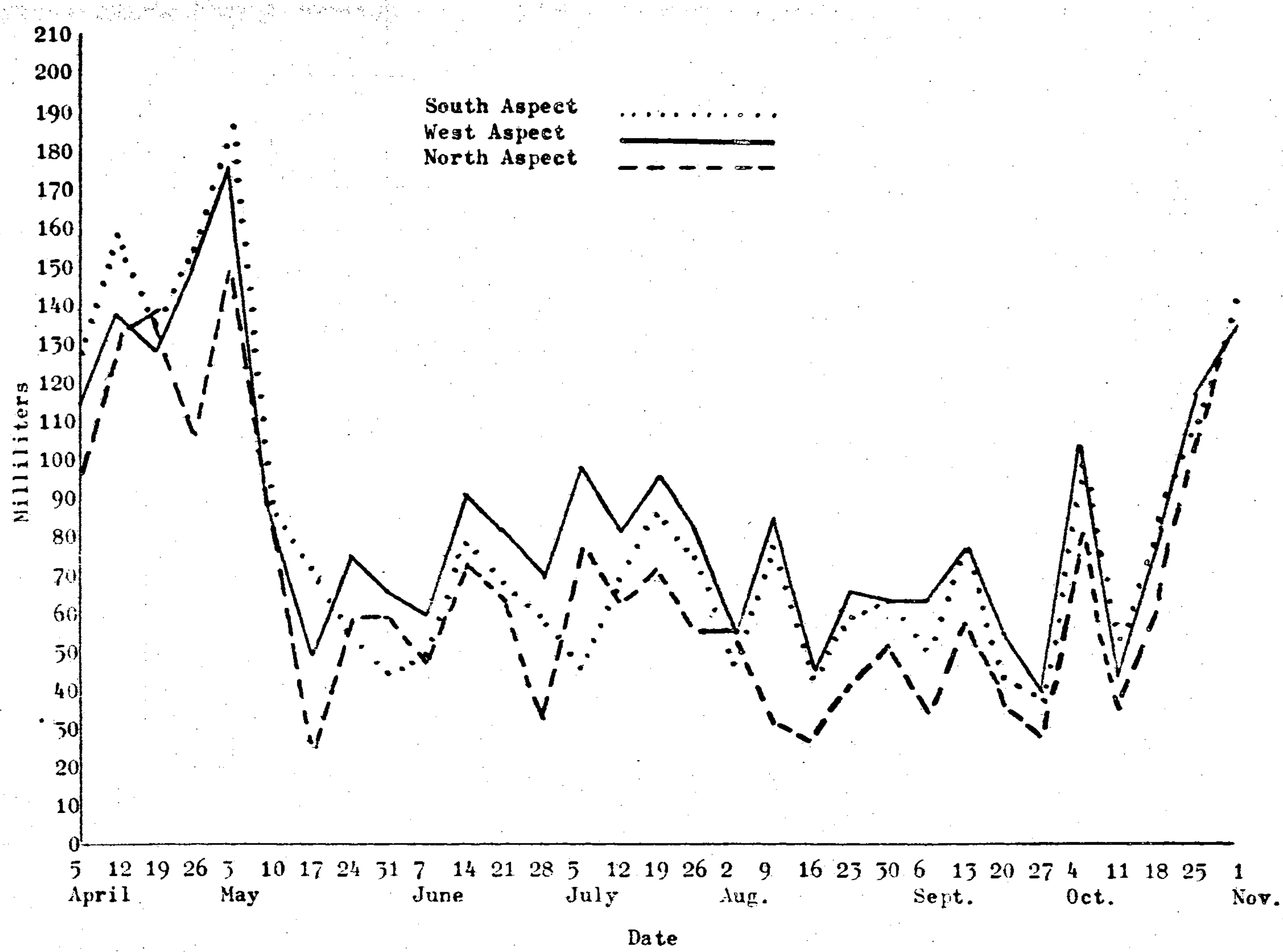

Figure 23. Weekly Rate of Evaporation From Livingston Atmometer Bulbs

of summer and fall coincide with a long period of minimal evaporation.

Just as correlation between plant communities on different aspects is valuable information, so also is the level of correlation between various microenvironmental factors on different sites. This information should aid in the attempt to recognize the parameters which, theoretically, comprise the limiting factors which control plant distribution.

Using the microclimatic data available from this study a coefficient (Table X) was calculated to compare the level of correlation between each of the parameters on the three aspects.

The level of correlation of microclimatic factors between the south and west aspects is generally high for all parameters. This is indicative of the similarity between the south and west aspects. Three exceptions are noted, one of which is the percent of moisture in the soil. This one factor is significantly contrary to all other data in that there is less correlation between south and west aspects than between any other two combinations. As mentioned previously, these unexpected results are thought to be due to topographic and/or edaphic conditions. Perhaps a concavity in the underlying bedrock acts as a vessel to collect and retain gravitational water whereas sloping underlying bedrock in adjacent areas tends to shed water.

Considering soil moisture at both collecting levels there is a relatively higher degree of correlation between south and north aspects and a low degree of correlation when either south or north aspect is correlated with the west aspect. This would tend to support the idea that soil moisture data from the west aspect is peculiar.

Another exception to the higher correlation between south and

TABLE X

CORRELATION COEFFICIENTS FOR ASPECTS
BASED UPON MICROCLIMATIC DATA

Microclimatic Parameter	Aspects Compared		
	west/north	south/west	south/north
Evaporation Rate	0.93437	0.94203	0.89229
Relative Humidity, Lower Limit	0.74563	0.93833	0.82328
Relative Humidity, Upper Limit	-0.08481	0.56569	0.11822
Average Minimum Air Temperature	0.97994	0.97803	0.98402
Average Maximum Air Temperature	0.78880	0.87744	0.81117
Average Minimum Soil Temperature	0.98226	0.98416	0.96415
Average Maximum Soil Temperature	0.95685	0.85920	0.87315
Percent Soil Moisture 0-6 Inches	0.34257	0.27546	0.42979
Percent Soil Moisture 6-12 Inches	0.16993	0.15306	0.44600

west aspects is the maximum soil temperature. Here the correlation coefficient of 0.95685, for west versus north, is substantially higher than that for the south versus west slopes (0.85920) which represents the lowest of the three possible combination. As is evident from the date (see Figure 20), north and west aspects revealed maximum soil temperatures which parallel one another and are considerably less than (approximately 8-10°F.) corresponding temperatures on the south exposure. Unusually high soil moisture, as noted previously, and its subsequent evaporation would provide a cooling effect which would account for this.

A third exception is noted in the minimum air temperature where the greater correlation is seen between north and south aspects, correlation coefficient 0.98402, and between west and north aspects (0.97994) than between south and west aspects (0.97803). The difference here is slight however, and is undoubtedly due to the more mesic conditions which prevail in the area of the recording station on the western aspect.

CHAPTER V

CONCLUSIONS

The Peckout Hollow area is dominated by three oaks, *Quercus alba*, *Quercus stellata* and *Quercus velutina*, each significant on a different aspect. Based on the density values of these three species, each aspect was significantly different at the 1% level. *Quercus velutina* was the dominant species on the south aspect whereas *Quercus alba* was dominant on the north. *Quercus stellata*, dominant on the west aspect, ranked second in importance value on the south and was insignificant on the north.

General trends in the data indicate that *Quercus stellata* is a more drought resistant species. Records of microclimate, measured at somewhat representative sites on each aspect, indicate the west aspect to be a more xeric area. *Quercus velutina* seemed to prefer the somewhat xeric-mesic conditions of the south aspect. Microclimatic conditions here were generally not as severe as the west aspect. *Quercus velutina*, dominant on the south, i. v. 95, decreased on the west and was found to be more abundant on the north aspect than on the west. The north slope, a much more mesic area as indicated by microclimatic records, was dominated by *Quercus alba*, i. v. 97. As previously mentioned, *Quercus velutina* was relatively abundant on the north with an i. v. of 46. In addition, *Cornus florida*, i. v. 52, and *Quercus rubra*, i. v. 38, absent or very insignificant on the other aspects, were relatively abundant on the north. This would tend to indicate their preference for mesic areas.

Using understory species as indicators, it would appear that no succession is occurring as generally the dominants of the overstory were also abundant as understory saplings. Of course many other understory species were present in significant numbers. The application of the Pichi-Sermolli (1948) index for maturity indicated this region to be an immature stand.

Although plant species are probably the best indicators of long term environmental conditions, data on microclimatic factors collected on each aspect verifies what is implied from the vegetational analysis.

Soils and underlying bedrock undoubtedly play an important part in that they serve as the matrix in which plants grow. Depth, texture, and composition of the soils exerts an influence upon plant growth. This influence has been indirectly observed in this study. Very shallow Gasconade soils on parts of the west aspect result in very xeric conditions. A shelf of bedrock under deeper Gasconade soil on the north edge of the west aspect holds moisture near the surface. Clarksville and Fullerton soils are generally deeper and support a more intense plant population, especially on the more mesic northern aspect.

Each species of plant exists within a range of tolerance to a complex of factors which constitute the edaphic and climatic environment. The limits, which may be very sharp, determine the distribution of the species. To determine the precise limits of tolerance would require very sensitive and accurate equipment. Only general trends and approximate limits can be detected from this study.

CHAPTER VI

SUMMARY

This study was undertaken to analyze a limited ecosite in Christian County, Missouri (Peckout Hollow) from vegetational, microclimatological, and edaphic points of view. The following results and conclusions were drawn from data collected during the tenure of this project.

1. Peckout Hollow is an area set aside by the Forestry Department as an outdoor laboratory. It includes the termination of Flyblow Ridge which presents three contrasting aspects--south, west and north. The intensity and duration of sunlight on the landscape influences the ecosystem, consequently, the topographic position is significant in respect to the biota it supports.
2. Microclimatic recording stations were established at representative sites on each aspect. Records of climatic conditions were collected over a period of two years. Those for the growing season of 1968 are included herein. Considered in general, these records coincide with long term records of the U. S. Weather Bureau. In addition, they indicate some degree of difference between the three aspects. These differences influence the flora of the area.
3. Quercus alba, Quercus stellata and Quercus velutina dominate the study area. Each species was dominant on a different aspect--

Quercus alba on the north, Quercus stellata on the west and Quercus velutin on the south.

4. Understory species indicate, generally, an abundance of the dominant overstory species, hence, succession in this area is probably not occurring.
5. A relatively large number of different species constituting the understory would indicate this region to be an immature stand of oaks. Understory species, generally, had a low density per species.
6. Soils and underlying bedrock undoubtedly play an important part in supporting a particular stand of trees. Their influence may be indirect and many times very obscure.
7. The three aspects of Peckout Hollow can be divided into two (or possibly three) regions based on the dominant plant species in each: A rather xeric-mesic south aspect, a very mesic north aspect, and, the possible third, a xeric west aspect. The west slope is actually a transition area. At the southern limit it is much like the south and of course the northern limit is very similar to the north aspect. At its mid-point the west aspect is uniquely different from the other two and presents a definite xeric area as a result of very shallow soils and intense solar radiation.

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VITA

Lawrence N. Stauffer

Candidate for the Degree of

Doctor of Education

Thesis: A PHYTOSOCIOLOGICAL AND MICROCLIMATOLOGICAL ANALYSIS OF A SELECT ECOSITE IN CHRISTIAN COUNTY, MISSOURI

Major Field: Higher Education

Biographical

Personal Data: Born in Cherokee, Oklahoma, December 11, 1930, the son of Leslie L. and Hazel Stauffer.

Education: Graduated from Cherokee High School, Cherokee, Oklahoma in 1948; attended Northwestern State College, Alva, Oklahoma from 1948 to 1952; received the Bachelor of Science degree, 1952; received the Master of Science degree from Oklahoma State University, Stillwater, Oklahoma in 1961; completed requirements for the Doctor of Education degree at Oklahoma State University in 1969.

Professional Experience: Employed as a science teacher in Holcomb, Kansas from 1955 to 1958, Valley Falls, Kansas from 1958 to 1960, Eldorado, Kansas from 1961 to 1962, Wichita, Kansas from 1962 to 1963; received appointment of and served in capacity of Assistant Professor of Biology at Drury College, Springfield, Missouri from 1963 to the present.

Professional Organizations: Member of the Botanical Society of America, American Association for the Advancement of Science, Missouri Academy of Science, and Phi Delta Kappa.