AN ECOLOGICAL AND TAXONOMIC STUDY OF THE JUGLANDACEAE ON THE NORTHWESTERN HIGHLAND RIM

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AN ECOLOGICAL AND TAXONOMIC STUDY OF THE JUGLANDACEAE ON THE NORTHWESTERN HIGHLAND RIM

An Abstract

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Louis Joseph Schibig

August 1972

ABSTRACT

An ecological and taxonomic study was made of Juglandaceae on the northwestern Highland Rim of Tennessee. Nine hickory and two walnut species and one variety were collected from the area: Carya carolinae-septentrionalis, C. cordiformis, C. glabra, C. illinoensis, C. laciniosa, C. ovalis var. ovalis, C. ovalis var. obcordata, C. ovata, C. pallida, C. tomentosa, Juglans cinerea, and J. nigra. Habitat affinities, species associations, and taxonomic status of these taxa are discussed. Three range extensions are noted, and a key to Juglandaceae of the area is supplied.

On the northwestern Highland Rim, vegetational analyses were made of seven forest communities which were predetermined on the basis of field observations. A name was assigned to each community based on its three component species with the greatest importance values. Community types delimited were the following:

1. Red Cedar-White Ash-Chinkapin Oak forests on limestone bluffs
2. Chestnut Oak-White Oak-Post Oak forests of ridges
3. White Oak-Black Oak-Post Oak forests on slopes with southern exposure
4. American Beech-Tulip Poplar-White Oak forests on slopes with northern exposure
5. Red Elm-Tulip Poplar-American Beech forests of ravines

6. Box Elder-Silver Maple-Sycamore forests of streambanks and alluvial bottomlands
7. Black Gum-Sweet Gum-Red Maple forests of upland flatlands

These communities were compared with those delimited by Duncan and Ellis (1969), and I found their communities to be approximately the same as those recognized by me, but certain discrepancies were noted.

Through random pairs sampling, I found 62 tree species in the area. Importance values of each species for the various communities were determined.

The four major genera, in overall importance, were *Acer*, *Carya*, *Quercus* and *Ulmus*. Generic representation and cumulative importance values for each of these were determined.

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August 1972

To the Graduate Council:

I am submitting herewith a Thesis written by Louis Joseph Schibig entitled "An Ecological and Taxonomic Study of the Juglandaceae on the Northwestern Highland Rim." I recommend that it be accepted in partial fulfillment of the requirements for the degree Master of Science, with a major in Biology.

Edward W. Chester
Major Professor

We have read this thesis and recommend its acceptance:

Floyd L. Brown
Second Committee Member

David Snyder
Third Committee Member

Accepted for the Council

Wayne E. Stamper
Dean of the Graduate School

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CHAPTER I

INTRODUCTION

Preliminary reconnaissance of mature forest stands on the northwestern Highland Rim revealed a mosaic of forest communities which appeared to be correlated with topographic variations. For example, ravine vegetation appeared greatly different from xeric ridge vegetation, qualitatively and quantitatively. Likewise, the flora of south-facing slopes contrasted markedly with the flora of north-facing slopes. Other topographic areas seeming to have fairly distinct floras were limestone bluffs, poorly drained upland flat-lands, and streambanks.

It was apparent that the Juglandaceae and Fagaceae were well represented in practically all forest stands. This investigation was concerned largely with the Juglandaceae.

Objectives of the Study

The primary objectives were to (1) ascertain which species of Juglandaceae inhabit the northwestern Highland Rim, (2) determine their relative importance in the various community types, (3) construct a key for the indigenous taxa of Juglandaceae, and (4) delimit the dominant and characteristic tree species of each topography-related community type.

Review of the Literature

Braun (1950) described the Highland Rim forests in a general way. She considered this area as being within the Mississippian Plateau Section of the Western Mesophytic Forest Association, Deciduous Forest Formation. Braun described the vegetation of this association as being transitional between the Mixed Mesophytic Association to the east and the Oak-Hickory Association to the west. She also pointed out that variations in topography accounted for variable forest types.

Kuchler (1964) described the original vegetation of the northwestern Highland Rim as chiefly an oak-hickory forest with prairie elements in northern portions. The Society of American Foresters (1967) classified the present forests of this area as being mostly oak while Nelson and Zillgitt (1969) described them as oak-hickory.

Very few vegetational studies of the forests of the northwestern Highland Rim have been undertaken. The most significant was that of Duncan and Ellis (1969) which provided quantitative information for numerous tree species for all of Montgomery County, Tennessee. Though quantitative analyses of specific topographic situations were not attempted by them, some community delimitations were made on the basis of field observations.

Frick (1939) conducted an ecological study of the vegetation on the slopes of the northwestern portion of the Nashville Basin which borders the Highland Rim. Plant communities were analyzed in various successional stages, and the vegetation was correlated with environmental factors.

Shanks (1958), in his study of the floristic regions of Tennessee, noted certain dominant species of this area, and Clebsch (1957) compiled a checklist of the woody flora for Montgomery County. Brook (1969) conducted a floristic survey of the woody flora of Stewart State Forest.

Keys for the vascular flora of Montgomery County were constructed by Scott (1967) and Yarbrough (1966). The latter listed Juglans nigra L. as the only walnut species for this County, and only six species of Carya were described.

Manning (1950) constructed an excellent key for the hickories north of Virginia and discussed the problematical taxa Carya glabra (Mill.) Sweet and C. ovalis (Wang.) Sarg. in some detail. Though he noted that many good botanists thought that C. ovalis should be considered a variety of C. glabra, he contended that C. ovalis should be maintained as a distinct species.

Little (1969) presented arguments for reducing C. ovalis to the variety, C. glabra (Mill.) Sweet var. odorata (Marsh.) Little. Also, he reduced C. carolinae-septentrionalis (Ashe) Engl. and Graebn. to C. ovata (Mill.) K. Koch var. australis (Ashe) Little. Stone et al. (1969) stated that these two were almost identical morphologically.

Hardin (1952) prepared a key with descriptions and ranges of species of Juglandaceae of Tennessee. Two species of walnuts and 11 species of hickories were listed as native to the state. He also pointed out that long and careful field studies of many species of Carya were needed for a complete understanding of the Tennessee populations.

Study Area

Collection of specimens, field observations, and sampling were undertaken mostly in Montgomery and Stewart Counties, Tennessee. Physiographically, these counties constitute the nucleus of the northwestern Highland Rim which Fenneman (1938) placed within the Interior Low Plateau. For purposes of this study, the boundaries of the northwestern Highland Rim are the Dripping Springs Escarpment on the north, the Central Basin on the east, the Tennessee River on the west, and the northern boundaries of Houston and Dickson Counties, Tennessee on the south.

Topographically, the area is characterized by dissected uplands, upland flatlands, and bottomlands. The uplands consist of rolling ridges, ravines, and bordering slopes. The elevation varies between 300 and 500 feet in Stewart County (U. S. Dept. of Interior, 1970) and averages about 500 feet in Montgomery County (Killebrew, 1874). The area is drained by the Tennessee River, the Cumberland River, the Red River, and numerous smaller streams. Detailed descriptions of the rock formations, soils, and climate may be found in papers by Scott and Snyder (1968) and Duncan and Ellis (1969).

CHAPTER II

METHODS AND MATERIALS

My investigation consisted of four basic operations: (1) field observations of forests of the area, noting species composition and giving special attention to *Carya* and *Juglans*; (2) collection of hickory and walnut specimens from various points throughout the study area; (3) study of *Carya* and *Juglans* specimens from the herbaria of Austin Peay State University, University of Tennessee, Vanderbilt University, and Western Kentucky University; (4) random pairs sampling of trees on limestone bluffs, xeric ridges, slopes with mostly southern exposure, slopes with mostly northern exposure, ravines, upland flatlands, and streambanks.

I observed that on each topographic area, certain tree species dominated, and certain other species were not dominant, but exhibited great fidelity for certain areas. Such observations indicated that composition of forest communities was correlated with topography, and this prompted vegetational analyses of the seven major topographic situations. Particular subjective notations were made of the habitat affinities, relative abundance, and morphological features of hickory and walnut species.

Numerous hickory and walnut specimens were collected in the late summer and autumn (an opportune time for collection of leaf, twig, and fruit specimens) of 1971. Manning

(1950) noted that the best characters for identifying the hickories were the mature fruit, winter terminal bud, mature leaves, and bark of the trunk, and that these were best represented on fruiting trees in the fall. He added that availability of all these characters made possible the definite identification of all the hickories. I used standard pressing and drying equipment, and the collected specimens are to be deposited in the Austin Peay State University Herbarium.

Observations and citations were made of walnut and hickory specimens at various universities, thus familiarizing me with the morphological variability of the taxa of the Juglandaceae and allowing me to recognize those characters which were the most constant and reliable. Perusal of these specimens indicated the intensity and areas of collection. An annotated list of Juglandaceae is included in Appendix I.

Vegetational studies were conducted on the seven topographic areas previously discussed. From each, four representative stands were selected for sampling. Each stand was (1) at least five acres in size, (2) not recently disturbed by fire, lumbering, or pasturing, and (3) mature or near maturity. The random pairs plotless sampling method as described by Phillips (1959) was used. Cottam and Curtis (1949), in their studies of oak-hickory forests, had found that this method was a rapid and accurate means of obtaining frequency, density, and dominance values for tree species. Only trees having a diameter breast height (dbh) of 10.2 cm or greater were included in the sampling. A total of one hundred pairs (25 pairs per stand) was sampled for each of the topographic areas, and the dbh of each sampled tree was recorded. Species area curves indicated that this sample size was adequate (curves for all 28 stands are provided in Appendix III). Equipment used in sampling consisted of a compass, dbh tape, linear tape measure, and recording materials. Detailed descriptions of sampling technique, stand conditions, and locations are supplied in Appendix II of this paper.

Relative density, relative frequency, and relative dominance were calculated for each species. An importance value index (IVI) was obtained by adding these relative values. The IVI was devised by Curtis and McIntosh (1951) who claimed it to be an excellent indication of the vegetative importance of a species within a stand. Community coefficients were derived from the frequency data, and used to ascertain the degree of similarity between the community types, by a method developed by Kulcynski (1927) and described by Oosting (1956).

A number of books were utilized in identifying the taxa of the Juglandaceae. Some which were especially valuable were those by Fernald (1950), Gleason (1952), Harlow and Harrar (1958), Sargent (1957), Steyermark (1963), and Braun (1950).

CHAPTER III

RESULTS

Table I presents importance values for all tree species sampled and reveals the dominant species for each of the topographic areas. Each topography-related community type has been named according to the three most significant species (those with the greatest IV). The recognized communities were the following:

1. Red Cedar-White Ash-Chinkapin Oak forests of limestone bluffs
2. Chestnut Oak-White Oak-Post Oak forests of xeric ridges
3. White Oak-Black Oak-Post Oak forests on slopes with southern exposure
4. American Beech-Tulip Poplar-White Oak forests on slopes with northern exposure
5. Red Elm-Tulip Poplar-American Beech forests of ravines
6. Box Elder-Silver Maple-Sycamore forests on streambanks and flood plains
7. Black Gum-Sweet Gum-Red Maple forests of upland flatlands.

Species exhibiting great fidelity (restriction to a community) and constance (number of stands of a community type in which a species is found) are very useful in characterizing communities. For example, Juniperus virginiana exhibited the greatest fidelity and constance for limestone bluffs,

TABLE I. Importance Values of the Tree Species[1] Encountered in Each of the Seven Recognized Topographic Areas[2]

Species	Communities and Importance Values						
	LB	XR	SFS	NFS	R	UF	SB
Acer Negundo L.					10.9		65.2
A. nigrum Michx. f.				1.7			
A. rubrum L.				1.1	4.4	42.5	
A. saccharinum L.							53.1
A. saccharum Marsh.	9.0	4.2	26.3	22.2	10.1	3.9	
Ailanthus altissima (Mill.) Swingle					6.7		
Asimina triloba (L.) Dunal					1.2		
Betula nigra L.							1.2
Carpinus caroliniana Walt.				1.1	9.4	6.1	
Carya cordiformis (Wang.) K. Koch				7.2	9.8		13.7
C. glabra (Mill.) Sweet		28.8	11.0	7.1		7.4	
C. laciniosa (Michx.) Loud.			1.3		8.5		2.4
C. ovalis (Wang.) Sarg.			12.7	17.3	9.5		
C. ovata (Mill.) K. Koch	9.0	1.9	7.6	3.0	6.5	2.5	
C. tomentosa Nutt.		10.2	20.2	6.7	1.6		
Celtis laevigata Willd.					9.7		5.5
C. occidentalis L.	1.7				1.3	4.1	16.9

1. Taxonomy follows Fernald (1950).
2. Abbreviations as follow: LB = limestone bluffs, XR = xeric ridges, SFS = southerly facing slopes, NFS = northerly facing slopes, R = ravines, UF = upland flatlands, SB = streambanks.

TABLE I. (continued)

Species	Communities and Importance Values						
	LB	XR	SFS	NFS	R	UF	SB
Cercis canadensis L.	1.2			1.1	1.3		
Cornus florida L.	5.3	1.2	2.4	7.3	1.2	3.6	
Diospyros virginiana L.						3.1	
Fagus grandifolia Ehrh.			2.0	56.0	23.8	2.4	
Fraxinus americana L.	37.9		2.1	1.1	1.2		
F. pennsylvanica Marsh.				3.9		5.1	4.4
Gleditsia triacanthos L.	1.6				1.4		10.2
Juglans cinerea L.					1.9		1.4
J. nigra L.			1.3	2.9	13.9		8.9
Juniperus virginiana L.	125.7						
Liquidambar Styraciflua L.	2.0			2.3	9.3	62.5	
Liriodendron Tulipifera L.				27.6	29.3	2.3	
Maclura pomifera (Raf.) Schneid.	9.1						1.6
Morus alba L.							1.2
M. rubra L.					1.2	1.2	3.9
Nyssa sylvatica Marsh.		10.0	9.1	19.3	3.7	87.8	
Ostrya virginiana (Mill.) K. Koch	7.9		2.5	6.4			
Oxydendrum arboreum (L.) DC.		13.1	1.2				
Platanus occidentalis L.					20.9	5.2	38.7
Populus deltoides Marsh.					9.3		18.9
Prunus serotina Ehrh.	7.8			8.7	8.1		1.3
Quercus alba L.	1.7	50.1	81.3	24.8	13.8	3.6	
Q. coccinea Muencch.		19.3	1.6				
Q. falcata var. falcata Michx.	1.3		10.5	3.2		1.8	
Q. falcata var. pagodaefolia Ell.				9.3	2.1	1.2	

TABLE I. (continued)

Species	LB	XR	SFS	NFS	R	UF	SB
	Communities and Importance Values						
Quercus cf. fontana Laughlin		8.0	1.6				
Q. imbricaria Michx.				1.3	1.3		1.4
Q. lyrata Walt.						1.8	
Q. macrocarpa Michx.							1.2
Q. marilandica Muenchh.		20.6	1.3				
Q. Michauxii Nutt.				1.5			1.5
Q. Muehlenbergii Engelm.	29.1		4.9	3.4	2.7		
Q. palustris Muenchh.						3.2	
Q. Phellos L.						7.8	
Q. Prinus L.		77.3					
Q. rubra L.	13.6	1.8	3.8	12.1	6.3		2.3
Q. Shumardii var. Shumardii Buckl.			1.5				
Q. Shumardii var. Schneckii (Britt.) Sarg.	3.2				5.2		4.8
Q. stellata Wang.		40.3	30.3	1.2			
Q. velutina Lam.		13.3	59.4	23.2		13.3	
Salix nigra Marsh.							6.8
Sassafras albidum (Nutt.) Nees.			2.5	10.0	1.2		
Ulmus alata Michx.	28.8		3.1	1.3		4.6	
U. americana L.			2.1			1.7	
U. rubra Muhl.	4.1			6.0	55.4	15.1	33.8
U. spp.[3]						6.4	

3. Either *Ulmus alata* Michx., *U. serotina* Sarg., or *U. Thomasi* Sarg.

being found on all four bluffs sampled, but absent from all other sampled stands (Table II). Carya ovata, however, was more widespread, being found in six of the seven community types.

Relative density, relative dominance, relative frequency, and importance values are given for each of the ten most important species for each community in Tables III through IX.

Table X shows the amount of similarity between the communities by use of community coefficients as described by Oosting (1956). If two communities were completely similar in species compostion, the coefficient of similarity would be 100, and if two communities were totally dissimilar the coefficient would be 0. This study revealed that xeric ridges and southerly-facing slopes were the most similar having a coefficient of 49.0. The two most different communities were xeric ridges and streambanks, with a coefficient of 0.6.

Cumulative importance values for the major genera are provided in Figure 1. Seventeen species of Quercus, six species of Carya, five species of Acer, and three species of Ulmus were encountered in the sampling. Through sampling, 31 species were found which represented these genera, and this accounted for one half the total species diversity encountered. Species diversity of each of these genera in the various community types is illustrated by Figure 2.

On the northwestern Highland Rim the Juglandaceae was represented by nine species and one variety of Carya and two species of Juglans.

TABLE II. Constancy and Number of Stems[1] of the Tree Species Encountered in Each and All of the Seven Recognized Topographic Areas

	Communities[2]							
Species	LB	XR	SFS	NFS	R	UF	SB	ALL
Acer Negundo					1(9)		4(48)	5(57)
A. nigrum				1(1)				1(1)
A. rubrum				1(1)	1(3)	4(27)		6(31)
A. saccharinum							3(27)	3(27)
A. saccharum	2(6)	1(3)	1(20)	3(16)	2(8)	1(3)		10(56)
Ailanthus altissima					2(5)			2(5)
Asimina triloba					1(1)			1(1)
Betula nigra							1(1)	1(1)
Carpinus caroliniana				1(1)	2(8)	2(5)		5(14)
Carya cordiformis				2(4)	3(7)		2(10)	7(21)
C. glabra		4(24)	4(9)	3(4)		1(6)		12(43)
C. laciniosa			1(1)		1(3)		1(2)	3(6)
C. ovalis			2(11)	1(6)	1(7)			4(34)
C. ovata	1(5)	1(1)	1(6)	1(2)	2(4)	1(2)		7(20)
C. tomentosa		1(8)	4(16)	1(4)	1(1)			7(29)
Celtis laevigata					3(6)		3(5)	6(11)
C. occidentalis	1(1)				1(1)	3(3)	3(13)	8(18)
Cercis canadensis	1(1)			1(1)	1(1)			3(3)
Cornus florida	2(4)	1(1)	2(2)	1(6)	1(1)	2(3)		9(17)
Diospyros virginiana						1(3)		1(3)

1. Number of stems parenthetically enclosed.
2. Abbreviations as in Table I.

TABLE II. (continued)

Species	Communities LB	XR	SFS	NFS	R	UF	SB	ALL
Fagus grandifolia			1(1)	2(29)	1(15)	1(1)		5(46)
Fraxinus americana	3(26)		1(1)	1(1)	1(1)			6(29)
Fraxinus pennsylvanica				2(2)		2(4)	2(4)	6(10)
Gleditsia triacanthos	1(1)				1(1)		3(7)	5(9)
Juglans cinerea					1(1)		1(1)	2(2)
J. nigra			1(1)	2(2)	3(9)		3(6)	9(18)
Juniperus virginiana	4(90)							4(90)
Liquidambar Styraciflua	1(2)			1(2)	1(2)	4(37)		7(43)
Liriodendron Tulipifera				4(19)	3(22)	1(2)		8(43)
Maclura pomifera	3(6)						1(1)	4(7)
Morus alba							1(1)	1(1)
M. rubra					1(1)	1(1)	2(3)	4(5)
Nyssa sylvatica		2(8)	2(8)	3(13)	1(3)	4(64)		12(96)
Ostrya virginiana	3(6)		1(2)	1(6)				5(14)
Oxydendrum arboreum		3(11)	1(1)					4(12)
Platanus occidentalis					3(14)	1(3)	3(24)	7(41)
Populus deltoides					2(3)		2(8)	4(11)
Prunus serotina	1(6)			1(8)	3(7)		1(1)	6(22)
Quercus alba	1(1)	4(32)	4(43)	4(17)	1(11)	1(2)		15(106)
Q. coccinea		3(12)	1(1)					4(13)
Q. falcata var. falcata	1(1)		2(6)	2(2)		1(1)		6(10)
Q. falcata var. pagodaefolia				1(6)	1(1)	1(1)		3(8)
Q. fontana		2(5)	1(1)					3(6)

TABLE II. (continued)

Species	LB	XR	SFS	NFS	R	UF	SB	ALL
	Communities							
Quercus imbricaria				1(1)	1(1)		1(1)	3(3)
Q. lyrata						1(1)		1(1)
Q. macrocarpa							1(1)	1(1)
Q. marilandica		3(15)	1(1)					4(16)
Q. Michauxii				1(1)			1(1)	2(2)
Q. Muehlenbergii	3(18)		1(4)	1(1)	1(2)			6(25)
Q. palustris						1(2)		1(2)
Q. Phellos						2(3)		2(3)
Q. Prinus		3(44)						3(44)
Q. rubra	2(6)	1(1)	2(2)	4(8)	1(4)		1(2)	11(23)
Q. Shumardii var. Shumardii			1(1)					1(1)
Q. Shumardii var. Schneckii	1(1)				1(1)		1(3)	3(5)
Q. stellata		3(29)	3(21)	1(1)				7(51)
Q. velutina		3(6)	3(38)	2(12)		1(6)		9(66)
Salix nigra							2(5)	2(5)
Sassafras albidum			1(2)	1(7)	1(1)			3(10)
Ulmus alata	2(16)			1(1)	1(2)	1(4)		5(23)
U. americana			1(1)			1(1)		2(2)
U. rubra	1(3)			2(5)	4(33)	2(11)	4(25)	13(77)
U. spp.						2(4)		2(4)

TABLE III. Density, Dominance, Frequency and Importance (IV) of Tree Species on Limestone Bluffs

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Juniperus virginiana	45.0	43.2	37.5	125.7
Fraxinus americana	13.0	11.1	13.8	37.9
Quercus Muehlenbergii	9.0	10.1	10.0	29.1
Celtis occidentalis	8.0	11.4	9.4	28.8
Quercus rubra	3.0	6.8	3.8	13.6
Maclura pomifera	3.0	3.0	3.1	9.1
Carya ovata	2.5	3.4	3.1	9.0
Acer saccharum	3.0	2.2	3.8	9.0
Ostrya virginiana	3.0	1.1	3.8	7.9
Prunus serotina	3.0	1.7	3.1	7.8
Other 9 spp.	7.5	6.0	8.6	22.1

TABLE IV. Density, Dominance, Frequency and Importance (IV) of Tree Species on Xeric Ridges

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Quercus Prinus	22.0	34.6	20.7	77.3
Q. alba	16.0	17.5	16.6	50.1
Q. stellata	14.5	12.2	13.6	40.3
Carya glabra	12.0	5.0	11.8	28.8
Quercus marilandica	7.5	6.0	7.1	20.6
Q. coccinea	6.0	7.4	5.9	19.3
Q. velutina	3.0	6.7	3.6	13.3
Oxydendrum arboreum	5.5	1.7	5.9	13.1
Carya tomentosa	4.0	2.1	4.1	10.2
Nyssa sylvatica	4.0	1.9	4.1	10.0
Other 5 spp.	5.5	5.0	6.6	17.1

TABLE V. Density, Dominance, Frequency and Importance (IV) of Tree Species on Southerly-Facing Slopes

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Quercus alba	21.5	39.5	20.3	81.3
Q. velutina	19.0	21.2	19.2	59.4
Q. stellata	10.5	9.3	10.5	30.3
Acer saccharum	10.0	6.4	9.9	26.3
Carya tomentosa	8.0	4.6	7.6	20.2
C. ovalis	5.5	2.0	5.2	12.7
C. glabra	4.5	2.4	4.1	11.0
Quercus falcata var. falcata	3.0	4.0	3.5	10.5
Nyssa sylvatica	4.0	1.0	4.1	9.1
Carya ovata	3.0	1.1	3.5	7.6
Other 15 spp.	11.0	8.5	12.1	31.6

TABLE VI. Density, Dominance, Frequency and Importance (IV) of Tree Species on Northerly-Facing Slopes

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Fagus grandifolia	14.5	28.7	12.8	56.0
Liriodendron Tulipifera	9.5	8.0	10.1	27.6
Quercus alba	8.5	7.9	8.4	24.8
Q. velutina	6.0	11.0	6.1	23.1
Acer saccharum	8.0	6.3	7.8	22.1
Nyssa sylvatica	6.5	5.6	7.3	19.4
Carya ovalis	8.0	2.6	6.7	17.3
Quercus rubra	4.0	3.7	4.5	12.2
Sassafras albidum	3.5	3.1	3.4	10.0
Quercus falcata var. pagodaefolia	3.0	3.5	2.8	9.3
Other 22 spp.	28.5	19.6	30.1	78.2

TABLE VII. Density, Dominance, Frequency and Importance (IV) of Tree Species in Ravines

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Ulmus rubra	16.5	26.0	12.9	55.4
Liriodendron Tulipifera	11.0	8.3	10.0	29.3
Fagus grandifolia	7.5	9.8	6.5	23.8
Platanus occidentalis	7.0	6.8	7.1	20.9
Juglans nigra	4.5	4.7	4.7	13.9
Quercus alba	5.5	3.0	5.3	13.8
Acer Negundo	4.5	2.3	4.1	10.9
A. saccharum	4.0	2.0	4.1	10.1
Carya cordiformis	3.5	2.2	4.1	9.8
Celtis laevigata	3.0	3.7	3.0	9.7
Other 26 spp.	33.0	31.2	38.2	102.4

TABLE VIII. Density, Dominance, Frequency and Importance (IV) of Tree Species on Streambanks

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Acer Negundo	24.0	18.8	22.4	65.2
A. saccharinum	13.5	26.7	12.9	53.1
Platanus occidentalis	12.0	14.9	11.8	38.7
Ulmus rubra	12.5	8.4	12.9	33.8
Populus deltoides	4.0	11.4	3.5	18.9
Celtis occidentalis	6.5	3.9	6.5	16.9
Carya cordiformis	5.0	3.4	5.3	13.7
Gleditsia triacanthos	3.5	2.6	4.1	10.2
Juglans nigra	3.0	2.4	3.5	8.9
Salix nigra	2.5	1.4	2.9	6.8
Other 14 spp.	13.5	6.1	14.2	33.8

TABLE IX. Density, Dominance, Frequency and Importance (IV) of Tree Species on Upland Flatlands

Species	Density (%)	Dominance (%)	Frequency (%)	IV
Nyssa sylvatica	32.0	27.8	28.0	87.8
Liquidambar Styraciflua	18.5	22.6	21.4	62.5
Acer rubrum	13.5	16.4	12.6	42.5
Ulmus rubra	5.5	3.9	5.7	15.1
Quercus velutina	3.0	7.4	2.9	13.3
Q. Phellos	1.5	4.6	1.7	7.8
Carya glabra	3.0	1.5	2.9	7.4
Ulmus spp.	2.0	2.1	2.3	6.4
Carpinus caroliniana	2.5	0.7	2.9	6.1
Platanus occidentalis	1.5	2.0	1.7	5.2
Other 16 spp.	17.0	11.0	17.9	45.9

TABLE X. Similarity of Community Types

Communities[1]	Other Communities in Order of Similarity Based on Community Coefficients Derived from Frequency Percentages					
LB	NFS 23.1	R 20.8	SFS 14.0	UF 10.5	SB 5.5	XR 4.2
XR	SFS 49.0	NFS 22.5	UF 13.9	R 11.3	LB 4.2	SB 0.6
SFS	XR 49.0	NFS 46.0	R 20.2	UF 16.8	LB 14.0	SB 1.8
NFS	SFS 46.0	R 40.7	UF 27.1	LB 23.1	XR 22.5	SB 9.0
R	SB 41.9	NFS 40.7	UF 23.7	LB 20.8	SFS 20.2	XR 11.3
UF	NFS 27.1	R 23.7	SFS 16.8	XR 13.9	LB 10.5	SB 5.8
SB	R 41.9	NFS 9.0	UF 5.8	LB 5.5	SFS 1.8	XR 0.6

1. Abbreviations as in Table I.

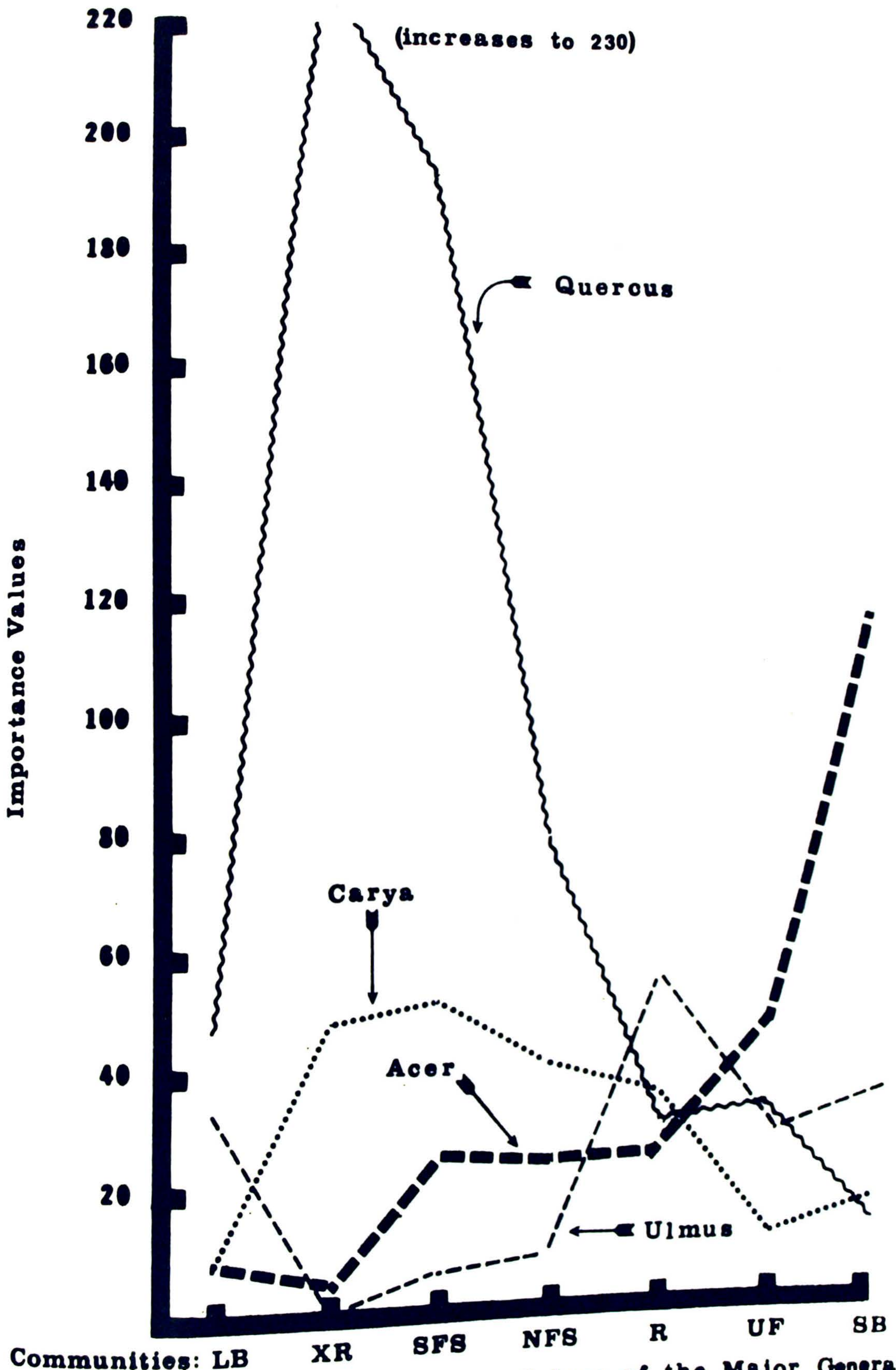

Figure 1. Cumulative Importance Values of the Major Genera

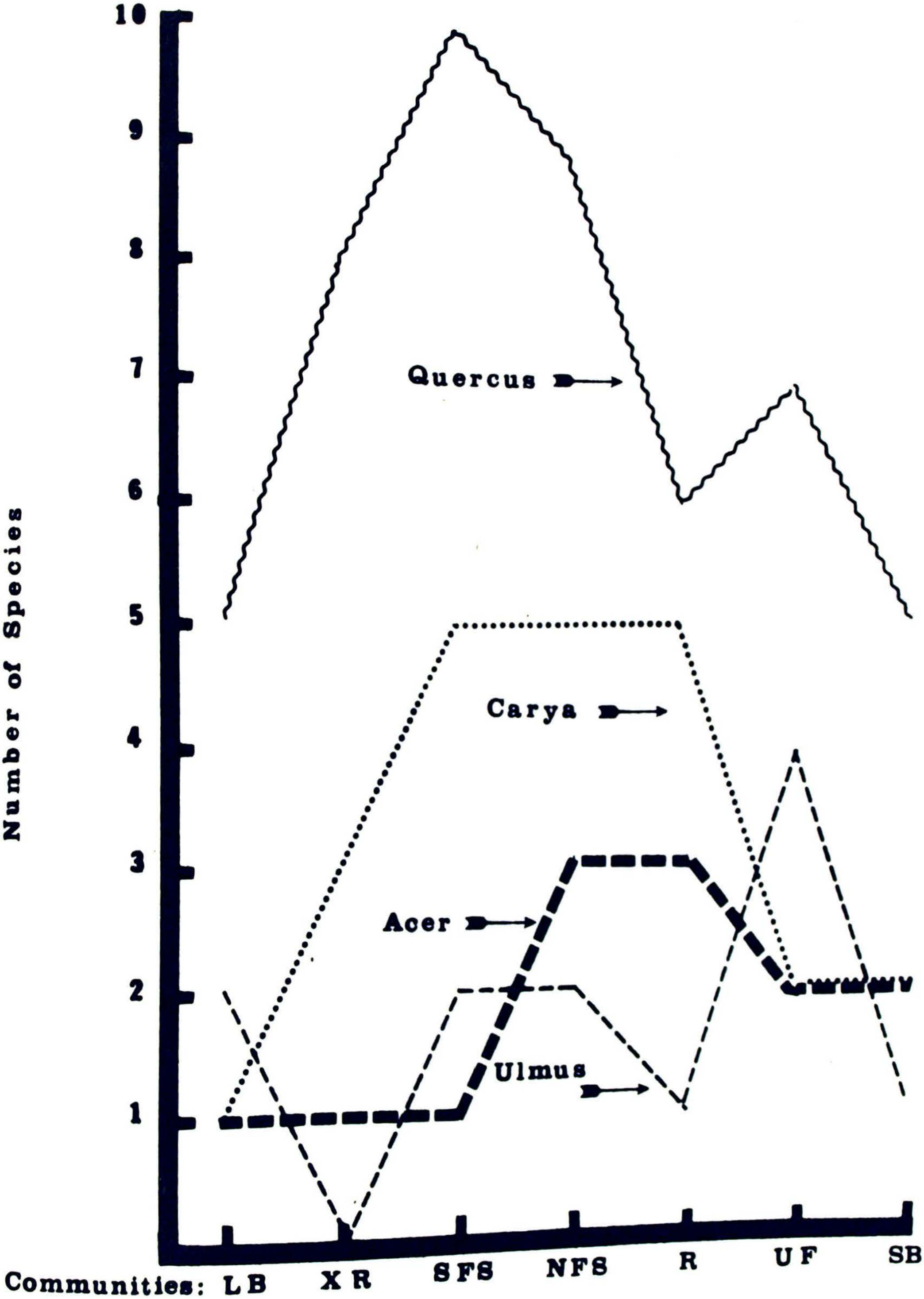

Figure 2. Species Diversity of the Major Genera on the Nortwestern Highland Rim

CHAPTER IV

DISCUSSION

Forest Communities

Duncan and Ellis (1969) studied the forests of Montgomery County and recognized these communities:

Upland Communities
- (a) White Oak-Northern Red Oak-Hickory
- (b) Post Oak-Black Oak
- (c) Beech-Maple

Lowland Communities
- (a) Bottomlands
- (b) Streambanks

Brief descriptions were given for the supposed dominant tree species of each community. Their delimitations correspond approximately with those of the present study.

The White Oak-Northern Red Oak-Hickory community of Duncan and Ellis (1969) is comparable to my northerly-facing slope community. On the most mesic slopes, they found *Acer saccharum* and *Fagus grandifolia* to be the dominant species. My studies of mesic (northerly-facing) slopes show that those two species were dominant, but that *Liriodendron Tulipifera* and *Quercus alba* had greater importance values (IVs) than *Acer saccharum*. These IVs were 27.6, 24.8, and 22.1, respectively.

On dry ridges, *Quercus coccinea*, *Q. Prinus*, and *Q. rubra* were listed as associates by Duncan and Ellis (1969). This listing approximates the species I found in sampling the xeric ridges, but Quercus alba, Carya glabra, and Quercus marilandica were also found to be chief constituents, having respectively, the second, third, and fifth highest IVs for this community type.

Duncan and Ellis (1969) listed Carya laciniosa, C. tomentosa, Juglans nigra, Quercus alba, and Q. rubra as associates in the Red Cedar-Hardwood Community. I found that community to be best described as a Red Cedar-White Ash-Chinkapin Oak forest with Maclura pomifera, Ostrya virginiana, Prunus serotina, and Quercus rubra as associates.

The well-drained bottomland community delimited by Duncan and Ellis (1969) approximates the ravine community of my study, although they listed Carya cordiformis, C. laciniosa, Quercus bicolor, Q. Michauxii, and Q. Phellos as abundant species. My research indicates that only C. cordiformis may be referred to as abundant in this community, having the ninth greatest IV (9.8) there. Quercus bicolor has never been officially reported (no voucher specimens collected) from Montgomery County. I have never seen it here, and if present it must be rare. Q. Michauxii was encountered only twice in my sampling and should be considered uncommon. I found Q. Phellos to be abundant on upland flatlands, having the sixth greatest IV (7.8) there, but was not found on any of the bottomland sites. In my study, Ulmus rubra, Liriodendron Tulipifera, and Fagus grandifolia were found to be the most important trees in ravines.

For streambank communities, Acer Negundo, Acer saccharinum, Platanus occidentalis, Populus deltoides, and Salix *nigra* were listed as abundant species by Duncan and Ellis (1969). This concurs with my findings for streambank forests. In order of IVs, *Acer Negundo*, *A. saccharinum*, and *Platanus occidentalis* were the major species. They further noted that *Carya aquatica*, *Fraxinus americana*, *Juglans nigra*, and *Ulmus rubra* were typical species on streambanks. I found *Juglans nigra* and *Ulmus rubra* to be typical associates, but *Fraxinus americana* was not found on streambanks--only on better-drained areas. Fowells (1965) stated that this species is not a common tree in flat bottoms of major streams. It is doubtful that *Carya aquatica* is a typical species on streambanks in this area, since it was not found in my study, and has not been verified as existing on the Highland Rim.

My data reveals that certain communities were more distinct than others. Limestone bluffs were characterized by a unique combination of tree species with *Juniperus virginiana*, *Fraxinus americana*, and *Quercus muehlenbergii* as consistent dominants (those species with importance values among the top ten for a given community). Upland flatlands and streambanks likewise had fairly distinct dominant species. Soil moisture is a major limiting factor in determining species representation, but a multitude of interacting edaphic and climatic factors as well as biotic influences are likely involved. It was not within the scope of this study to measure such environmental factors but only to make certain phytosociological analyses of the resultant forest communities.

The least similar communities were xeric ridges and streambanks. Their coefficient of similarity was only 0.6

(Table X), and this was due to the coincidence of only one species, Quercus rubra. As might be expected, streambanks also contrasted greatly with southerly-facing slopes having a coefficient of 1.8, and this represents the overlap of three species: Carya laciniosa, Juglans nigra, and Quercus rubra. Communities exhibiting the greatest similarity were southerly-facing slopes and xeric ridges, with a coefficient of 49.0, and 14 species were common to both. Also, southerly-facing slopes were similar to northerly-facing slopes: Their coefficient of similarity was 46.0 due to the coincidence of 19 species.

Ravines and northerly-facing slopes exhibited the greatest diversity of species, having 36 and 32 species, respectively. The least diversity was found on xeric ridges (15 species) and limestone bluffs (19 species).

The Juglandaceae

The Juglandaceae is comprised of monoecious shrubs and trees with alternate, pinnately compound leaves. The staminate flowers are elongate catkins with a two to six lobed calyx, subtended by an adnate, narrow bract, and with short filaments. Pistillate flowers occur at the termini of young branches and are subtended by cup-shaped involucres with connate bracts. The inferior, one-celled ovary terminates in two plumose stigmas (Gleason, 1952).

This family is composed of six genera and about 55 species, mostly indigenous to the north temperate zone. Carya and Juglans are the two genera native to Tennessee. The four foreign genera are _Alfaroa_, _Engelhardtia_, _Platycara_, and _Pterocarya_.

All walnut species have tassel-like, unbranched catkins. The pistillate flowers are borne on erect terminal spikes, and the indehiscent fruit is a drupaceous nut with a thick, leathery husk. Twigs have pith which is distinctly chambered (Brockman, 1968).

Hickories are generally slow-growing trees with a long tap root, and they usually have fewer and broader leaflets than have the walnuts. The staminate flowers are in three-branched catkins, and the fruits are dehiscent. Twigs have solid pith (Brockman, 1968).

Stone et al. (1969), in a worldwide listing of the taxa of _Carya_, recognized 18 species. Four were restricted to southeastern Asia, one to Mexico, and the other 13 species were native to eastern United States. Nine of these have been collected from the Highland Rim and include: _Carya carolinae-septentrionalis_, _C. cordiformis_, _C. glabra_, _C. illinoensis_, _C. laciniosa_, _C. ovalis_ var. _ovalis_, _C. ovalis_ var. _obcordata_, _C. ovata_, _C. pallida_, and _C. tomentosa_. Two walnut species, _Juglans cinerea_ L. and _J. nigra_ L., were collected.

Carya pallida, _C. ovalis_ var. _obcordata_, _C. illinoensis_, and _C. carolinae-septentrionalis_ were collected but not encountered in the sampling; thus, they may be considered rare in this area. Ecological data for the sampled species are provided in the tables already enumerated. Keys for the hickories and walnuts of the Highland Rim follow.

Key to the Genera of Juglandaceae

Husk indehiscent; pith chambered; nut furrowed; staminate catkins simple.................................. Juglans
Husk partly or competely dehiscent; pith homogenous; nut not sculptured; staminate catkins ternately branched...
.... Carya

Key to the Species of Juglans L. (Wallia Alef.)

Leaflets commonly 11-17, oblong lanceolate, downy with fascicled hairs, base rounded; fruit ovoid to short-cylindric, clammy and racemose; bark with smooth ridges; leaf scar surmounted by a velvety ridge..... J. cinerea
Leaflets commonly 11-23, ovate-lanceolate, downy on undersurface with solitary or paired hairs, base cordate or unequal; fruit globose, not clammy, usually solitary or paired; bark with rough ridges; leaf scar notched and smooth...................................... J. nigra

Key to the Species of Carya Nutt. (Hicoria Raf.)

Scales of terminal bud 4-6 paired and valvate; leaflets 7-17
.... Section Apocarya C. DC.
Terminal buds yellow, narrow and flattened; mature husk not splitting to base; leaflets rarely falcate....
.... C. cordiformis
Buds brownish with yellow hairs; mature husk splitting to the base; leaflets strongly falcate............
.... C. illinoensis
Scales of terminal bud 6-12, imbricated; leaflets 3-9.......
.... Section Carya C. DC.
Margins of leaflets having persistent subterminal tufts of hairs on serrations; leaflets normally 5.
Buds black; fruit 2.5-3.5 cm long; terminal leaflet lanceolate, about a fourth as wide as long........... C. carolinae-septentrionalis
Mature buds dark brown; fruit 3.5-5 cm long; terminal leaflet obovate, a third to half as wide as long........................ C. ovata
Subterminal tufts of hairs not present on serrations of mature leaflets; leaflets 5-9.
Terminal winter buds 10-25 mm long; leaflets 7-9; fruits with heavy husk 4-8 mm thick.
Nuts compressed strongly 3-6 cm long, wedge-shaped at base, longer than broad; bark exfoliating into thin gray plates; stalk of terminal leaflet longer than 8 mm;

hairs on rachis not definitely in fascicles.................... *C. laciniosa*

Nuts only slightly compressed to terete in cross-section, 1.5-3 cm long, rounded at base, about as broad as long; bark not exfoliating into plates; stalk of terminal bud less than 8 mm in length; hairs on rachis clearly in separate fascicles .... *C. tomentosa*

Terminal winter buds less than 10 mm in length; fruits with thin husk 2-4 mm thick; leaflets 5-9.

Leaf rachis normally shaggy having definite separated fascicles of curly hairs; buds and tips of twigs with yellow glands.... .... *C. pallida*

Rachis varying from glabrous to pubescent; hairs usually solitary or in pairs, not curly; buds without yellow glands; leaflets 5-7.

Leaflets mostly 5; fruit typically pyriform, husk mostly indehiscent, sometimes splitting to the base along one suture; bark not scaly... .... *C. glabra*

Leaflets mostly 7 (occasionally 5); rachis base normally reddish; fruit short-oblong, subglobose to ellipsoid, husk splitting to base along 3-4 sutures; bark of mature trees exfoliating into narrow strips..... .... *C. ovalis*

Annotations of the Juglandaceae of the Northwestern Highland Rim

Carya carolinae-septentrionalis (Ashe) Engl. and Graebn.

Southern Shagbark Hickory ranges from southern Virginia to Tennessee and Georgia. It occurs in widely scattered locations in Tennessee, but has not been reported officially from Montgomery or Stewart Counties. Though it was not encountered in my sampling, I collected it in both counties, and voucher specimens will be placed in the Austin Peay State University Herbarium.

Due to the rareness of Southern Shagbark Hickory, I am unable to state its habitat affinities on the Highland Rim. However, Hardin (1952) noted that it is found on various sites including dry limestone hills, riverbottoms, and low woodlands.

Carya cordiformis (Wang.) K. Koch

Bitternut Hickory is the most uniformly distributed of the hickories. It ranges from New Hampshire and southern Quebec, west to Minnesota, and south to eastern Texas and northern Florida. On the northwestern Highland Rim, Bitternut Hickory is restricted to the mesic sites, and is a dominant on streambanks and in ravines. According to Fowells (1965), Bitternut Hickory is more restricted to moist sites in the southern part of its range than it is in the northern part.

On ravine slopes in eastern Virginia, Bitternut Hickory is associated with Acer rubrum, Fagus grandifolia, Juglans cinerea, J. nigra, Liquidambar Styraciflua, Liriodendron Tulipifera, Platanus occidentalis, and Quercus alba (Fowells, 1965). Sampling and observation of ravines in my study indicated that the associates were basically the same (Table VII). Streambank associates are given in Table VIII.

Carya glabra (Mill.) Sweet

Pignut Hickory is found from southwestern New Hampshire west to southern Vermont, southern Ontario, southern Michigan, Illinois, and southeastern Kansas, and south to eastern Texas and central Florida. On the northwestern Highland Rim, Pignut Hickory was found mostly on dry slopes and ridges, exhibiting 100 per cent constance for both (Table II). For xeric ridges, an IV of 28.8 was recorded, making it the fourth most important species in that community, and on southerly-facing slopes it was seventh in importance. Hardin (1952) also considered it a species of dry uplands.

According to Fowells (1965), Pignut Hickory is a minor component of two forest cover types, Post Oak-Black Oak (Type 40) and White Oak-Red Oak-Hickory (Type 52). In my area, it was a major component of the Chestnut Oak-White Oak-Post Oak forests of xeric ridges and the White Oak-Black Oak-Post Oak forests of southerly-facing slopes.

Carya illinoensis (Wang.) K. Koch

Pecan is found westward from southern Indiana, Illinois, and southeastern Iowa to eastern Kansas and central Texas, and east to western Mississippi and western Tennessee. It does not appear to be native to my study area, since it has been found only on homesites. Putnam (1951) noted that, throughout its natural range, Pecan is limited mostly to first-bottom alluvial soils of relatively recent origin.

Fowells (1965) considered Pecan a major component of the Sycamore-Pecan-American Elm forest cover Type (Type 94).

Carya laciniosa (Michx.) Loud.

Shellbark Hickory is found from New York and southern Ontario to Indiana and south to North Carolina, Mississippi, and Oklahoma. In my study area, Shellbark Hickory is limited to mesic sites, and is common only locally. Its greatest importance values were achieved in ravines and streambanks (8.5 and 2.4 respectively). Fowells (1965) stated that although this species may be found growing under a wide range of physiographic conditions, it grows best on the bottomlands.

Fowells (1965) considers Shellbark Hickory a minor component of the Bur Oak Type (Type 42) and the Swamp Chestnut Oak-Cherrybark Oak Type (Type 91). In this area, chief associates are *Acer Negundo*, *A. saccharinum*, *Juglans nigra*, *Platanus occidentalis*, and *Ulmus rubra*.

Carya ovalis (Wang.) Sarg.

Red Hickory is found from Massachussetts to Wisconsin south to Georgia, Mississippi, and Missouri. It is found most often on moist or dry uplands (Gleason, 1952). In my study Red Hickory was found growing only on well-drained areas, especially slopes, but was not encountered on xeric ridges.

Associates of Red Hickory are listed in Tables V and VI.

Carya ovalis has been treated by some authors as merely a variety of *C. glabra*. For example, Little (1969) argued that it be reduced to *C. glabra* var. *odorata* (Marsh.) Little, maintaining that the principle difference between the two is in the husk of the fruit, opening late and partly in *C. glabra* or promptly splitting to the base in *C. ovalis*. He pointed out that the line of indehiscence is only a minor character in other taxonomic groups, and noted that the ranges of the two are about the same. Gleason (1952) described *C. ovalis* as a polymorphic species, expecially variable in the shape and size of its fruits, and possibly a hybrid between C. ovata and C. glabra. Manning (1950), the current authority on Carya, contended that these two should be maintained as distinct species, since he felt that the pure forms of each were very different morphologically. He also noted that they were probably recently evolved and that hybrids between the two were common.

Most C. ovalis specimens that I have observed were readily distinguished from C. glabra when fruits or bark were available. The best characters for identifying C. ovalis include exfoliating bark, glabrous leaves with seven leaflets usually, and husk of the fruit splitting all the way to the base immediately upon maturity. C. glabra may be recognized by these characters: tight bark, slightly hairy leaflets which almost always are five in number, and husk of the pyriform fruit dehiscing only partly and late.

Carya ovalis var. obcordata was found in the area for the first time, and it appears uncommon compared to the typical variety. The former may be differentiated only by its fruits which are obcordate at the apex.

Carya ovata (Mill.) K. Koch

Shagbark Hickory ranges from Quebec and Maine to Michigan and southeastern Minnesota south to Florida and Texas. It has the greatest range of any hickory species in North America with the possible exception of C. glabra. On the northwestern Highland Rim, Shagbark Hickory was found on all topographic areas except for streambanks. It was the only hickory found on limestone bluffs where it was the seventh most important species.

Because of its adaptability to diverse sites, it had numerous associates in this area, as it has throughout its range.

Shagbark Hickory is very similar morphologically to C. carolinae-septentrionalis. Little (1969) considers the latter a variety of the former and has named it C. ovata var. australis (Ashe) Little. The chief differences between the two are leaf shape, color of the buds, and fruit size.

Carya pallida (Ashe) Engl. and Graebn.

Sand Hickory is most common on the coastal plain, but Hardin (1952) noted that it has been reported from many areas in Tennessee. He listed its habitat preferenda as dry stony ridges or sandy soil. Though Sand Hickory was not sampled in my study, it was observed on the driest ridges of the area, but was common on only a few sites.

I have reported Sand Hickory for the first time from Stewart County, Tennessee, and Lyon and Trigg Counties, Kentucky. It still has not been found in Montgomery County, Tennessee.

Carya tomentosa Nutt.

Mockernut Hickory is found from Massachussetts to Ontario and Indiana south to Florida and Texas. Throughout its range this species attains its best development on fertile uplands (Boisen et al., 1910). In my study area Mockernut Hickory was encountered mostly on slopes and ridges. It was most important on southerly-facing slopes, having the fifth greatest importance value (20.2) for that community. It was found on all four stands of this community type, and for each of the other communities, its constance did not exceed 25 per cent (Table II).

Over its range it is found in many communities, but in my area common associates were those species listed in Tables IV and V.

Juglans cinerea L.

Butternut is found from New Brunswick to Ontario, northern Michigan, and Minnesota south to Virginia, Georgia, Arkansas, and Kansas. According to Gleason (1952), this species is becoming rare over much of its range. Since only two specimens were found through sampling, Butternut must be considered uncommon in my study area. Observations indicated that it was restricted to ravines and streambanks, and it appeared to be more abundant on the former. Perhaps the better drainage in ravines accounted for this. Baker (1949) stated that Butternut occurs most frequently in coves, on streambanks, on slopes, and on other sites with good drainage.

Fowells (1965) noted that throughout its range Butternut is associated with numerous species, and he listed as common associates: _Acer rubrum_, _A. saccharum_, _Betula lutea_, _Carya_ spp., _Fagus grandifolia_, _Fraxinus americana_, _Juglans nigra_, _Liriodendron Tulipifera_, _Prunus serotina_, _Tilia_ spp., and *Ulmus spp*. In my study area primary associates were those listed in Tables VII and VIII.

Juglans nigra L.

Black Walnut ranges from western New England to Michigan, Minnesota, and Nebraska south to Forida and Texas. On the northwestern Highland Rim, Black Walnut was most abundant in ravines, streambanks, and northerly-facing slopes. Auten (1945) noted that this species develops best on deep, well-drained, nearly neutral soils which are generally moist and fertile.

According to Fowells (1965) Black Walnut is associated with many other species, but generally where *Liriodendron Tulipifera* and *Fraxinus americana* grow well, Black Walnut thrives. In my study area, major associates were the same as those listed for *Juglans cinerea*.

As a group Juglandaceae was found to be second only to Fagaceae in general importance on the northwestern Highland Rim. They were very significant on southerly-facing slopes (Table V, Figures 1 and 2), where *Carya tomentosa*, *C. ovalis*, *C. glabra*, and *C. ovata* had the fifth, sixth, seventh, and tenth highest IVs, respectively. Altogether, six species (five hickories and one walnut) represented the family in this community, and their cumulative IV was 52.2. On ravine sites, both walnut species and five hickory species yielded a total IV of 51.7. On northerly-facing slopes, five species of hickories and one walnut species, *Juglans nigra*, combined to yield an IV of 44.2. Only three hickory species were recorded for xeric ridges, and in combination they yielded an

IV of 40.9. On streambanks, a total IV of 26.4 resulted from the presence of two hickory species and both walnut species. On upland flatlands, a cumulative IV of 9.9 was recorded representing only two hickory species. Only one hickory, _Carya ovata_, was found on the dry limestone bluffs, and its IV was 9.0.

CHAPTER V

SUMMARY

Vegetational studies were conducted on seven topography-related community types on the northwestern Highland Rim of Tennessee. For each community four mature representative stands were selected and 50 trees were sampled on each stand. From the sampling data an importance value index was calculated for each species and dominants determined from those values. These communities recognized were the following:

1. Red Cedar-White Ash-Chinkapin Oak forests on limestone bluffs
2. Chestnut Oak-White Oak-Post Oak forests of ridges
3. White Oak-Black Oak-Post Oak forests on slopes with southern exposure
4. American Beech-Tulip Poplar-White Oak forests on slopes with northern exposure
5. Red Elm-Tulip Poplar-American Beech forests of ravines
6. Box Elder-Silver Maple-Sycamore forests of streambanks and alluvial bottomlands
7. Black Gum-Sweet Gum-Red Maple forests of upland flat-lands.

Table I lists all species sampled and their importance values in each of the various communities. Constance values and stem numbers of the species in each community are supplied in Table II, and Tables III-IX list density, frequency, basal area, and importance values for the 10 dominants of each community. Table X supplies coefficients of similarity between the seven communities.

Figure 1 gives the cumulative importance values of each of the four major genera (*Acer*, *Carya*, *Quercus*, and *Ulmus*) in each community. Figure 2 shows the number of species representing each of these genera in each community. Altogether, 17 species of *Quercus*, six of *Carya*, five of *Acer*, and three of *Ulmus* were encountered in the sampling, and these four genera accounted for 31 species, which was one half the total number of species sampled.

The results of my research are compared with those of Duncan and Ellis (1969). Their findings approximate those of my study, but certain discrepancies are noted.

On the northwestern Highland Rim, nine hickory and two walnut species were collected. Three hickory species, *Carya carolinae-septentrionalis*, *C. illinoensis*, and *C. pallida* were observed but not encountered in sampling probably due to their rareness in the area. A key is supplied for these 11 species based on leaf, bud, and fruit characters. Associates and habitat affinities of each endemic hickory and walnut species are discussed. Three taxa were collected from the area for the first time: *Carya carolinae-septentrionalis* from Montgomery and Stewart Counties, Tennessee; *C. ovalis* var. *obcordata* from Montgomery County; and *C. pallida* from Stewart County, Tennessee, and Lyon and Trigg Counties, Kentucky.

I conclude that Juglandaceae is a significant family on the northwestern Highland Rim. It is well represented by at least one species in all communities studied. Overall, the family is most important on ridges, slopes, and ravines, and is least important on limestone bluffs and upland flat-lands.

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APPENDIX I

ANNOTATED LIST OF JUGLANDACEAE

This list is constructed in alphebetical order. The herbaria visited include: Austin Peay State University (APSU), University of Tennessee (TENN), Vanderbilt University (VDB), and Western Kentucky University (WKU). Specimen information is arranged in this order: binomial and author, common name, county, state, location, date of collection, collector and his number, herbarium abbreviation, and inscription number if collector's number was not available.

Carya carolinae-septentrionalis (Ashe.) Engl. and Graebn., Southern Shagbark Hickory, Stewart Co., Tn., LBL, near marker 9N1, 18 July, 1966, B. Forrester s. n., (APSU), 01958; Hardin Co., Tn., southwest of Saltido, 10 July, 1948, A. J. Sharp, A. Clebsch, E. Clebsch, S. Fairchild 9503, (TENN); Maury Co., Tn.,,17 Sept., 1969, R. Kral 36956 (VDB).

Carya cordiformis (Wang.) K. Koch, Bitternut Hickory, Stewart Co., Tn., 0.5 miles south of marker 10L3, 18 July, 1966, B. Evans s. n. (APSU) 01960; Anderson Co., Tn., 72,500 ft. east of Melton Hill Reservoir, 31 July, 1961, W. H. Ellis 28939 (TENN); Cheatham Co., Tn., 16 April, 1963, J. C. Kinkaid s. n. (VDB) 17508; Warren Co., Ky., 22 June, 1970, E. E. Gough 2747 (WKU).

<u>Carya</u> <u>glabra</u> (Mill.) Sweet., Pignut Hickory, Lyon Co., Ky., between markers 5D3 and 5C3 on Hwy. 58, 6 July, 1966, <u>B</u>. <u>Forrester</u> <u>s</u>. <u>n</u>. (APSU) 01755; Hampshire Co., Mass., field off Barrett St., 24 May, 1941, <u>W</u>. <u>E</u>. <u>Manning</u> <u>8121</u> (TENN); Blount Co., Tn., 22 June, 1969, <u>K</u>. <u>Rogers</u> <u>43642</u> (VDB); Muehlinberg Co., Ky., 2 July, 1969, <u>J</u>. <u>Conrad</u> <u>277</u> (WKU).

<u>Carya</u> <u>illinoensis</u> (Wang.) K. Koch, Pecan, Stewart Co., Tn., LBL, close to marker 6L2, 4 Aug. 1966, <u>E</u>. <u>Wofford</u> <u>s</u>. <u>n</u>. (APSU) 02316; Blount Co., Tn., Chilhowee Mt., 30 Aug., 1965, <u>R</u>. <u>D</u>. <u>Thomas</u> <u>s</u>. <u>n</u>. (TENN); Obion Co., Tn., 12 Sept., 1963, <u>D</u>. <u>Demaree</u> <u>49164</u> (VDB); Henderson Co., Ky., 16 June, 1969, <u>J</u>. <u>Conrad</u> <u>s</u>. <u>n</u>. (WKU) 2800.

<u>Carya</u> <u>ovalis</u> (Wang.) Sarg. var. <u>ovalis</u> Sarg., Red Hickory, Stewart Co., Tn., LBL, 0.25 miles west of marker 8N3, 5 July, 1966, <u>B</u>. <u>C</u>. <u>Evans</u> <u>s</u>. <u>n</u>. (APSU) 01725; Cheshire Co., New Hampshire, Winchester, 2 Aug., 1944, <u>W</u>. <u>E</u>. <u>Manning</u> <u>8102</u> (TENN); Dickson Co., Tn., 2 Aug., 1969, <u>R</u>. <u>Kral</u> <u>35927</u> (VDB).

<u>Carya</u> <u>ovata</u> (Mill.) K. Koch, Shagbark Hickory, Stewart Co., Tn., 1 mile east of marker 9P1, 27 June, 1966, <u>E</u>. <u>Wofford</u> <u>s</u>. <u>n</u>. (APSU) 01707; Anderson Co., Tn., 17000 ft.,north of Melton Hill Reservoir, 10 July, 1961, <u>W</u>. <u>H</u>. <u>Ellis</u> <u>28777</u> (TENN); Giles Co., Tn., 12 Sept., 1949, <u>R</u>. <u>E</u>. <u>Shanks</u> <u>91680</u> (VDB); Butler Co., Ky., 2 July, 1969, <u>J</u>. <u>Conrad</u> <u>315</u> (WKU).

<u>Carya</u> <u>pallida</u> Ashe., Sand Hickory, Stewart Co., Tn., LBL, 0.25 miles east of marker 8N3, 5 July, 1966, <u>E</u>. <u>Wofford</u> <u>s</u>. <u>n</u>. (APSU) 01842; Blount Co., Tn., Chilogatee Gap, 9 Oct., 1965, <u>R</u>. <u>D</u>. <u>Thomas</u> <u>s</u>. <u>n</u>. (TENN); Cocke Co., Tn., east ridge

of English Mt., 1 July, 1955, J. A. Chapman s. n. (TENN); Carroll Co., Tn., southeast of Buena Vista near Big Sandy River, 7 July, 1948, S. Fairchild 8489 (TENN).

Carya tomentosa Nutt., Mockernut Hickory, Trigg Co., Ky., LBL, 0.25 miles north of marker 8F1, 9 Oct., 1965, W. H. Ellis s. n. (APSU) 00776; Hampshire Co., Mass., 21 May, 1946, W. E. Manning s. n. (TENN); Dickson Co., Tn., 2 Aug., 1969, R. Kral 35298 (VDB); Edmonson Co., Ky., 3 May, 1969, H. W. Elmore 780 (WKU).

Juglans cinerea L., Butternut, Stewart Co., Tn., LBL, 0.25 miles west of marker 9K3 near Hicks Spring, 4 Aug., 1966, B. Forrester s. n. (APSU) 02315; Sevier Co., Tn., Walden's Creek near Doyle Springs, 31 Sept., 1965, R. D. Thomas s. n. (TENN) 1881; Hickman Co., Tn., 20 Sept., 1968, R. Kral 33450 (VDB); Edmonson Co., Ky., 16 July, 1970, K. A. Nicely s. n. (WKU) 4885.

Juglans nigra L., Black Walnut, Stewart Co., Tn., LBL, 0.5 miles east of marker 8P3, 11 July, 1966, E. Wofford s. n. (APSU) 01823; Anderson Co., Tn., Melton Hill Reservoir, W. H. Ellis 28718 (TENN); Robertson Co., Tn., 15 Aug., 1968, K. E. Blum 2907 (VDB); Warren Co., Ky., 5 June, 1968, K. A. Nicely 1646 (WKU).

APPENDIX II

SAMPLING TECHNIQUES, LOCATIONS, AND STAND DESCRIPTIONS

Limestone bluffs:

Sampling involved a single transect 200 meters in length for each of the four stands; twenty-five stations at eight meter intervals were included in each transect. At each station the dbh was recorded for the two nearest trees, one on each side of the 180 degree exclusion angle (Phillips, 1959).

Stand one is located at the junction of Highways 48 and 13, Montgomery County, Tennessee. The area is slightly sloping with southeasterly exposure. The soil is shallow, and consists of Baxter chert.

Stand two is situated just north of the Red River bridge on the right of Highway 76, Montgomery County, Tennessee. The area is moderately sloping with mostly southern exposure.

Stand three is situated in New Providence, Montgomery County, Tennessee. It is a river bluff approximately two miles north of the confluence of the Red and Cumberland rivers. It is steep-sloping and is southerly-facing. The shallow soil has much limestone outcropping.

Stand four is located 0.1 miles northwest of the New Providence boat launching and picnic area, Montgomery County, Tennessee. The area is slightly sloping and exhibits a great deal of limestone outcropping.

Xeric Ridges:

For each of the four stands, two transects were involved. One consisted of 13 stations at eight meter intervals and the other included 12 stations; one line ran parallel to and 10 meters below the ridge crest. The other ran likewise but on the other side of the crest.

Stand one is located at the junction of Highway 49 and the road to Bard's Dam, Stewart County, Tennessee. The soil type of this ridge is Dickson.

Stand two is situated on the crest of the road to Wallace Cemetery, Stewart County, Tennessee. The soil consists of Bodine chert.

Stand three is situated on the ridge crest overlooking Ginger Bay in Stewart County, Tennessee, and the soil is Bodine chert.

Stand four is located 0.9 miles west of marker BM3, Stewart County, Tennessee. The soil type is Brandon silt loam.

Southerly-facing Slopes:

On slopes three transects were involved; one ran through the middle of the slope parallel to the crest and consisted of nine stations. The two other transects were run such that one was 16 feet above the middle transect and the other was 16 feet below the middle transect; each of these flanking transects consisted of eight stations.

Stand one is located on E. T. Wickham's Farm, along Cannan Road, Montgomery County, Tennessee. The site is approximately 100 meters behind the log house at Wickham's Stone Park. The slope is moderate, and the soil is Baxter chert.

Stand two is situated on the Austin Peay State University Farm, close to the tobacco barn, Montgomery County, Tennessee. The angle of slope is about 45 degrees, and the soil type is Baxter chert.

Stand three is found at the junction of the Blue Spring Road with the Fort Henry Road, Stewart County, Tennessee. The slope is moderate, and the soil consists of Bodine chert.

Stand four is found in Stewart State Forest, Stewart County, Tennessee. The site is 0.7 miles south of the north entrance to the forest on Highway 49 (right side of road). The slope angle is about 45 degrees, and the soil type is Bodine chert.

Northerly-facing Slopes:

Sampling methods for these stands were the same as those for southerly-facing slopes.

Stand one is situated on Cannan Road (right side of road), 0.3 miles west of the junction with Oak Ridge Road, Wickham Farm, Palmyra, Montgomery County, Tennessee. The slope angle is about 45 degrees and the soil consists of Baxter chert.

Stand two is found close to the tobacco barn at Austin Peay State University Farm, Montgomery County, Tennessee. The slope is moderate, and the soil type is Baxter chert.

Stand three is located 0.1 miles south of marker 7N1 on the Blue Spring Road, LBL, Stewart County, Tennessee. The slope is moderate, and the soil consists of Bodine chert.

Stand four is situated 0.7 miles south of the north entrance to Stewart County, Tennessee. The slope is moderate and the soil is cherty.

Ravines:

On ravine stands, a single transect was run through the center of the ravine. Twenty-five stations at intervals of eight meters were included in each transect.

Stand one is located between the northerly-facing slope and the southerly-facing slope at the Austin Peay State University Farm, Montgomery County, Tennessee. The soil type is Hamblen.

Stand two is situated at the base of the slopes on the Shiloh Road (right side) 0.5 miles north of the junction with Broom Road, Wickham Farm, Montgomery County, Tennessee. Baxter chert is the soil type.

Stand three is situated at the junction of Highway 49 and the Blue Spring Road, Stewart County, Tennessee. The soil is largely Humphreys silt loam.

Stand four is located 0.7 miles north of the entrance to Stewart State Forest on Highway 49 (right side of road), Stewart County, Tennessee. The soil type is Humphreys silt loam.

Upland Flatlands:

Sampling technique was basically the same as that used on slopes. Three transects were involved, one in the middle of the stand and one below and one above; the middle station consisted of nine stations, and each of the other two consisted of eight stations.

Stand one is found at the junction of Highway 41 A with Sango Road, Montgomery County, Tennessee. Russelville soil is found in the area.

Stand two is situated one mile east of the junction of Highway 41 A and the Sango Road, Montgomery County, Tennessee. The soil type is Gutherie.

Stand three is located on Highway 76 (on left of road) just west of the boundary of Montgomery and Stewart Counties, Tennessee. The soil type is Lax.

Stand four is found on Liberty Road, opposite J. W. Waters home, Montgomery County, Tennessee. Gutherie soil occupies the area.

Streambanks:

Streambanks were sampled by running a single transect parallel to and 10 meters from the stream's edge; 25 stations at eight meter intervals constituted the transect.

Stand one is located along Smith's Branch extending from the mouth 200 meters upstream; this area is in Montgomery County, Tennessee, and the soil type is Huntington silt loam.

Stand two is situated along Ringold Creek close to the Bridge on Highway 41 A, Montgomery County, Tennessee. Huntington silt loam occupies the area.

Stand three is situated along Dyers Creek close to the Rebel's Gas Station on Highway 79, Montgomery County, Tennessee. Lobilville silt loam is found in the area.

Stand four is located along Cross Creek, 1.1 miles north of the junction of Highways 49 and 149, Stewart County, Tennessee. The soil type is Ennis silt loam.

APPENDIX III

SPECIES AREA CURVES

Species area curves indicated that the sampling size was adequate for most stands. Curves for the 28 stands follow.

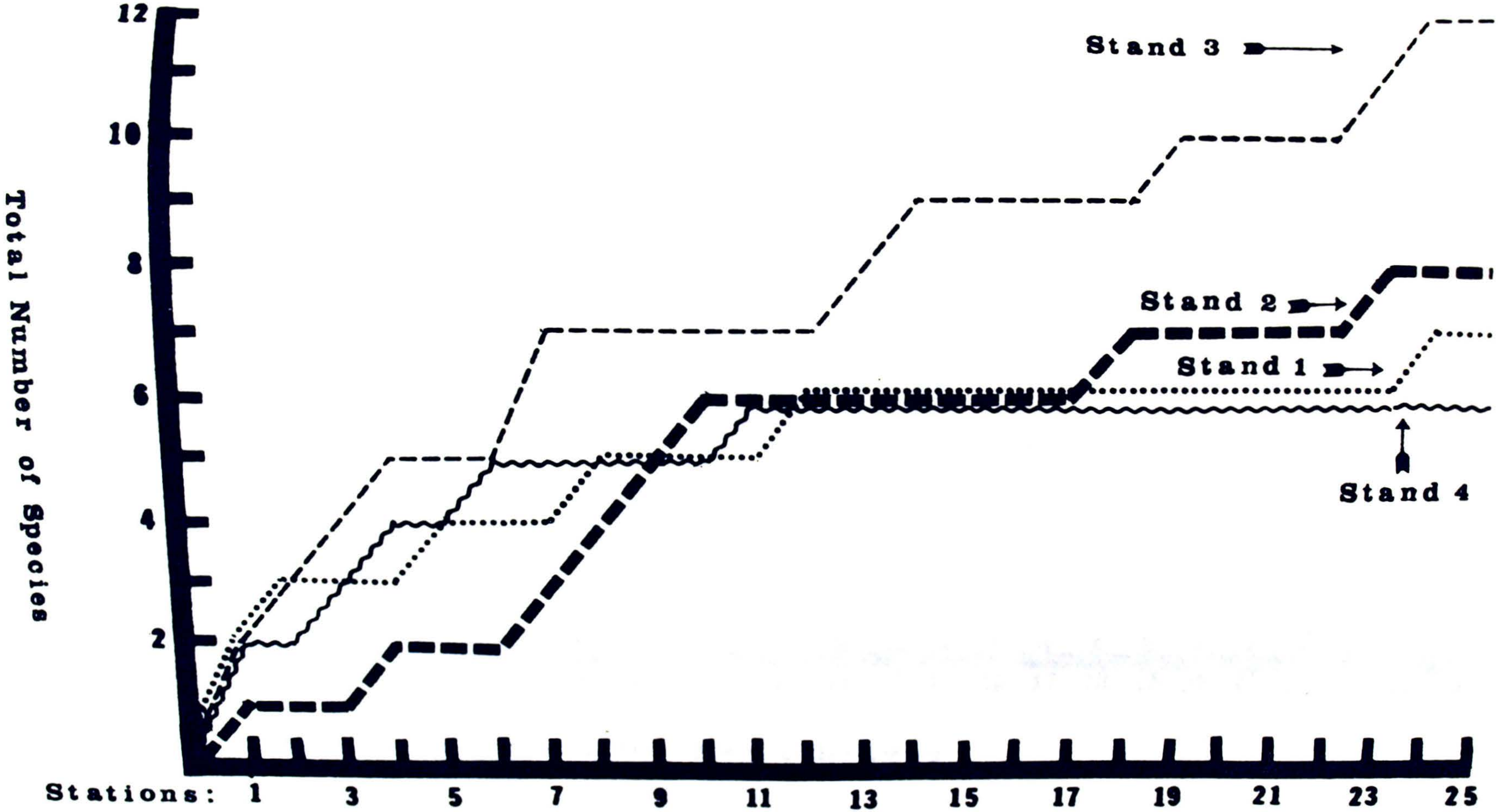

Figure 3. Species Area Curves for Limestone Bluffs

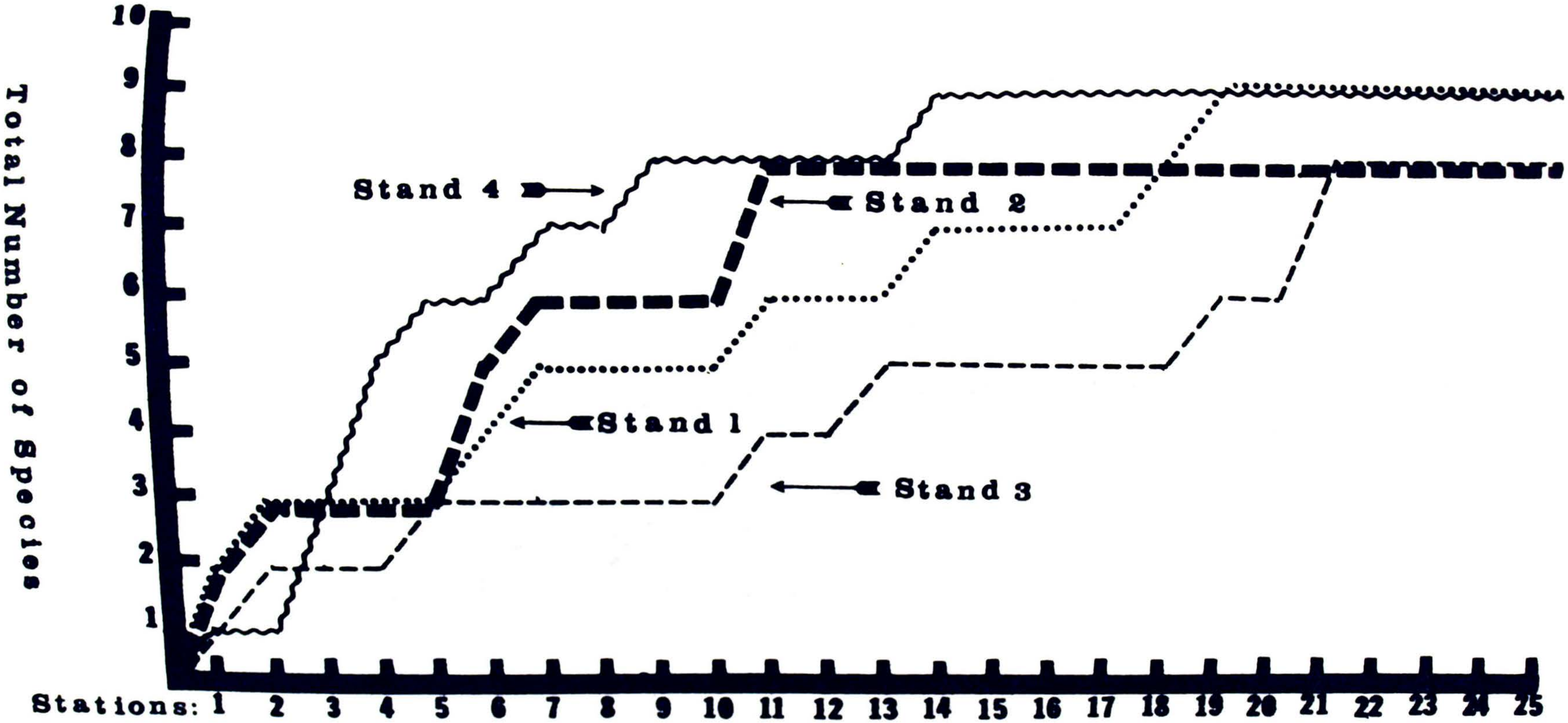

Figure 4. Species Area Curves for Xeric Ridges

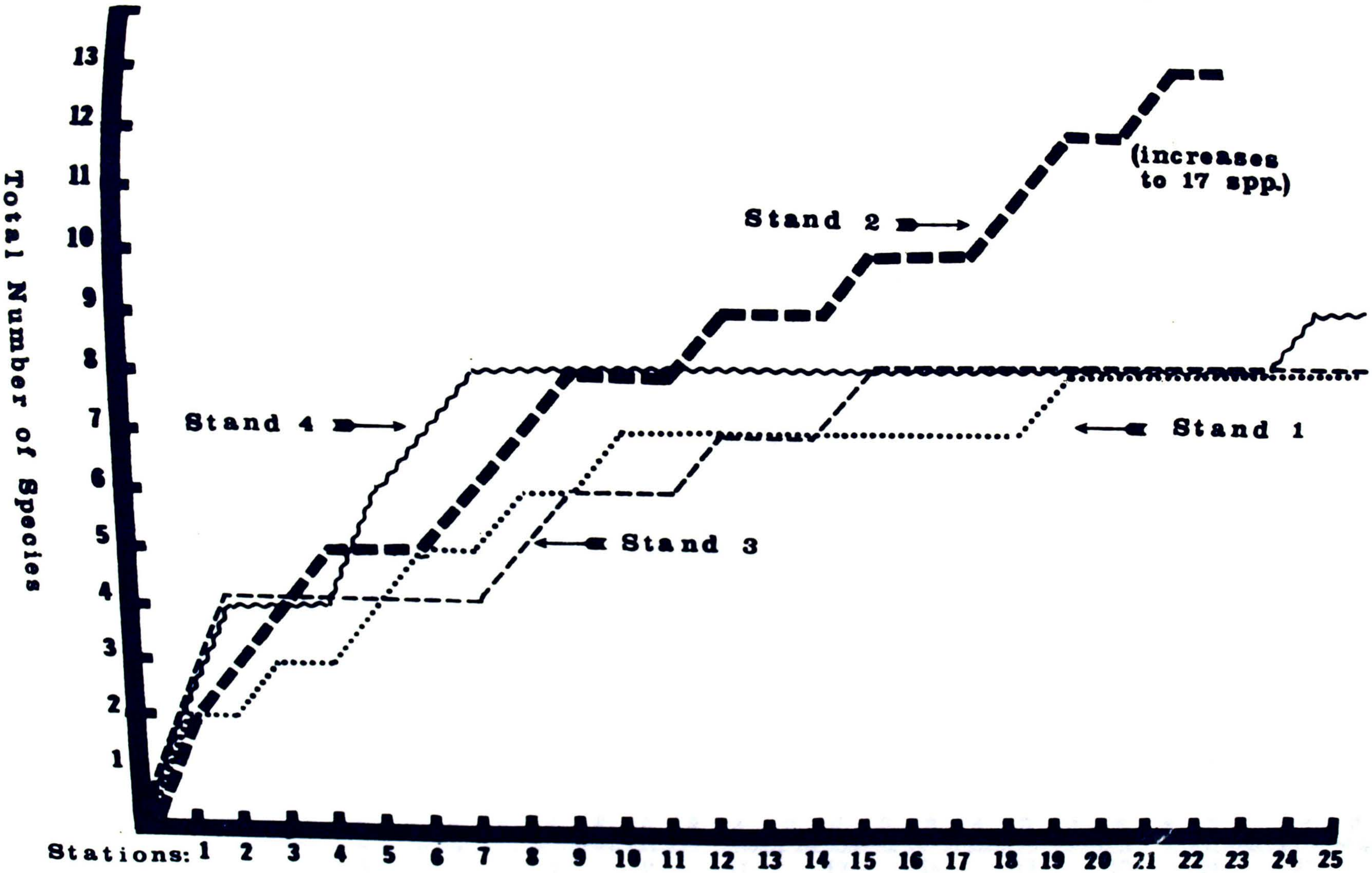

Figure 5. Species Area Curves for Southerly-facing Slopes

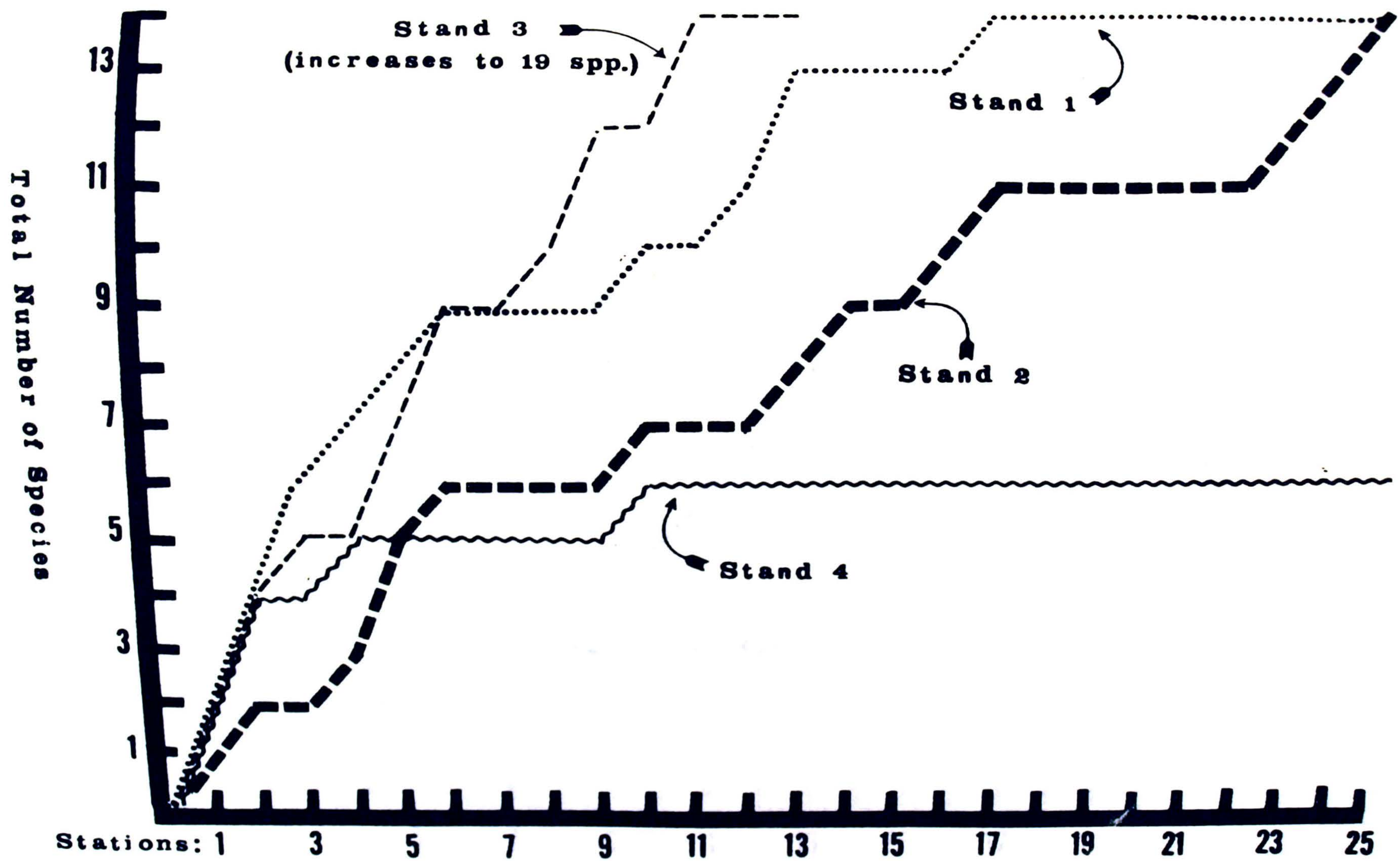

Figure 6. Species Area Curves for Northerly-facing Slopes

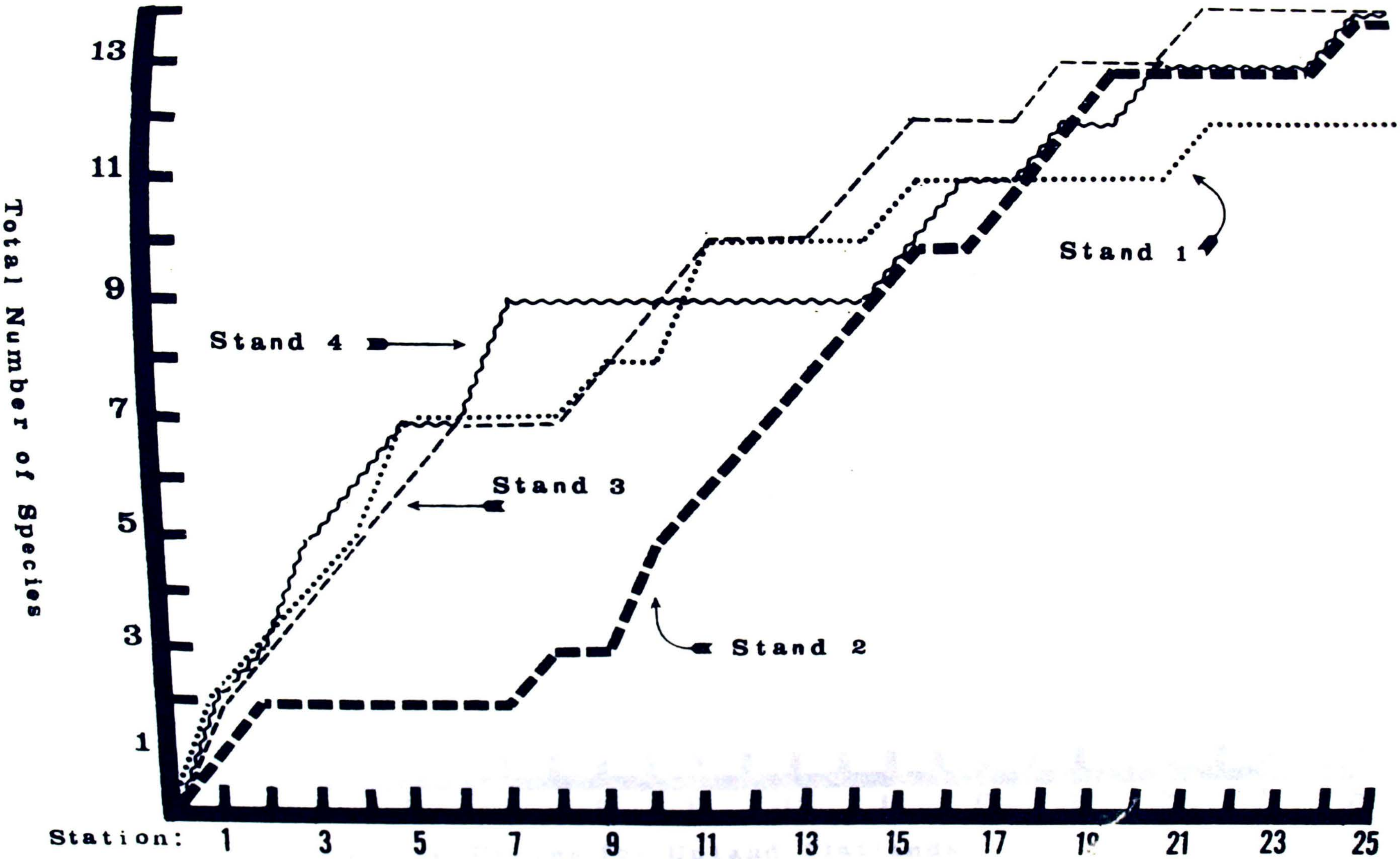

Figure 7. Species Area Curves for Ravines

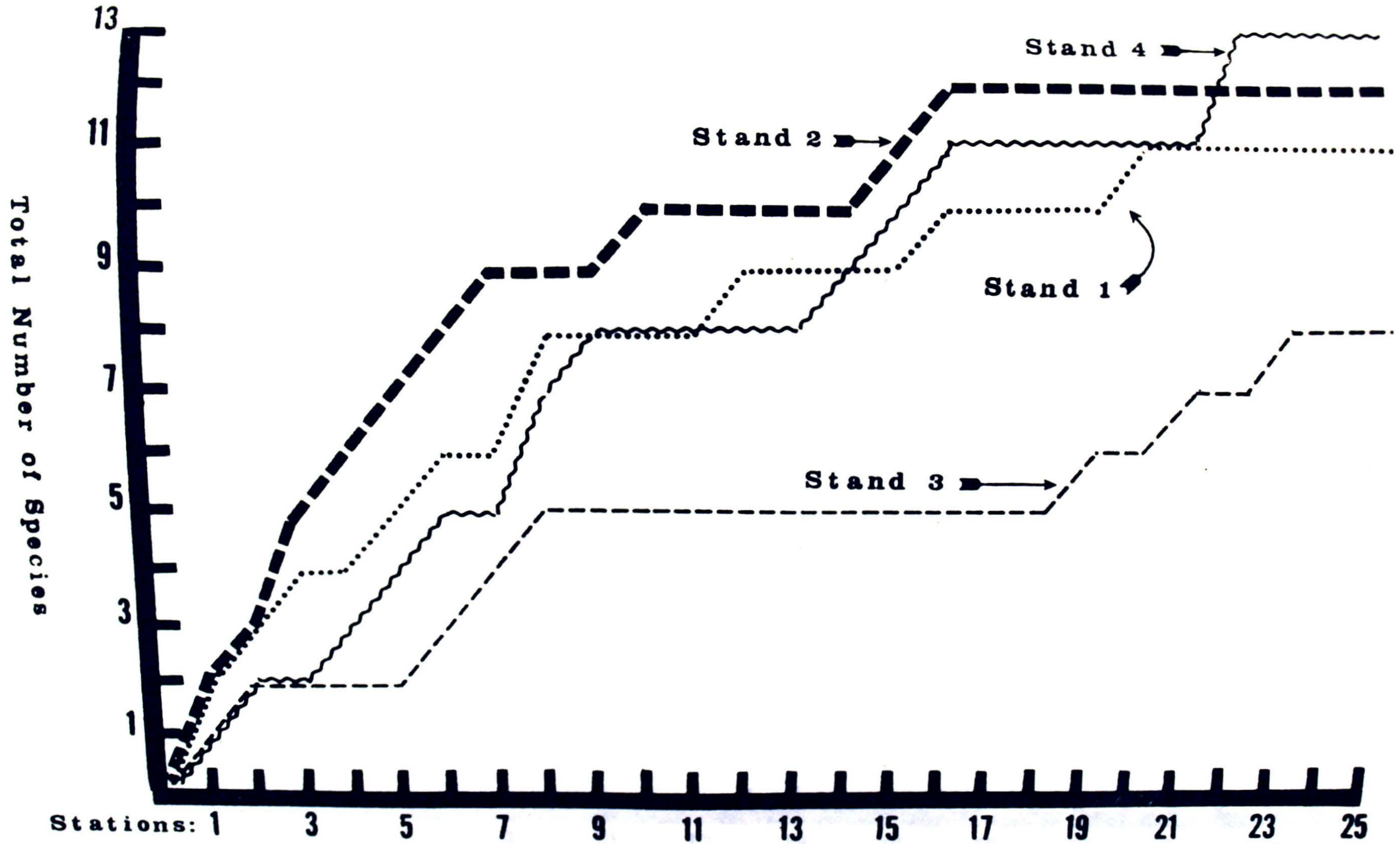

Figure 8. Species Area Curves for Upland Flatlands

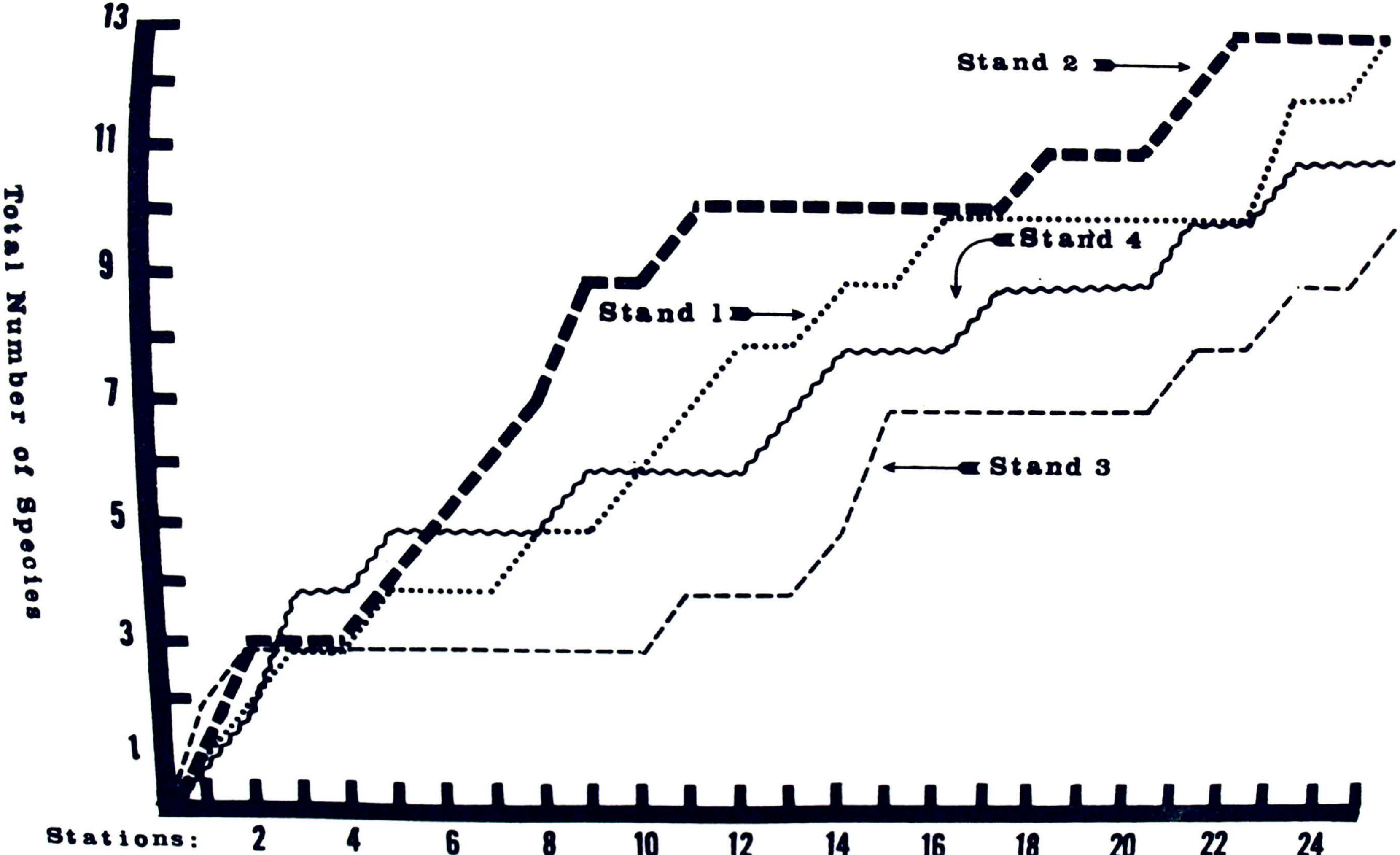

Figure 9. Species Area Curves for Streambanks