A PHYTOSOCIOLOGICAL ANALYSIS OF AN UPLAND WET WOODS ON THE PENNYROYAL PLAIN, MONTGOMERY COUNTY, TENNESSEE

SUSAN MARIE FLETCHER

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Edward. W. Chester, Major Professor

We have read this thesis
and recommend its acceptance:

A. Floyd Scott

Don C. Dailey

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A PHYTOSOCIOLOGICAL ANALYSIS OF AN UPLAND WET WOODS ON THE PENNYROYAL PLAIN, MONTGOMERY COUNTY, TENNESSEE

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DEDICATION

This thesis is dedicated to

Bobby, Mary, Lisa, and Bob.

The difficulties we experience illuminate

the lessons we need most.

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ABSTRACT

Linebaugh Woods is an 8.1-ha forest within an upland depression on the Pennyroyal Plain in Montgomery County, Tennessee. The known history of the woods indicates that most oaks were removed prior to 1950, but there has been little disturbance since. Analyses of this older, secondary woodland revealed dominance by *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Acer rubrum* in the canopy. The same potential canopy taxa dominated the sapling/small tree and shrub/woody seedling layers, indicating that the forest will change little over time. Oaks, normally represented by several taxa and dominating such pristine upland forests on the Pennyroyal Plain, were absent except for *Quercus palustris*. Twenty-one woody taxa were found. The herbaceous strata included more than 80 species, many recognized as wetland taxa. Only one taxon, *Platanthera peramoena*, the purple fringeless orchid, is considered rare in the area.

The results of the study, presented in tabular form and discussed, contribute to the existing data on secondary forests of upland wet soils on the Pennyroyal Plain, and provide insight into presettlement forests and successional trends within the area.

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CHAPTER 1

INTRODUCTION

Most forests in middle Tennessee and central Kentucky are secondary and have been subjected to various anthropogenic influences since settlement in the late 1700s (Chester et al. 1995a). Little information is available on presettlement forests of these areas, especially those on the Pennyroyal Plain Subsection (PPS), where most forests were removed to provide land for agricultural production soon after settlement (Smalley 1980). In a few cases, studies of apparent old-growth and secondary remnants have provided insight into presettlement conditions, but few such remnants exist in this Subsection.

An older, relatively undisturbed, secondary stand has been located on the PPS in northern Montgomery County, Tennessee. The flora and vegetation of the 8.1-ha stand were studied in 2001-2002 with the following objectives:

1. to quantitatively characterize and statistically analyze the woody vegetation by quadrat sampling of the canopy, sapling/small tree, shrub/woody seedling, and woody vine strata;
2. to qualitatively investigate the herbaceous flora through one growing season by regular visits in which voucher specimens were collected, enumerated by seasonal occurrence, and categorized by wetland status;
3. to compare results with published data on area old-growth and secondary

4. to present the results in a thesis, in a departmental seminar, and for review by peers.

The results of this study will contribute to the existing information pool on secondary forests of the southern PPS, and provide additional insight into presettlement forest conditions of the area.

The Pennyroyal Plain Subsection

The PPS is part of the Highland Rim Section of the Interior Low Plateaus Physiographic Province (Fenneman 1938). It is named after Pennyroyal of America (*Hedeoma pulegioides* (L.) Pers.), an herbaceous member of the mint family commonly found in the area (Smalley 1980). The PPS extends from northern Tennessee through Kentucky to southern Illinois and Indiana; in Tennessee it occupies parts of northern Montgomery and Robertson counties, the northeastern corner of Stewart County, and the northwestern corner of Sumner County.

Topography

The topography mostly is a karst landscape with sinkhole plains, sinking streams, upland flats, and depressions with shallow basins (Baskin et al. 1997). The Green, Barren, Little Barren, Little, and Red River are the main rivers, often with flood plains, terraces, and rocky cliffs (Baskin et al. 1997). Smaller, permanent streams are few and most drainage occurs through extensive systems of underground caverns (Smalley 1980). The elevation ranges from 150-300 m above mean sea level (Smalley 1980).

Geology

Mississippian age limestones and shales are the carbonate rocks that result in the karst topography of the PPS (Baskin et al. 1994). The primary bedrock is Ste. Genevieve Limestone, referred to as one of the "Cavernous Limestones" by Sauer (1927). It is a light-gray to brownish-gray limestone that is thick bedded, cherty, and fossiliferous. It is medium- to coarse-grained with several fine- to very fine-grained layers (Klemic 1964).

Soils

The soil associations in the PPS are Crider-Baxter and Fredonia-Pembroke in Kentucky, and Pembroke-Crider and Baxter-Bewleyville-Pembroke in Tennessee (Smalley 1980). Baskin et al. (1994) divided the PPS soils into the following three main categories: (1) deep, moderately- to well-drained soils on level to steeply rolling uplands; (2) deep, well- to poorly-drained soils on floodplains, upland flats, and depressions; and (3) shallow to moderately deep well-drained soils of ridges, knobs, and benches that often are associated with limestone rock outcrops. The most typical soils of upland depressions in the PPS are Robertsville in Kentucky, and Guthrie in Tennessee (Baskin et al. 1994). Fragipans often develop on the weakly dissected upland flats from the imperfectly drained soils (Griffy et al. 1997, Chester and Ellis 1989). Agriculture, including pastures and cultivation, makes up 75 percent of the region due to the fertile soil and level landscape (Smalley 1980). Some soil erosion into sinkholes occurs because of agriculture use (Dicken and Brown 1938).

Climate

The climate is a humid mesothermal type with long warm summers and mild winters (Thornthwaite 1948). The average annual precipitation is 12.5 cm. The increase in precipitation from December to March, along with the poorly drained soils and few permanent streams, accounts for frequent flooding and ponding in winter and spring (Smalley 1980). Several snowfalls of a few cm occur during the winter months and soils are rarely frozen for more than four days (Chester and Ellis 1989, Griffy et al. 1997).

Vegetation

The PPS is included within the Mississippian Plateau Section of Braun's (1950) Western Mesophytic Forest Region. This Section is transitional and includes elements from the more xeric Oak-Hickory Region to the west and the more mesic Mixed Mesophytic Region to the east. Most PPS woodlands occur in areas that are too steep or poorly drained for agriculture (Smalley 1980). Vegetation diversity includes barrens, prairie remnants, forests, swamps, and wetlands (Chester and Ellis 1989).

Almost all forests are secondary, and pre-settlement vegetation can only be predicted for the most part. Composition and structural data for three old-growth stands are available: Keever (1971) and Bougher and Winstead (1974) described Bonayer Forest in Barren County, Kentucky; Winstead (1987) provided data from a winter-flooded forest in Warren County, Kentucky; and Chester et al. (1995b) provided a phytosociological analysis of Greenwood Forest in Christain County, Kentucky. Data from secondary stands, all on the southern PPS in Montgomery and Stewart counties, Tennessee were

provided by Chester et al. (1995a), and from Robertson County, Tennessee by Chester and Ellis (1989). Baskin et al. (1997) provided a review and synthesis of the PPS forest vegetation.

The Study Area

Location and Site Description

The study area, Linebaugh Woods, is on the southern PPS in northeastern Montgomery County, Tennessee, about 20 km northeast of Clarksville and about 3 km southeast of Guthrie, Kentucky. It is centered at 36°38'12" north latitude and 87°07'15" west longitude (U.S. Geological Survey 1950).

Linebaugh Woods is an 8.1 ha stand in an upland depression; it is secondary but without recent disturbance. Elevations range from 173-177 m above sea level (U.S. Geological Survey 1950). Two soil types are found in the study area (U.S. Department of Agriculture 1975). Guthrie silt loam makes up 90 percent of the area, extending from the northern boundary nearly across the depression. This nearly level soil was formed in loess on upland flats and in depressions where standing water occurs, often through winter, spring and into summer. It is very acidic, has a fragipan, and thus drains slowly; it is commonly called crawfishy land. A narrow strip of Taft silt loam occupies the southern edge of the depression (less than 10 percent of the area). This nearly level soil also was formed in loess, has a fragipan, is acidic, and is usually ponded for short periods in winter and spring. Both Taft and Guthrie silt loams are deep and fertile, but poor drainage hinders their agricultural usage.

History

The forest has been part of the Linebaugh family since September 1852; the first purchase of the 60.7-ha farm was from Paul Isabell and the remainder was purchased in 1857 from S.F. Mitchell. Mr. Mack Linebaugh is the current owner and uses most of the farm for row crops and hay. A few woodlands remain within the farm property, all surrounded by agriculture fields. According to Mr. Linebaugh, the last timber removed from the targeted woodland was in about 1950 and it has not been pastured or burned in recent memory.

CHAPTER 2

METHODS

Woody Vegetation

Quantitative data for forest analyses were collected 2, 3, and 5 July 2001. Thirty 0.04-ha (0.1-acre) circular plots at 30-m centers were established along three equidistant parallel transects running east to west through the forest. Transect lines ended 15.24 m from forest borders to avoid edge effects. Within each plot, all woody stems with a diameter breast height (dbh, 135 cm above ground) $\geq$ 2.5 cm were measured and recorded by species. Stems with dbh $\geq$10.0 cm (4 inches) were grouped as canopy; stems with a dbh of 2.5-9.99 cm (1-3.9 inches) were grouped as saplings or small trees.

For each group, basal area (cross section measured at 135 cm above ground level), relative basal area (percentage of basal area of a species to all species), density (number of individuals per area sampled), relative density (percentage density of a species to that of all species), frequency (percentage of sample plots in which a species occurred), and relative frequency (percentage frequency of a species to that of all species) were calculated (Oosting 1956, Cain and Castro 1959). The sum of relative density, relative basal area, and relative frequency gave an importance value (IV) of 300 maximum (Curtis and McIntosh 1950). Other parameters calculated include a size-class chart and average dbh for all trees. Woody vines were recorded by species and the data used to calculate frequency and relative frequency for this group.

A circular plot of 0.004-ha (0.01-acre) was nested at the center of each 0.4-ha

plot. Within each of these plots woody seedlings and shrubs with a dbh <2.54 cm (1 inch) were counted by species. These data were used to calculate density, relative density, frequency, and relative frequency. The IV (maximum 200) was calculated by summing relative density and relative frequency.

Linebaugh Woods data were compared to characteristics of old-growth forests, summarized by Parker (1989) for the Central Hardwood Region of the eastern United States, and by Martin (1992) for the Mixed Mesophytic Forests of the southern Appalachians to further characterize the stand.

Herbaceous Flora

Trips were made to the study site from May through October 2001, and during April of 2002. During each trip, the forest was surveyed by walking three pre-determined transect lines. Voucher specimens of vascular plants were collected, prepared according to standard procedures, and accessioned into the Austin Peay State University Herbarium. Identification and nomenclature followed Gleason and Cronquist (1991) and Wofford and Kral (1993). Abundance of each species was estimated at the time of collection following the scheme of Murrell and Wofford (1987): abundant (throughout, usually in large numbers), frequent (often encountered, not always in large numbers), occasional (occasionally encountered, rarely in large numbers), and infrequent (rarely encountered, usually in small numbers). Taxa were categorized by seasonal occurrence during the growing season as: spring (1 April-31 May), summer (1 June-31 August), and autumn (1 September-15 October).

The wetland indicator status for each herbaceous species was taken from the designations of the U. S. Fish and Wildlife Service, as published by the U.S. Department of Agriculture (2001). The indicator categories include: Obligate Wetland (OBL), occurs almost always (estimated probability 99 percent) in wetlands; Facultative Wetland (FACW), usually occurs in wetlands (estimated probability 67 percent-99 percent); Facultative (FAC), equally likely to occur in wetlands or non-wetlands (estimated probability 34 percent-66 percent); Facultative Upland (FACU), usually occurs in non-wetlands (estimated probability 67 percent- 99 percent), but occasionally found on wetlands (estimated probability 1 percent-33 percent); Obligate Upland (UPL), occurs in non-wetlands under natural conditions in the region; No indicator (NI), insufficient information was available to determine an indicator status.

CHAPTER 3

RESULTS

Woody Vegetation

A total of 941 stems (21 species) with a dbh ≥2.54 cm was measured. The majority of the stems (575, 60.8%) were in the ≥10-cm dbh size class; 366 stems (39.2%) had a dbh of 2.54-10.0 cm (Tables 1, 2). The average dbh for all stems was 8.55 cm (Table 1). Dead tree trunks (snags) were not identified to genus or species, but they were measured and added to the data. The individual trees with the largest dbh (cm) included: *Quercus palustris* (89.41, 89.66), *Liquidambar styriaciflua* (82.04), and *Nyssa sylvatica* (73.15). The species with the largest average dbh for all stems were: *Quercus palustris*, 56.39 cm, found only in the canopy; *Salix nigra*, 54.61 cm, only one stem sampled; *Platanus occidentalis*, 41.05 cm for all stems, 44.09 for canopy stems; *Prunus serotina*, 38.02 cm, all canopy.

The 16 canopy species and snags included 575 stems (Table 2). Canopy density was 473.61 stems/ha and canopy basal area was 50.44 m^2/ha. The sapling/small tree stratum included 366 stems of 18 species and snags (Table 3). Density was 301.48 stems/ha and basal area was 0.70 m^2/ha. *Celtis laevigata, Morus alba,* and *Quercus stellata* were observed in the floristic studies but not found in the plots. The shrub/woody seedling stratum included 17 species (Table 4); 627 stems were counted, giving a density of 516.45 stems/ha.

Plot studies (Table 5) showed the prevalence of three woody vines: *Rhus*

radicans, *Smilax rotundifolia*, and *Parthenocissus quinquefolia*. Less-common vines were *Campsis radicans* and *Lonicera japonica*. Two woody vine species, *Smilax bona-nox* and *Rosa palustris*, were observed in floristic studies but not found in plots.

A summary of community structure for the three woody strata is shown in Table 6. Table 7 provides a comparison of importance values (IV) for species within each stratum.

Herbaceous flora

The known herbaceous flora of Linebaugh Woods consists of 82 species within 34 families (Appendix). Table 8 includes an alphabetical list of these species along with the degree of abundance, seasonal occurrence (maturity), and wetland classification.

Table 1. Size class chart for sampled taxa with dbh ≥ 2.54 cm from Linebaugh Woods, Montgomery County, Tennessee.

Taxa	No. Stems	Avg. DBH[1]	Avg. DBH[2]	Size in cm 2.5-9.9	10.0-20.0	20.1-30.2	30.3-40.4	40.5-50.6	50.7-60.8	60.9-70.9	71.0-81.1	> 81.2
Acer rubrum	125	29.92	32.99	14	30	22	30	10	14	3	2	-
Aralia spinosa	5	3.30	-	5	-	-	-	-	-	-	-	-
Asimina triloba	133	3.68	-	133	-	-	-	-	-	-	-	-
Carya cordiformis	30	28.96	31.29	3	5	10	6	3	2	-	1	-
Celtis occidentalis	43	9.42	18.69	32	7	2	2	-	-	-	-	-
Cornus florida	1	9.91	-	1	-	-	-	-	-	-	-	-
Fraxius americana	5	3.86	-	5	-	-	-	-	-	-	-	-
Fraxinus pennsylvanica	2	26.04	48.26	1	-	-	-	1	-	-	-	-
Ilex decidua	9	3.15	-	9	-	-	-	-	-	-	-	-
Liquidambar styraciflua	218	28.45	36.09	53	31	27	42	34	19	11	-	1
Liriodendron tulipifera	3	21.16	46.99	2	-	-	-	1	-	-	-	-
Morus rubra	8	13.56	16.00	2	6	-	-	-	-	-	-	-
Nyssa sylvatica	198	20.12	25.76	60	59	33	23	19	2	1	1	-
Platanus occidentalis	12	41.05	44.09	1	3	1	-	-	4	3	-	-
Populus heterophylla	9	28.75	35.79	2	-	2	2	3	-	-	-	-
Prunus serotina	3	38.02	38.02	-	-	1	1	-	1	-	-	-
Quercus palustris	35	56.39	56.39	-	-	3	4	6	8	6	6	2
Robinia pseudoacacia	3	15.82	40.89	2	-	-	-	1	-	-	-	-
Salix nigra	1	54.61	54.61	-	-	-	-	-	1	-	-	-
Ulmus alata	9	6.53	11.43	8	1	-	-	-	-	-	-	-
Ulmus rubra	31	14.35	23.85	17	7	3	2	2	-	-	-	-
Snags	63	20.50	27.91	21	14	13	9	3	2	1	-	-

[1]average dbh for all stems >2.5 cm [2]average dbh for stems >10.0 cm

Table 2. Species composition and structure of the canopy layer (≥ 10.00 cm dbh) in Linebaugh Woods, Montgomery County, Tennessee.

Taxa	No. Stems	No. Plots	Density (No./ha)	Rel. Density	Basal Area (m^2/ha)	Rel. Basal Area	Freq.	Rel. Freq.	IV (300)	% of IV
Acer rubrum	111	26	91.43	19.31	9.54	18.92	86.67	15.76	53.99	18.00
Carya cordiformis	27	9	22.24	4.70	2.08	4.12	30.00	5.45	14.27	4.76
Celtis occidentalis	11	6	9.06	1.91	0.30	0.59	20.00	3.63	6.13	2.04
Fraxinus pennsylvanica	1	1	0.82	0.17	0.15	0.30	3.33	0.61	1.08	0.36
Liquidambar styraciflua	165	30	135.91	28.70	16.65	33.02	100.00	18.18	79.90	26.63
Liriodendron tulipifera	1	1	0.82	0.17	0.14	0.29	3.33	0.61	1.07	0.36
Morus rubra	6	5	4.94	1.04	0.10	0.20	16.67	3.03	4.27	1.42
Nyssa sylvatica	138	29	113.67	24.00	7.39	14.65	96.67	17.57	56.22	18.74
Platanus occidentalis	11	4	9.06	1.91	1.72	3.40	13.33	2.42	7.73	2.58
Populus heterophylla	7	2	5.77	1.22	0.61	1.21	6.67	1.21	3.64	1.21
Prunus serotina	3	2	2.47	0.52	0.31	0.61	6.67	1.21	2.34	0.78
Quercus palustris	35	16	28.83	6.09	7.93	15.72	53.33	9.70	31.51	10.50
Robinia pseudoacacia	1	1	0.82	0.17	0.11	0.22	3.33	0.61	1.00	0.33
Salix nigra	1	1	0.82	0.17	0.19	0.38	3.33	0.61	1.16	0.39
Ulmus alata	1	1	0.82	0.17	0.01	0.02	3.33	0.61	0.80	0.27
Ulmus rubra	14	10	11.53	2.44	0.64	1.26	33.33	6.06	9.76	3.25
Snags	42	21	34.60	7.31	2.57	5.09	70.00	12.73	25.13	8.38
Totals	575	-	473.61	100.00	50.44	100.00	549.99	100.00	300.00	100.00

Table 3. Species composition and structure of the sapling/small tree layer (2.54-9.99 cm dbh) in Linebaugh Woods, Montgomery County, Tennessee.

Taxa	No. Stems	No. Plots	Density (No./ha)	Rel. Density	Basal Area (m^2/ha)	Rel. Basal Area	Freq.	Rel. Freq.	IV (300)	% of IV
Acer rubrum	14	12	11.53	3.82	0.03	4.55	40.00	11.54	20.70	6.87
Aralia spinosa	5	1	4.12	1.36	0.00	0.57	3.33	0.96	2.89	0.96
Asimina triloba	134	9	110.38	36.61	0.14	19.35	30.00	8.65	64.60	21.41
Carya cordiformis	3	2	2.47	0.82	0.01	1.71	6.67	1.92	4.45	1.47
Celtis occidentalis	27	11	22.24	7.37	0.06	9.10	36.67	10.58	27.10	8.97
Cornus florida	1	1	0.82	0.27	0.01	1.00	3.33	0.96	2.23	0.74
Fraxinus americana	5	2	4.12	1.37	0.01	0.85	6.67	1.92	4.14	1.37
Fraxinus pennsylvanica	1	1	0.82	0.27	0.00	0.00	3.33	0.96	1.23	0.41
Ilex decidua	9	3	7.41	2.46	0.01	0.85	10.00	2.88	6.19	2.05
Liquidambar stryaciflua	53	11	43.66	14.48	0.09	12.94	36.67	10.59	38.00	12.59
Liriodendron tulipifera	2	2	1.65	0.55	0.01	1.29	6.67	1.92	3.76	1.24
Morus rubra	2	2	1.65	0.55	0.01	0.71	6.67	1.92	3.18	1.05
Nyssa sylvatica	59	19	48.60	16.12	0.20	28.31	63.33	18.28	62.70	20.78
Platanus occidentalis	1	1	0.82	0.27	0.00	0.57	3.33	0.96	1.80	0.60
Populus heterophylla	2	2	1.65	0.55	0.00	0.28	6.67	1.92	3.75	1.24
Robinia pseudoacacia	2	1	1.65	0.55	0.00	0.28	3.33	0.96	1.79	0.59
Ulmus alata	8	2	6.6	2.19	0.02	2.99	6.67	1.92	7.10	2.35
Ulmus rubra	17	8	14.00	4.64	0.05	7.54	26.67	7.69	19.90	6.59
Snags	21	14	17.30	5.74	0.05	7.11	46.67	13.46	26.30	8.72
Totals	366	-	301.48	100.00	0.70	100.00	346.68	100.00	300.00	100.00

Table 4. Species composition and structure of the shrub/woody seedling layer (dbh <2.54 cm) in Linebaugh Woods, Montgomery County, Tennessee.

Taxa	No. Plots	No. Stems	Freq. (%)	Rel. Freq.	Density	Rel. Density	IV (200)	% of IV
Acer rubrum	1	5	3.33	1.39	4.12	0.80	2.19	1.09
Aralia spinosa	1	4	3.33	1.39	3.29	0.63	2.02	1.01
Asimina triloba	7	60	23.33	9.72	49.42	9.56	19.28	9.65
Carya cordiformis	6	3	20.00	8.33	2.47	0.47	8.80	4.40
Celtis occidentalis	12	30	43.33	18.05	24.71	4.78	22.83	11.43
Fraxinus americana	3	9	10.00	4.16	7.41	1.43	5.59	2.80
Liquidambar styraciflua	7	26	23.33	9.72	21.42	4.15	13.87	6.94
Liriodendron tulipifera	1	1	3.33	1.39	0.82	0.16	1.55	0.78
Morus rubra	2	5	6.66	2.78	4.12	0.80	3.58	1.79
Nyssa sylvatica	10	21	33.33	13.89	17.29	3.35	17.25	8.62
Populus heterophylla	2	30	6.66	2.78	24.71	4.78	7.56	3.78
Quercus palustris	4	5	13.33	5.56	4.12	0.80	6.36	3.18
Robinia pseudoacacia	2	6	6.66	2.78	4.94	0.96	3.74	1.87
Rubus argutus	2	17	6.66	2.78	14.00	2.71	5.49	2.75
Sambucus canadensis	1	3	3.33	1.39	2.47	0.49	1.88	0.94
Symphoricarpos orbiculatus	8	399	26.66	11.11	328.67	63.64	74.75	37.37
Ulmus rubra	2	3	6.66	2.78	2.47	0.49	3.27	1.64
Totals	-	627	239.93	100.00	516.45	100.00	200.00	100.00

Table 5. Frequency chart for woody vines in Linebaugh Woods, Montgomery County, Tennessee.

Taxa	No. Plots	Freq.	Rel Freq.
Rhus radicans	30	100.00	34.89
Parthenocissus quinquefolia	23	76.66	26.74
Smilax rotundifolia	22	73.33	25.58
Campsis radicans	6	20.00	6.98
Lonicera japonica	5	16.66	5.81
Totals	-	286.65	100.00

Table 6. Summary of community parameters for Linebaugh Woods, Montgomery County, Tennessee.

Stratum	No. Taxa	Avg. dbh (cm)	Density (no./ha)	Basal Area (m2/ha)
Canopy (>10.0cm dbh)	16	34.65	473.61	50.44
Sapling/Small Tree (2.54-10.0cm dbh)	18	5.56	301.48	0.70
Shrub/Woody Seedling (<2.54cm dbh)	17	-	516.45	-

Table 7. Comparison of percentage IVs for sampled taxa in three strata of woody vegetation in Linebaugh Woods, Montgomery County, Tennessee.

	Strata		
Taxa	Canopy ≥10.16 cm	Saplings/ Small trees 2.54-10.15cm	Shrubs/ Seedlings <2.54cm
Acer rubrum	18.00	6.87	1.09
Aralia spinosa	-	0.96	1.02
Asimina triloba	-	21.41	9.65
Carya cordiformis	4.76	1.47	4.41
Celtis occidentalis	2.04	8.97	11.42
Cornus florida	-	0.74	-
Fraxinus americana	-	1.37	2.80
Fraxinux pennsylvanica	0.36	0.41	-
Ilex decidua	-	2.05	-
Liquidambar styraciflua	26.63	12.59	6.93
Liriodendron tulipifera	0.36	1.24	0.77
Morus rubra	1.42	1.05	1.79
Nyssa sylvatica	18.74	20.78	8.62
Platanus occidentalis	2.58	0.60	-
Populus heterophylla	1.21	1.24	3.78
Prunus serotina	0.78	-	-
Quercus palustris	10.50	-	3.18
Robinia pseudoacacia	0.33	0.59	1.87
Rubus argutus	-	-	2.74
Sambucus canadensis	-	-	0.94
Symphoricarpos orbiculatus	-	-	37.36
Salix nigra	0.39	-	-
Ulmus alata	0.27	2.35	-
Ulmus rubra	3.25	6.59	1.63
Snags	8.38	8.72	-
Totals	100.00	100.00	100.00

Table 8. Abundance, seasonal occurrence, and wetland classification for herbaceous specimens collected in Linebaugh Woods, Montgomery County, Tennessee. Spring = 1 April through 31 May, Summer = 1 June through 31 August, and Fall = 1 September through 15 October.

Taxa	Abundance	Spring	Summer	Fall	Wetland Classification
Agrostis perennans	Infrequent			X	FACU
Alcalypha virginica	Occasional			X	FACU
Allium vineale	Occasional	X	X		FACU
Arisaema dracontium	Infrequent	X	X		FACW
Asclepias syriaca	Infrequent		X		NI
Asplenium platyneuron	Occasional	X	X	X	FACU
Athryium asplenioides	Infrequent	X	X		FACU
Bidens aristosa	Occasional			X	FACW
Bidens discoidea	Occasional			X	FACW
Boehmeria cylindrica	Occasional		X		FACW
Botrychium dissectum	Occasional			X	FAC
Botrychium virginianum	Occasional	X	X		FACU
Carex amphibola	Infrequent		X		FACW
Carex blanda	Infrequent	X	X		FAC
Carex complanata	Infrequent	X	X		FAC
Carex intumescens	Infrequent		X		FACW
Carex lupulina	Infrequent		X		OBL
Carex retroflexa	Infrequent	X	X		FACW
Carex squarrosa	Infrequent	X	X		FACW
Carex tribuloides	Rare		X	X	FACW
Carex vulpinoidea	Infrequent	X	X		OBL
Cinna arundinaceae	Infrequent		X		FACW
Circaea lutetiana	Infrequent		X	X	FACU
Commelina communis	Occasional	X			FAC
Commelina virginica	Occasional		X		FACW
Cyperus echinatus	Occasional		X		FAC
Erechtites hieraciifolia	Infrequent			X	FAC
Erigeron annuus	Infrequent	X	X		FACU
Erigeron philadelphicus	Infrequent	X	X		FAC
Eupatorium aromaticum	Occasional		X		NI
Galium aparine	Infrequent	X	X		FACU
Galium tinctorium	Occasional		X	X	FACW
Galium triflorum	Occasional		X		FACU
Geranium carolinianum	Rare	X	X		FACU
Geum canadensis	Occasional		X		FAC
Glyceria striata	Occasional		X	X	OBL

Table 8 (continued)

Taxa	Abundance	Spring	Summer	Fall	Wetland Classification
Gratiola neglecta	Infrequent		X	X	OBL
Impatiens capensis	Frequent	X	X		FACW
Juncus acuminatus	Infrequent		X		OBL
Juncus effusus	Infrequent		X	X	FACW
Leersia virginica	Infrequent		X	X	FACW
Lobelia cardinalis	Occasional		X	X	FACW
Lycopus virginicus	Occasional			X	OBL
Lysimachia lanceolata	Occasional		X		FAC
Microstegium vimineum	Abundant			X	FAC
Mimulus alatus	Infrequent		X		OBL
Myosotis macrosperma	Infrequent		X		FAC
Onoclea sensibilis	Infrequent		X		FACW
Ophioglossum engelmannii	Rare	X			FACU
Oxalis grandis	Infrequent	X	X		UPL
Panicum anceps	Occasional			X	FAC
Panicum dichotomum	Occasional		X	X	FACW
Panicum laxiflorum	Infrequent		X	X	FAC
Panicum scoparium	Occasional		X	X	FACW
Parietaria pensylvanica	Rare		X	X	FAC
Passiflora lutea	Occasional		X		NI
Phyllanthus caroliniensis	Infrequent			X	FAC
Phytolacca americana	Occasional	X	X	X	FACU
Pilea pumila	Rare			X	FACW
Platanthera peramoena	Infrequent		X		FACW
Podophyllum peltatum	Abundant	X	X		FACU
Polygonum caespitosum	Occasional		X	X	FACW
Polygonum pensylvanicum	Occasional		X	X	FACW
Polygonum punctatum	Occasional		X	X	FACW
Polygonum virginianum	Infrequent		X	X	FAC
Ranunculus abortivus	Occasional	X	X		FAC
Ranunculus recurvatus	Occasional	X	X		FAC
Rhynchospora corniculata	Occasional		X	X	OBL
Rubus argutus	Occasional	X	X		FACU
Sanicula canadensis	Rare	X	X		FACU
Scirpus atrovirens	Infrequent		X		OBL
Scutellaria lateriflora	Occasional		X		FACW
Solanum carolinense	Infrequent	X	X		FACU
Solanum ptychanthum	Infrequent		X		FACU
Stellaria media	Occasional	X	X		FACU
Taraxacum officinale	Infrequent		X		FACU

Table 8 (continued)

Taxa	Abundance	Spring	Summer	Fall	Wetland Classification
Teucrium canadense	Occasional		X		FACW
Tipularia discolor	Rare			X	FACU
Triadenum tubulosum	Infrequent			X	OBL
Triadenum walteri	Infrequent			X	OBL
Triodanis perfoliata	Occasional	X			FACU
Vernonia gigantea	Infrequent			X	FAC

CHAPTER 4

DISCUSSION

Woody Vegetation

Four species shared canopy dominance based on percent of Importance Value (IV); *Liquidambar styraciflua* (26.63 percent), *Nyssa sylvatica* (18.74), *Acer rubrum* (18.00), and *Quercus palustris* (10.50) made up 73.87 percent of total IV (Table 2). Other important contributors were *Carya cordiformis* (4.76) and *Ulmus rubra* (3.25). The remaining 10 species (*Platanus occidentalis, Celtis occidentalis, Morus rubra, Populus heterophylla, Prunus serotina, Salix nigra, Fraxinus pennsylvanica, Liriodendron tulipifera, Robinia pseudoacacia, Ulmus alata*) accounted for 9.74 percent of the total IV. Snags were the remaining 8.38 percent of IV.

Asimina triloba (21.41 percent), *Nyssa sylvatica* (20.78), *Liquidambar styraciflua* (12.59), and *Celtis occidentalis* (8.97) dominated the sapling/small tree layer, making up 63.75 percent of total IV (Table 3). Other important contributors were *Acer rubrum* (6.87) and *Ulmus rubra* (6.59). The remaining 12 species (*Ulmus alata, Ilex decidua, Carya cordiformis, Fraxinus americana, Liriodendron tulipifera, Populus heterophylla, Morus rubra, Aralia spinosa*, *Cornus florida, Platanus occidentalis, Robinia pseudoacacia*, and *Fraxinus pennsylvanica*) accounted for 14.07 percent of the total IV. Snags were the remaining 8.72 percent of IV.

Prunus serotina, *Quercus palustris*, and *Salix nigra* were present in the canopy

but absent from the sapling/small tree layer (Table 7). The following species were found both in the canopy and the sapling/small tree layer: *Acer rubrum*, *Carya cordiformis*, *Celtis occidentalis*, *Fraxinus pennsylvanica*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Morus rubra*, *Nyssa sylvatica*, *Platanus occidentalis*, *Populus heterophylla*, *Robinia pseudoacacia*, *Ulmus alata*, *and Ulmus rubra*. One potential canopy species (i.e., species that can become canopy but presently does not occur in the canopy), *Fraxinus americana,* was found in the sapling/small tree layer.

Symphoricarpos orbiculatus (37.37 percent), *Celtis occidentalis* (11.43), *Asimina triloba* (9.65), and *Nyssa sylvatica* (8.62) dominated the shrub/woody seedling layer, making up 67.05 percent of the total IV (Table 4). *Liquidambar styraciflua* (6.94) and *Populus heterophylla* (3.78) made important contributions. *Fraxinus americana* was the only potential canopy species found in the shrub/woody seedling layer. *Quercus palustris* (3.18) was present in this layer, although it was absent from the sapling/small tree layer, and present in the canopy layer. One non-native taxon (*Lonicera japonica*) was present in this stratum.

Acer rubrum, *Carya cordiformis*, *Celtis occidentalis*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Morus rubra*, *Nyssa sylvatica*, *Populus heterophylla*, *Robinia pseudoacacia*, and *Ulmus rubra* are canopy species that were present in all three strata. Four species, *Asimina triloba* (21.41 percent), *Ilex decidua* (2.05), *Aralia spinosa* (0.96), and *Cornus florida* (0.74), were restricted to the sapling/small tree layer and comprised 25.16 percent of total IV in this stratum. Five species without canopy potential, *Symphoricarpos orbiculatus* (37.36 percent), *Asimina triloba* (9.65), *Rubus argutus*

(2.74), *Aralia spinosa* (1.02), and *Sambucus canadensis* (0.94), comprised 51.71 percent of total IV in the shrub woody/seedling layer.

The prevalence of *Liquidambar styraciflua* (26.63 percent IV), *Nyssa sylvatica* (18.74), and *Acer rubrum* (18.00), and the lack of *Quercus* taxa in the canopy layer characterize Linebaugh Woods as a secondary forest based on published analyses of pristine PPS forests. In Bonayer Forest, Barren County, Kentucky (Bougher and Winstead 1974), oaks (*Quercus alba*, *Quercus velutina*, *Quercus coccinea*, and an unidentifiable oak) had a total IV of 81.9, which made up 27.3 percent of the total IV (300) for all species. *Quercus alba* had a greater relative dominance than any other tree species, was present in all five size classes, and the only species so evenly distributed (Bougher and Winstead 1974). In Bonayer Forest, based on IV, the predominate species over 5 cm (2 inches) were *Quercus alba* (29.1 percent), *Nyssa sylvatica* (29.1), *Carya ovata* (26.8), and *Liquidambar styraciflua* (22.1).

In Greenwood Forest, Christian County, Kentucky (Chester et al. 1995b), eleven *Quercus* spp. had an IV of 98.87, making up 32.96 percent of total IV (300) for all species; and four *Carya* spp. had an IV of 56.49, making up 18.83 percent of total IV. The canopy, based on IV (300), was dominated by *Carya ovata* (46.22 percent), *Acer rubrum* (31.96), *Quercus falcata* (24.11), *Liquidambar styraciflua* (21.40), *Quercus palustris* (19.44) and *Quercus michauxii* (17.74).

Linebaugh Woods canopy contains few of the taxa found in these old-growth PPS forests. The sapling/small tree and shrub/woody seedling layers, normally expected to replace the canopy as present species are eliminated, are dominated by *Acer rubrum*,

Liquidambar styraciflua, and *Nyssa sylvatica*, along with the potential canopy taxon *Celtis occidentalis*. These taxa are indicative of second-growth PPS forest (Chester and Ellis 1989, Chester et al. 1995a). Also, the known history of Linebaugh Woods indicates an older, but secondary forest.

Herbaceous flora

The herbaceous flora included ferns or fern allies (6 species, 7.32 percent) and angiosperms: monocots (29 species, 35.37 percent), and dicots (47 species, 57.32 percent). Four families, Cyperaceae (12 taxa), Poaceae (9), Asteraceae (8), and Polygonaceae (4), included 39.2 percent of the flora. Families with three taxa (18.2 percent of the flora) included: Urticaceae, Rosaceae, Rubiaceae, Lamiaceae, and Ophioglossaceae. Families with two taxa (24.4 percent of the flora) included: Woodsiaceae, Commelinaceae, Orchidaceae, Campanulaceae, Clusiaceae, Euphorbiaceae, Ranunculaceae, Scrophulariaceae, Solanaceae, and Juncaceae. Families with one taxon (18.2 percent of the flora) included: Aspleniaceae, Araceae, Liliaceae, Asclepiadaceae, Balsaminaceae, Berberidaceae, Boraginaceae, Caryophyllaceae, Geraniaceae, Ongraceae, Oxalidaceae, Passifloraceae, Phytolaccaceae, Primulaceae, and Apiaceae.

The herbaceous flora occured in growing-season categories as follows (Table 8): 3.66 percent spring; 28.05 percent summer; 18.29 percent fall; 26.83 percent spring and summer; 20.73 percent summer and fall; 2.44 percent spring, summer, and fall. The lower percentage for spring is the result of the standing water throughout much of the

early growing season

An estimation of the abundance of each species was made upon collection (Table 8). Most species (87 percent) occurred infrequently or occasionally. Seven species (8 percent) were estimated to be rare. These include *Carex tribuloides*, *Geranium carolinianum*, *Ophioglossum engelmannii*, *Parietaria pensylvanica*, *Pilea pumila*, *Sanicula canadensis*, and *Tipularia discolor*. *Podophyllum peltatum* and *Impatiens capensis* occurred frequently, and *Microstegium vimineum* was abundant.

The study included one threatened plant, *Platanthera peramoena* (Wofford and Kral 1993). The non-native taxa were *Allium vineale*, *Commelina communis*, *Microstegium vimineum*, *Stellaria media*, and *Taraxacum officinale* (Wofford and Kral 1993). The non-native taxa made up 6.10 percent of the total flora. An annotated catalog is provided in the Appendix.

Species determination based on wetland classification indicated that 32 percent of the flora usually occurs in wetlands (FACW), 27 percent usually occur in non-wetlands (FACU), 23 percent equally occur in wetlands or non-wetlands (FAC), and 13 percent occur almost always in wetlands (OBL) (Table 8). An indicator status has not been determined for three species (4 percent), and one specie (1 percent) occurs almost always in non-wetlands in the region (UPL). The portion of the total herbaceous flora from Linebaugh Woods normally occurring in wetlands is 68 percent.

CHAPTER 5

SUMMARY

The Pennyroyal Plain Subsection of the Interior Low Plateau extends from northern Tennessee into southern Indiana and Illinois. The area is known for the karst features and presence of prairie elements in the original vegetation. Little data exists on original forests, and even older, second-growth stands are rare, especially on the relatively flat uplands where most forests have been removed for agricultural production.

Linebaugh Woods is a relatively small (8.1 ha) stand on upland wet soils in northern Montgomery County, Tennessee, with a known history since settlement, or slightly thereafter. The stand thus represents a secondary, but older forest. Knowledge of its composition and structure will add to the information existing on forests of this type, and will provide insight into settlement-era conditions.

Analyses of the woody flora showed canopy dominance by *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Acer rubrum*, all species of disturbance. Oaks, normally represented by several taxa and dominating pristine forests of the Pennyroyal Plain, were absent except for *Quercus palustris*. The sub-canopy strata indicated future dominance by the same species that are now dominant in the canopy.

The herbaceous stratum included more that 80 species, many recognized as wetland taxa. Only one taxon, *Platanthera peramoena*, the purple fringeless orchid is considered rare in the area. The presence of a dense stand of exotic Japanese grass (*Microstegium viminium*) is an indicator of disturbance.

Long-term studies of Lingbaugh Woods, and similar secondary stands, will be required to ascertain if such forests will succeed into the oak-dominated stands which preceded them. This study describes conditions at this time on the successional continuum, and provides a benchmark for future monitoring.

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APPENDIX

Appendix. Categorized list of taxa found at Linebaugh Woods, Montgomery County, Tennessee, from 16 May through 15 October 2001 and April 2002. Numbers following taxa names are the author's personal collection numbers.An asterisk indicates a non-native taxon.

Pteridophyta, Ferns and Fern Allies

Aspleniaceae

Asplenium platyneuron (L.) Britton, Sterns & Poggenb.; 30.

Ophioglossaceae

Botrychium dissctum (Spreng);154, 174.
Botrychium virginianum (L.) Sw.; 48.
Ophioglossum engelmannii Prantl.; 5.

Woodsiaceae

Athryrium aspleniodes (Michx.) Hulten.; 25.
Onoclea sensibilis L.; 167.

Spermatophyta: Angiospermae, Monocotyledoneae

Araceae

Arisaema dracontium (L.) Schott.; 1.

Commelinaceae

**Commelina communis* L.; 175.
Commelina virginica L.; 114.

Cyeraceae

Carex amphibola Steud.; 105.
Carex blanda Dewey.; 24.
Carex complanata Torr. & Hook.; 28.
Carex intumescens Rudge; 162.
Carex lupulina Willd.; 135.
Carex retroflexa Willd.; 27.
Carex squarrosa L.; 20, 123.
Carex tribuloides Wahlenb.; 22, 26.
Carex vulpinoidea Michx.; 43.
Cyperus echinatus (L.) A.W. Wood; 124.
Rhynchospora corniculata (Lam.) A. Gray; 163.
Scirpus atrovirens Willd.; 136.

Juncaceae
Juncus acuminatus Michx.; 41.
Juncus effusus L.; 94.

Liliaceae
**Allium vineale* L.; 95

Orchicaceae
Platanthera peramoena (A. Gray) A. Gray; 134.
Tipularia discolor (Pursh) Nutt.; 161

Poaceae
Agrostis perennans (Walter) Tuck.; 181.
Cinna arundinacea L.; 165.
Glyceria striata (Lam.) Hitchc.; 21,102.
Leersia virginiaca Willd.; 146.
**Microstegium vimineum* (Trin.) A. Camus; 185.
Panicum anceps Michx.; 182.
Panicum dichotomum L.; 42.
Panicum laxiflorum Lam.; 103.
Panicum scoparium Lam.; 112.

Smilacaceae
Smilax bona-nox L.; 163.
Smilax rotundifolia L.; 100.

Spermatophyta: Angiospermae, Dicotyledoneae

Aceraceae
Acer rubrum L.; 96.

Annonaceae
Asimina triloba (L.) Dunal; 97, 115.

Apiaceae
Sanicula canadensis L.; 29.

Aquifoliacaeae
Ilex decidua Walter; 51, 137.

Araliaceae
Aralia spinosa L.; 144.

Asclepiadaceae
Asclepias syriaca L.; 118.

Asteraceae
Bidens aristosa (Michx.) Britton; 176.
Bidens discoidea (Torr. & A. Gray) Britton; 177.
Erechtites hieraciifolia (L.) Raf.; 173.
Erigeron annuus (L.) Pers; 88.
Erigeron philadelphicus L.; 7.
Eupatorium aromaticum L.; 149.
**Taraxacum officinale* Weber; 119.
Vernonia gigantea (Walter) Trel.; 183.

Balsaminaceae
Impatiens capensis Meerb.; 101.

Berberidaceae
Podophyllum peltatum L.; 3.

Bignoniaceae
Campsis radicans (L.) Seem. Ex Bureau; 120.

Boraginaceae
Myosotis macrosperma Engelm.; 92.

Campanulaceae
Lobelia cardinalis L.; 166.
Triodanis perfoliata (L.) Nieuwl.; 44.

Caprifoliaceae
**Lonicera japonica* Thunb.; 50.
Sambucus canadensis L.; 89.
Symphoricarpos orbiculatus Moench; 147.

Caryophyllaceae
**Stellaria media* (L.) Vill.; 49.

Clusiaceae
Triadenum tubulosum (Walter) Gleason; 170.
Triadenum walteri (J.G. Gmel.) Gleason; 169.

Cornaceae
Cornus florida L.; 130.

Ebenaceae
Diospyros virginiana L.; 150.

Euphorbiaceae
Alcalypha virginica L.; 168, 172.
Phyllanthus caroliniensis Walter; 184.

Fabaceae
Robinia pseudoacacia L.; 98, 125.

Fagaceae
Quercus palustris Munchh; 45.
Quercus stellata Wangenh; 46.

Geraniaceae
Geranium carolinianum L.; 53.

Hammamelidaceae
Liquidambar styraciflua L.; 113.

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Moraceae
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Nyssaceae
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Oleaceae
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Ongraceae
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Pilea pumila (L.) A. Gray; 186.

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VITA

Susan Marie Fletcher was born in Kingsport, Tennessee on 3 January 1978. She graduated valedictorian from Rye Cove High School, Duffield, Virginia, May of 1996. She entered Lincoln Memorial University, Harrogate, Tennessee, in the Fall of 1996 with an athletic and academic scholarship, and graduated in May of 2000 with a Bachelor of Science degree in biology (major) and chemistry (minor). In January of 2001 she entered graduate school at Austin Peay State University in Clarksville, Tennessee, and received her Master of Science degree in May 2002.