1999

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ELSEVIER

Forest Ecology and Management 114 (1999) 377–383

Forest Ecology and Management

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Abstract

A total of 2314 trees was sampled from 170 randomly located plots to investigate ecological community relationships and species similarities of the vegetation covering the 12 000 ha Sipsey Wilderness in Alabama. Thirty-two tree species, 14 vegetation types and 10 landtypes were identified. Within each plot, the species were ranked based on their basal area to determine the relative importance of the species. A variety of species including white oak (*Quercus alba* L.), post oak (*Quercus stellata* Wangenh.), chestnut oak (*Quercus prinus* L.), northern red oak (*Quercus rubra* L.), red maple (*Acer rubrum* L.), sugar maple (*Acer saccharum* Marsh.), loblolly pine (*Pinus taeda* L.), virginia pine (*Pinus virginiana* Mill.), pignut hickory (*Carya glabra* Sweet) and yellow poplar (*Liriodendron tulipifera* L.) were important species differentiating the ecological communities. Percent basal area (BA%) of each species in the plots was also computed. The vegetation-types and landtypes were characterized by average ranks and BA% of the species. Relationships between the vegetation-types were examined by cluster analysis. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Sipsey Wilderness; Community classification; Cluster analysis; Basal area

1. Introduction

The proper management of any natural resource requires effective analysis of data regarding that resource. This is true regardless of whether the dominant use is plantation management, wilderness, recreation, wildlife habitat or any of the varied uses for natural resources. An understanding of the ecological relationships between communities and species is imperative. Early studies of the vegetation communities of the Southeast (Mohr, 1901; Braun, 1950) provided a great deal of information regarding the variety of species and communities found throughout the region. These and more recent publications note that the hardwood forests of the Tennessee Valley region contain a varied mixture of hardwood species (McGee, 1982; Fralish and Crooks, 1989; Monk et al., 1990; Baskin et al., 1995; McNabb, 1996; Oswald et al., 1996). Interspersed with plantations of shortleaf pine (*Pinus echinata* Mill.), loblolly pine (*Pinus taeda* L.), and virginia pine (*Pinus virginia*

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PII: S0378-1127(98)00368-5

Mill.), most of these stands have developed without any specific management or silvicultural practices, and have been subjected to fire, insect and disease outbreaks.

The area which is now the Sipsey Wilderness in the Bankhead National Forest in Alabama has been managed under varying management strategies across time and landscape. These management strategies included farming, logging, and homesteading, and contained areas of Native America of archaeological importance as well as areas of relatively low disturbance. Due to the variety of past use, no baseline information of the entire area from the same time period has been available. The landbase offers a unique opportunity to examine ecological relationships among the various species found in the region. The objective of this study was to quantify the ecological relationships of the overstory component of these ecosystems using basal area (BA) coverage as a measure of relative importance.

2. Methods

Two sets of aerial photographs covering the Sipsey Wilderness (leaf-on color IR and leaf-off natural color) were used for a preliminary delineation of the overstory communities. Initial delineation was based on obvious changes in overstory vegetation (conifer vs. hardwood); further delineation was performed based on changes in topography, determined from topographic maps. A total of 170 different stands was delineated and a single plot within each stand was randomly located.

During the 1994 growing season each plot location was visited and the plot established and sampled. Each rectangular plot was 1000 m^2 (0.1 ha) in size and subdivided into 10 square subplots measuring 100 m^2 (0.01 ha). Plots were oriented two subplots by five subplots. All plots were marked with rebar in each plot corner and identified with plot and subplot number. Plots did not straddle vegetation-types, and as far as could be determined from soil maps, subplots did not straddle soil map units.

Three subplots within each plot were randomly chosen for sampling of the overstory. All trees greater than 10 cm dbh were identified by species, and the diameter and height recorded. Information on the understory was also collected, but not reported in this study.

Each plot visited was classified using the SAF cover-type classification (Eyre, 1980) and ecological community classification (Allerd, pers. commun.). Thirteen confirmed SAF cover-types were found, as well as an additional three types that did not fit the current SAF classification. The SAF cover-types closely correlated with the ecological community classification units which had nine confirmed types and an additional five new types. An initial description of the cover-types and ecological communities found has been presented by Oswald and Green (in press). For this study, we used the ecological classification system to identify the 14 different communities listed by dominant overstory species (Table 1).

Tree basal area (m^2) was calculated and summarized by species within each plot. Relative importance of each species was identified by ranking the species total basal area within the plot (Monk et al., 1990), i.e. the species with the largest basal area was ranked as 1, the species with the second largest basal area was ranked as 2, and etc. The number of times each species was ranked 1, 2, or 3 was counted. Percent basal area (BA%) of each species in the plot was computed by dividing the species total basal area by the plot total basal area for all trees. Average rank and BA% of each species in all plots were calculated for the 14 ecological vegetation communities.

The mean BA% of the 32 species were used to conduct a cluster analysis on the 14 ecological vegetation-types. PROC CLUSTER with AVERAGE linkage in statistical analysis system (SAS Institute, 1990) was employed and producing the dendrogram shown in Fig. 1.

3. Results and discussion

A total of 2314 trees was sampled producing a mean dbh of 21.64 cm (10–85 cm range). Thirty-two overstory species were identified in the sample and summary statistics of each species are presented in Table 2. The five oak species found on these sites (white, *Quercus alba* L., post, *Q. stellata* Wangenh., chestnut, *Q. prinus* L., northern red oak, *Q. rubra* L. and southern red oak., *Q. falcata* Michx.) represented 35% of the stems sampled. The three pine species

Table 1
List of ecological community classification types identified in this study

Code	Common name of community	Ecological vegetation community type
A	Loblolly pine	*Pinus taeda* upland forest alliance
B	Beech–sugar maple	*Fagus grandifolia–Acer saccharum–Liriodendron tulipifera* forest alliance
C	White oak–black oak–red oak	*Quercus alba–Quercus–Carya* forest alliance
D	Chestnut oak	*Quercus prinus–Quercus–Carya* forest alliance
E	Northern red oak	*Quercus rubra* forest alliance
F	Eastern redcedar	*Juniperus virginiana–Fraxinus–Quercus* forest alliance
G	Loblolly pine–hardwoods	*Pinus taeda–Quercus* forest alliance
H	Virginia pine	*Pinus virginiana–Quercus* forest alliance
I	Eastern hemlock	*Tsuga canadensis–Liriodendron tulipifera* upland forest alliance
J	Hickories	
K	Red maple	
L	Yellow poplar–white oak–northern red oak	
M	No overstory	
N	Bigleaf magnolia–blackgum	

Types J–N are not confirmed types according to current ecological classification system. The common names listed are those used in the narrative. The official descriptive names in the second column are from Allerd (pers. commun.).

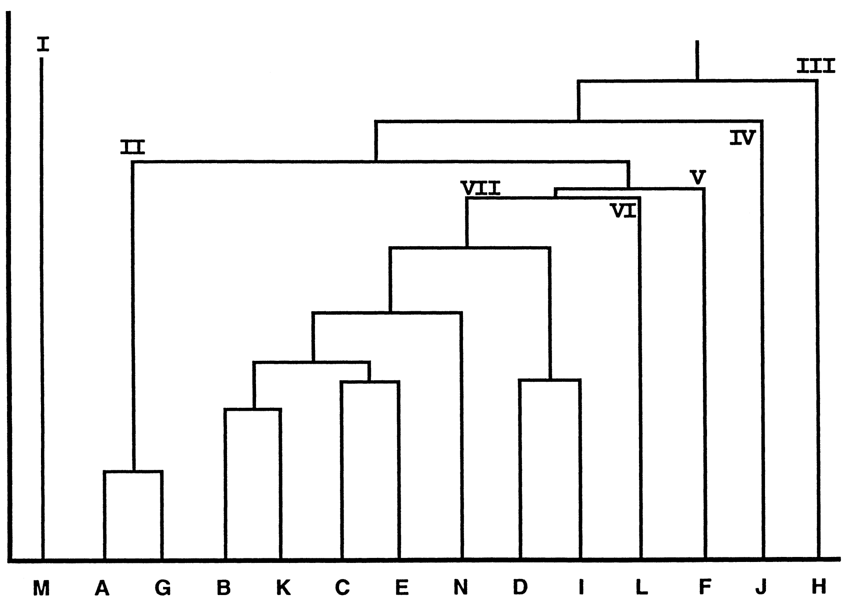

Fig. 1. Cluster diagram of 14 ecological classification communities.

(loblolly, *Pinus taeda* L., virginia, *P. virginiana* Mill. and shortleaf, *P. echinata* Mill.) accounted for an additional 31%. White oak, loblolly pine, virginia pine and chestnut oak had a larger total dbh ($\sum$dbh), and these, with northern red oak, had larger basal areas ($\sum$BA) (Table 2). The use of $\sum$dbh accounted for differences in diameter distributions of each species between plots (Stout and Nyland, 1986).

Many of these same species were ranked in the top 10 that dominated basal area in the plots (Table 3). White, chestnut, and northern red oak, along with virginia and loblolly pine, substantially dominated

Table 2
Summary statistics of sampled trees

Species	N	Mean dbh	Range	$\sum$(dbh)	$\sum$(BA)
Pinus taeda	385	24.1	10.0–84.0	9281.5	26.86
Quercus alba	383	24.5	10.0–71.0	9386.5	27.24
Pinus virginiana	336	22.9	10.0–53.0	7689.3	20.06
Quercus prinus	253	22.6	10.0–67.0	5719.5	15.18
Carya glabra	128	21.7	10.0–54.0	2777.5	7.10
Acer rubrum	123	14.6	10.0–44.0	1794.1	2.92
Quercus rubra	122	28.4	10.5–63.0	3459.5	11.67
Magnolia macrophylla	86	13.8	10.0–23.0	1184.0	1.72
Oxydendrum arboreum	81	14.4	10.0–26.5	1169.9	1.80
Liriodendron tulipifera	78	23.6	10.0–85.0	1843.5	5.76
Acer saccharum	70	15.7	10.0–42.5	1098.5	2.04
Nyssa sylvatica	40	15.0	10.0–27.0	601.5	0.98
Cornus florida	37	12.8	10.0–21.0	472.0	0.62
Fagus grandifolia	30	19.4	10.0–56.5	581.5	1.57
Tsuga canadensis	30	15.2	10.0–37.0	455.5	0.78
Quercus stellata	28	23.8	10.0–44.0	666.0	1.90
Cercis canadensis	27	14.5	10.0–24.0	392.5	0.61
Quercus falcata	16	19.7	10.0–42.5	314.5	0.74
Prunus serotina	13	14.8	10.0–20.0	192.5	0.29
Fraxinus pennsylvanica	9	24.1	12.0–53.5	216.5	0.64
Juniperus virginiana	9	23.1	15.5–36.0	207.5	0.51
Carya ovata	8	16.8	11.5–23.0	134.0	0.24
Ostrya virginiana	6	12.4	10.0–14.5	74.5	0.09
Diospyros virginiana	4	19.9	12.5–32.0	79.5	0.18
Magnolia acuminata	2	22.5	21.5–23.5	45.0	0.10
Ilex opaca	2	11.5	10.0–13.0	23.0	0.03
Liquidambar styraciflua	2	40.2	30.0–50.5	80.5	0.35
Pinus echinata	2	28.8	24.0–33.5	57.5	0.17
Celtis occidentalis	1	35.0		35.0	0.12
Magnolia virginiana	1	14.0		14.0	0.02
Sassafras albidum	1	12.0		12.5	0.02
Ulmus alata	1	18.0		18.0	0.03

dbh is in cm, BA is in m^2.

the basal areas of the plots. Species listed as occurring in the sample but are not listed in Table 2 were not in the top three in rankings more than 10 times overall.

Using the different ecological communities previously listed, we determined the average ranks (Table 4) and the average percent basal areas (Table 5) of the top-ranked species. These tables reflect the dominance of these species within the various vegetation communities. Not surprisingly, loblolly pine dominated the loblolly pine (A) and loblolly pine/hardwood (G) communities in terms of basal area. Chestnut oak, virginia pine, yellow poplar (*Liriodendron tulipifera* L.), red maple (*Acer rubrum* L.), and pignut hickory (*Carya glabra* Sweet) dominated the types that their names identified (D), (L), (H), and (J). White oak was a major component of many types.

Some of the species that dominated the types in terms of basal areas were not the identifying species of that type. White oak dominated (65.9%) the basal area of the bigleaf magnolia (*Magnolia macrophylla* Michx.)/black gum (*Nyssa sylvatica* Marsh.) types (N). Red and sugar maples were substantial components of the eastern hemlock (I) and hickories (J), respectively. This dominance appears to reflect the role of red maple as a mid-successional species on hemlock sites.

Monk et al. (1990) state that there is little evidence to support the term oak–hickory forests in the eastern North American forests. Our findings support their

Table 3
Number of plots each of the top species was ranked 1, 2, or 3 in importance based on basal area. Twenty-two species had total ranking of less than 10

Species	Rank 1	Rank 2	Rank 3	Total
Quercus alba	39	33	15	87
Pinus virginiana	36	13	17	66
Pinus taeda	33	20	12	65
Quercus prinus	23	19	14	56
Quercus rubra	11	27	17	55
Carya glabra	10	15	14	39
Liriodendron tulipifera	4	11	7	22
Acer rubrum	2	6	8	16
Acer saccharum	2	4	8	14
Quercus stellata	1	5	4	10

premise that hickory rarely dominates an area, and if found in significant numbers to allow for identification as a hickory-type, this designation is transitory, and succession will often continue to create the more common oak-dominated mixed-hardwoods forests of the region. Dominance of the maples in these communities reflects the mixed successional role of hickory in these forests.

Without disturbance, we do not anticipate the loblolly pine and virginia pine communities to maintain themselves at their present levels within the Sipsey Wilderness. In the protected constraints of wilderness designation, human-caused disturbance, such as harvesting and replanting will not occur. Human disturbance was the common source of many of the loblolly pine stands. Many of the virginia pines and shortleaf pines also established themselves on disturbed sites. As in the land between the lake area of Tennessee (Fralish et al., 1990), these communities, without anthropogenic and natural disturbance, will be replaced by oak-dominated communities.

Cluster analysis identified seven clusters (Fig. 1). These clusters identified similarity of community-types in how species dominate or distinguish that type.

Cluster 1 represented the sites that lacked an overstory, being either an abandoned field or a plantation with poor seedling survival that was not replanted prior to wilderness designation. As these two communities were found on different types of sites, and are surrounded by different communities, we are hesitant to predict future community structures for the two sites.

The two community-types dominated by loblolly pine were cluster 2. Virginia pine and hickory communities were identified as clusters 3 and 4, respectively. Cluster 5 was the eastern redcedar community-type (L). These types were found on shallow dry soils and rocky outcrops, conditions where eastern redcedar is often the only species able to successfully establish (Oswald et al., 1996). The yellow poplar/white oak/northern red oak communities were found in cluster 6. These were the only communities where yellow poplar was the dominant species (Tables 4 and 5).

All of the remaining communities were placed in the cluster 7. No discernible trends were detected within this cluster to allow further delineation at this

Table 4
Mean rank of top species by ecological classification. The lower the number the higher the mean rank[a]

Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Quercus alba	4.0	3.8	1.9	3.0	2.0		3.2	3.3	3.5		10.0	2.5		1.0
Pinus virginiana	2.5	1.5	3.0	3.5			3.1	1.2	3.0	3.0				
Pinus taeda	1.1	2.0	2.7	3.0			1.6	2.5	1.0	2.0	6.0			
Quercus prinus	3.6	6.0	3.7	1.3		3.0	2.9	2.7	1.5			5.5		
Quercus rubra	4.0	1.0	2.4	3.3	1.0	2.0	3.1	3.1	4.0	3.0	5.0	3.0		
Carya glabra	2.0	2.4	3.7	4.0			4.0	2.8		1.3	3.0	2.0		
Liriodendron tulipifera	4.3	4.7	4.0	4.0			3.2	3.2				1.0		
Acer rubrum	3.0	1.0	4.8	3.4			4.8	4.3	2.0	3.0	2.0			
Acer saccharum	6.0	3.7	4.0	4.8		6.0	3.6	3.0		1.0		5.0	0.0	
Quercus stellata			3.7	5.0			4.8	4.3	2.0	3.0	2.0	–	–	

[a]A=Loblolly pine; B=Beech/Sugar maple; C=White oak/Black oak/Red oak; D=Chestnut oak; E=N. red oak; F=Eastern redcedar; G=Loblolly pine/Hardwood; H=Virginia pine; I=Eastern hemlock; J=Hickory; K=Red maple; L=Yellow poplar/White oak/Northern red oak; M=No overstory; N=Bigleaf magnolia/Blackgum.

Table 5
Mean percent basal area (BA%) of top species by ecological classification communities[a]

Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Quercus alba	7.6	15.6	38.6	18.7	24.1		11.6	11.0	17.1		2.5	21.0		65.9
Pinus virginiana	17.0	38.5	20.5	13.2			17.4	62.0	23.0	17.4				
Pinus taeda	69.0	19.6	25.2	12.1			53.2	23.5	47.4	32.4	5.0			
Quercus prinus	7.5	5.9	16.8	53.7		19.8	22.6	8.8	55.9			5.0		
Quercus rubra	3.3	9.3	23.4	20.6	33.3	33.1	11.2	11.0	11.8	15.0	7.4	4.6		
Carya glabra	21.0	26.6	13.3	5.0			8.8	17.7		55.9	18.3	30.1		
Liriodendron tulipifera	1.4	7.6	10.5	14.0			18.7	15.5				50.3		
Acer rubrum	10.0	35.7	5.6	8.3			6.6	7.2	45.0	14.9	19.3			
Acer saccharum	1.7	12.2	12.5	4.2		2.1	4.6	7.0		38.8		3.0		
Quercus stellata			19.4	4.9			10.9	11.5						

[a]A=Loblolly pine; B=Beech/Sugar maple; C=White oak/Black oak/Red oak; D=Chestnut oak; E=N. red oak; F=Eastern redcedar; G=Loblolly pine/Hardwood; H=Virginia pine; I=Eastern hemlock; J=Hickory; K=Red maple; L=Yellow poplar/White oak/Northern red oak; M=No overstory; N=Bigleaf magnolia/Blackgum.

time. Some of the closely-matched communities within this cluster should become more distinguishable in the future as succession continues, while others appear to have little in common at this time. An example of the latter would be the chestnut oak (D) and eastern hemlock types (I). These two types were found on totally different sites, with the chestnut oaks on the dry ridgetops and upper slopes of the highly dissected terrain common to the region, and the hemlock on the lower slopes and coves. What these two types have in common is the relative dominance of chestnut oak and eastern hemlock within each type. Other closely matched types within this cluster were the white oak/black oak/red oak type (C) and the northern red oak type (E). These types occupy similar sites and the role of the oak species within these communities are similar.

4. Conclusions

The use of basal area as a determining factor in evaluating the importance of various species found in the mixed hardwoods forests and associated coniferous stands of the Tennessee Valley appears to be very effective. In most cases, the important species were also those species most commonly associated with specific communities, such as chestnut oak in chestnut oak communities. In others, the important species were only those that represented the most basal area, not the unique species noted for that community (red maple in hickory communities). The latter supports the premise that the name oak–hickory is a misnomer in most cases, and that hickory-dominated stands are transitional communities succeeding into other mixed-hardwood communities. Repeated over time, the information gathered may provide a more complete evaluation of the successional status of the different vegetative communities of this region. Such information would increase our knowledge of the ecological relationships within and between these communities, which would be important in the management of these ecosystems.

Acknowledgements

The authors wish to acknowledge Mr. David Wergowski and the USFS in Montgomery, Alabama for financial support and a variety of technical assistance throughout the course of the project. We would also like to acknowledge the assistance of Lewis Bingham, Rogers Rose, Jeffrey Rice and Shawn Posey in the collection of the field data.

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