SPECIES-SITE RELATIONSHIPS IN A NORTHERN ARKANSAS UPLAND FOREST

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Abstract—Phytosociological aspects of the forest vegetation were described for a 780-ha area on the Sylamore Experimental Forest in northern Arkansas. Pronounced changes in species composition occurred with topographic position in this deeply dissected area. For the overstory, oaks and pines dominated the upper slope positions, while other tree species dominated the lower slopes and hollows. However, other tree species dominated the understory and reproduction strata of all topographic positions. Species diversity was highest in the hollows and declined going upslope for the overstory and understory, but diversity was lowest in the hollows for reproduction, which probably reflected the dominance of several shrub species. Some variation in species composition could also be attributed to aspect. The described gradients in species composition have implications for the silvicultural ease of obtaining reproduction of targeted species within the area.

INTRODUCTION

The structure of forest vegetation is a function of past disturbance, gradients in environmental factors (e.g., elevation, soils), and life history strategies of tree species. In highly dissected landscapes of the southern and eastern United States, a number of studies have documented that the environmental conditions associated with different topographic positions and aspects greatly influence forest composition (Collins and Carson 2004, Desta and others 2004, Elliott and others 1999, Rubino and McCarthy 2003). However, we are unaware of any study that reports species-site relationships in the Ozark Mountains of Arkansas.

The Sylamore Experimental Forest (SEF) is a 1,740-ha tract on the Ozark-St. Francis National Forest in northern Arkansas. It was established in 1934 by the USDA Forest Service and represented forest conditions typical of the Ozark Mountains. The region is characterized by steep slopes, narrow valleys, and very stony soils (Ward 1983). The SEF was the center of a wide-ranging silvicultural research program from the 1930s through the 1950s. By the early 1960s, however, research activity on the SEF had decreased dramatically. There has been little research or management on the forest for the past 40 years.

Several years ago, the field data sheets were located for a portion of the 1934 inventory of the SEF. We reinventoried this area in 2002 with an overall goal of determining how the forest vegetation changed over a span of nearly 70 years. In this paper, we have focused on the phytosociological aspects of the forest vegetation existing in 2002.

METHODS

The 780-ha study site encompassed three sections (Township 16 North, Range 11 West, sections 7, 17, and 18) of the SEF. Transects were established in 2002 that roughly corresponded to the 1934 cruise. Along each transect, sampling locations were established at 122-m intervals for a total of 201 sample points. At each location, overstory trees (>14.0 cm d.b.h.) were tallied by species and d.b.h. on a 0.04-ha circular plot, understory trees (1.4 to 14.0 cm d.b.h.) were recorded by species and d.b.h. on three 0.004-ha plots, and reproduction (<1.4 cm d.b.h.) was counted by species on three 0.0004-ha plots. Each location was ocularly classified as to relative topographic position (fig. 1). Aspect and percent slope were determined by compass and clinometer.

Species importance values were calculated for each location and stratum based on relative density, basal area (overstory and understory), and frequency of occurrence (Curtis and McIntosh 1951). Diversity indices were calculated from species importance values (Odum 1971). Vegetation data by species and stratum were tested for significant differences among topographic positions or aspects using the non-parametric Kruskal-Wallis test of group comparisons, because the data lacked homogeneity and normality (SAS 1989). Significance was accepted at $P < 0.05$.

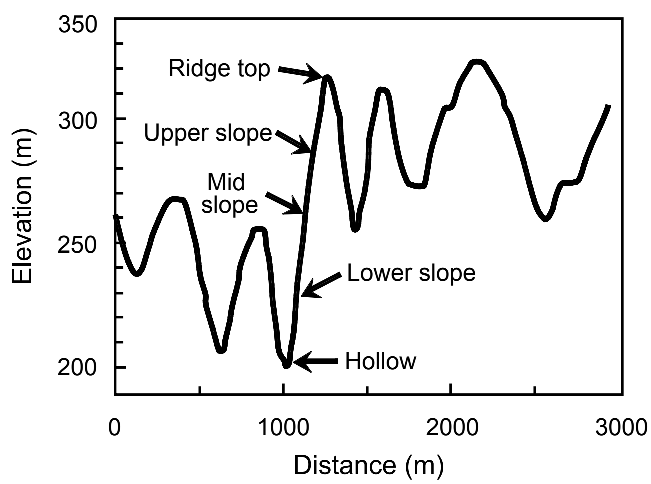

Figure 1—An example of elevations along a typical transect through the Sylamore Experimental Forest showing the five relative topographic positions recognized in the study.

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RESULTS AND DISCUSSION

General Terrain and Vegetative Features

The five topographic positions were fairly equally distributed. Hollows (16 percent) and ridge tops (15 percent) were less frequent than the slope positions (lower 23 percent, mid 22 percent, and upper 24 percent). Slopes ranged from 2 to 78 percent. The lowest mean slopes occurred on ridge tops (25 percent) and in hollows (34 percent). Mean slopes for the lower-, middle-, and upper-slope positions were fairly consistent and averaged 39, 40, and 36 percent, respectively. Aspects occurred in every bearing. Northwest and southeast aspects were the least common and together made up 13 percent of the locations. In contrast, east and west aspects were most common and together made up 35 percent of the locations.

The differences in total basal area and stem numbers were fairly minor among topographic positions. For example, overstory basal area totaled 18.1 m^2/ha in the hollows and 24.1 m^2/ha on ridge tops (P=0.001), whereas total understory basal area was a maximum on mid-slope positions at 4.6 m^2/ha and declined to about 3 m^2/ha for both hollows and ridge tops (P=0.015). Stem density for reproduction was least in the hollows (14,000 stems/ha) and highest on the ridge tops (22,000 stems/ha) (P=0.001).

Composition of forest communities changed dramatically across topographic positions (fig. 2). On ridge tops, the overstory was composed of about equal percentages of red oaks, white oaks, and pines, while other tree species only made up 7 percent of the basal area. In contrast, hollows were 45 percent in other trees, and the contribution of white oaks (33 percent) far exceeded red oaks (13 percent) and pines (9 percent). The understory was mainly composed of other tree species in all topographic positions, with the red oaks, white oaks, and pines only making up 11 to 33 percent of the basal area. For reproduction, red oaks, white oaks, and pines only made up 7 to 14 percent of the total number of stems. The percentage of red oaks increased going up slope, while shrubs declined. The percentage of pine reproduction was virtually nil on all positions.

Species-Topographic Relationships

Of the 33 overstory species recorded, 8 species showed significant variation with topographic position. Some species, like *Carya cordiformis* (Wangenh.) K. Koch and *Liquidambar styraciflua* L., were important in hollows but did not occur on ridge tops (table 1). Other species (*Quercus rubra* L. and *Q. velutina* Lam.) occurred on all topographic positions but were most important on upper slopes and ridge tops. *Pinus echinata* Mill. occurred on all positions but was most important on the upper slopes. *Quercus alba* L., the dominant overstory species, did not vary significantly with topographic position (P=0.16); importance values were fairly uniform across the landscape, varying only from 22 to 31 percent.

Of the 46 species recorded in the understory, 12 showed significant variation with topographic position. *Carpinus caroliniana* Walt., *Fraxinus americana* L., *Liquidambar styraciflua*, and *Ostrya virginiana* (Mill.) K. Koch decreased in importance going upslope (table 1). In contrast, some species, like *Cornus florida* L., were most important on upper slopes and ridge tops. *Carpinus caroliniana* and *Liquidambar styraciflua* were not observed on ridge tops positions in this stratum.

For reproduction, 16 of the 48 recorded species showed significant variation with slope position. *Carpinus caroliniana* and *Fraxinus americana* decreased in importance going upslope (table 1). In contrast, *Quercus rubra*, *Quercus alba*, and *Sassafras albidum* (Nutt.) Nees increased in importance going upslope.

Species Diversity

Species diversity for overstory vegetation was highest in the hollows and lowest on the ridge tops (Shannon's Index: 1.4 versus 1.3; richness: 4.9 versus 4.3; P<0.01). A similar pattern occurred for understory vegetation (Shannon's Index: 1.6 versus 1.2; richness: 6.2 versus 4.0; P<0.01). However, a different

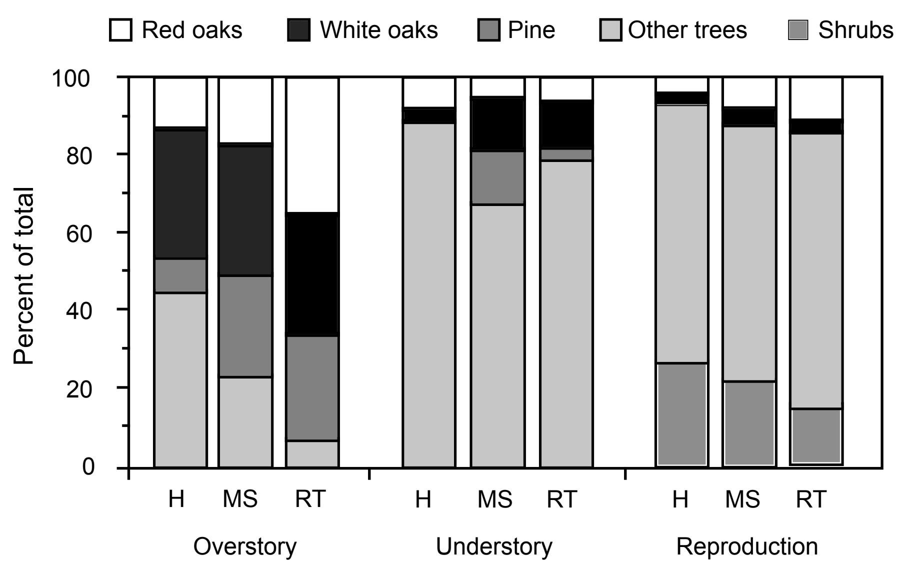

Figure 2—Contribution of species groups to community composition for hollows (H), mid slopes (MS), and ridge tops (RT). Overstory and understory based on basal area, reproduction on numbers.

Table 1—Importance values (percent) of selected species by topographic position on the Sylamore Experimental Forest in northern Arkansas

Species[a]	Hollow	Lower slope	Mid slope	Upper slope	Ridge Top	*P*
	- - - - - - - - - *overstory (>14.0 cm d.b.h.)* - - - - - - - - - -					
Carya cordiformis	4.1	0.2	0.3	0.0	0.0	0.001
Liquidambar styraciflua	15.3	6.6	4.0	0.5	0.0	0.001
*Pinus echinat*a	6.6	11.6	18.1	22.6	17.5	0.007
Quercus rubra	6.8	11.3	7.5	14.6	19.2	0.003
Quercus velutina	2.3	8.7	8.3	15.1	12.3	0.001
	- - - - - - - *understory (1.4 to 14.0 cm d.b.h.)* - - - - - - -					
Carpinus caroliniana	10.7	1.7	1.3	0.5	0.0	0.001
Cornus florida	11.8	20.4	16.3	25.0	20.5	0.046
Fraxinus americana	6.0	4.0	1.5	2.5	0.6	0.002
Liquidambar styraciflua	8.9	2.1	1.8	0.4	0.0	0.001
Ostrya virginiana	8.6	10.6	8.8	7.9	3.2	0.010
	- - - - - - - - - *reproduction (<1.4 cm d.b.h.)* - - - - - - - - -					
Carpinus caroliniana	8.5	3.0	2.5	1.2	1.0	0.001
Fraxinus americana	8.9	7.2	4.1	3.2	4.1	0.006
Quercus rubra	3.7	4.5	4.1	6.8	12.1	0.009
Quercus alba	0.9	3.7	3.6	5.4	4.7	0.037
Sassafras albidum	8.2	17.0	14.1	23.7	24.9	0.001

[a] Limited to the five most important species in each stratum showing a significant difference.

pattern emerged for vegetation in the reproduction-size class, where lower slopes had the highest diversity and hollows the lowest (Shannon's Index: 1.8 versus 1.5; richness: 6.7 versus 5.6; *P*<0.01). It was interesting that the hollows had the greatest diversity in the overstory and understory but the lowest diversity for reproduction. This may reflect the influence of some dominating shrubs, like *Asimina triloba* (L.) Dunal and *Lindera benzoin* (L.) Blume, which were common in hollows (combined importance value of 16 percent) but rare elsewhere.

Effect of Aspect

For the combined mid-slope, upper-slope, and ridge-top positions, there were five species that varied significantly with aspect in the overstory, eight in the understory, and five in reproduction. Examples of the patterns are shown for selected species in the overstory and understory in figure 3. *Carya tomentosa* (Poir.) Nutt. was most important on a northeast aspect in the overstory and a southeast aspect in the understory. In contrast, *Pinus echinata* showed highest importance on south aspects in both overstory and understory strata. *Quercus alba* in the overstory was variable in importance with no clear trend, while *Quercus alba* in the

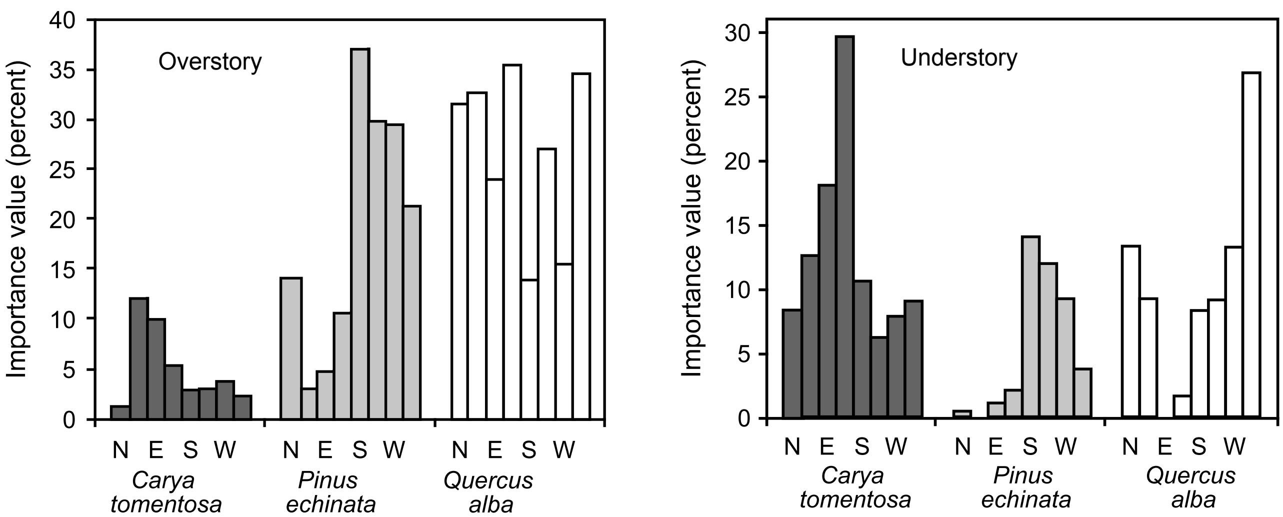

Figure 3—Effects of aspect on importance values of three selected species on mid-slope, upper-slope, and ridge-top positions.

understory was most important on northwest aspects and least important on east aspects. The reproduction of these three important species showed no significant relationship with aspect.

CONCLUSIONS

The vegetation community existing in a particular location depends on a complex set of factors and their interaction. Our study documents these relationships for a portion of the Ozarks which heretofore has received little attention. In mountainous terrain, topography and aspect are key features of a forest site, because they have a pronounced effect on soils, water, and light. The habitat requirements of species (Burns and Honkala 1990, Lawson 1990) interact with well-known environmental gradients associated with topography and aspect (Geiger 1950) to determine the distribution of vegetation across this study site. Some species, like *Quercus alba*, are generalists and can become established and develop across the entire landscape of the SEF. Other species, like *Carya cordiformis*, are specialists and show a distinctive pattern of occurrence within the landscape (Barnes and others 1998). Competition among plant species for limited resources is also a principal determinant of the observed distribution patterns. For example, the low diversity of the reproduction stratum in hollows was thought to be due to intense competition from two shrubs that were very well adapted to that topographic position.

Some of the observed relationships may reflect the past disturbance history of the SEF, which included the strong influence of fire (Guyette and Spetich 2003). For example, the presence of overstory pines in the hollows suggests a disturbance history in the past far different than that of the present, where pine reproduction was virtually non-existent. Oaks and pines tended to dominate the upper slope positions, while other tree species dominated the hollows and lower slopes. These relationships also have implications about the difficulty of regenerating specific areas to targeted species. Oak and pine reproduction will likely be difficult to secure in hollows and on the lower slopes.

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