SPECIES COMPOSITION OF YOUNG CENTRAL HARDWOOD STANDS THAT DEVELOP AFTER CLEARCUTTING[1]

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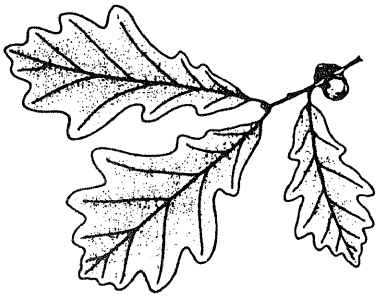

ABSTRACT.--Regeneration that developed after clearcutting mature upland oak stands was sampled on 29 clearcuts in Ohio, Kentucky, and Indiana. Clearcut ages ranged from 5 to 26 years. Site index ranged from 50 to 80. Statistical tests revealed that species composition depends on both age and site. Oaks dominate poor sites as stand age increases. Yellow-poplar, maple, and other commercial species such as black cherry, bigtooth aspen, and white ash eventually dominate the good sites.

INTRODUCTION

The upland oak type, occupying nearly 109 million acres, is the largest timber type in the United States. It stretches from the Lake States south to the Gulf Coast, and from Kansas east to Massachusetts. Clearcutting became a common timber harvesting practice in this type 20 to 30 years ago, and for several years forest-land managers have realized that oaks are not regenerating in desired numbers on the better sites. Oaks apparently are being replaced by faster-growing species such as yellow-poplar, red maple, bigtooth aspen, and white ash (see Little (1979) for scientific names of all species referred to in this paper).

Effective management in the "upland oak" timber type requires knowledge of the species composition of the new stands. This paper examines the relationship of the species composition of the regenerated stands to stand age and site index.

METHODS

Data

All regeneration taller than 4.5 feet was sampled on 29 clearcuts located across the upland oak timber type: 18 in southeastern Ohio, in eastern Kentucky, and 4 in southcentral Indiana. Six to twelve temporary 1/100-acre plots were established on each clearcut. Species was recorded for each tree on the plot. A total of 13,078 stems were measured on 273 plots.

Clearcut ages were determined from office records that designated the year the area was cut. Records were validated by felling 5 to 10 trees on each clearcut and counting tree rings at stump height. Age ranged from 5 to 26 years.

Slope position, slope steepness, soil depth, and soil texture were used to assign a black oak site index to each 1/100-acre plot according to soil/site relationships developed by Carmean (1964). Site index ranged from 50 to 80.

All clearcuts selected for sampling were composed of at least 60 percent upland oaks (by volume) prior to harvest. Other species in the original stands included primarily hickory and yellow-poplar. Records of advanced regeneration before clearcutting were not available. This information may or may not have been valuable in predicting the species composition of the stand after clearcutting. While stump sprouts from advanced regeneration account for much of the regeneration on poor and medium sites, much of the regeneration on good sites after clearcutting originates from seed (Sander and Clark 1971). For example, all but a fraction of the yellow-poplar reproduction on a north-facing clearcut in southeastern Ohio was seedlings that became estabished after cutting (Merz and Boyce 1958).

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Analysis

Only the dominant and codominant stems on each 1/100-acre plot were used in the analysis. A maximum of two dominant or codominant stems were used from each group of sprouts from a single stump. The 2,938 dominant and codominant stems in the analysis data set best indicate what species are established on a given site. Plot values were expanded to a per acre basis for analysis.

All plots within a given clearcut were assigned ages corresponding to the number of years since clearcutting. Site index had been determined for each plot.

The total number of dominant and codominant stems per acre for three age by three site categories were then calculated by averaging plot values. Age categories were 5-9 years, 10-14 years, and 15+ years. Site index (S.I.) categories were poor (S.I. 50-59), medium (S.I. 60-69), and good (S.I. 70-80). The number of plots in each age x site category are listed in Table 1.

TABLE 1.--Number of 1/100-acre plots in each age and site category.

Site Index	Age (years) 5-9	10-14	15 +	Total
Poor (S.I. 50-59)	35	41	14	90
Medium (S.I. 60-69)	69	45	18	132
Good (S.I. 70-80)	19	12	20	51
Total	123	98	52	273

To analyze species composition, the dominant and codominant trees on each 1/100 acre plot were further divided into five species groups: (1) oaks, (2) yellow-poplar, (3) red and sugar maples, (4) other commercial species, and (5) noncommercial species. Other commercial species were primarily bigtooth aspen, black cherry, white ash, and hickory. Noncommercial species included primarily dogwood, sassafras, and ironwood.

Since the number of stems per acre is a function of stand age (and perhaps site index), percentages were used to analyze species composition. The percentage of trees in a given species group was calculated for each plot by dividing the number of trees in that group by the total number of trees on the plot. Percentages calculated in this manner scale the number of trees from the plots to an equal basis for comparison purposes.

A multivariate analysis of variance was used to analyze species composition because the percentages of trees in the species groups are correlated. For example, the percentage of oak on a given plot depends on the percentage of yellow-poplar on the plot, and vice versa. The dependent variable in the multivariate analysis is a vector of the five percentages for the species groups from each plot. The three age and three site categories were used as classification variables. The multivariate analysis also produces univariate analysis of variance tables for each species group. This information in useful for revealing differences detected by the overall multivariate tests.

RESULTS AND CONCLUSIONS

Stems Per Acre

The total number of dominant and codominant stems per acre, as expected, decreased as age increased within a given site category (Table 2). However, the number of stems also was expected to decrease as site index increased for a given age category. This was the case for the youngest age category, 5-9 years, but not for the 10-14 or 15+ categories.

TABLE 2.--Total number of dominant and codominant trees per acre. Coefficient of variation (in percent) listed in parentheses.

Site Index	Age (years) 5-9	10-14	15 +
Poor (S.I. 50-59)	1586 (45)	927 (44)	607 (43)
Medium (S.I. 60-69)	1451 (69)	764 (44)	617 (47)
Good (S.I. 70-80)	1221 (98)	883 (77)	620 (45)
Weighted Average	1453 (66)	846 (50)	615 (44)

This result is most likely attributed to the large variation in species composition across sites for a given age (Fig. 1). For example, the 15+ age x poor site category is composed mostly of oaks, while the 15+ age x good site category is composed mostly of species such as yellow-poplar, maple, cherry, aspen, and ash. If the latter category would also have contained mostly oaks, we would have expected fewer trees (Schnur 1937). However, the good site is capable of supporting more trees per acre because growing-space requirements are less for the species that are present compared to oaks (Gingrich 1967; Roach 1977).

Until further research can address this complex issue in more detail, I recommend using the average values in Table 2 to eliminate irregularities in the number of stems across sites for a given age.

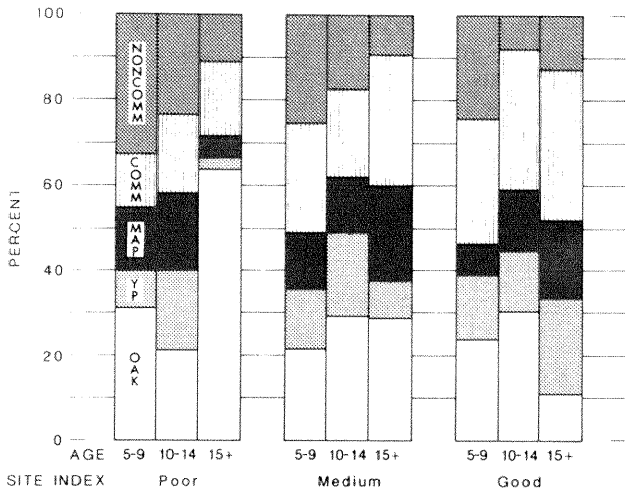

FIGURE 1.--Percent species composition of dominant and codominant trees.

Species Composition

The percent composition for each of the five species groups is shown in Figure 1 for the nine age x site categories. Percentage values in Figure 1 can be multiplied by the average values in Table 2 to determine the number of dominant and codominant trees in each species group.

The coefficients of variation for the percentages were fairly uniform across all species x age x site categories, and averaged 130 percent. This value indicates that there can be considerable variation in the species composition for any given age and site. This variation, however, is taken into account by the multivariate analysis of variance (Table 3).

The overall multivariate test, which uses a vector of the percentages from each plot as the dependent variable, reveals that the age x site interaction term is significant (α =0.05 level). On the basis of this result, we conclude that species composition depends on both age and site. In other words, species composition is significantly different between ages, but the differences depend on the site. Since the overall age x site interaction term is significant, the overall age and overall site effects are not meaningful, even though both were highly significant (Neter and Wasserman 1974).

In essence, the multivariate results complete the analysis of the data. We are justified in using the percentages in Figure 1 as our estimates of species composition for various age and site combinations. However, univariate analyses of variance for each of the species group percentages help us understand why the overall age x site interaction term was significant.

TABLE 3.--Multivariate and univariate analyses of variance for species composition by age and site.

Source	DF	F value	Pr > F
Overall:			
Age	(10,520)[a]	2.73[a]	0.0028
Site	(10,520)[a]	3.29[a]	0.0004
Age x site	(20,863)[a]	1.87[a]	0.0116
Oak:			
Age	2	1.75	0.1758
Site	2	6.27	0.0022
Age x site	4	6.76	0.0001
Yellow-Poplar:			
Age	2	1.80	0.1672
Site	2	1.48	0.2298
Age x site	4	1.65	0.1609
Maples:			
Age	2	0.65	0.5224
Site	2	0.86	0.4245
Age x site	4	2.32	0.0578
Other Commercial:			
Age	2	0.57	0.5678
Site	2	6.40	0.0019
Age x site	4	0.64	0.6333
Noncommercial:			
Age	2	8.37	0.0003
Site	2	1.29	0.2766
Age x site	4	0.64	0.6327

[a] F values based on Wilks' criterion for overall multivariate effects.

The age x site interaction term also was significant when the percentage of oak was considered by itself (Table 3). A quick glance at Figure 1 reveals why: oak makes up 64 percent of the stems in the 15+ age category on the poor sites, but only 11 percent in the 15+ age category on the good sites. Even though the percentage of oak is fairly consistent (22-31 percent) for the two younger age classes regardless of site, oak eventually dominates only the poorer sites. Yellow-poplar, maple, cherry, ash, and aspen eventually control the better sites.

None of the age, site, or age x site interaction terms were significant for yellow-poplar or maple. These results were surprising for yellow-poplar. During data collection we noticed considerably more yellow-poplar on the better sites, particularly in older stands. This trend, though not significant, is illustrated in Figure 1. Yellow-poplar makes up only 3 percent in the 15+ age category on the poor sites, and 23 percent on the good sites. On the other hand, these results do point out that yellow-poplar is a prolific seeder that can become established (at least for awhile) even on poor sites.

The results for maple were not surprising. We also have noticed in other field studies that red maple regenerates on a wide range of sites, regardless of the harvesting method (Bailey 1984; Heiligmann et al. 1985). Stump sprouts from

advanced red maple regeneration can compete with oak sprouts on medium sites or yellow-poplar trees on good sites. As suggested by Figure 1, however, maple begins to have trouble competing on poor sites as stand age increases.

Site was significant for other commercial species. This species group comprises an average of 16 percent on the poor sites, 26 percent on the medium site, and 33 percent on the good sites. Since age was not significant, these results indicate that the percentage of trees in this species group is likely to remain the same with increasing stand age on a given site. The composition of this group will certainly vary: in one stand it may be mostly cherry and in another mostly aspen. However, in most instances, the stand will contain a mixture of the species in this group (Bailey 1984).

Age was significant for noncommercial species. This result was not surprising because it is well known that species such as dogwood, sassafras, ironwood, and sourwood regenerate substantially after clearcutting but are unable to compete with the commercial tree species as stand age increases. The fact that site was not significant indicates that the percentage of trees in this group is fairly constant across sites, averaging 27 percent for ages 5-9, 16 percent for ages 10-14, and 11 percent for ages 15 and older.

DISCUSSION

The evidence presented in this study is clear. Forest-land managers in the upland oak timber type can expect oaks to eventually dominate only the poorer sites after clearcutting. The oaks are being replaced on the better sites with a mixture of yellow-poplar, maple, and other commercial species such as black cherry, bigtooth aspen, and white ash. These species are here to stay on these sites.

This study represents an initial investigation into the species composition of young central hardwood stands following clearcutting. Future analyses will be aimed at developing regression equations that more accurately define species composition as a mathematical function of stand age and site index. Individual-tree height and volume equations also will be developed as input for stand yield prediction equations. We also hope to establish a series of permanent plots in the clearcuts. These plots not only would provide precise monitoring of changes in species composition over time, but also valuable data for growth and yield modeling.

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