Early Development of Mixed-species Stands on the Wayne National Forest

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Abstract: The species compositions of many upland hardwood forests in southeastern Ohio appear to be changing. Since the arrival of settlers, most of the mixed mesophytic forest has been cleared at least once as a result of timber cutting, burning, and agriculture. The compositions of the second-and third-growth forests are shifting toward a smaller component of oaks (*Quercus* spp.) and larger proportions of other species such as red maple (*Acer rubrum*). This study examines the development of existing young stands after clearcutting on the Wayne National Forest. A chronosequence of 5- to 30-year old mixed species stands on upper, south-facing slopes is being examined. The soils formed in residuum and colluvium derived from siltstone, sandstone and shale. Thus far, data has been collected on three sample plots in each of five stands. Total number of stems has generally decreased with age, from 24,255 stems/ha at age 6 to 5162 stems/ha at age 20. The oak proportion of the stems decreased from 25.4 to 7.7 percent over time, and the proportion of dominant/codominant oaks as a proportion of all upper crown stratum stems decreased from 51.6 percent at age 6 to 11.9 percent at age 20. Red maple and mixed commercial hardwoods accounted for 55 percent of all dominant/codominant stems at age 20. Hickories (*Carya* spp.), as a group, were a minor component of the sampled stands throughout the entire chronosequence.

INTRODUCTION

The mixed-oak forest comprises the majority of the forestland in the unglaciated, "Hill Country" of southeastern Ohio (Dennis and Birch 1979). A large proportion (42%) of these stands are mature (Redett et al. 1982), and many will most likely be harvested during the next few decades. Although oaks are a major component of the forest, they often do not regenerate and become established following conventional cutting practices; less-valuable, shade-tolerant species are replacing oaks throughout the region (Johnson 1976, Hilt 1985, Beck and Hooper 1986, Crow 1988, Myers and Buchman 1988, George and Fisher 1989).

Some research on tree regeneration following clearcutting has been conducted in southeastern Ohio. Early studies examined the reproduction present immediately after cutting (Merz and Boyce 1958, Walter 1963); more recently the compositions of medium-sized stands (Heiligmann et al. 1985a, Hilt 1985, Ward and Heiligmann 1990) have been investigated. However, very little is known about the developmental processes occuring during the early stages of stand development.

The objective of the current study is to examine the species composition of existing young stands that regenerated following complete clearcutting, and compare them to mature stands on similar sites.

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STUDY AREA

This is an on-going study which is being conducted on the Athens Ranger District of the Wayne National Forest. The district is comprised of land-holdings in five counties (Perry, Hocking, Vinton, Athens and Morgan) located in southeastern Ohio (Figure 1). The Marietta Sub-Unit is not included in this study. Located in the physiographic region known as the Unglaciated Allegheny Plateau (Fenneman 1938), the landscape is characterized by hilly terrain, steep winding valleys and outcroppings of bedrock. The soils, classified as Ultic Hapludalfs, formed in residuum and colluvium derived from siltstone, sandstone and shale (USDA 1989).

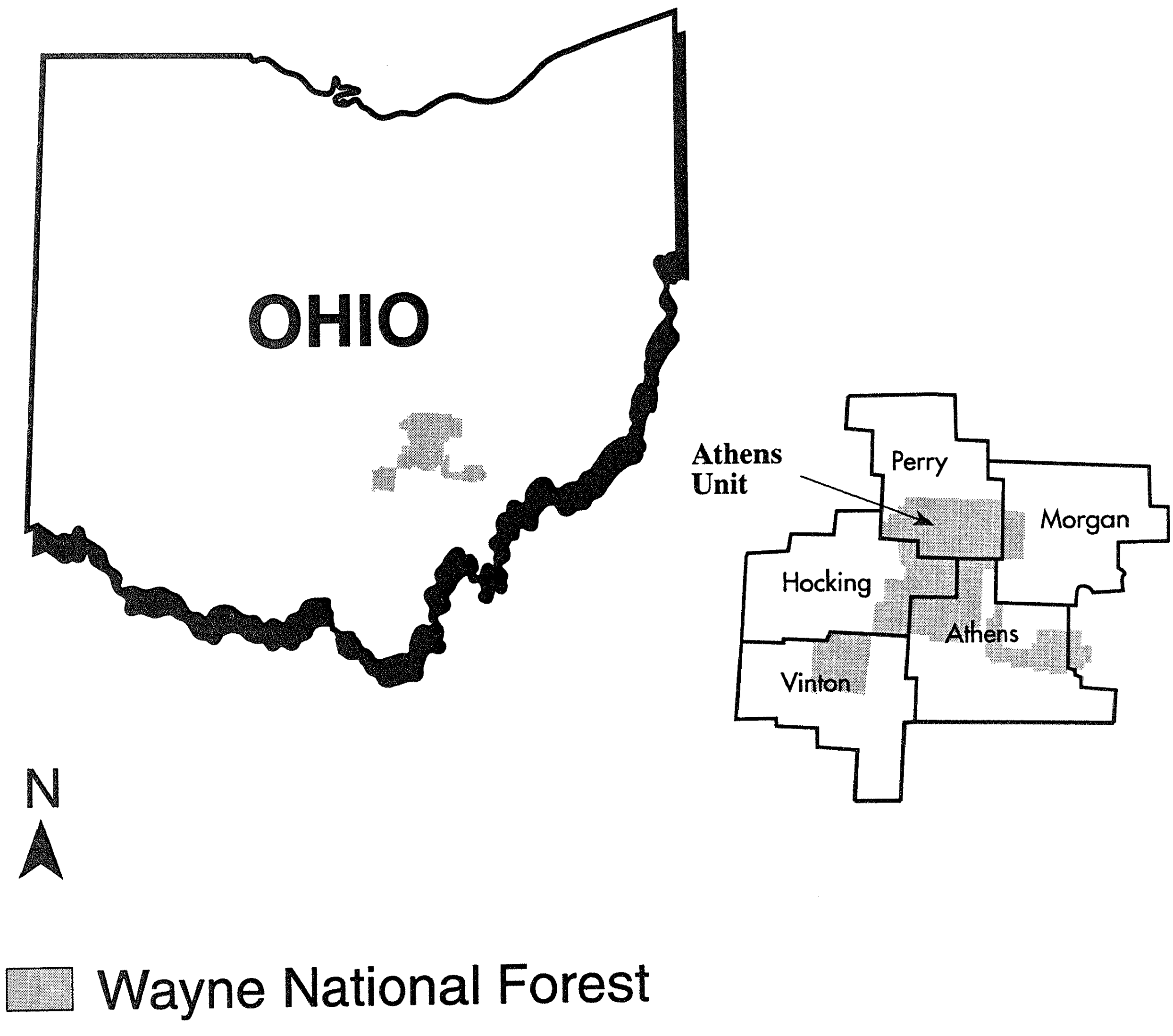

Figure 1.—Location of the Athens Unit, Wayne National Forest.

METHODS

A sequence of stands of different ages (chronosequence) (Oliver 1982) and growing on analogous sites (all one ecosystem unit) (Barnes et al. 1982) is being sampled. Individual ecosystem types or units have predictable pathways or patterns of early successional dynamics (Host et al. 1987, Hix and Lorimer 1991). The ecosystem unit selected for study is mixed-oaks growing on upper south-facing slopes with soils derived from residuum and colluvium.

Even-aged stands that meet the following criteria are being included in the pool from which a sample is being selected:

a. The present stand originated following complete clearcutting.
b. The present stand ranges in total age from 5 to 30 years.
c. The stand is located on a slope with an aspect from 135° - 225°.
d. The soil is derived from residuum and colluvium.
e. No major disturbances have occured since the cutting that established the current stand.

At least three sample plots will be randomly located within each stand. Sampling is being done on circular plots of variable radii, with the plot size increasing with stand age. The species, diameter at 137 cm above the ground (dbh), crown class, and origin (seedling, seedling-sprout, stump-sprout, root-sprout) are being recorded for all living trees greater than or equal to 1.37 m in height. Species and dbh are being recorded for all dead stems. Stand age is being determined from stand history records and by counting the annual rings on disks sawn from the base of the dominant and codominant trees. On each plot, the topographic variables being measured are: aspect, slope, and slope position (relative distance from the bottom of the slope.

Mature, undisturbed stands will be sampled, and their composition will be compared with that of the young, disturbed stands using analysis of variance.

PRELIMINARY RESULTS AND DISCUSSION

Thus far, data has been collected on 15 sample plots ranging in size from 0.003 to 0.027 ha. The results shown in Figure 1 and Tables 1-4 are based on three sample plots in each of five clearcuts of varying ages. Although there is much variability between plots within each stand, some trends are beginning to emerge.

Total number of stems across the choronsequence has generally decreased with stand age, from 24,255 stems/ha at age 6 to 5162 stems/ha at age 20 (Figure 2). The basal area (m^2/ha) has trended upward, but in a much less consistent manner (Table 1).

The pattern is more variable, however, between individual species and species groups. Oaks as a group were a dominant species prior to clearcutting, but by age 20 they are a minor part of the stand composition (Figure 2). Except for the 15-year-old stand, the component of oaks has steadily decreased from 25.4 to 7.7 percent of the total number of stems. When the importance value [(relative density + relative basal area)/2] is considered, the decrease is even more dramatic. At age 6, oaks accounted for about 34 percent of the stand, but by age 20, oaks were the second least important species group (Table 2). This is indicative of one aspect of the oak regeneration problem: oaks which are present early in the development of a stand die for various reasons over time.

Table 1.—Basal area (m^2/ha) of woody stems on complete clearcuts of different ages, by species or species group[1]

Age	Species/species group							
	Oaks	Red maple	Yellow-poplar	Hickories	Mixed comm.	Mixed non-comm.	Small trees & shrubs	Total
6	3.21	2.38	0.05	0.06	0.55	0.88	0.57	7.70
8	3.94	0.23	0.00	0.95	0.77	3.15	0.25	9.29
14	3.40	2.36	6.72	0.11	6.87	1.94	0.04	21.44
15	2.73	1.60	0.00	0.42	0.53	1.26	0.28	6.82
20	1.98	6.71	3.12	0.21	6.60	1.78	<0.00	20.40

[1]Oaks - *Quercus alba, Quercus coccinea, Quercus prinus, Quercus rubra, Quercus velutina*
Red maple - *Acer rubrum*
Yellow-poplar - *Liriodendron tulipifera*
Hickories - *Carya glabra, Carya tomentosa, Carya cordiformis, Carya ovata, Carya laciniosa*
Mixed commercial - *Fagus grandifolia, Fraxinus americana, Acer saccharum, Juglans nigra, Robinia pseudoacacia, Populus grandidentata, Ulmus rubra, Ulmus americana, Prunus serotina, Nyssa sylvatica*
Mixed non-commercial - *Sassafras albidum, Cornus florida, Ostrya virginiana, Carpinus caroliniana, Oxydendrum arboreum, Cercis canadensis*
Small trees and shrubs - *Corylus americana, Hamamelis virginiana, Rhus glabra, Rhus copallina, Amelanchier arborea, Asimina triloba, Viburnum acerifolium*

Table 2.—Importance values[1] of woody stems on complete clearcuts of different ages, by species or species groups[2]

Age	Species/species group							
	Oaks	Red maple	Yellow-poplar	Hickories	Mixed comm.	Mixed non-comm.	Small trees & shrubs	Total
6	33.54	28.84	0.93	1.13	7.69	16.52	11.35	100
8	31.20	2.01	0.00	7.33	8.86	45.85	4.75	100
14	13.86	11.00	26.58	1.52	29.42	16.36	1.26	100
15	42.89	16.14	0.00	8.67	8.02	19.25	5.03	100
20	8.69	25.38	13.82	1.86	34.94	15.09	0.22	100

[1]Importance value, $IV = \frac{\text{Relative density + relative basal area}}{2}$

[2]Refer to Table 1 for species or species group categories.

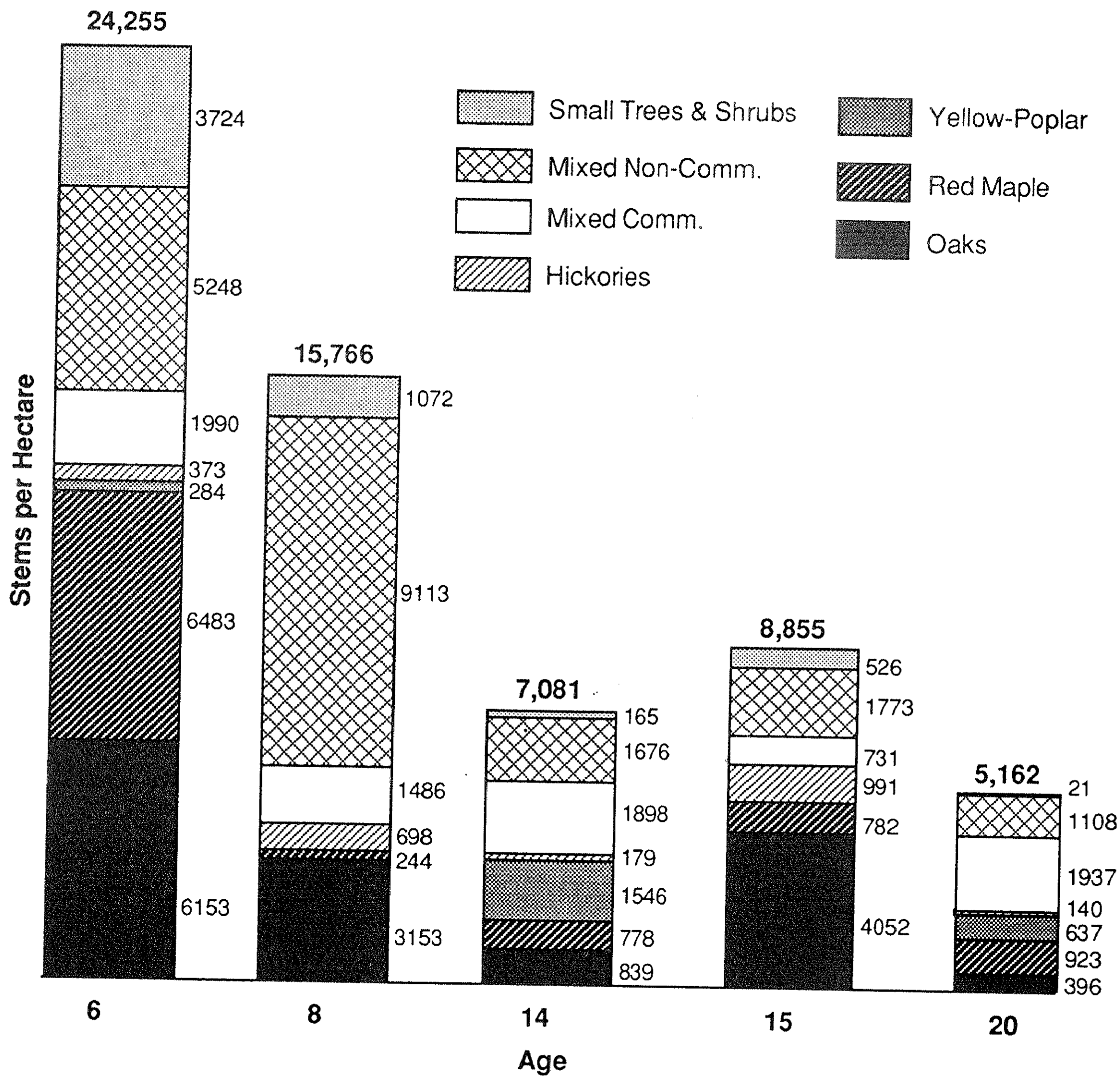

Figure 2.—Number of woody stems (≥1.37 m tall) per hectare on complete clearcuts of different ages, by species or species group categories[2].

There are also changes in the structure of the oak component. The proportion of dominant and codominant oak stems is relatively stable throughout the entire chronosequence, averaging 26.4 percent (Table 3), but the proportion of intermediate stems decreased while the overtopped stems increased. This suggests that, within the oak group, those stems which achieved dominance early in the stand retained it, while many of the intermediate stems eventually became overtopped. However, when viewed as a component of the entire population of dominant stems, the performance of the oaks is poor. At age 6, dominant and codominant oaks accounted for 51.6 percent (1646 stems/ha) of the upper canopy stems, but by age 20, the proportion had decreased markedly, to 11.9 percent (106 stems/ha).

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[2]Refer to Table 1 for species or species group categories.

Table 3.—Stand structure (stems/ha) of woody stems on complete clearcuts of different ages, by crown class and species or species group[1]

Species/species group	Stand age 6	8	14	15	20
Oaks					
Dominant/Codominant	1646	836	219	1050	106
Intermediate	2331	779	201	861	114
Overtopped	2176	1538	419	2141	396
TOTAL	6153	3153	839	4052	396
Red maple					
Dominant/Codominant	911	142	107	115	257
Intermediate	1945	0	118	299	227
Overtopped	3627	102	553	368	439
TOTAL	6483	244	778	782	923
Yellow-poplar					
Dominant/Codominant	0	0	588	0	230
Intermediate	229	0	396	0	111
Overtopped	55	0	562	0	296
TOTAL	284	0	1546	0	637
Hickories					
Dominant/Codominant	0	222	0	0	0
Intermediate	55	267	11	46	12
Overtopped	318	209	168	945	128
TOTAL	373	698	179	991	140
Mixed commercial					
Dominant/Codominant	476	133	455	43	262
Intermediate	548	357	213	41	289
Overtopped	966	996	1230	647	1386
TOTAL	1990	1486	1898	731	1937
Mixed non-commerical					
Dominant/Codominant	54	364	22	0	37
Intermediate	1311	2529	203	115	33
Overtopped	3883	6220	1451	1658	1038
TOTAL	5248	9113	1676	1773	1108
Small trees and shrubs					
Dominant/Codominant	104	0	0	0	0
Intermediate	1313	209	0	130	0
Overtopped	2307	863	165	396	21
TOTAL	3724	1072	165	526	21

[1]Refer to Table 1 for species or species group categories.

The regionwide trend of increasing red maple dominance on clearcuts (Hilt 1985a) is being observed in this study. At age 6, red maple accounted for 28.8 percent of the total stems and was still present in greater numbers (923 stems/ha) than the oaks (396 stems/ha) at age 20. The importance of red maple in the sampled clearcuts is also evidenced in the upper crown stratum. Twenty years after clearcutting, red maple accounts for more than twice as many dominant and codominant stems as do the oaks (Table 4).

Table 4.—Dominant/codominant stems (stems/ha) for two species/species groups as a proportion of all dominant/codominant stems (stems/ha).

OAKS[1]

Age	Dominant/codominant oak stems	All dominant/codominant stems	Proportion of oak (%)
6	1646	3191	51.6
8	836	1697	49.3
14	219	1391	15.7
15	1050	1208	86.9
20	106	892	11.9

[1]*Quercus alba, Quercus coccinea, Quercus prinus, Quercus rubra, Quercus velutina*

RED MAPLE

Age	Dominant/codominant red maple stems	All dominant/codominant stems	Proportion of red maple (%)
6	911	3191	28.6
8	142	1697	8.4
14	107	1391	7.7
15	115	1208	9.5
20	257	892	28.8

The remainder of the species or species groups have development trends that still appear to be ambiguous, primarily due to the small number of stands sampled so far. The group of non-commercial mixed species (e.g., *Cornus florida*, *Sassafras albidum*, and *Ostrya virginiana*) has an inconsistent trend. At ages 6 and 8, there were 5248 and 9113 stems/ha respectively. Species such as flowering dogwood and sassafras regenerate in large numbers after clearcutting but are unable to compete with commercial hardwood species over time (Hilt 1985a). In the remainder of the chronosequence (14-20 years) non-commercial species ranged from 20 to 23.7 percent of the total stems/ha.

Hickories, as a group, were a very minor component of the entire chronosequence. Although there was no consistent trend, by age 20 hickory stems only comprised 2.7 percent of the total.

Yellow-poplar was another species inconsistent in its development pattern. A very minor component at age 6 (1.2% of the total stems), it was absent in the 8- and 15-year-old stands that were sampled. At age 20, it comprised a larger component of the stand than all of the oaks combined. The continued presence and role of yellow-poplar in these stands at maturity is uncertain, however. The species is not considered to be a strong competitor on xeric sites such as those sampled; mortality is usually high when stressful growing conditions develop, especially drought (Hilt 1985b).

The remainder of the comercially-valuable species were aggregated in a single group, consisting of such species as sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), and others. Although this group was a minor component at age 6, it represented the largest category (37.5% of the stems) at age 20. While this is an artificial aggregation of species with different silvical characteristics, it is indicative of the heterogeneous nature of the stand at an early age.

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