AGE DISTRIBUTION OF OAK FORESTS IN NORTH-CENTRAL ARKANSAS

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Abstract—We used tree ring analysis to reconstruct the tree establishment patterns in four mature white oak (*Quercus alba* L.)-northern red oak *(Quercus rubra* L.)-hickory (*Carya* spp.) forests in the Ozark Mountains of north-central Arkansas. Cross sections were removed from the stumps of 321 recently harvested trees and total age determined for each. All four stands originated between 1900 and the 1920s following a stand-level disturbance(s) such as timber harvesting and/or wildfire. Oak establishment was abundant for 10-30 yrs following the disturbance(s) but steadily declined thereafter. There was no oak establishment at the study sites over the past 50-60 yrs. Establishment since the 1940s and 1950s was dominated by shade tolerant species such as flowering dogwood (*Cornus florida* L.) and red maple (*Acer rubrum* L.)

INTRODUCTION

The Ozark Mountains are the dominant physiographic feature in northern Arkansas. They include over 15 million ac of oak-dominated forests. Oaks have been important species in the region over the past 6,000 yrs (Delcourt and Delcourt 1991), and there are compelling financial and ecological reasons for maintaining a significant oak component in the landscape. Species such as northern red oak (*Quercus rubra* L.), white oak (*Quercus alba* L.), and black oak (*Quercus velutina* Lam.) have historically been, and continue to be, sources of valuable timber. The harvesting of these prized species provides economic benefits to the rural people and communities involved with the logging industry. From a wildlife perspective, acorns are an essential seasonal food supply for a variety of game species such as deer, bear, and turkey.

Despite the current abundance of mature oak forests, the long-term sustainability of oak is uncertain in northern Arkansas and much of the eastern United States. Difficulties in naturally regenerating oaks have been documented in the Lake States (Crow 1988, Lorimer 1993), the northeast (Abrams 1997), the Appalachians (Carvell and Tryon 1961, Loftis 1990), and the central hardwood region (including northern Arkansas) (Graney 1989, Sander 1972, Sander and Graney 1993). In the Arkansas Ozarks, oak generally is succeeded by species like blackgum (*Nyssa sylvatica* Marsh.), flowering dogwood (*Cornus florida* L.), red maple (*Acer rubrum* L.), and black cherry (*Prunus serotina* Ehrh.).

There are several possible contributing factors to the oak regeneration problem. These include acorn predation (Bowersox 1993), damage to oak seedlings by insects and diseases (Oak 1993), and excessive tree competition resulting from decreased fire frequency (Abrams 1992, Brose and others 1999, Van Lear and Waldrop 1989). The latter hypothesis, that shade tolerant non-oak species accumulate beneath mature oaks in the absence of fire and inhibit the recruitment of oak seedlings, has been cited as a dominant factor by the research community. Yet any of these factors would hinder or eliminate the development of advance oak seedlings and saplings. Regardless of the cause(s), traditional silvicultural practices that simply involve cutting the overstory without regard to these factors can lead to upland forests that are compositionally and structurally different from the previous forest.

The abundance of mature oak forests in northern Arkansas demonstrates that oak regeneration has not always been a problem. Indeed, previous disturbance conditions appear to have facilitated successful oak establishment and development. To better understand current oak regeneration difficulties, it is important to gain information on when and how today's mature oak forests regenerated. We selected four oak stands in north-central Arkansas for detailed study. The objective was to use tree ring analysis to reconstruct the patterns of tree establishment in each stand.

METHODS

Study Areas

Four mature white oak-northern red oak-hickory (*Carya* spp.) stands in north-central Arkansas were selected for study. The stands, located in the White River Hills and Springfield Plateau subsections of the Ozark Mountains (USDA Forest Service 1999), were on the Sylamore Ranger District of the Ozark-St. Francis National Forest in Stone County and Baxter County, AR. Sites were no closer than 0.5 miles from each other; the distance between the two most widely spaced stands was 12 miles. Elevations ranged from 700 to 1400 ft. Soils were Clarksville and Noark very cherty silt loams (Ward 1983, Ward and McCright 1983), and slopes were 8 to 40 percent. Site index for upland oak was 70 ft at base age 50 (Ozark-St. Francis National Forest, unpublished data).

All four stands had been commercially harvested from 1998 to 2000 using the group selection system. With this method, approximately one-sixth of the area in each stand was regenerated in 0.25–1.0 ac scattered openings. All merchantable trees in the openings were harvested and removed, while non-merchantable trees greater than 1-in in d.b.h. (diameter at breast height) were killed by stem injection with herbicide (glyphosate). In addition, a commercial thinning from below was conducted in some parts of the forest matrix between the openings.

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Data Collection

In 2000 and 2001, we established one transect in each stand and systematically selected three openings for further study. Depending on stand size, the distance between the openings chosen was 500 to 2000 ft. In each opening we established one 0.25-ac circular plot. Using chainsaws, a cross section was cut from all non-rotten stumps within the plots that possessed a ground line diameter larger than 2 in. The cross sections were tallied by species or species group (e.g., red oak). In most of the openings, at least several unmerchantable trees were not felled during harvesting. We felled and removed cross sections from the stumps of these trees if their ground-line diameters exceeded 2 in. In all, we collected 321 sound cross sections.

To calculate the pre-harvest tree density and basal area in each stand, we sampled the forest matrix between the openings. Two 0.05-ac overstory/midstory plots were established 100 ft north and south of the northern and southern boundaries of each opening sampled; 6 plots were established in each stand. Plots were offset if they included skid trails or areas that had been commercially thinned. Within each plot, species and d.b.h. were tallied for all living trees greater than 4.5 in d.b.h.

Laboratory Procedures

Tree cross sections were transported to the University of Arkansas – Monticello for preparation and analysis. Each cross section was sanded with progressively finer sandpaper so that individual tree rings were clearly visible. Tree age for each cross section was determined by counting the tree rings under a dissecting microscope. About ten percent of the samples were independently recounted to check the precision of our work. The mean difference between the original counts and recounts was 2.1 yrs. Tree ages were grouped by decade to reconstruct tree establishment and stand development patterns at each site.

RESULTS AND DISCUSSION

Stand Structure

The four stands were similar in terms of total overstory/midstory tree density and basal area (table 1). Densities ranged from 193 to 204 trees per ac, and basal areas varied from 114 to 122 ft^2 per ac. White oak, red oak (including northern red oak and black oak), and hickories were the dominant species. In each stand, they combined for at least 92 percent of the tree density and at least 96 percent of the basal area. There were more white oak stems than red oak or hickory in all four stands. Associated species included flowering dogwood, red maple, eastern redcedar (*Juniperus virginiana* L.), and shortleaf pine (*Pinus echinata* Mill.).

Age Distribution

The age distributions of the study areas exhibited a number of similarities (figs. 1A through 1D). First, there was an abrupt pulse of tree establishment beginning in the 1900s (fig. 1C) or 1910s (figs. 1A, 1B, and 1D). It is likely that a disturbance such as timber harvesting and/or wildfire triggered this regeneration response by removing all or portions of the forest canopy. Separate age distributions of each 0.25-ac plot (not depicted) indicate that disturbances were likely stand-level in scale. That is, an establishment pulse during a particular decade in one plot was also evident in the other two plots in that stand.

Second, few of the trees we sampled originated prior to 1900. Although red oaks are not particularly long-lived – for example, physiological maturity of black oak occurs near age 100 (Sander 1990) – white oak is a long-lived species with rotation ages of 120+ yrs (Rogers 1990). Therefore, some older trees probably were killed by the same disturbance(s) responsible for the regeneration pulse. The near-absence of older trees also suggests that post-disturbance establishment was dominated by either germinating seedlings or the release of advance regeneration.

Third, tree establishment was particularly abundant for 10 to 30 yrs following disturbance, but steadily decreased with increasing stand age. Perhaps the initial disturbance in each stand was the sole disturbance, or subsequent disturbances were relatively small and had little effect on establishment. Lorimer (1985) observed that examining age distributions alone may be insufficient to reconstruct stand disturbances. We are currently analyzing tree radial growth patterns to more accurately describe disturbance history of the study areas.

Table 1—Stand characteristics of trees greater than 4.5 in dbh at the four study sites

	Stand 1		Stand 2		Stand 3		Stand 4	
Species	Density	Basal area	Density	Basal area	Density	Basal area	Density	Basal area
	trees/ac	*ft^2/ac*	*trees/ac*	*ft^2/ac*	*trees/ac*	*ft^2/ac*	*trees/ac*	*ft^2/ac*
White oak	93	46	80	46	87	48	110	73
Red oak[a]	73	60	47	44	53	63	43	32
Hickories	20	7	60	21	43	10	37	11
Flowering dogwood	—	—	10	2	7	1	3	1
Other[b]	10	5	7	1	3	< 1	7	1
Totals	196	118	204	114	193	122	200	118

[a] Includes northern red oak and black oak.

[b] Includes red maple, eastern redcedar (*Juniperus virginiana* L.), and shortleaf pine (*Pinus echinata* Mill.).

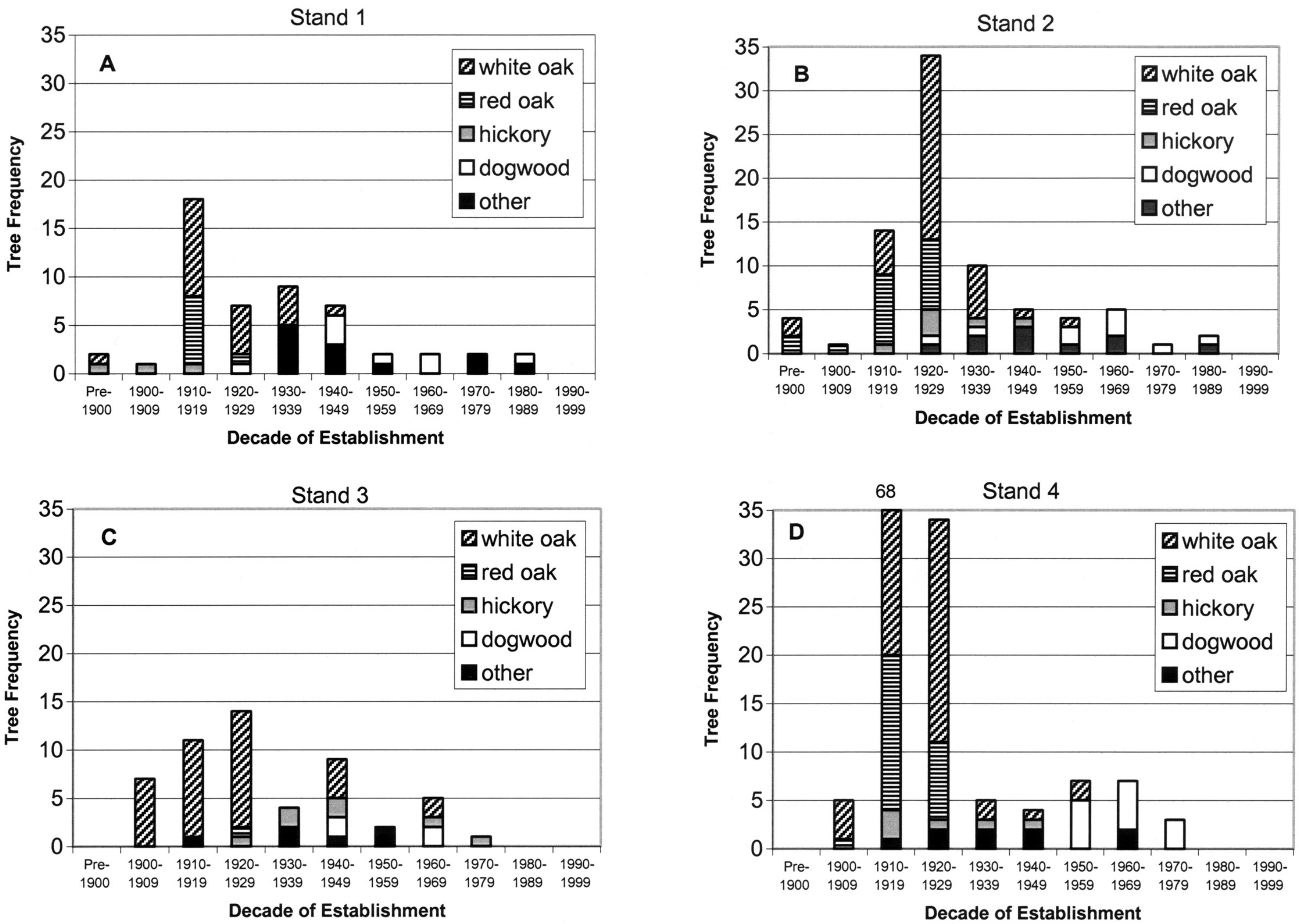

Figure 1—Age distributions for trees greater than 2 in at ground-line diameter at (A) Stand 1, (B) Stand 2, (C) Stand 3, and (D) Stand 4. Note that the "Other" category includes blackgum, red maple, and sassafras (*Sassafras albidum* (Nutt.) Nees).

Finally, different species established at certain times. White oak and red oak aggressively colonized the disturbed study areas from the 1900s through the 1920s (fig. 1A-1D). In the 1930s, white oak continued to establish, albeit at reduced levels, but red oak establishment ceased and never resumed. Although white oak is considered intermediate in shade tolerance, it is more tolerant than northern red oak and black oak, and is most tolerant as a seedling or sapling (Rogers 1990). White oak was clearly able to establish in the shaded conditions of the developing stands better than red oaks. Yet after the 1930s, white oak establishment also decreased and ceased by 1950 to 1970. Coincident with the cessation in oak establishment was an increase in establishment of shade tolerant species such as flowering dogwood and red maple (fig. 1A-1D). These species consistently established from the 1930s through the 1970s and 1980s; field observations at the study sites indicated they were abundant in seedling and sapling size classes not sampled in this study.

CONCLUSIONS

The four mature oak stands we studied in north-central Arkansas originated following stand-level disturbances that occurred between 1900 and 1930. Following the disturbances, oak establishment continued for decades, with the more tolerant white oak establishing for a longer period than red oaks. Few white oaks, and no red oaks, established at the study sites over the past 50 to 60 yrs. Instead, establishment became dominated by shade tolerant species. These results demonstrate that disturbance is a prerequisite for successful oak regeneration. Current investigations into tree radial growth patterns should provide additional information on the type and frequency of disturbances at the study sites.

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