PRE- AND POST-CLEARCUT TREE SPECIES DISTRIBUTION IN TWO PHYSIOGRAPHIC REGIONS OF THE SHAWNEE NATIONAL FOREST, ILLINOIS

Michael A. Long and John W. Groninger[1]

Abstract—Seventy-four upland oak stands distributed across the Shawnee National Forest, Illinois were inventoried 15 to 26 years after clearcutting and harvest records examined to determine the effect of physiographic province on the distribution of oak and associated tree species before and after clearcutting. Oak represented 62 percent of harvest volume in the Shawnee Hills versus 51 percent in the Ozark Plateau. The latter is characterized by high site quality resulting from the deposition of wind blown loess soils originating from the adjacent Mississippi River floodplain. Oak proportion based on stem density was significantly less in post-clearcut stands in both physiographic provinces but a pre-harvest trend toward relatively higher values in the Shawnee Hills (21 percent) versus the Ozark Plateau (11 percent) persisted. The increased dominance of yellow-poplar across the Shawnee Hills could have important management implications if this species persists.

INTRODUCTION

The oak-hickory (*Quercus*/*Carya*) forest is the primary forest type in the Central Hardwood Forest (CHF), covering 127 million acres (Hicks 1998). The oak/hickory forest type is important to the CHF because oak (*Quercus* sp.) trees are an important primary producer (Ostfeld and others 1996), supporting a diverse and productive ecosystem. Acorns are used by over 180 birds and mammals across the United States (Rogers 1990), and are a highly preferred food source for rodents, squirrels, birds, chipmunks, wild turkey, and white-tail deer.

The pre-settlement forests in southern IL varied widely in composition depending on topography, slope position and physiographic region (Fralish and others 1991). Two major upland forest types are recognized for southern IL: the mesic oak-hickory forest of the Shawnee Hills and the mixed hardwood forest of the Ozark Plateau (Leitner and Jackson 1981). The Shawnee Hills extends across southern IL from east to west and the Ozark Plateau is located on the western border of southern Illinois along the Mississippi River floodplain.

The mesic oak-hickory forest of the Shawnee Hills consisted of white oak (43.6 percent), black oak (19.6 percent), northern red oak (2.2 percent), and hickory species (6.8 percent) which combined for 72 percent importance (Leitner and Jackson 1981). The Mixed Hardwood Forest occurred in the western portion of the Shawnee Hills and within the Ozark Plateau. Site quality on broad ridgetops and ravines in the Ozark Plateau was increased by the deposition of loess soils from the adjacent Mississippi River floodplain (Fralish 1976). Greater soil depth, moisture availability and competition relative to the Shawnee hills located to the east. High site quality increased the development of the Mixed Hardwood Forest in the Ozark Plateau. Importance percentages for white and black oak were 24.7 and 9.5 percent, respectively (Leitner and Jackson 1981). The deep loess soils also supported typically mesophytic species, especially American beech [*Fagus grandifolia* (22.1 percent)], sweetgum [*Liquidambar styraciflua* (8.3 percent)], and yellow-poplar [*Liriodendron tulipifera* (6.9 percent)] (Leitner and Jackson 1981). The mixed hardwood community consistently dominated the Ozark Plateau landscape.

Clearcutting is the removal of the entire stand in one entry, including all merchantable and unmerchantable timber 2 inches in diameter and greater (Smith 1986). Clearcutting is intended to create the conditions necessary for rapid growth of moderately shade tolerant and shade intolerant species, and for the development of an even-aged stand. Historically, clearcutting had proven to be a successful technique in halting succession and promoting oak regeneration, as well as that of other shade intolerant hardwood species (Bey 1964). More recently, land managers have struggled to maintain the oak/hickory forest type with this silvicultural technique (Lorimer 1993). The suppression of fire has left the understory of oak/hickory stands stocked with shade tolerant mesophytic species and an abundant yellow-poplar seed supply (Beck and Della–Bianca 1981). These individuals out compete oak seedlings for dominance upon release from overstory suppression.

Between 1980 and 1990, the United States Forest Service conducted 160 clearcuts throughout the Shawnee National Forest, with the stated objectives of regenerating the stands to valuable hardwood species, such as red and white oak, white ash, and yellow-poplar. The objectives of this study were to identify past and present distribution of oak and other common tree species across two physiographic regions and to evaluate the effectiveness of clearcutting in achieving management goals.

METHODS

The 74 stands used in this study were chosen randomly from 160 total stands that were clearcut by the Shawnee National Forest between 1980 and 1990. These stands were located in the Ozark Plateau and Shawnee Hills physiographic regions and were representative of the full range of landscape positions found therein. Transects were

[1]Research Assistant and Associate Professor, Southern Illinois University, Carbondale, IL, respectively.

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systematically located on topographic maps to represent a wide range of topographic and site quality variation within each stand. Inventory plots were placed at equal distances along the transect line. Selected stands were assigned four to six inventory plots (depending on size) which were located on photocopied maps prior to inventorying sites.

A total of 343 inventory plots were installed during summers 2005 to 2006. Data were collected at each plot using the Common Stand Exam (CSE) protocols (Common Stand Exam Users Guide 2003). Overstory data were collected using a 10 basal area factor variable radius plot. All tallied trees were measured for diameter at breast height (d.b.h.), total height, crown class, and crown ratio, and identified to species. Sales folders maintained by the Shawnee National Forest were available for 57 of the stands. These reported stumpage quantities by species groups in thousand board feet units. Species groups most often used by Forest Service personnel who created these records were white oak, red/black oak, mixed hardwoods, and yellow-poplar. These data were used to determine past species composition.

Present and past oak proportions were analyzed as a function of physiographic region. Present, but not past, oak proportions were transformed with a square root transformation to satisfy the assumptions of ANOVA. This analysis sought to determine the effects of longitude and associated site quality on oak density. Because of their location relative to one another, physiographic region acted as a proxy for longitude.

Species that represented more than 6.5 percent of the total density for all trees tallied were used for individual analysis (table 1). These included *Quercus alba, Quercus rubra, Quercus velutina, Acer saccharum, Prunus serotina,* and *Liriodendron tulipifera*. Northern red oak and white oak had densities less than 6.5 percent of the total density, but were included in the individual analysis because they were considered keystone species (Bond 1994). All hickory species were grouped into a *Carya* category. These species include *Carya ovata, Carya glabra, Carya illinoensis, Carya cordiformis,* and *Carya tomentosa*.

Table 1—Relative density of oak and associated species (6.5 percent or greater) across 74 stands 15-26 years following clearcutting in the Shawnee National Forest

Species	Relative stem density (*percent*)
Yellow-poplar (*Liriodendron tulipifera*)	13.9
Sugar maple (*Acer saccharum*)	11.8
Black cherry (*Prunus serotina*)	6.9
Black oak (*Quercus velutina*)	6.9
Sassafras (*Sassafras albidum*)	6.8
White oak (*Quercus alba*)	5.4
Northern red oak (*Quercus rubra*)	1.8

RESULTS

Past oak percentage as measured by harvest was greater in the Shawnee Hills (62 percent) than the Ozark Plateau (51 percent) ($f=4.09$, $df=1$, $p=0.0481$). 15-26 years following clearcutting, oak proportions as measured by stem density was lower in both physiographic provinces than pre-harvest volumes. The regions did not differ significantly from one another by this measure ($f=2.65$, $df=1$, $p=0.1094$) but pre-harvest trends remained with oak density higher in the Shawnee Hills (21 percent) versus the Ozarks (11 percent).

Yellow-poplar represents 14 percent of the total tree density and 29 percent of basal area across the 74 post-clearcut stands (table 1). In contrast, all oak species combined comprised 15 percent total basal area. Pre-settlement records indicate that yellow-poplar was limited to lower slope positions on north aspects and on terraces, where it reached 17 percent importance (Fralish 1991). Sales folders indicated that yellow-poplar comprised 15 percent of the volume in pre-harvest stands, of which 89 percent came from the Ozark Plateau.

Differences in species distribution were noted between the physiographic provinces following clearcutting 43, 57 and 78 percent of the respective density northern red oak, black oak, and white oak in the Shawnee Hills. Hickory had 43 percent of its density in the Shawnee Hills. Mesophytic distribution is also variable across physiographic regions. Following clearcutting, 37, 45, and 72 percent of sugar maple, yellow-poplar, and black cherry density were in the Shawnee Hills.

DISCUSSION

Pre-harvest oak proportion was lower in the Ozark Plateau versus the less productive Shawnee Hills. This is consistent with previous observations in this region (Fralish 1976). Oak species have shown a decrease in density from pre-harvest to mid-rotation age. This finding supports the work of others who have observed a decrease in oak density across a range of site qualities in eastern oak forests (Beck and Hooper 1986, Elliot and others 1997, Gould and others 2005, Jenkins and Parker 1998).

The decrease in oak species within these stands appears to be more prevalent in the Ozark Plateau than in the Shawnee Hills. Similar results were found in PA where third generation oak stands regenerated in equal proportions in the Ridge and Valley and Blue Ridge provinces, areas where oak dominated second generation forests. In contrast, third generation oak dominated stands were totally absent in the Appalachian Plateaus, where the previous oak forest was in transition with the mesophytic Allegheny hardwood forest type (Gould and others 2005), a situation similar to the mixed hardwoods and productive sites of the Ozark Plateau.

Species distribution across the landscape appears to be more strongly driven by life history characteristics and

growth patterns. For example, yellow-poplar was a small component of presettlement and second growth forests, existing primarily on the lower north and terrace slope positions (Fralish 1991). Pre-harvest data showed yellow-poplar was mostly found on high quality sites in the Ozark Plateau at densities far smaller than oak and hickory species. Today, yellow-poplar is widely distributed across landscape positions in both physiographic provinces, even where it was historically rare or absent (Fralish 1991). The relatively high proportion of sugar maple in the Ozark Plateau is expected considering the mesic site conditions associated with this region. The prevalence of yellow-poplar and black cherry in the relatively dry Shawnee Hills is noteworthy. Continued persistence of these species at the expense of oaks would represent a significant change in species composition toward mesophytes in this relatively dry region. Further monitoring will be needed to determine whether the present dominance of meosphytes in Ozark Plateau and Shawnee Hills stands originating from clearcutting portends a lasting compositional change. If so, intermediate silvicultural treatments may be considered to satisfy current management objectives focused on maintaining oak dominance.

CONCLUSION

The occurrence of third generation oak species in even-aged upland hardwood stands is primarily an effect of site quality and life history characteristics. Oak in upland clear cut stands approaching mid-rotation in the Shawnee National Forest has decreased from 55 percent total pre-clearcut volume to 16 percent post clearcut density. The increasing similarity of forest composition between the Ozark Plateau and Shawnee Hills suggests that different silvicultural strategies should be specified within these regions if maintaining pre-harvest composition is a priority. Management activities implemented at this stage of development could help influence future stand composition, increase d.b.h. growth and crown development of desirable species, and increase mast production for wildlife habitat and future regeneration sources. Questions remain regarding the survivability of yellow-poplar and black cherry on drought-prone, low quality sites and of northern red oak on high quality sites where competition is intense.

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