REGENERATIVE EFFECTS OF PATCH-CUT HARVESTS AT NATCHEZ TRACE STATE FOREST IN WEST TENNESSEE AFTER MORE THAN 25 YEARS

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ABSTRACT

Patch cutting is a regeneration method with little precedent in the Central Hardwoods Region of the United States. Patch cuts are defined as small scale clearcuts of 1–5 acres and are generally prescribed to lessen the aesthetic impact of harvesting in highly visible areas. This study examines species composition and stand development after patch cutting in the 1990s at Natchez Trace State Forest, located in the Coastal Plain of western Tennessee. Patch cuts were hypothesized to have a greater proportion of shade-intolerant species in the center of the opening and transitioning to more shade-intermediate and shade-tolerant species toward the edge of the harvest. Results indicate that patch cuts were dominated by yellow-poplar (*Liriodendron tulipifera*) across the light gradient of the patch opening. Few shade-intermediate (oaks, *Quercus* spp.) and shade-tolerant species were encountered. Yellow-poplar has greater light plasticity in these transitory light conditions toward the edge of the patch cut, regenerating, and outgrowing other species with lesser light requirements, thus nullifying the hypothesis in this research.

INTRODUCTION

Patch cutting, which is often referred to as "small clearcuts" or "patch clearcutting" refers to a regeneration harvest of 1–5 acres. These patches create small, even-aged areas within a larger, uneven-aged landscape (Meadows and Stanturf 1997). This regeneration regime is used primarily to lessen the aesthetic impact of harvesting. Patch cutting is not a common harvest regime in central hardwood or southern bottomland hardwood areas and its regenerative effects have not been extensively studied, especially after more than 25 years. Similar harvest regimes of interest such as clearcutting and group selection have been evaluated in the southern Appalachian Mountains (McNab and Oprean 2021). Typically, larger area, complete cuts support regeneration of shade-intolerant species while group-selection regeneration favors more intermediate-light and shade-tolerant species. Patch cutting is more common in New England (Yamasaki and others 2014) and most of the literature on the subject is from that region.

The patch cuts at Natchez Trace State Forest (NTSF) were initially publicly referred to as group-selection regeneration. True group-selection openings are much smaller than patch cuts. Nyland (2002) defines group selection as an opening that is one to two times the height of the surrounding mature trees. With group selection, the entire opening is influenced by the adjacent trees on the edge of the opening (LeDoux 1999). Patch cuts are large enough that there is at least some area in the center of the opening that receives direct or full sunlight and is not influenced by adjacent trees (Yamasaki and others 2014).

The goal of this study was to investigate regenerative effects of patch cuts on species composition in relation to the establishment and growth of oak (*Quercus*) species, a keystone genus for wildlife and timber in Tennessee (Clatterbuck 2019). Oaks are classified as light-intermediate species (Fox and Creighton 2016, Johnson and others 2009). Patch cuts may provide moderate light conditions that benefit oak regeneration, growth, and development. Faster-growing,

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shade-intolerant yellow-poplars (*Liriodendron tulipifera*) are common in full sunlight, while more shade-tolerant species such as maples (*Acer* spp.) and American beech (*Fagus grandifolia*) are frequent in partial light areas adjacent to edges of openings.

METHODS

Study Area

Natchez Trace State Forest, State Park, and Wildlife Management Area encompasses 46,000 acres in western Tennessee, approximately 30 miles east of Jackson, TN. The State Forest (36,000 acres) completely encircles the 10,000-acre State Park. The land was acquired in 1949 when purchased by the Federal Government as part of the New Deal. Much of the flatter ridges and upper slopes were farmed, causing broad erosion and abandonment within a few years (McClurkin and others 1985). These areas were planted with loblolly pine (*Pinus taeda*) to control erosion. Other areas had more rolling topography including narrow ridges, short side slopes ranging to 10 percent, and V-shaped valleys that were left undisturbed in forests. Smalley (1991) classified the forest as the Coastal Plain Physiographic Province, East Gulf Coastal Plain Region, Upper Coastal Plan Hills Subregion, and two Landtype Associations: (A) Sandy and Loamy Hills, and (B) Clayey and Sandy Clay Hills. Most of the unsustainable agricultural practices occurred on Landtype Association A. Sample stands were from Landtype Association B which historically were undisturbed and included Lexington, Providence, Ruston, Savannah, and Smithdale soil series, soil textures of sandy loams and silt loams, and classified as alfisols and ultisols, some with fragipans. Site index at 50 years ranged from 80 to 90 feet for yellow-poplar and 65 to 75 feet for oaks (Smalley 1991).

Stands were mature at harvest with closed canopies. Overstory species included red oaks (*Quercus rubra*) and white oaks (*Quercus alba*), yellow-poplar, hickories (*Carya* spp.), sweetgum (*Liquidambar styraciflua*), black cherry (*Prunus serotina*), and maples. Planted, mature loblolly pine stands were adjacent to a few harvest units, but not directly next to the patch cuts.

Data Collection

Four patch-cut harvest units were selected across NTSF. Within each harvest unit, there were many individual patch cuts. Four patch cuts were selected from each harvest unit based on accessibility and determining patch cut boundaries. Patch cuts were often difficult to delineate and determine boundaries of the cut area after more than 25 years of growth. Six 0.05-acre plots were sampled within each selected patch cut. The plots taken were categorized based on their proximity to the edge of the harvest area. Two plots were taken near the edge of the harvest area, two plots near the center, and two plots in the intermediate range between the edge and center. Most patch cuts were 2–3 acres. Since the size and shape of patch cuts varied, plot selection was subjective, but without preconceived bias (Mueller-Dombois and Ellenberg 1974). The three plot locations (center, intermediate, and edge) were sampled to determine if a change in species composition and stand structure occurred along the gradient of light conditions at time of harvest. A chi-square test evaluated whether there was a relationship between plot location and individual species. Within each plot, every tree with a diameter at breast height (4.5 feet, d.b.h.) ≥5 inches was measured and species determined. This process yielded 96 plots: 4 harvest units (stands), 4 patch cuts sampled for each harvest unit, and 6 plots for each patch cut.

RESULTS

A total of 969 trees that were ≥5 inches d.b.h. were tallied on 96 plots. Measured trees on the patch cuts across harvest units represented an average of 201.7 trees per acre (TPA) and 65.6 square feet of basal area for the study area.

Yellow-poplar was the most prominent species present in the patch cuts across all stands and locations, accounting for 44 percent of total stems measured (table 1) with 88 TPA. Sweetgum with 19 percent and 39 TPA and black cherry with 13 percent and 27 TPA were the second- and third-ranked species. Red oaks and white oaks combined composed 3 percent of the total stems with 6 TPA. The remaining trees were maples (6 percent, 12 TPA) and the miscellaneous category (15 percent, 30 TPA).

Table 1—Composition, average diameter, and basal area of patch-cut openings for stems ≥5 inches in diameter

Species	Composition	Average diameter	Basal area
	percent (trees per acre)	*inches*	*square feet per acre (percent)*
Yellow-poplar	44 (88)	7.8	32.7 (50)
Black cherry	13 (27)	6.2	5.9 (9)
Sweetgum	19 (39)	7.0	11.1 (17)
Maples	6 (12)	5.9	2.6 (4)
White oaks	2 (4)	7.0	1.3 (2)
Red oaks	1 (2)	6.7	0.7 (1)
Miscellaneous	15 (30)	7.6	11.1 (17)

Each miscellaneous species composed <4 percent of the total stems.

The diameter distribution follows the reverse-J (negative exponential) pattern typical of stratified, even-aged stands (fig. 1). Yellow-poplar was not only the most abundant species, but also the greatest in average diameter at 7.8 inches (table 1). Sweetgum was the second-ranked species in diameter.

Yellow-poplar was even more prominent with 50 percent of the total basal area and 32.7 square feet of basal area in the patch cuts (table 1). Sweetgum and black cherry were the second- and third ranked species with 11.1 and 5.9 square feet of basal area per acre, respectively. Red and white oaks combined represented 3 percent or 2 square feet of basal area per acre.

Plot Location

For plots near the edges of the patch cuts, yellow-poplar was the most common species accounting for 34 percent of total stems per acre but composed greater percentages in the intermediate (51 percent) and center (46 percent) locations (table 2). The proportion of individual species

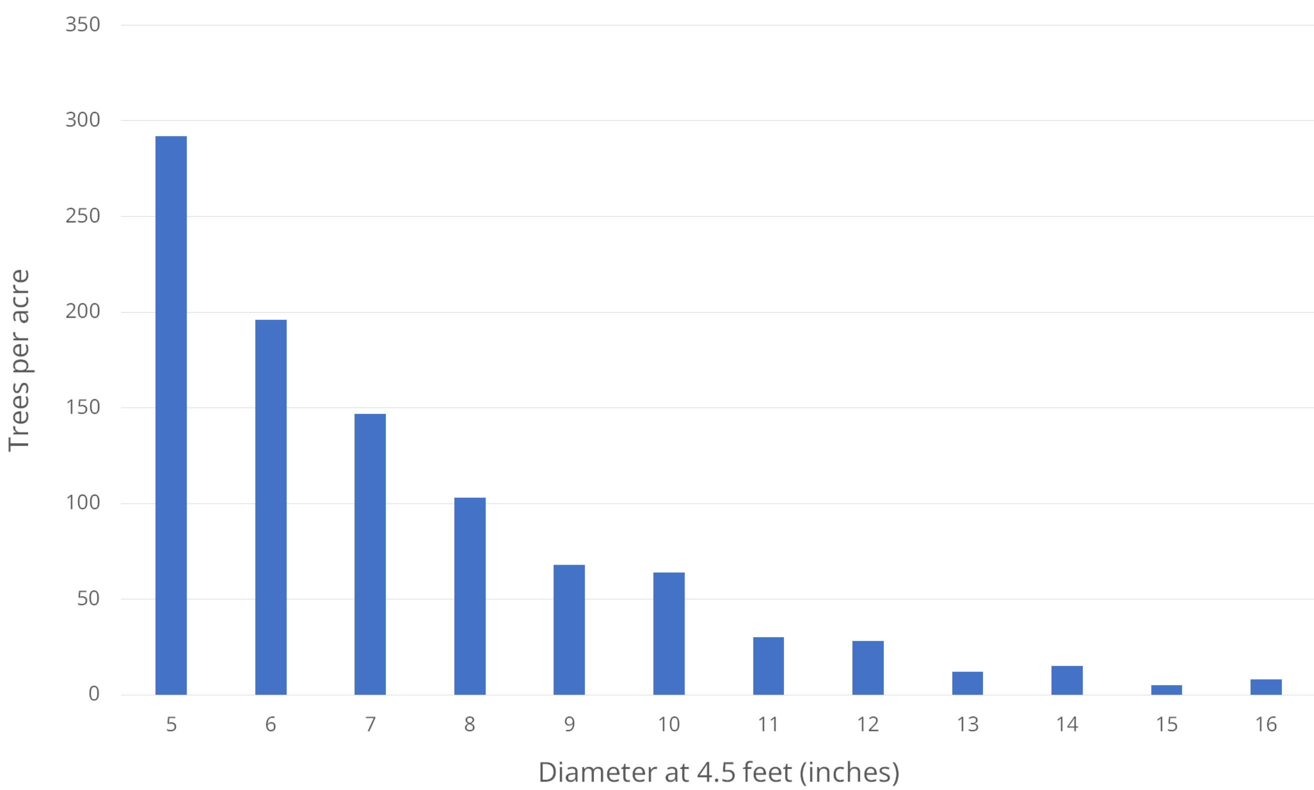

Figure 1—Patch cut diameter distribution across species from 96 plots at Natchez Trace State Forest.

Table 2—Species composition as a percentage of total trees for each of the three patch-cut locations

Species	Edge	Intermediate	Center
	~ ~ ~ ~ ~ ~ ~ ~ ~ ~	*percent*	~ ~ ~ ~ ~ ~ ~ ~ ~ ~
Yellow-poplar	34.1	50.8	45.6
Black cherry	14.4	12.0	13.8
Sweetgum	18.1	13.6	24.9
Maples	8.4	7.1	3.0
White oaks	2.3	1.6	1.7
Red oaks	0.3	2.6	1.1
Miscellaneous	22.4	12.3	9.9

The increase in miscellaneous species in the edge plots was from the natural seeding of loblolly pine from adjacent stands in one of the harvest units.

The chi-square test failed to demonstrate any real association between plot location and species at the $P = 0.05$ level.

was similar across plot locations. The increase in miscellaneous species in the edge plots was from the natural seeding of loblolly pine from adjacent stands in one of the harvest units.

DISCUSSION

The patch-cut survey results were surprising. While the hypothesis of this study predicted that shade-tolerant species would constitute a significantly greater proportion of the species composition in the patch-cut area, this was not the case. Yellow-poplar dominated these areas, including the edges. Shade-tolerant species such as maple were present, but they were virtually absent from the overstory. Given the dominance of yellow-poplar on these sites, it was not surprising that sweetgum and black cherry were commonly observed species (Eyre 1980). Sweetgum regenerates with yellow-poplar at sites within a stand that are too moist for yellow-poplar. Black cherry is shade-intolerant and is often associated with yellow-poplar as a pioneer species. However, yellow-poplar superseded sweetgum and black cherry on the study sites. The environmental and site conditions in the regeneration and continued growth of the patch cuts favored yellow-poplar more than sweetgum and black cherry.

Using basal area of the patch-cut areas, yellow-poplar composed 50 percent of the total species composition (table 1), further emphasizing the dominance of yellow-poplar, not only in number, but in occupied growing space. Yellow-poplars are the largest stems and occupy more growing space than any other species. Maples were the shade-tolerant species expected to be the beneficiary of patch cuts along the edges, but they accounted for 6 percent of stems and 4 percent of the basal area.

The edge plots did show an increased proportion of shade-tolerant species when compared to the intermediate and center plots (table 2). This increase was not as much, as expected, based on the decrease of direct sunlight approaching the edge of the opening and the literature review (McNab and Oprean 2021, Yamasaki and others 2014) that suggested shade-tolerant and light-intermediate species would be more common near the edge of the openings. Species composition did not change appreciably from the edge, to the intermediate, to the center of the patch openings.

The near absence of oaks in patch cuts despite mature oaks being prominent before the harvest is perplexing. Oaks, being shade intermediate, lead to the expectation that they would appear more often than they did as the patch-cut opening gradually transitioned to the edge. Many studies have documented that 20 to 30 percent of full sunlight is necessary for developing competitive oak seedlings (Clatterbuck 2019). Sander (1972) and Sander and others (1976) suggest that adequate number and size (≥4 feet tall) of oak advance reproduction is vital to successfully regenerate oak. Preharvest regeneration data for the areas that were patch cut at NTSF are not available. We assume that there was little oak advance reproduction present at the sites prior to harvest. Even if oak advance reproduction were present, there would be some question whether the slower growth of oaks would be able to develop with faster growing yellow-poplar, even in diminished light conditions (Schweitzer and others 2016).

CONCLUSION

Yellow-poplar was expected to dominate in the center of regenerated patch cuts with its fast growth, seed viability for several years, and sprouting ability under full light conditions (Beck and Della-Bianca 1981). However, yellow-poplar was not expected to dominate the regenerated stands as the amount of sunlight subsided toward the edge of the patch cuts. More shade-intermediate (oaks) and shade-tolerant species (maple and beech) were anticipated. The hypothesis that a greater diversity of species would occur across the changing light conditions from the center of the patch cut to the edge was rejected. Based on these studied sites, yellow-poplar as a shade-intolerant species is much more adaptable to less sunlight than previously reported.

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