FIELD NOTE

Composition of Oak Stands in the Illinois Ozark Hills 2 Decades following Light Harvesting and No Cutting

Eric J. Holzmueller, John W. Groninger, Charles M. Ruffner, and Trevor B. Ozier

ABSTRACT

Light harvesting and no cutting are two common management regimes in oak-dominated forests in the Ozark Hills of southern Illinois. We compared changes in overstory stand composition between 1980 and 2000 among forest inventory plots that were lightly harvested after initial sampling and plots that were uncut during the same time period. Total white oak (*Quercus alba* L.) basal area increased for both management regimes. Black oak (*Quercus velutina* Lam.) overstory density decreased, and sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.) density increased for both management regimes. Although overall density of oak was maintained by both management regimes, species and diameter class-specific response varied. Additional silvicultural activities may be necessary to sustain oak in both lightly harvested and uncut plots, with light harvesting providing opportunities to at least partially offset costs.

Keywords: central hardwoods, diameter distribution, *Quercus*, oak ecosystem management, partial harvest

In the lower Midwest, foresters are often faced with resistance to harvesting on private and public lands for fear of negatively affecting forest structure and composition (Jackson 1993, Cohen et al. 2008), a trend likely to increase with shrinking mean ownership size, shortened land tenure, and an urbanizing ownership base (Mehmood and Zhang 2001). When forests are harvested, they are often lightly cut, that is, scattered mature individuals are removed throughout a stand while canopy continuity is maintained. Silvicultural treatments to encourage long-term oak sustainability are not commonly undertaken. Consequently, increased abundance of shade-tolerant mesophytic species in many oak forests within the region threatens the perpetuation of this forest type (Fralish and McArdle 2009) and potentially reduces the wildlife habitat and species diversity this forest type provides (McShea et al. 2007).

This report evaluates the consequences of two management regimes common in forests of the lower Midwest, light harvesting and no cutting. Using long-term forest inventory plots in an oak-dominated forest in the Ozark Hills of southern Illinois, we analyzed the changes in forest composition and structure for these management regimes over a 20-year period.

Methods

This study was conducted in Trail of Tears State Forest (TTSF), a 5,200-ac forested area located in the Ozark Hills region of Union County, Illinois (Schwegman 1973). Mean annual temperature is 56°F, and mean annual precipitation is 46 in. This study focused on the oak-dominated forest type within TTSF associated with moderate to steep side slopes (15–44%) and southeast to southwest facing aspects. Soils present in these areas are primarily well-drained, loess-derived, Menfro silt loams and somewhat excessively drained, colluviums over cherty residuum-derived, Clarksville gravelly silt loams (Natural Resources Conservation Service 2008).

TTSF was purchased by the Illinois Department of Conservation in 1929. Before it was purchased, the area was owned by multiple entities and was subject to timber harvesting, fire, and grazing (Ozier et al. 2006). It was during this time that most of the overstory oak species trees were established (van de Gevel 2002). Shortly after purchase, the state initiated a fire suppression policy that subsequently encouraged the development of fire-intolerant species (van de Gevel 2002). Timber harvesting, however, still occurred until 1989. From 1950 to 1989, nearly 2.5 million board feet (International ¼-inch) of timber was removed, primarily with light harvesting of mature stems (without accompanying understory or midstory control).

In 1980, 238 permanent circular one-fifth-ac plots were established at the intersection of a 924 $\times$ 924 ft grid system across TTSF. Plots were resampled in 2000. Compartments of TTSF that were lightly harvested from 1980 to 1989 were selected for data analysis of harvested stands. Partial cutting removed approximately 5 trees ac^{-1} and 1,600 board feet ac^{-1} (International ¼-inch) from these compartments. Ten plots fell within the oak-dominated forest type of lightly harvested compartments, and all 10 of these were analyzed for changes in species composition and structure over the 20-year period. In addition, 10 plots were randomly selected in oak-dominated stands within adjacent compartments that had not been harvested since 1929 (uncut) to analyze changes in species composition and structure over the same time period in uncut areas. The dbh of all overstory stems ($\geq$3 in. dbh) was recorded by species on all plots.

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Table 1. Basal area (mean; values in parentheses are SE) of select overstory species (≥3 in. dbh) and combined total of all species on uncut and lightly harvested plots for the 1980–2000 sampling period.

Species	Uncut			Lightly harvested		
	Basal area			Basal area		
	1980	2000	*P* value	1980	2000	*P* value
	.... (ft^2 ac^{-1})			.... (ft^2 ac^{-1})		
Red maple	0.6 (0.3)	0.3 (0.2)	0.37	0.9 (0.6)	1.3 (1.2)	0.57
Sugar maple	0.0 (0.3)	4.5 (1.4)	0.01	1.1 (0.4)	4.4 (1.5)	0.04
Hickory spp.	7.9 (2.2)	7.3 (2.0)	0.82	7.7 (2.3)	5.0 (1.7)	0.37
Flowering dogwood	1.0 (0.6)	1.0 (0.3)	0.92	1.3 (0.3)	1.8 (0.6)	0.26
American beech	0.3 (0.2)	1.6 (0.7)	0.03	3.6 (3.3)	3.4 (1.6)	0.90
Ash spp.	0.6 (0.2)	1.7 (0.7)	0.18	3.4 (1.4)	2.7 (1.0)	0.48
Yellow-poplar	0.7 (0.7)	1.4 (1.3)	0.28	2.4 (2.4)	2.6 (0.2)	0.91
Cucumber magnolia	0.2 (0.2)	0.0 (0.0)	0.34	0.2 (0.1)	0.3 (0.3)	0.51
Blackgum	0.3 (0.2)	2.9 (2.0)	0.25	0.7 (0.3)	0.8 (0.3)	0.80
Ironwood	0.2 (0.1)	0.3 (0.1)	0.62	0.6 (0.3)	0.4 (0.1)	0.46
White oak	26.5 (4.4)	38.5 (5.9)	0.01	38.3 (5.8)	49.9 (9.2)	0.04
Northern red oak	9.5 (3.3)	12.5 (4.4)	0.57	11.4 (3.1)	5.9 (3.0)	0.17
Black oak	37.9 (8.3)	29.0 (8.5)	0.22	30.1 (8.5)	16.4 (7.7)	0.12
Sassafras	0.7 (0.3)	1.0 (0.3)	0.29	2.0 (0.7)	1.4 (0.5)	0.28
Elm spp.	0.0 (0.0)	0.1 (0.1)	0.34	0.4 (0.3)	0.4 (0.3)	0.84
Total	97.0 (8.7)	102.1 (8.3)	0.32	106.0 (7.4)	99.6 (7.8)	0.35

Table 2. Stem density (mean; values in parentheses are SE) of select overstory (≥3 in. dbh) species and combined total of all species on uncut and lightly harvested plots for the 1980–2000 sampling period.

Species	Uncut			Lightly harvested		
	Stem density			Stem density		
	1980	2000	*P* value	1980	2000	*P* value
	......(stems ac^{-1})			.......(stems ac^{-1}).......		
Red maple	6 (2)	2 (1)	0.17	4 (3)	4 (2)	1.00
Sugar maple	8 (3)	36 (11)	0.01	10 (4)	27 (8)	0.02
Hickory spp.	30 (7)	29 (9)	0.94	14 (3)	12 (4)	0.76
Flowering dogwood	12 (7)	14 (4)	0.73	14 (4)	21 (4)	0.29
American beech	2 (1)	12 (3)	0.01	6 (3)	18 (4)	0.01
Ash spp.	5 (2)	6 (1)	0.76	11 (3)	10 (3)	0.62
Yellow-poplar	1 (1)	1 (1)	0.34	1 (1)	6 (2)	0.09
Cucumber magnolia	1 (1)	0 (0)	0.34	2 (1)	2 (1)	1.00
Blackgum	4 (2)	8 (3)	0.15	4 (2)	8 (2)	0.24
Ironwood	2 (2)	4 (2)	0.52	4 (2)	5 (1)	0.51
White oak	71 (10)	63 (7)	0.19	108 (19)	68 (15)	0.01
Northern red oak	15 (3)	11 (4)	0.28	13 (3)	4 (2)	0.01
Black oak	38 (11)	19 (6)	0.02	20 (5)	8 (4)	0.01
Sassafras	8 (3)	8 (2)	0.68	16 (4)	8 (2)	0.06
Elm spp.	0 (0)	1 (1)	0.34	2 (1)	2 (1)	0.73
Total	202 (14)	213 (8)	0.58	228 (14)	204 (15)	0.12

Carya, *Fraxinus*, and *Ulmus* species were combined into hickory, ash, and elm groups, respectively. Stem density and basal area were calculated for all species for the 1980 and 2000 inventories. Stem density was separated by diameter class for select species for the 1980 and 2000 inventories. Paired *t*-tests were used to detect change over the 20-year sampling period within each management regime.

Results

Overall, there was no significant difference between total overstory basal area between 1980 and 2000 in uncut plots ($P = 0.32$) and lightly harvested plots ($P = 0.35$; Table 1). In both uncut and lightly harvested plots in 1980 and 2000, oak species, primarily white oak (*Quercus alba* L.) and black oak (*Quercus velutina* Lam.), made up the majority (73–79%) of total basal area. Between 1980 and 2000, white oak increased in basal area on uncut and lightly harvested plots ($P < 0.01$ and $P = 0.04$, respectively) but was the only oak species to show a significant change (Table 1). Hickory species made up the next largest species group, ranging from 5 to 8% of total basal area. There was no significant change in hickory species basal area between 1980 and 2000 for both management regimes. All other species occupied less than 5% of the total basal area for both management regimes, but two of those species showed significant increases in basal area between 1980 and 2000. Sugar maple (*Acer saccharum* Marsh.) increased 400% on uncut plots and 300% on lightly harvested plots, whereas American beech (*Fagus grandifolia* Ehrh.) increased 430% on uncut plots (Table 1).

Overstory stem density was similar between 1980 and 2000 on uncut plots ($P = 0.58$) and lightly harvested plots ($P = 0.12$; Table 2). In 1980 and 2000 for both management regimes, white oak was the most common overstory tree (Table 2), although the species did decrease in density between 1980 and 2000 on lightly harvested plots ($P < 0.01$). Northern red oak (*Quercus rubra* L.) stem density decreased by 70% on lightly harvested plots. Black oak, the second most abundant species in 1980 for both management regimes, decreased in density by 50% on uncut plots and 60% lightly harvested

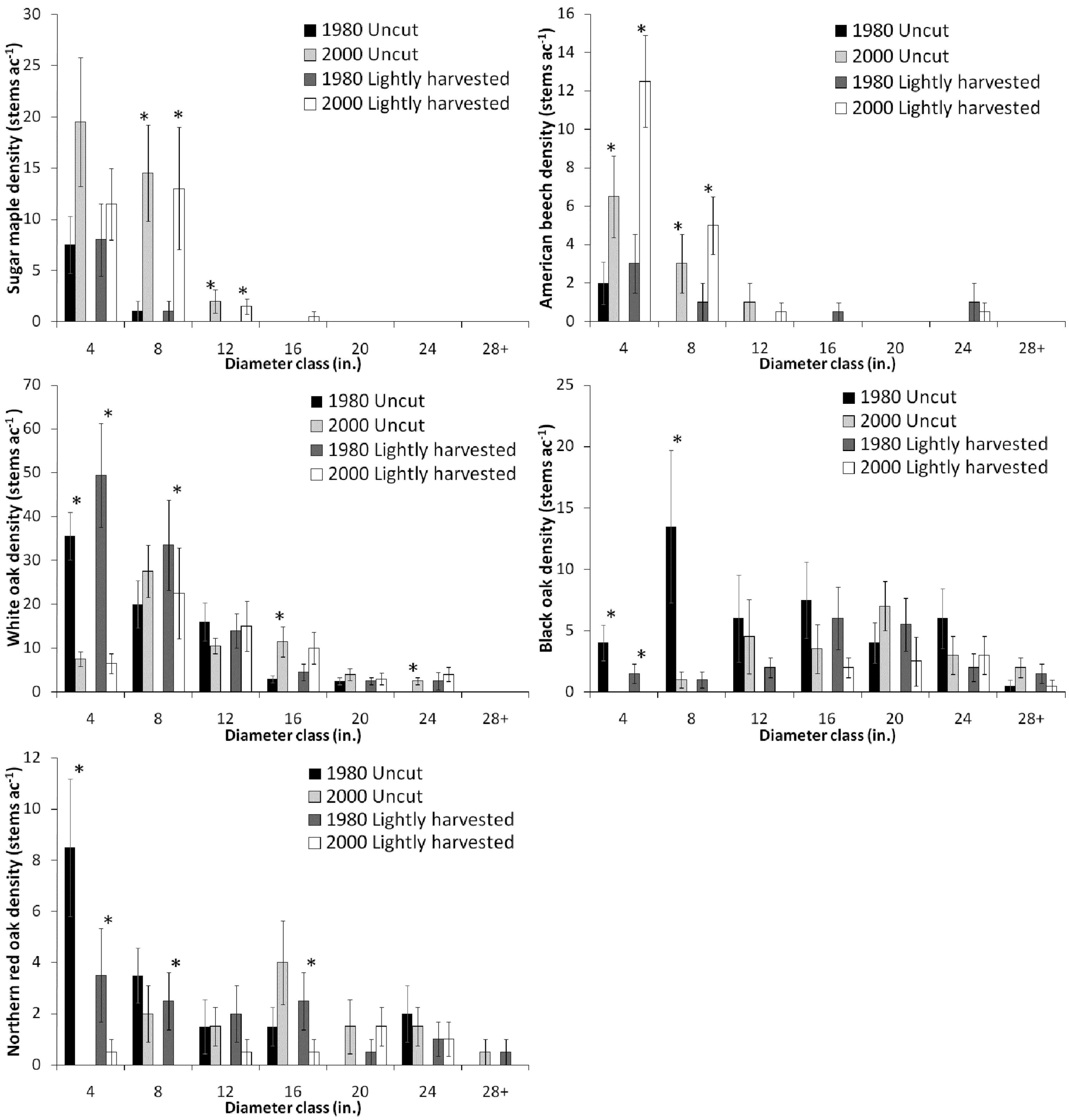

Figure 1. Diameter distributions of select species on uncut and lightly harvested plots within Trail of Tears State Forest sampled in 1980 and 2000. Comparisons of the 20-year sampling period were made separately for each diameter class for both management regimes (*$P < 0.05$).

plots. Hickory species density (6–15% of total stem density) remained the same for both management regimes ($P \geq 0.76$). Sugar maple made up 4% of stem density in 1980 for both management regimes. After 20 years, however, it made up 17% of stem density on uncut plots and 13% of stem density on lightly harvested plots, making it the second most abundant species for both management regimes. Similar results were observed for American beech for both management regimes (Table 2).

Significant losses of stems were observed in the 4-in. diameter class for white oak, black oak, and northern red oak for both management regimes over the 20-year sampling period (Figure 1). No significant losses were observed for the same species over the sampling period in the larger diameter classes (>20 in.) for either management regime (Figure 1). Most of the sugar maple and American beech stem density occurred in the smallest diameter classes (4 and 8 in.), and some significant increases in stem density occurred over the 20-year period in uncut and lightly harvested plots (Figure 1).

Discussion

The increase of white oak basal area and loss of black oak density over the sampling period suggests that both management regimes had variable affects on the oak resource. Most of the overstory oak trees in the study area were established in the 1850s and 1930s, and the forest conditions of the study area could be classified as approaching late successional conditions (van de Gevel 2002, Fralish and McArdle 2009). Although some researchers have reported the widespread reduction of white oak across its range (Abrams 2003), here this species appears to continue its overstory dominance, while mesophytic species continue to overwhelm midstory strata. Perhaps more striking is the virtual loss of black oak and northern red oak in these stands, most likely explained by the maturation of these shorter-lived oak species (Ozier et al. 2006), which has been observed in other oak-dominated forests in the Central Hardwood forest region as well (Zaczek et al. 2002, Fralish and McArdle 2009).

Even more important to long-term maintenance of the oak resource was the loss of oak density in the 4-in. diameter class and the absence of any oak stems <3 in. dbh in both uncut and lightly harvested plots (Ozier et al. 2006). These losses cannot be attributed to recruitment in larger diameter classes (Figure 1). The near total removal of surface fires from these uplands has reduced the competitive position of most oak species and is now recognized as the principal factor in the combined loss of critical wildlife habitat and mast resources, reduced understory herbaceous cover, and the progressive succession of these oak forests toward mixed mesophytic dominated forests (Ruffner and Groninger 2006, Nowacki and Abrams 2008). In addition to the loss of oak species, there was a corresponding increase in sugar maple and American beech stem density between 1980 and 2000. Similar increases in the dominance of shade-tolerant, mesophytic species following an absence of disturbance in mature oak forests are consistent with other studies in the Central Hardwood region, which have also reported low (<50 stems ac^{-1}) levels of oak saplings in undisturbed areas (Goebel and Hix 1996, Rentch et al. 2003). Because of the increased composition of mesophytic foliage in potential fuelbeds across these forests there is some concern regarding their flammability and long-term viability for prescribed burning (Abrams 2005). Our experience, however, suggests that with one or two prescribed fires, oak forest fuelbeds become more conducive to carrying surface fires (Ruffner and Groninger 2006).

Regardless of the management regime (light harvesting or no cutting), silvicultural activities are needed to encourage oak regeneration to sustain oak development (Albrecht and McCarthy 2006, Ruffner and Groninger 2006, Iverson et al. 2008). For example, Iverson et al. (2008) reported that thinning and repeated fires increased oak and hickory regeneration in oak forests by 32% over a 6-year period in the Central Hardwood region. Oak species respond favorably to increased light availability following midstory removal (Dillaway et al. 2007, Lhotka and Loewenstein 2008), but further canopy disturbance may be needed to allow these individuals to reach canopy status.

The short- and long-term viability of both management regimes is questionable where sustaining oak ecosystems is a priority, and we do not endorse the use of either regime for this purpose. Specifically, the decline of small oak and the increase of mesophytes observed here suggests that midstory control and other silvicultural practices will become more drastic and perhaps more time-consuming to begin the oak regeneration process and then maintain their competitive position. Furthermore, caution should be taken to ensure that the opportunities are not lost to regenerate some of the shorter lived oak species. Delaying regeneration practices could cause remaining overstory individuals to exceed the ages where they can contribute reproductively. Inadvertently selecting these individuals through continued light cutting would only exacerbate this process.

However, for landowners or agencies presently considering only the two options studied here, we suggest that revenues generated from light harvesting could be invested in subsequent silvicultural treatments needed to encourage oak regeneration. No cutting results in similar stand development patterns but with no opportunity to offset increasingly costly investments in the silvicultural measures needed to sustain the oak resource. In situations where landowners and stakeholders are unwilling to consider other management options known to effectively regenerate oak species, light harvesting should be further evaluated, both economically and ecologically, as a possible precursor to or component of a silvicultural system to sustain oak.

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