Two decades of change in the composition and structure of old-growth forests in the Central Hardwood Region

Christy A. Lowney[1], Michael A. Jenkins[1], Marty A. Spetich[2], Stephen R. Shifley[3], Bradley D. Graham[1], and Christopher E. Zellers[1]

[1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN
[2]Southern Research Station, USDA Forest Service, Hot Springs, AR
[3]Northern Research Station, USDA Forest Service, Columbia, MO

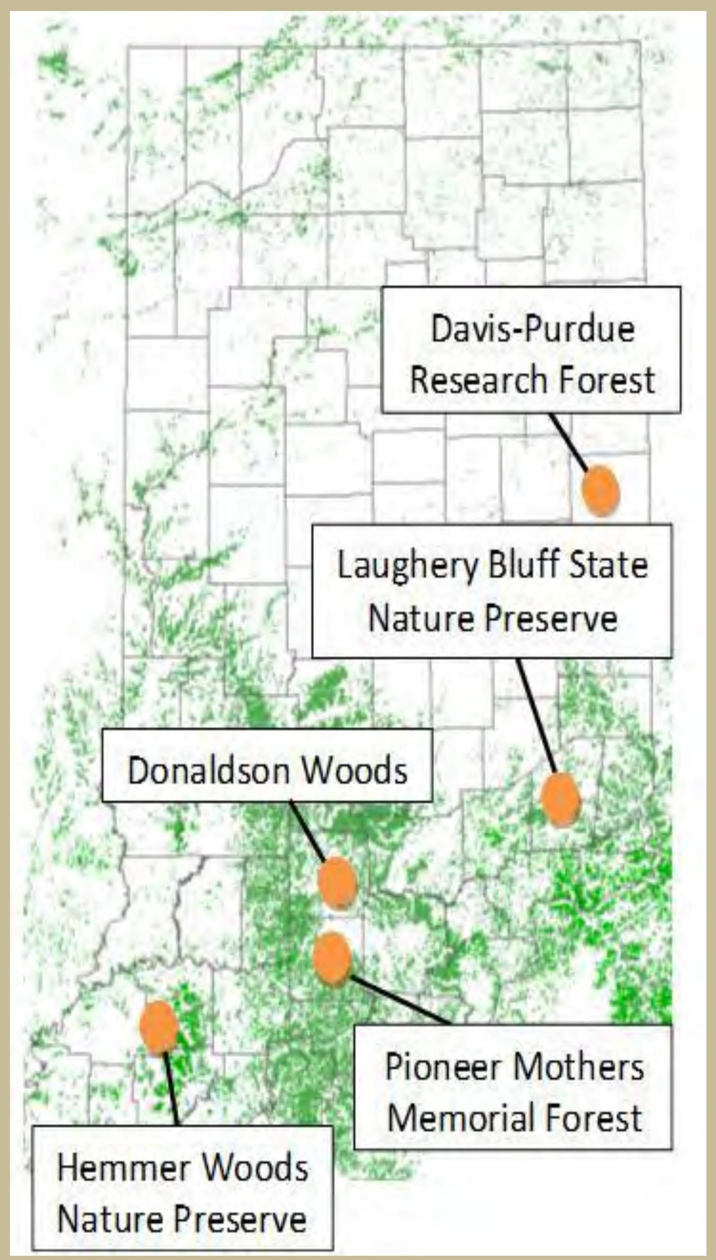

Figure 1. Location of old-growth study sites in Indiana.

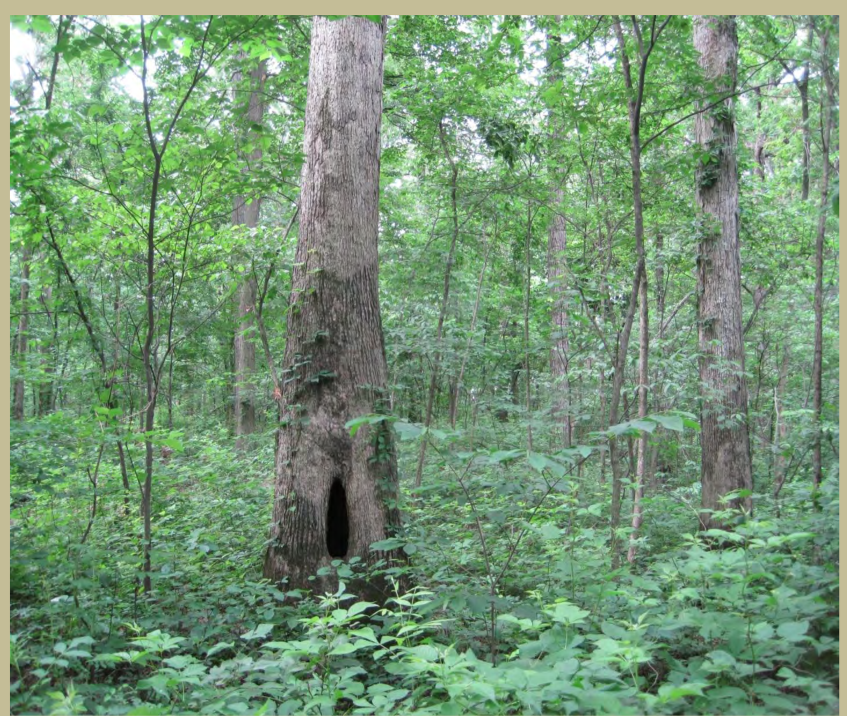

Figure 2. Cavity tree in Hemmer Woods Nature Preserve.

Figure 3. Broadhead skink utilizing coarse woody debris in Hemmer Woods Nature Preserve.

Introduction

Over a century of forest clearing has resulted in highly fragmented landscapes throughout the Central Hardwood Region (CHR). Within these landscapes, old-growth forests typically occur as small scattered remnants. Forests across the CHR have experienced a compositional shift from shade-intolerant, fire-dependent species, such as oak (*Quercus* spp.), to shade-tolerant, fire-intolerant species, such as maple (*Acer* spp.). To gain a better understanding of the changes taking place in old-growth forests of the CHR, permanent research plots were installed by Purdue University and Forest Service researchers in eleven forests across four states (Indiana, Illinois, Iowa, and Missouri) between 1992 and 1994. During the summer of 2011, we resampled the five old-growth forests located in Indiana (Figure 1), as well as one forest in Illinois. Repeated sampling of these sites over the coming decades will allow us to examine the long-term dynamics in old-growth forests. This will improve our understanding of the changes in composition and structure taking place, while providing insight into how these changes may affect desired forest conditions and valuable ecosystem services (Figures 2, 3, and 4).

Figure 4. Canopy gap created by a snag in Donaldson Woods.

Methods

At each study site, we sampled 0.1 ha circular plots (n=30). In each plot, we recorded the dbh (1.3-m above ground level) and species of trees ≥10 cm dbh.

Using these data we calculated:

- Overstory mortality (%) of the trees originally sampled in 1992-93
- Density (trees/ha) and basal area (BA, m^2/ha) of the overstory trees in 1992-93 and 2011

We used a mixed-model ANOVA with time (sample year) as a fixed effect and site as a random effect to examine changes in the density and BA of overstory oaks and maples between 1992-93 and 2011 across Indiana, weighting to correct for unequal variance as needed.

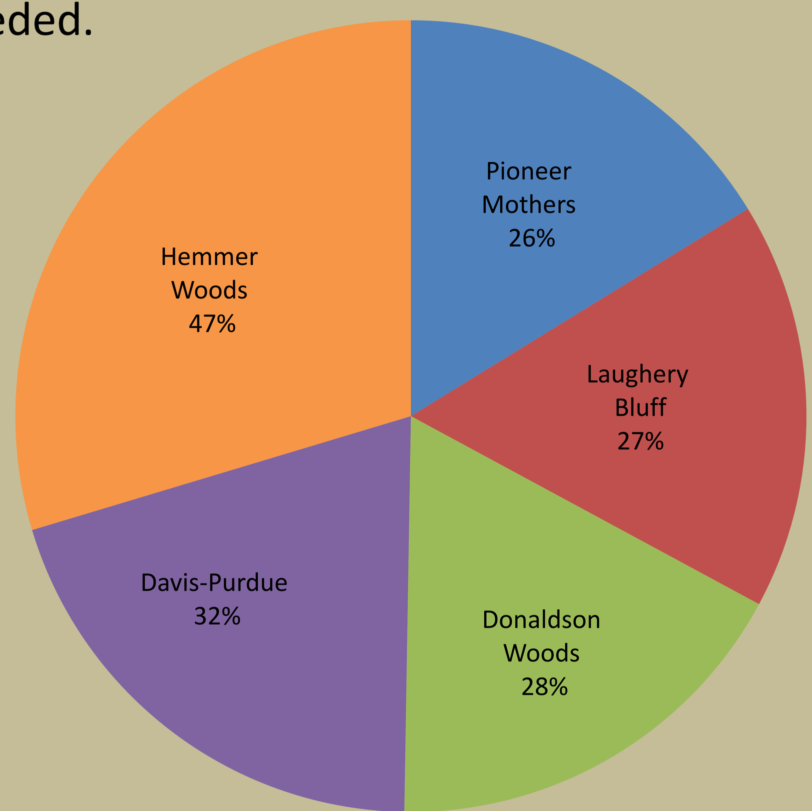

Figure 5. Overstory (>10 cm dbh) mortality of all species between 1992-93 and 2011 of cohort sampled in 1992-93 in five Indiana old-growth forests.

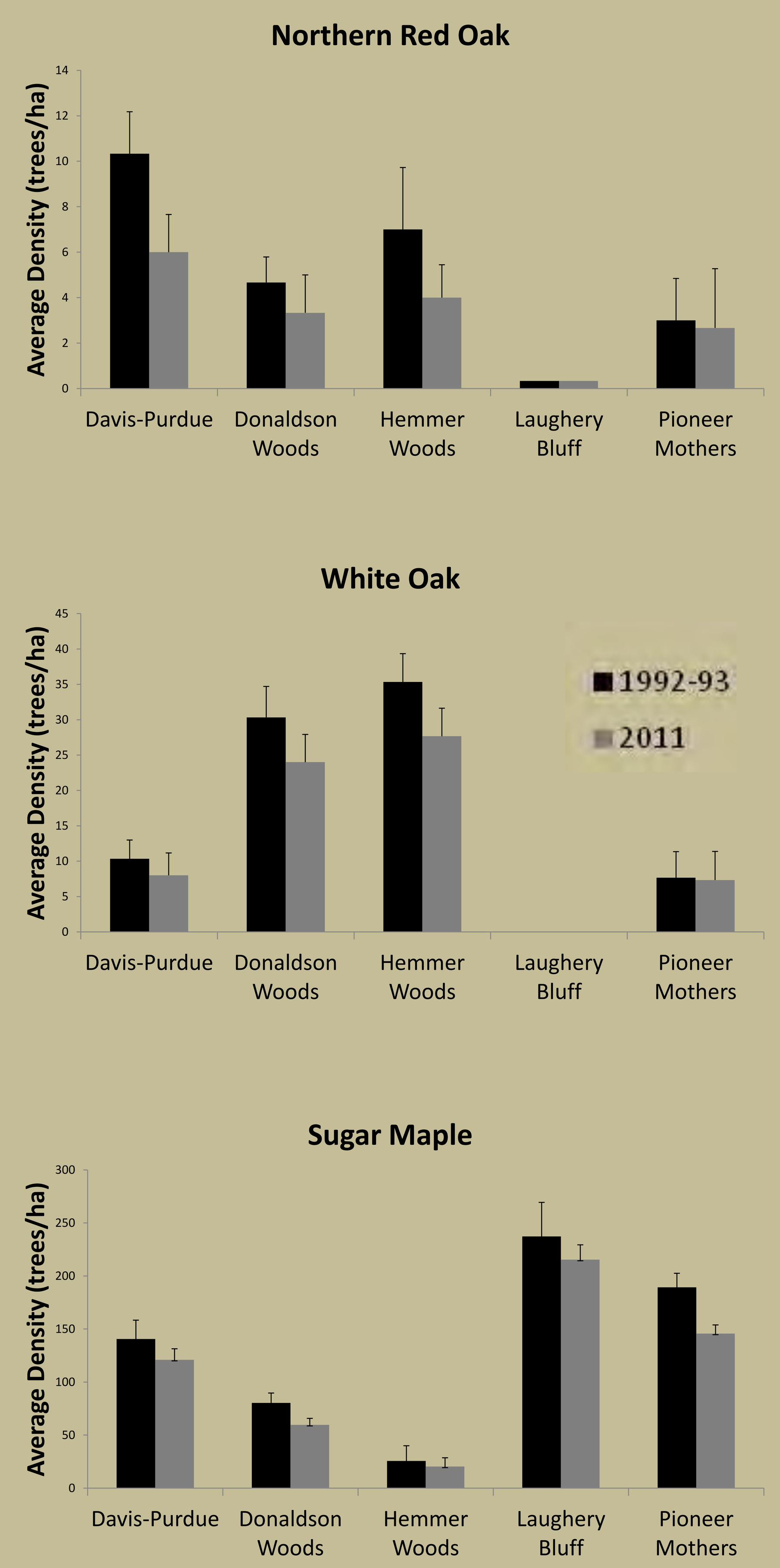

Figure 6. Average overstory (>10 cm dbh) density (tree/ha) of northern red oak *(Q. rubra)*, white oak *(Q. alba)*, and sugar maple *(A. saccharum)* in 1992-93 and 2011 in five Indiana old-growth forests.

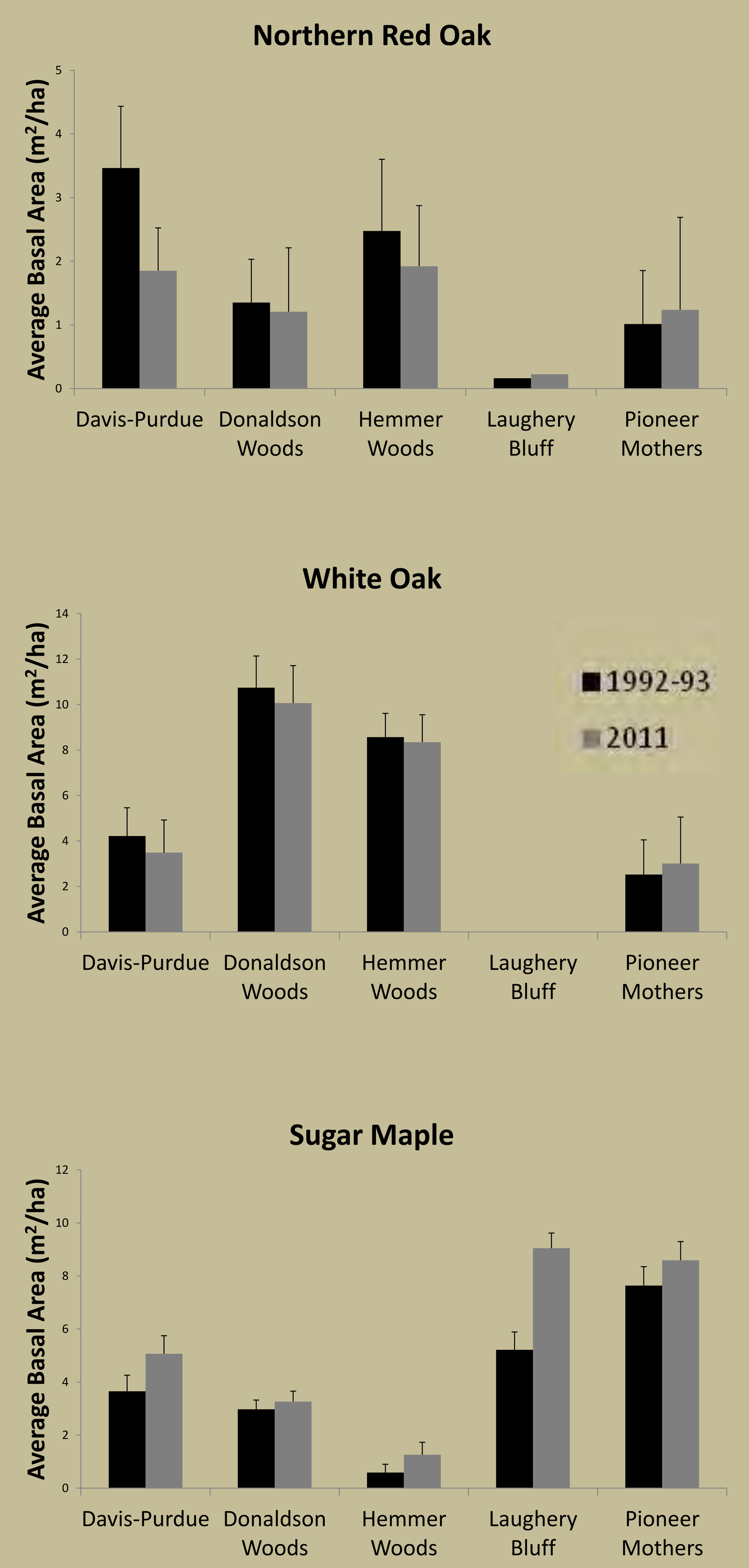

Figure 7. Average overstory (>10 cm dbh) basal area (m^2/ha) of northern red oak *(Q. rubra)*, white oak *(Q. alba)*, and sugar maple *(A. saccharum)* in 1992-93 and 2011 in five Indiana old-growth forests.

Results

- Our results show that many of the overstory trees present on our plots in 1992-93 were dead during our 2011 resurvey. Hemmer Woods Nature Preserve experienced the greatest mortality across all species of this cohort of trees (47%) while Pioneer Mothers Memorial Forest had the lowest overstory mortality (26%; Figure 5).
- The density (trees/ha) of northern red oak, white oak, and sugar maple decreased significantly between 1992-93 and 2011 with both time and site as contributing factors, though site was the overwhelming factor contributing to this decrease in density for all three species (Figure 6).
- The BA (m^2/ha) of northern red oak and white oak did not experience a significant change between 1992-93 and 2011 (Figure 7). The BA of sugar maple increased significantly between 1992-93 and 2011, with both time and site being significant factors, though site was the overwhelming factor contributing to this increase in sugar maple BA (Figure 7).

Figure 8. Multi-cohort stand in Pioneer Mothers Memorial Forest.

Conclusion

Our results indicate that the high rates of mortality we observed in old-growth forests in Indiana have resulted in a decrease in overstory density. Despite this decrease in overstory density, sugar maple displayed a significant increase in overstory BA throughout the old-growth forests we sampled. This indicates that late-successional, shade-tolerant species such as sugar maple have increased in diameter following mortality of the original cohort, leading to a shift in forest composition towards shade-tolerant self-replacing species (Figure 8).