



Delayed Tree Mortality After Prescribed Fires in Mixed Oak Forests in Northwestern Ohio

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In this study, authors assessed delayed mortality of multiple tree species after a single prescribed fire at the Oak Openings Preserve, located in northwestern Ohio, USA. Fire is commonly used to selectively reduce fire-sensitive tree species and size classes. However, lack of understanding of delayed mortality (e.g., >2 growing seasons post-fire) limits land managers' ability to predict prescribed fire outcomes. The fates of trees in burned and unburned oak forests were tracked for 3-4 growing seasons after fire, and tree survival was modeled using tree diameter and bole char variables. Tree species tracked in the study were red maple, white oak, black oak, and sassafras.

Three burned sites (17-46 acres in size) were studied: two mature oak forests (black and white oak trees 80-200+ yrs old), and a third site was a young oak

MANAGEMENT IMPLICATIONS

- Delayed non-oak tree mortality following a prescribed fire can be significant, and may not be evident until 3-4 growing seasons post-fire.
- Change point values of 6 and 5 inches DBH were identified for red maple and sassafras trees for expected survival or canopy death from low-severity fire.
- Prescribed fire efforts aiming to maintain open oak forests should prioritize sites in which non-oak invading trees are smaller than these size thresholds.

forest (~10-20 yrs old). Both mature forest study sites had pre-burn basal areas of 113 ft²/acre (trees ≥ 0.4 inches at diameter at breast height (DBH)), with overstories dominated by black and white oak, and understories consisting mostly of red maple and sassafras. The young forest had a basal area of 17.4 ft²/acre. No fire is known to

have occurred at these sites for at least the prior 70 years.

All three sites were burned in late April. Ignition patterns included backing, flanking, and head fires, and fuels consisted primarily of leaves, sedge, tree seedlings, and blueberry and huckleberry shrubs. Fire behavior was described as low-severity surface fire (i.e., most flame lengths ≤ 6 ft and rates of spread of ~6-9 ft/minute), a common type of prescribed fire behavior in eastern US deciduous forests.

Sites were inventoried twice during summer months corresponding to periods 1-2 (initial mortality) and 3-4 growing seasons (delayed mortality) post-fire. The fates of all individual trees (≥ 0.4 inches DBH) were assessed and tracked in plots located within burned sites, and DBH, tree status (live canopy, dead canopy but resprouting, and dead with no resprouting), maximum char height, and percentage of bole charred were recorded for all trees during each inventory. Unburned sites in nearby mature and young oak forests were inventoried in the same manner as those in burned forests to identify background mortality of unburned trees.

Statistical analyses assessed changes in tree status using categorical data analysis,



Significantly higher levels of red maple mortality were observed 3-4 growing seasons after a single low-severity prescribed fire compared to 1-2 years post-fire. (Photo: Scott Abella)

Delayed Tree Mortality After Prescribed Fires

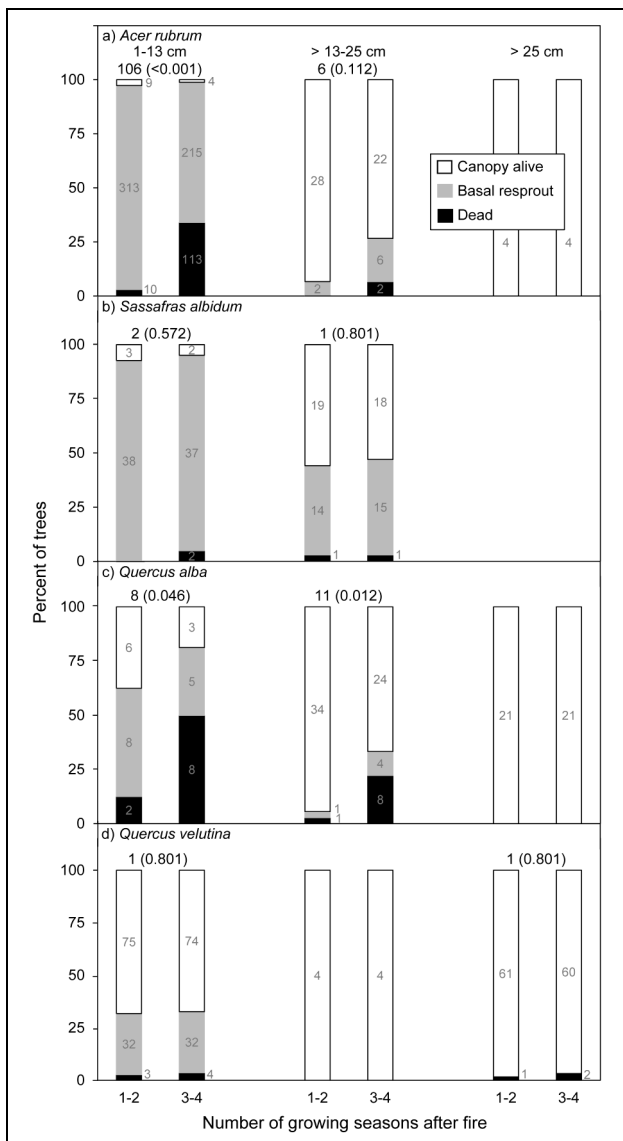


Fig. 1. Change in status of trees on burned sites between 1–2 and 3–4 growing seasons after prescribed fires in oak forests, Oak Openings region, Ohio. Trees are divided by species, diameter (saplings, 1–13 cm (0.4–5.1 in.) in diameter at 1.4 m (4.6 ft); poles, >13–25 cm (>5.1–9.8 in.); and overstory, >25 cm (>9.8 in.)), and status including live canopy, dead canopy but resprouting around the trunk base, or completely dead. Statistics at the top of bars show McNemar-Bowker tests of symmetry for repeated measures (*S*-statistic with *P*-values in parentheses) and compare proportions among status categories between 2018 and 2020 (no statistics are given if <15 trees occurred or if there was no variation between years). No sassafras (*Sassafras albidum*) trees >25 cm (>9.8 in.) in diameter were present. Numbers on or adjacent to bars are numbers of trees by status category.

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postfire canopy survival as a function of predictor variables (DBH, species, char height, percentage of bole charred), and potential changepoints in predictor variables at which postfire survival of tree canopies shifted between live and dead. Trees were categorized by DBH as saplings (0.4–5.1 inches), poles (>5.1–9.8 inches), and overstory (>9.8 inches).

Postfire delayed mortality varied by species and tree size. A significant difference was detected between initial (1–2 growing seasons post fire) and delayed (3–4 growing seasons) effects on red maple saplings and white oak saplings and pole trees. The percentage of red maple saplings top-killed and with no resprouts increased 11-fold (from 3% to 34%) between initial and delayed mortality measurements. Thirty percent of red maple trees < 9.8 inches DBH which had initially retained live canopies had died by 3–4 growing seasons post fire. Also by then, only 8% of inventoried red maple trees had live canopies. Though many sassafras and black oak saplings were top-killed initially, no significant delayed mortality was detected. White oak saplings and poles experienced four- and eight-times increased mortality respectively, after 3–4 growing seasons compared to 1–2 growing seasons, while neither oak species had significant mortality in overstory trees.

Background mortality measured in unburned sites was low for all species and size classes, e.g., less than 1% of any species died between measurements.

Models showed that DBH was related to canopy survival for all species, and that bole char variables were important for all except red maple. Changepoints in DBH and bole charring on canopy survival were identified, including that only 1.5% of red maple trees < 6 inches DBH retained live canopies, all

sassafras < 5 inches DBH experienced canopy death, 97% of black oaks > 1 inch retained live canopies, and 93% of black oaks 0.4 to 1.0 inches DBH retained live canopies when ≤ 15% of the bole was charred. The importance of DBH in survival agrees with existing understanding regarding tree size and fire protection related to bark thickness. Authors suggest that the lack of association between bole char variables and canopy death in red maple trees may indicate that small amounts of bole damage can result in canopy mortality, and that physical features of red maple may reduce susceptibility to charring though still experiencing heat damage.

Contrary to previous research, this study shows that single fires can significantly reduce red maple sapling density through delayed mortality. Previous studies have found single fires to maintain or increase red maple density, but in this study, one-third of all red maple saplings completely died (top-killed + no basal sprouts), suggesting that mortality rates may be significantly higher when accounting for delayed mortality. The authors suggest this could be related to the shaded conditions which persisted post-fire (i.e., no overstory oak trees were top-killed), as red maples have been shown to suffer from compromised resource acquisition or carbon reserve depletion when top-killed in shaded conditions (see [Reich et al. 1990](#) for more information).

FOR FURTHER READING

[Reich, P.B., M.D. Abrams, D.S. Ellsworth, E.L. Kruger, and T.J. Tabone. 1990. Fire affects ecophysiology and community dynamics of central Wisconsin oak forest regeneration. *Ecology* 71:2179–2190.](#)

