RESEARCH BRIEF

Structure and composition of an oak-hickory forest after over 60 years of repeated prescribed burning in Missouri, U.S.A

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MANAGEMENT IMPLICATIONS

- Long-term, repeated prescribed burning created conditions that approximate woodlands.
- Lack of recruitment from saplings to overstory suggests that periods without fire may be necessary for replacing overstory trees.
- Repeated prescribed burning led to increased herbaceous plant abundance in the understory.

The longest-running study to date of repeated prescribed burns in an oak - hickory forest produced results consistent with past studies, giving land managers additional evidence that controlled fires can create woodland conditions and increase richness and diversity in understory flora.

At the inception of this research in 1949, the study area was described as an upland flatwoods oak-hickory stand of all ages. It was moderately well-stocked and dominated by post oak (*Quercus stellata*), scarlet oak (*Q. coccinea)*, black oak (*Q. velutina)*, southern red oak (*Q. falcata)*, and hickories (*Carya* spp.). No burning or grazing had taken place for one to two decades prior to 1949, but extensive timber extraction occurred throughout the region in the decades surrounding 1900, so the study area was likely to have been selectively cut around that time.

Study plots were subjected to one of three treatments for more than 60 years: no burning, annual burning, or periodic burning every four years. All burns were conducted between the months of March and May at the University Forest Conservation Area in Butler County in southeast Missouri, in the Ozark Highlands.

Over the years, data from this long-term experiment have been used in other studies. Objectives for the current research were to describe, for all three treatments: the overall forest structure and composition; regeneration and recruitment patterns for tree species; and the composition of plant communities in the understory. Of particular interest was the impact of long-term, repeated prescribed burning on oak regeneration and recruitment into the forest canopy.

After six decades, the unburned areas had more trees and less plant diversity than burned areas. Annually burned plots had high species diversity and abundant ground flora but no tree seedlings more than a year old. Periodic plots also contained diverse and abundant ground flora plus ample tree seedlings, but those seedlings did not recruit into the canopy.

In 2013, post oaks dominated the **canopy** in burned plots. But for all three treatments, no significant differences were observed in tree diameter, tree height, the number of red oaks, the number of white oaks, and the total number of trees. Trees with large diameters were mostly red oaks in all three treatments. However, some canopy differences were apparent. Total basal area and the number of hickories were greater in control plots. In the periodic plots, overstory density was reduced and its composition shifted from a mixture of white and red oak species plus hickories to mostly white oak species. Canopy conditions were relatively open in

Long-term annual burning (left foreground) and periodic burning (right foreground) affected forest structure and composition. No burn treatment is in the background. Note the dense herbaceous layer in the annual treatment versus the greater number of tree seedlings in the periodic treatment. Photo: Ben Knapp

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60 years of prescribed burning in an oak-hickory forest

burned plots compared to the control plots. In contrast, studies running fewer than 10 years have generally shown little mortality in canopy trees resulting from prescribed burning.

Midstory vegetation was markedly different between treatment types. The control plots supported far more large saplings than the two burned treatments. Species associated with mesic conditions were missing from the burned plots, but present in the sapling layer of the control plots, including flowering dogwood (*Cornus florida*), black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), and slippery elm (*Ulmus rubra*).

Repeated burning eventually eliminated all trees smaller than 11 cm in diameter at breast height (DBH) in the annual plots, and burning at four-year intervals eliminated all woody stems greater than 4 cm DBH and less than 16 cm DBH in the periodic plots. Thus, in burned areas the midstory lacked available saplings to be recruited into the canopy.

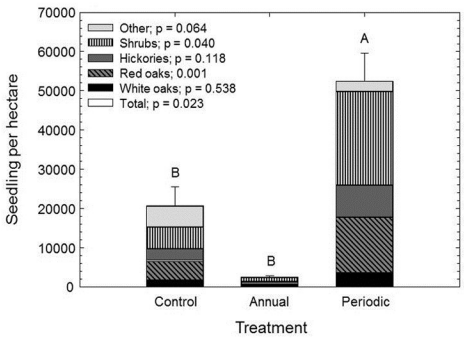
In the **understory**, results in the herbaceous layer were consistent with other studies in that burning increased the abundance, diversity, and richness of herbaceous plants. Diversity was greater across all species in burned plots than in control plots, with total species richness two to three times greater. Forbs made up the majority of understory plants on both types of burn plots, dominating cover, biomass, and richness. Graminoids made up only a small component of the understory on burn plots. Understory biomass was mostly herbaceous on annual plots, was mixed in the periodic plots, but on the control plots biomass was mostly woody, with virtually no herbaceous plants.

Woody **regeneration** in the understory on periodic plots consisted primarily of red oaks, hickories, and winged sumac (*Rhus copallinum*). The periodic treatment produced the greatest total woody seedling densities, and the greatest red oak seedling density, at 14,250 seedlings per hectare. Red oak seedling density was lowest in the annual plots, at 500 per hectare. Small hickories and black oak showed higher levels of tolerance for fire than other regenerating species.

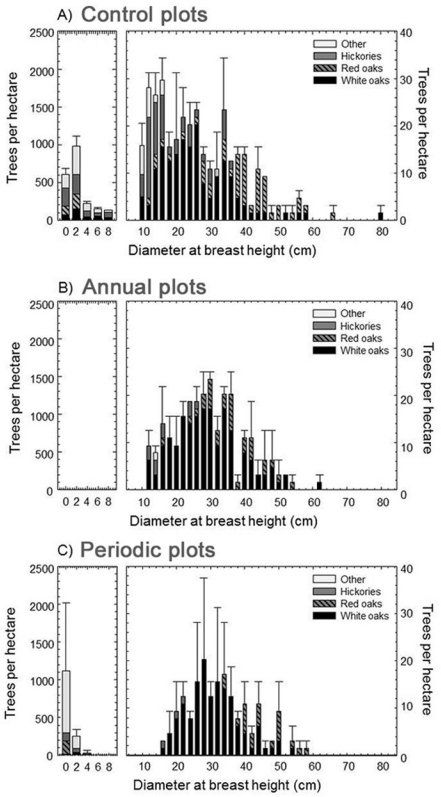
In summary, this study supports prior findings, showing that long-term, repeated prescribed fire can be used as a management tool to promote woodland conditions. Such woodlands include an open canopy and an understory plant community with an increase in richness, diversity, abundance, and evenness as compared to areas that are not burned.

While results suggest that over time burning alone can reduce canopy cover and create woodland conditions, managers may want to consider mechanical removal of stems to reach specific canopy density targets, particularly if management goals include encouraging the growth of certain herbaceous understory species.

Importantly, a desirable long-term woodland community structure is not possible without periodic replacement of overstory trees. The study demonstrates that annual burning and periodic, four-year burning will suppress recruitment into the canopy by top-killing seedlings and saplings. Therefore, the study underlines the importance of an occasional extended interval between fires to allow for tree recruitment into the overstory. Variation in fire frequency may be the best way to balance management objectives of oak-hickory woodlands.



Seedlings per hectare (mean and one standard error) by species group and study treatment. The p-values are levels of significance from the ANOVA tests for treatment effects for each group, and the same letters on bars indicate no significant difference among pair-wise comparisons.



Diameter distributions (mean and one standard error) by species group for each treatment in 2013. Note that the scale differs between the left and right y-axes. The left axis represents saplings and the right axis depicts the overstory.

FOR FURTHER READING

Brose, P.H., Dey, D.C., Phillips, R.J., Waldrop, T.A., 2013. A meta-analysis of the fire-oak hypothesis: does prescribed burning promote oak reproduction in eastern North America? Forest Science 59:322–334.

Huddle, J.A., Pallardy, S.G., 1996. Effects of long-term annual and periodic burning on tree survival and growth in a Missouri Ozark oak-hickory forest. Forest Ecology and Management 82:1–9.

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