Synthesizing the history of fire and oak development in the Appalachian Region

Adam T. Naito1, Charles W. Lafon2, William T. Flatley3, Sally P. Horn4, Thomas A. Waldrop5

School of Natural Resources and the Environment, University of Arizona; 1Department of Geography, Texas A&M University, 2Department of Geography, University of Central Arkansas, 3Department of Geography, University of Tennessee, Knoxville, 4Retired, U.S. Department of Agriculture, Forest Service, Southern Research Station

Abstract

We have compiled and synthesized the history of fire and oak development in the Appalachian Mountains by processing fire scar data, forest inventory data, and stand age structure data from 40 sites across the Appalachian region. We have employed a suite of fire interval analysis tools to understand the historical fire regime. To better understand the effects of fire on oak and pine development, we fit a Weibull distribution to the filtered fire interval data to determine if fires were frequent, infrequent, or of intermediate frequency. We found that the fire interval data from different sites and across all sites were consistent with the historical fire regime of the Appalachian region. We identified 19 studies representing 40 sites that reported analyses of pre-exclusion fire history in the Appalachian region. The results show that the fire interval statistics reported in these studies—or that we calculated—indicate that fires burned frequently across the Appalachian region before the era of fire exclusion.

Introduction

• Declines and ongoing replacement of oak (Quercus) and pine (Pinus) by mesophytic species in the Appalachian region suggest that vegetation development under a history of frequent burning prior to the fire-exclusion era (c. 1930). During the pre-exclusion period, frequent, low-severity fires maintained an overstory of fire-adapted oak and pine species while minimizing recruitment of both fire-adapted and fire-sensitive mesophytic species in the understory.

• High-resolution fire scar data, combined with stand age structure analysis, can elucidate how vegetation developed under historical fire regimes, and how vegetation changed under fire exclusion.

• Through the use of statistical software like FH2 and FHAES, researchers may calculate a variety of statistics regarding fire interval (periods between different fire events). These may include the mean fire interval (MFI), Weibull median interval (WMI), lower exceedance interval (LEI), and upper exceedance interval (UEI). Generally, 75% of all fire intervals between the LEI and UEI. Fire interval periods below the LEI are unusually short, while fire interval periods above the UEI are unusually long.

Study Area

A map of the entire Appalachian region and the locations of the study sites synthesized in this study.

Methods

• As part of a General Technical Report for the US Forest Service, we conducted a synthesis of the literature to examine the role fire has played in vegetation development in the Appalachian region.

• We identified 19 studies representing 40 sites that reported analyses of pre-exclusion fire history in the Appalachian region.

• Our synthesis allowed us to examine historic fire regimes across the Appalachian region and comment on the impact they may have had on vegetation development, particularly as they relate to pine and oak.

Results

• Composite MFI varies between 1.9 years and 19.5 years across much of the Appalachian Mountains, with an average of 6.8 years across all sites.

• LEI (Lower Exceedance Interval) and UEI (Upper Exceedance Interval), which estimate the bounds within most of fire intervals fell, indicate that about 75% of fire intervals ranged between about 2 and 15 years.

• However, the occasional longer intervals were likely important ecologically, especially for tree establishment.

• Oak seedling establishment may require an interval of >10 years to enable seedlings to grow large enough to survive subsequent fires. We estimated the probability of any specific interval using the modeled Weibull distribution to determine whether the pre-exclusion regime could have favored oak. We find that roughly one-third of fire intervals exceeded this critical length.

• Age structure analysis suggests that oak and pine readily recruited into the understory during the pre-exclusion era. Recruitment declined significantly under fire exclusion, while mesophytic (other) species became heavily favored.

Discussion and Implications

• The fire interval statistics reported in these studies—or that we calculated from them—indicate that fires burned frequently across the Appalachian region before the era of fire exclusion.

• The regime of frequent fires appears to have favored oak and pine dominance by killing mesophytic competitors, while the occasional longer interval (>10 years) enabled oak seedlings and sprouts to grow to a fire-resistant size before the next fire. Under the pre-exclusion fire regime, oak could be maintained indefinitely, with young plants replacing those lost in the overstory. Chestnut oak (Quercus montana) was especially favored under the historic fire regime, as to some extent were white oak (Q. alba), scarlet oak (Q. coccinea), and black oak (Q. velutina).

• Immediately following fire exclusion, mesophytic species (e.g., red maple, Acer rubrum) rapidly recruited and contributed to a more diverse tree assemblage. In time, as fire-adapted oaks disappear from the overstory, these mesophytic understory species will likely assume overstory dominance. This ongoing shift is altering the topographic patterning of forest vegetation across entire landscapes.