# PRESCRIBED FIRE, OAK REGENERATION, AND FUTURE FOREST FLAMMABILITY

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**Extended abstract**—Prescribed fire is a common management tool applied to upland oak (*Quercus*) forests of the Central Hardwoods and southern Appalachian Regions to promote oak regeneration. Increased use of prescribed fire is largely driven by paleoecological and dendrochonological evidence showing fire and upland oaks co-occurred across the landscape, morphological and physiological traits suggesting oaks are fire-adapted, and increased dominance of shade-tolerant "mesophytes" following fire suppression. To assess whether fire restoration to these forests could improve oak regeneration, we implemented several studies across the region to evaluate the:

1) Impacts of single vs. multiple dormant-season burns on understory light conditions and tree seedling growth and survival;
2) Effects of a period of fire cessation following multiple burns;
3) Interacting role of fire season and mammalian herbivory on re-sprout success of top-killed trees; and
4) Variability in tree bark, canopy, and leaf litter traits that could influence future forest flammability through changes in fuel characteristics.

In two separate studies, we examined the impacts of prescribed fire treatment (unburned, single, and multiple) on oak and mesophyte regeneration. In the first study, we measured regeneration density in response to prescribed fires in areas with and without natural canopy gaps. We found that single fires increased red maple (*Acer rubrum* L.) sapling (≥ 1.5, < 4 m height) density 10-fold, while multiple fires reduced red maple large seedling density (≥ 0.5, < 1.5 m height) and increased white oak (*Quercus alba* L.) large seedling density. However, canopy gaps did not accentuate prescribed fire trends, likely because gaps were too small (111–522 $m^2$) to substantially alter light, or because they occurred too many years prior to fire treatment. In the second study, we monitored the impacts of prescribed fire on stand structure and composition, canopy cover, and regeneration growth. We found that single and multiple fires did not alter canopy cover, overstory stems, or seedling density. Single fires reduced American beech (*Fagus grandifolia* Ehrh.) saplings approximately 40 percent but had no impacts on red maple and oak species saplings. Seedling growth of all species increased after single and multiple fires; however, prescribed fire failed to improve competitive status of oaks because oak growth was similar to mesophytes.

Our work has also examined the effects of multiple burns after a period of fire cessation. For example, where regeneration was measured 5–7 years after frequent and less frequent burning, there was some indication that oak and hickory (*Carya*) regeneration increased relative to competitors, primarily in the sites burned less frequently. In another study where midstory stems were measured after a fire-free interval of approximately 10 years following sites burned four times, burned treatments had significantly lower red maple relative stem density and increased relative stem density of oaks compared to earlier measurements. In contrast, on sites with continued absence of fire, the relative stem density of midstory (10–20 cm dbh) red maple increased, and relative density of oak stems decreased. These findings support the idea that fire-free periods, and not burning alone, strongly influence the abundance and species composition of tree species regeneration. Significant changes in stand structure and species composition may require time to unfold, as subsequent canopy disturbances differentially impact burned and unburned sites.

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Citation for proceedings: Clark, Stacy L.; Schweitzer, Callie J., eds. 2019. Oak symposium: sustaining oak forests in the 21st century through science-based management. e-Gen. Tech. Rep. SRS-237. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 192 p.

Our research also suggests that matching fire phenology (i.e., timing of burn) with natural fire seasons may be essential to promote oak regeneration indirectly through a shared herbivore. That is, when fires occur during the lightning season (i.e., June), a resource pulse in resprouting vegetation attracts white-tailed deer (*Odocoileus virginiana*) during the extreme nutritional stress of lactation and antler growth. Preliminary results indicate the resource pulse is far greater in magnitude in common mesophytes than oaks, and herbivore preference shifts strongly to mesophytes. Coupling the attraction of deer to recently burned areas with the shift in preference appears to exert strong top-down control of mesophyte regeneration, which may allow oaks to indirectly outcompete mesophytes. Our data indicate that fires in the traditional anthropogenic fire phenology (i.e., March) result in a resource pulse that co-occurs with green-up, a time when high-quality forage is abundant, weakening attraction to the area, the shift in preference, and ultimately, top-down control. In fact, mesophytes obtained the same height with or without deer herbivory following March top-kill, whereas June top-killed trees were twice the height by the end of the growing season when deer were excluded. Two growing seasons after the June top-kill, a majority of regenerating stems either died or were still trapped in the understory by herbivory.

Finally, our research indicates that the presence of mesophytes may reduce the flammability of upland oak forests through their canopy, bark, and leaf litter traits, which may dampen prescribed fire effectiveness as an oak regeneration tool. For example, some mesophytes, such as American beech (*Fagus grandifolia* Ehrh.), red maple, and sugar maple (*Acer saccharum* Marshall.), have greater canopy depth and slower rates of bark thickening as trees reach larger overstory sizes (20–60 cm dbh) compared to oaks, which may allow these trees to reduce understory light and generate more stemflow. Coupled with greater leaf area, American beech also had 30-percent lower understory light levels when compared to chestnut oak (*Q. montana*) and white oak, which may foster the growth of shade-tolerant seedlings in their understory and contribute to a cooler and moister microclimate. We also discovered that mesophytes may alter litter distribution; the understory of American beech, red maple, and sugar maple had 18-percent less oak leaf litter when compared to the understory of upland oaks. Because these mesophytes also have smaller, thinner, and less curly leaf litter with faster decomposition rates, higher proportions of their quickly decomposing, less flammable litter may reduce fuel loads and lead to an overall reduction in flammability.

Thus far, these findings suggest that:

1) Multiple dormant-season burns marginally improve oak regeneration;
2) A fire-free period following multiple burns is needed for oaks to reach competitive size classes;
3) Growing-season burns may enhance oak regeneration by increasing herbivory on mesophytes; and
4) Mesophytes may suppress future forest flammability by reducing fuel loads and increasing fuel moisture.