Oak Regeneration Response to Frequent Growing-Season Burns After a Shelterwood with Reserves Harvest

In 1999, an influential study by Patrick Brose and David Van Lear reported oak and hickory regeneration success could be improved by conducting a shelterwood harvest followed by a single prescribed fire several years later (Brose and Van Lear 1998). Fire was more effective when it was higher-intensity and conducted in the growing season (late spring or late summer) because non-oak competitors, primarily yellow-poplar and red maple, experienced greater mortality than oaks and hickories. Study Site: Implementing a higher-intensity burn in the growing season is challenging, limited by weather and fuel conditions, as well as rules and regulations governing prescribed fire application. Managers who have attempted to apply the shelterwood-burn system have experienced mixed outcomes for oak regeneration, likely caused by variations in site quality, the initial density and size of oak regeneration compared to that of competitors, and the timing and intensity of the prescribed fire. However, there is limited information on whether several, frequent low-intensity fires could accomplish similar objectives as a single higherintensity burn.

A new paper by a team of researchers from the University of Tennessee examines tree regeneration outcomes 13 years after a shelterwood with reserves harvest, which was followed by frequent growingseason burns. The 2025 paper is titled, "Effects of growing season fire timing on oak regeneration", and was published in the journal Fire Ecology; the authors are Mark Turner, Jacob Bones, Spencer Marshall, and Craig Harper. These same study sites were used to examine deer and turkey habitat and use – that component of the study was also featured in a CAFMS research brief in 2024.

Study Site:

The study was conducted at Chuck Swan State Forest in the Ridge and Valley physiographic province in east Tennessee. Study sites were on south- and west-facing slopes and supported mature oak-dominated forests. Mesophytic species were also common in the midstory, understory, and seedbank, and included yellow-poplar, red maple, beech, blackgum, and black cherry.

Spring early growing-season burn

Experimental Treatments:

- Shelterwood with reserves harvests in 2010 removed about 50% of tree basal area and increased understory light to an average of 30% of full sunlight. Nearly all residual overstory trees were oaks.
- Four 4-acre treatment units were installed at each of four study sites:
    - Control (CON). No cutting or fire.
    - Shelterwood with reserves harvest (SW) with no prescribed fire.
    - Shelterwood with reserves harvest + early growing-season fire (EGS; mid-April to early May, after leaf-out)
    - Shelterwood with reserves harvest + late growing-season fire (LGS; SeptemberOctober, prior to leaf drop)
- Six fires were conducted on each EGS and LGS unit with an average return interval of 2.2 years. The EGS burns were more complete and burned with moderate intensity, whereas the LGS burns were lower-intensity on average with less-complete coverage.

Fall late growing-season burn

Field Methods:

- In 2023, the research team installed four study plots in each unit (64 plots total) to document posttreatment composition and abundance of tree regeneration (stems less than 4.5 feet tall) and the midstory (stems 4.5 feet tall to 4.5 inches diameter-at-breast- height [DBH]).

- Tree species were grouped to test for differences among treatments: red oaks (mostly black and northern red), white oaks (nearly all Quercus alba), mesophytes (yellow-poplar, red maple, beech, blackgum, black cherry), sassafras, and sumac.
- Understory light levels were measured as a percentage of full sunlight using ceptometers

Key Findings, Year 13:

- **Control (no cutting, no fire):**
  - Understory light levels were 3.2% of full sunlight and 95% of midstory stems were mesophytes. Although oak understory stems were moderately abundant, the density of mesophytes was 3.5X that of oaks.
- **Shelterwood harvest with reserves with no fire:**
  - By year 13, the midstory in these stands had become dense, and the understory was heavily shaded (2.6% of full sun). The midstory was dominated by mesophytes, and oaks comprised only 1.1% of stems.
  - The understory stratum was overtopped by a dense midstory. Mesophyte stems were significantly more abundant than all other species groups, and their density was >2X that of oaks.
- **Shelterwood harvest with reserves with early growingseason fires:**
  - Fires maintained open understory conditions (28% of full sun) with no midstory (no stems > 4.5 feet tall) as the last fire occurred in the spring of 2023, just prior to data collection.
  - White oak understory stem density was greater than control but did not differ for the red oak group. The density and proportion of mesophyte seedlings was much reduced, whereas the density of all oak understory stems was approximately 1.5X that of mesophytes. However, fire-adapted sumacs were by far the most abundant group, comprising about 40% of all understory stems, followed by sassafras, also a fire-adapted species.
- **Shelterwood with reserves harvest with late growing-season fires:**
  - Similar to the EGS treatment, LGS fires sustained open understory conditions (38% of full sun) and the midstory was absent.
  - Red oak understory stem density was significantly greater than in all other treatments (>4,000 stems per acre), and mesophytic regeneration was reduced. There were more total understory oak stems than sassafras stems, but there were 1.5X more understory sumac than oak stems.


Control. No cutting, no fire.


Shelterwood w/reserves, no fire.


Shelterwood w/reserves, + early growing-season fires.


Shelterwood w/reserves, + late growing-season fires.

Take Home Points:

- Without fire, the shelterwood with reserves harvest resulted in a dense midstory dominated by mesophytes; a poor outcome if sustaining oak is a priority. Also, the open

understory condition, which provides improved habitat for deer and turkey (Turner and others, 2024), was rapidly lost in the absence of fire.

- In general, the abundance of understory oak stems was not greatly increased in the burn units. Red oak stems were most dense following repeated early fall burns, and white oak stems were more dense following repeated spring burns compared to the control unit without canopy reduction or fire.
- One major impact of repeated fires in either season was the density of **mesophytes was significantly reduced**, compared to the control and shelterwood-only treatments.
- Despite being less-intense and having reduced coverage, late growing-season burns were as effective at reducing mesophytes as early growing-season burns. Managers using fire during this period can accomplish their objectives with reduced risk of intense fire that could damage overstory trees.
- Prescribed fire during any season often promotes the establishment of sumac, which was essentially absent without fire in this study. Sumacs have hard-coated seeds that can persist for decades in the seedbank. Germination is stimulated by fire and once established, sumacs sprout vigorously after additional fires and grow rapidly in high-light conditions. Sumac density was reduced following LGS fire compared to EGS fire, which may be a consideration for some forest managers.
- The authors emphasize that if the fire-return was lengthened or ceased with the objective to regenerate oaks, the oak stems would have much less competition from mesophytes, which tend to outcompete oaks without fire, during midstory redevelopment. Although abundant sumac and sassafras compete with oak regeneration, surviving oaks may be trained by these species and should outgrow and overtop these species, which are typically confined to the lower midstory strata.

Links to Paper:

Turner, M.A., Bones, J.T., Marshall, S.G. and Harper, C.A., 2025. Effect of growing season fire timing on oak regeneration. Fire Ecology, 21(1), p.6.

https://doi.org/10.1186/s42408-025-00350-x.
https://www.appalachianfire.org/_files/ugd/696505_ba36e26cf95a4565b66e43a541c838b6.pdf

Related Research:

Brose, P.H. and Van Lear, D.H., 1998. Responses of hardwood advance regeneration to seasonal prescribed fires in oak-dominated shelterwood stands. Canadian Journal of Forest Research, 28(3), pp.331-339.
https://doi.org/10.1139/x97-218

Turner, M.A., Bones, J.T., Marshall, S.G. and Harper, C.A., 2024. Canopy reduction and fire seasonality effects on deer and turkey habitat in upland hardwoods. Forest Ecology and Management, 553, p.121657.
https://doi.org/10.1016/j.foreco.2023.121657
https://www.appalachianfire.org/_files/ugd/696505_8c88571cbed34ad6833301a9c1f6c9a7.pdf

About the Authors:

The lead author, Mark Turner, recently earned a PhD at the University of Tennessee; his doctoral dissertation was titled “Evaluating the effects of forage availability and landscape composition on whitetailed deer morphometrics across the eastern U.S.” Mark is now an Assistant Professor in the Department of Natural Resource Ecology and Management at Oklahoma State University. Craig Harper, a professor and the Extension Wildlife Specialist at the University of Tennessee, was Mark’s major professor; to learn more about Dr. Harper’s work, click here.