MULTIPHASED SHELTERWOOD ON THE DANIEL BOONE NATIONAL FOREST, KENTUCKY, TESTS HERCULEAN EFFORT TO REGENERATE OAK

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EXTENDED ABSTRACT

Our desire to maintain biodiverse forests is predicated on a desire to maintain oaks (*Quercus* spp.) in dominant canopy positions and high stocking levels. Oak reproduction is advance-growth dependent; that is, there must be adequate numbers of oak seedlings in competitive sizes prior to a canopy-replacing disturbance. Therefore, adaptive regeneration strategies are needed to position oak reproduction for recruitment into future canopy positions.

Regenerating oaks with a shelterwood prescription that manipulates understory light by deadening midstory stems, followed by release of oak stems that have recruited into larger size classes in response to increased light, has been extensively tested across the Eastern United States (Brose and others 2008, Craig and others 2014, Hutchinson and others 2016, Janzen and Hodges 1987, Lockhart and others 2000, Loftis 1990, Miller and others 2014, Parrott and others 2012, Schweitzer and Dey 2011). Because of the mesic nature of contemporary forests, coupled with additional time since last disturbance, modification to this prescription may be warranted. For example, an additional treatment targeting undesirable understory stems is needed to combat the overwhelming competition of red maple (*Acer rubrum*) in some stands (Arthur and others 1997, Lhotka 2012, Parrott and others 2012).

We engaged in stand-level treatments under an adaptative management strategy to position oak reproduction in more competitive positions prior to a regeneration harvest on the Daniel Boone National Forest in Kentucky. The initial hypothesis was that by reducing midstory stems in a mature upland hardwood forest, we would stimulate growth and recruitment of oak advance reproduction while discouraging the response of undesirable species (Cold Hill Silvicultural Assessment 2006). Ten years after the

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midstory removal, we added an additional treatment targeting the red maple competition that had accumulated in understory and midstory positions prior to overstory removal (Cold Hill HFRA Applied Silvicultural Assessment, Phase II 2018). Finally, in completing the shelterwood process, we predicted that, following overstory canopy removal, the large oak advance reproduction would continue to recruit into upper canopy positions, and the stands would remain well stocked with oak, especially as compared to undisturbed stands.

The oak shelterwood treatment (OSW) was implemented in 2006 by treating midstory stems of undesirable species in six stands (20 to 25 acres each). We followed reproduction by surveying stems in permanent measurement plots by species and 1-foot height classes, from <1 foot tall and ≤1.5 inches in diameter at breast height (d.b.h.). Ten years post-treatment, oaks in the largest size class, ≥4 feet tall and ≤1.5 inches d.b.h., increased to 163 stems per acre (SPA). In this same size class, red maple, a less desirable species, increased to 1,377 SPA (Schweitzer 2019; Schweitzer and others 2008, 2011, 2014, 2020). We did a preharvest treatment in 2019, characterized as “site preparation for natural regeneration” in the National Environmental Policy Act documentation. Red maple stems were targeted using the herbicide imazapyr (Arsenal AC®, BASF Corporation, Research Triangle Park, NC) via a hack-and-squirt or cut-surface application to red maples 0.5–11.9 inches d.b.h. Because of travel restrictions during the COVID-19 pandemic, we were unable to collect data immediately following this treatment. The overstory was removed by Kentucky Hardwood Lumber Company LLC using a mechanical tracked feller-buncher in September 2020, and stands were remeasured in 2022. We compared results in the OSW stands to six control stands in the same study.

In 2005, the OSW overstory basal area was 99 square feet per acre [4 percent hickories (*Carya* spp.), 64 percent oaks, and 13 percent red maple] and density was 127 SPA (3 percent hickories, 51 percent oaks, and 30 percent red maple) for trees >5.4 inches d.b.h. After harvest, the residual basal area was 27 square feet per acre (6 percent hickories, 50 percent oaks, and 29 percent red maple) with 25 SPA (8 percent hickories, 60 percent oaks, and 20 percent red maple) for trees >5.4 inches d.b.h.

Oak reproduction included black oak (*Q. velutina*), chestnut oak (*Q. prinus*), scarlet oak (*Q. coccinea)*, and white oak (*Q. alb*a). Oak reproduction was maintained over time (F = 1.01, P = 0.3869) at 2,730 SPA in 2008, 4,183 SPA in 2016, and 3,937 SPA in 2022 (fig. 1). In 2008 (F = 0.57, P = 0.4685) and 2016 (F = 3.22, P = 0.1030) differences in total oak density and density within any size class were not significant between the control and OSW. In 2022, total oak density was less in the OSW with 3,937 SPA compared to 8,490 SPA in the control (F = 6.46, P = 0.0293). This was mostly due to the reproduction of the smallest size class (<1 foot tall), which was 6,457 SPA in the control compared to 2,073 SPA in the OSW (F = 10.19, P = 0.0096). From 2005 to 2022 the largest size class (≥4 feet tall and ≤1.5 inches d.b.h.) increased for both treatments, from 20 to 180 SPA for the control and from 43 to 143 SPA for the OSW (fig. 2).

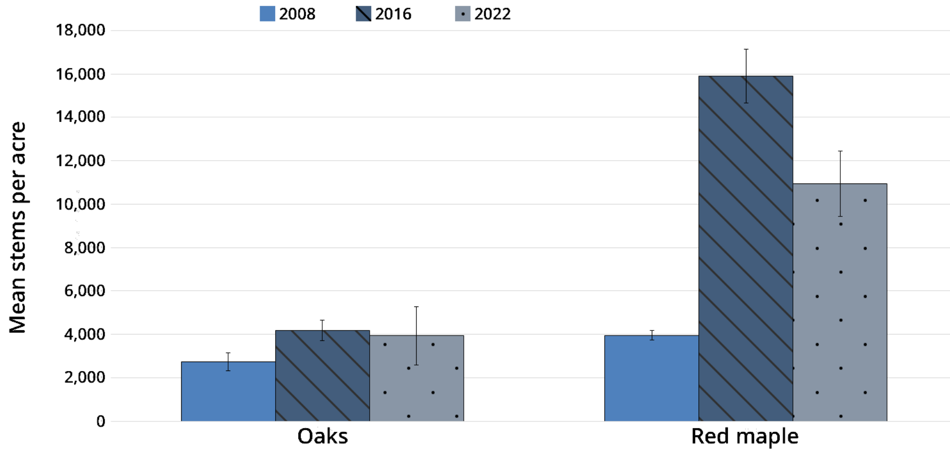

Figure 1—Mean stems per acre for total oak and red maple reproduction (≤1 foot tall and ≤1.5 inches d.b.h.) under an oak shelterwood prescription. 2008 represents pretreatment density, 2016 is after the first midstory herbicide treatment, and 2022 is following a second midstory treatment and final overstory harvest.

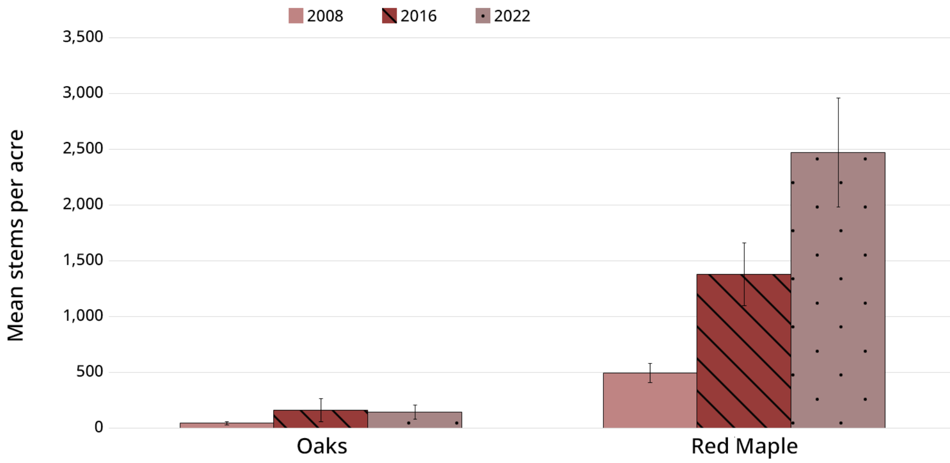

Figure 2—Mean stems per acre for oak and red maple reproduction in the largest size class, ≥4 feet tall and ≤1.5 inches d.b.h., under an oak shelterwood prescription. 2008 represents pretreatment density, 2016 is after the first midstory herbicide treatment, and 2022 is following a second midstory treatment and final overstory harvest.

Total red maple reproduction in the OSW stands significantly changed over time ($F = 27.95$, $P < 0.0001$), from 3,957 SPA in 2008 to 15,897 SPA in 2016 and 10,950 SPA in 2022 (fig. 1). Red maple in the largest size class in the OSW had significantly more stems in 2022 (2,470) than in 2008 (495) and 2016 (1,377) ($F = 9.08$, $P = 0.0026$) (fig. 2). In the smallest size class, reproduction of OSW red maple was significantly greater ($F = 20.26$, $P < 0.0001$) in 2016 (11,257 SPA) than in 2008 (2,187 SPA) and 2022 (4,283 SPA). Total red maple stems in the control stands increased ($F = 73.04$, $P < 0.0001$), changing from 4,423 (2008) to 14,327 (2016) to 20,290 (2022) SPA. This was the result of significant increases in the smallest size class only ($F = 54.04$, $P < 0.0001$), and represented 57, 85, and 90 percent of the total red maple SPA for 2008, 2016, and 2022, respectively. In 2008 and 2016 total red maple seedling densities were not different between control and OSW stands. However, in 2022 control stands had a greater density of red maple stems (20,290 SPA) than OSW (10,950 SPA) ($F = 25.74$, $P = 0.0005$). Control stands also had greater stem densities in all size classes compared to OSW except for the 1- to 2-foot height class, which did not differ.

Intensive management was undertaken to ensure sufficient oak stocking after a regeneration harvest, and oaks maintained their stocking within the OSW stands. The effects of mesophication are complicating the reproduction response, with small and most likely new germinants of red maple proliferating in both treatments. Targeting red maple with multiple treatments reduced its density compared to controls. These intense and targeted treatments have resulted in the increase and maintenance of competitive oak, although future release may be warranted.

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