

Seven-Year Response of Planted Northern Red Oak (*Quercus Rubra*) Seedlings to Regeneration Harvesting, Burning, and Herbicide Treatments in Western North Carolina

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Overview:

- We tested high-quality, locally adapted seedlings (1-0) of northern red oak (*Q. rubra*) planted in four silvicultural treatments on high quality sites in western North Carolina: prescribed fire (Rx-burn), midstory-removal (MR), shelterwood-burn (SWB), and a control.
- The most efficacious treatment was the SWB where trees had more than 80% survival after 7 years and had maximum heights of 20 ft. Prescribed burning at year 5 in the SWB treatment negatively affected planted seedlings, however, reducing survival by 8% and height by 7 ft.
- Seedlings planted in noncommercial treatments (control, MR, Rx-burn) were short (averaging less than 4 ft) and had poor survival (< 51%) after 7 growing seasons.

Summary:

Management problem: Oaks have been difficult to regenerate for the last 50 years, primarily due to changes in the disturbance regime, herbivore pressure, a wetter climate, and lack of proven management prescriptions. Oak reproduction must be relatively large (e.g., > 3–4 ft) prior to overstory removal to be competitive, and understory light regimes in undisturbed forests are too low for small oaks to recruit into larger size classes. Treatments that target the midstory and understory, such as burning and herbicide, increase light levels that favor oak regeneration and reduce competitors, but planting in these treatments have not been adequately tested.

Management need: Oak planting offers a potential solution to mitigate the oak regeneration problem, but artificial regeneration has not been widely studied in productive forests of the eastern United States. Technological advancements that produce high-quality, improved

nursery seedlings have only been recently developed and tested. Availability of dependable, locally adapted seed sources are still mostly lacking, and planting can be expensive; therefore, planting should be conducted using the most efficacious methods available.

Research purpose: We planted high-quality (e.g., height averaged > 3 ft) northern red oak seedlings in four replicated silvicultural treatments—prescribed burn only (Rx-burn), midstory removal (MR), shelterwood-burn (SWB), control—on Cold Mountain Game Lands in western North Carolina. Sites were productive (site index > 80 ft for red oak). The Rx-burn treatment was implemented in the late dormant season just prior to planting and again 5 years after planting. The midstory removal was a noncommercial herbicide (Garlon® 3A) injection applied just prior to planting to remove the midstory canopy layer (all non-oak and hickory trees between 2 to 10 inches d.b.h.). The shelterwood harvest (residual BA = 50 ft² per acre) was implemented just prior to planting and was burned once during the late dormant season 5 years after planting.

Silvicultural Concepts:

- Noncommercial treatments designed to improve the development of natural oak reproduction in the understory (e.g., Rx-burn, MR) were not beneficial to underplanted oak seedlings. Trees in these treatments generally lost height through dieback of the main stem and had relatively low survival (fig. 1), presumably due to low light levels.
- The SWB treatment was the most beneficial treatment after 7 years. Seedlings averaged 6.6 ft in height but could be as tall as 22 ft (fig. 1). Approximately half of the seedlings in this treatment were free-to-grow (no competition was above their terminal bud). Seedlings that were burned over had similar free-to-grow status as trees that escaped fire (47%).
- Prescribed burning was not beneficial for planted seedlings in the Rx-burn or in the SWB treatments. Fire burned 96% of trees in the Rx-burn treatment, killing 24% of trees that were burned, while 65% of trees in the SWB were burned, resulting in a mortality of 8%. Larger size trees in the SWB were better able to withstand fire, compared to the smaller size trees in Rx-burn only treatment. Seedlings that sprouted after top-kill from burning were less than half of the height of unburned seedlings 2 years following the fire (fig. 2).

Management Applications:

- Prescribed burning is becoming increasingly popular to improve ecological diversity, reduce fuel loads, and benefit the oak regeneration process (Arthur et al. 2012). Our results demonstrated that prescribed fire was not beneficial to planted northern red oak seedlings in the shelterwood harvest or as a stand-alone treatment. A targeted

practice, such as crop-tree release, might be more beneficial to release planted oaks than a prescribed fire in even-aged regeneration systems.

- Planting can be expensive and difficult, but our results show that it can directly improve the density of competitive oak reproduction in a shelterwood harvest. We used relatively large seedlings (representing the top 50% of seedlings from the nursery) from locally adapted seed sources, which contributed towards their success (Clark et al. 2016).
- Because of the costs and resources required to implement artificial regeneration, we do not recommend prescribed fire following planting until seedlings have bark thick enough to resist top-kill. Uneven fuel distributions from logging contributed toward a patchy fire in the SWB treatment, allowing some trees to escape fire and develop relatively large sizes. The Rx-burn treatment was less patchy, and most seedlings that were burned resprouted following fire. In both the Rx-burn and SWB treatments, seedlings did not obtain their original height prior to the fire.
- Planted seedlings will perform best in a regeneration harvest and will not perform well planted in noncommercial treatments, as implemented in this study. We postulate that light levels were too low to maintain photosynthetic demands required to sustain seedlings' relatively large root systems.



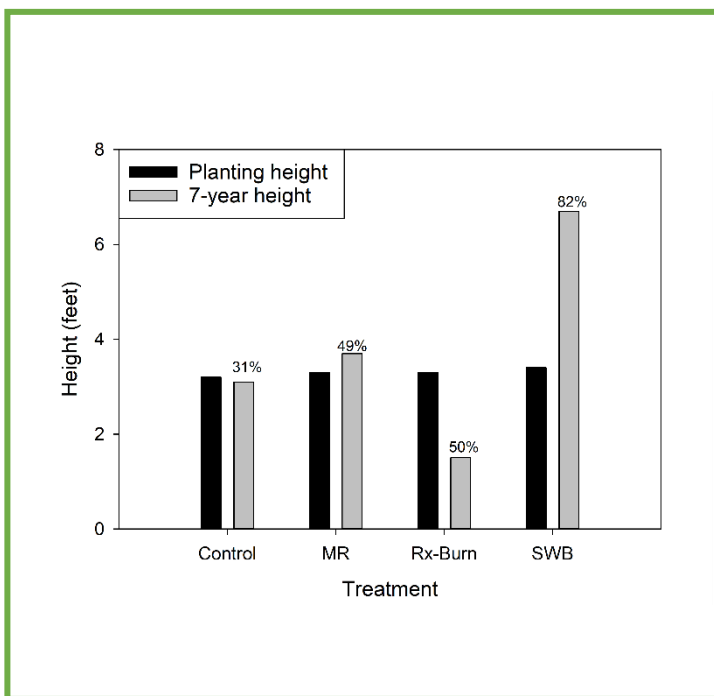


Figure 1—Mean height of planted northern red oak in each silvicultural treatment. Numbers above 7-year height bars are mean survival. MR = midstory-removal, Rx-Burn = prescribed burn, SWB = shelterwood-burn.

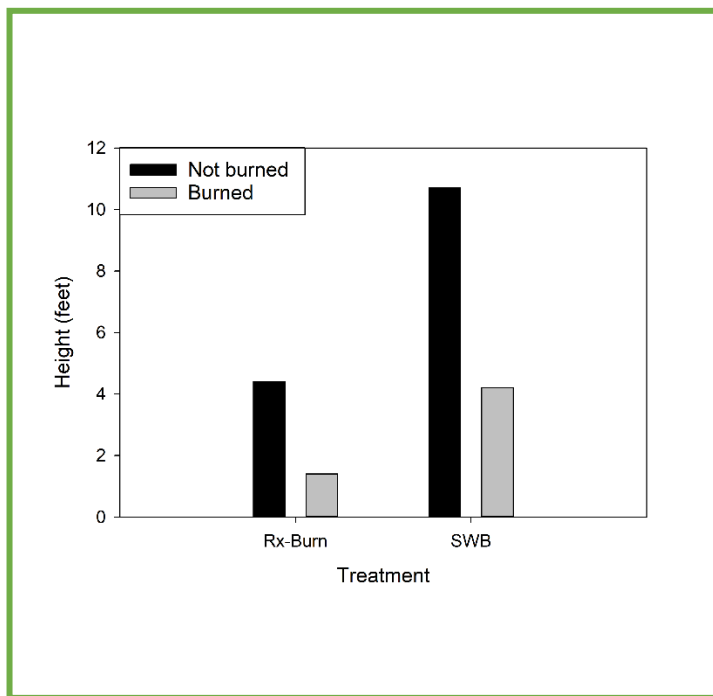


Figure 2—Mean height for the prescribed-burn (Rx-burn) and shelterwood-burn (SWB) treatments for planted northern red oak seedlings that were burned over or that escaped fire.

References

- Arthur, M.A.; Alexander, H.D.; Dey, D.C.; Schweitzer, C.J.; Loftis, D.L. 2012. Refining the oak-fire hypothesis for management of oak-dominated forests of the eastern United States. *Journal of Forestry*. 110: 255–266.
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