



# The Shelterwood-burn Technique for Regenerating Oaks

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## Introduction

The value of oak-dominated forests for wildlife and timber benefits is well-known to most people who have some connection to the outdoors. The lack of oak regeneration in eastern forests over the past several decades has become a major concern for foresters and other natural resource managers. Without the natural influence of fire, species such as sweetgum (*Liquidambar styraciflua*) and yellow poplar (*Liriodendron tulipifera*) grow vigorously into openings or gaps created by overstory disturbance, while red maple (*Acer rubrum*) and beech (*Fagus grandifolia*) can outgrow oak seedlings under closed canopy conditions.

Periodic fire was an important ecological factor in the development of oak forests in North America (Abrams 2005), and previous research has shown that prescribed fire can promote advanced oak regeneration (Little 1974, Sander 1988, Van Lear and Waldrop 1989).

Mimicking natural fire regimes in existing mature oak stands can increase the relative amount and quality of oak in the regeneration pool (Figure 1) (Barnes and Van Lear 1998).

However, increasing this regeneration may require repeated burns applied over a period of years — in one study, more than 20 years (Carvell and Tryon 1961). Nevertheless, oak regeneration can be enhanced with fire before any type of harvesting activity.

However, many landowners do not want to enter into such a long-term prescribed burning program. Fortunately, further research has shown that a single, well-timed fire can produce desirable results (Barnes and Van Lear 1998). Such burns may provide landowners the ability to use the natural oak stand replacement benefits of fire without the necessity of a long-term prescribed burning program. However, a better approach is to introduce fire into an existing oak stand after a partial harvest. This method, the shelterwood-burn technique, offers a cost-effective strategy to help land managers and landowners maintain their oak forests (Brose et al. 1999, Van Lear et al. 2000).



Figure 1. Workers utilize drip torches to prescribe burn a mature oak stand. Photo courtesy of Joseph O'Brien, USDA Forest Service.

## The Setup

In order to apply the shelterwood-burn technique, the site must meet these prerequisites:

- The site must already be dominated by mature oaks.
- The site must be located such that prescribed burning is possible, and the landowner must be willing to use fire (Figure 2).
- The site must have adequate stocking of commercial timber to support two harvests.
- The stand must already have oak regeneration in it, even if it is suppressed and not of the best quality. If the first three requirements are met but the regeneration is not in place, simply hold off until after a good acorn crop and the establishment of oak seedlings — a process that can take only a few to many years.
- And, finally, site quality must be considered. Sites that are either too poor or too productive are not good candidates for this approach. See the Some Limitations section on p. 8 for further details.

New seedlings should be established for three to five years before burning. If the prescribed fire is introduced too soon, the seedlings may not have developed the root reserves or structural capacity to resprout and will not survive. Well-established oak seedlings must be in place before the first phase can proceed.

## Step One — The Shelterwood Cut

The initial shelterwood cut accomplishes several things necessary for making this technique successful (Figure 3) (Brose et al. 1999). First, it stimulates existing oak seedlings, allowing them to develop stronger root systems and, in turn, enhances their ability to resprout vigorously after a burn. Second, the added light reaching the forest floor encourages



Figure 2. A mature mixed hardwood stand with an understory dominated by shade-tolerant species. Oak seedlings are present but are noncompetitive.

Photo courtesy of Patrick H. Brose, Clemson University.



Figure 3. Shelterwood cutting in mixed hardwood releases understory growth.

Photo courtesy of Brian Lockhart, USDA Forest Service.

competitors, such as yellow poplar and red maple, to germinate and stump sprout. However, with the partial canopy left after the initial shelterwood harvest, the competitors grow more slowly and are less likely to dominate the site. The third benefit is increased fuel (tree limbs and tops or “slash”), which can help carry a fire of sufficient intensity to kill undesirable competition during the burning phase (Brose 1999). Finally, the large remaining oaks provide sufficient leaf litter to produce a continuous fuel layer.

The initial cut should reduce the canopy by about half, leaving roughly 25 to 50 of the best quality oaks per acre. In most cases, marking the trees selected for saving is easier than marking those for harvesting. Undesirable species (e.g., maples, sweetgum and yellow poplar) and poor quality oaks should be removed in this harvest. Oaks to be left should be larger canopy trees with good form, a clean bole and a full crown. Generally, such trees will not sprout epicormically (small lateral branches coming from

the main stem of the tree that are often quite prolific), will provide leaf litter for fuel, and will provide a valuable final harvest when the time comes. Lesser-quality oaks (i.e., those with small, poorly developed crowns) tend to sprout epicormically, which may reduce their timber value. However, stems of exceptionally high value, such as veneer, should be removed in this harvest to minimize any potential loss or degradation from fire. Other fire-adapted species with value for either timber or wildlife, such as shortleaf pine (*Pinus echinata*), hickories (*Carya spp.*) or blackgum (*Nyssa sylvatica*), could be retained but will impact future stand composition.

Slash left after the harvest should not be allowed to accumulate around the base of leave trees. The intensity of fire created by dried slash against a leave tree can damage or kill it. The suggested reductions in stand density should leave plenty of space between leave trees so that the use of directional felling can avoid this situation. However, removal of the slash from the base of some leave trees may still be necessary. Even without such measures, only about 5 percent of remaining overstory trees will be damaged by a proper prescribed burn (Brose and Van Lear 1999).

## Step Two — Wait Three to Five Years

Releasing the oak seedlings from full shade will quickly accelerate their root development (Gottschalk 1985, Miller et al. 2004); those in a full shade have almost no chance of developing into good advanced regeneration. The less desirable hardwood species will devote proportionally more of their newly acquired solar energy to shoot growth. This inherent difference in growth patterns allows oaks to develop the root reserves that make them more fire-tolerant than many of their competitors. The naturally deeper position of oak seedlings' root collars within the soil compared to the less fire-tolerant

competition is another reason for oaks' greater ability to survive fires (Korstian 1927, Brose and Van Lear 2004).

The root collar diameter also is a good measure of the oak seedlings' ability to survive a fire and support new, vigorous shoot growth. Oak seedlings should have a minimum root collar diameter of 0.5 to 1.0 inch for resprouting and developing into desired advanced reproduction. Recent research indicates that nearly all oak species will develop this root collar diameter after a waiting period of four to five years (Brose 2008). A good target for successful regeneration is about 400-500 seedlings of this size per acre (Sander et al. 1983). Where deer browsing is heavy, the waiting period may have to be longer; where browsing is especially severe, wait to implement the harvest until after deer density has been reduced on the site. Otherwise, regeneration may fail.

The waiting period also allows the large residual oaks time to recover from the stress of the harvesting operation, making them less vulnerable to any stress from burning. During this time, these trees also produce the continuous, fine fuel layer required to carry a fire.

## Step Three — The Prescribed Fire

The purpose of fire is to top-kill all of the regeneration on the site and force it to sprout from the rootstock (Figure 4) (Brose et al. 1999). As just described, the oaks are more capable of this than other species. To further encourage the domination of oak regeneration, schedule the prescribed fire for the spring or late summer. Although the mechanism is not clear, oaks have a competitive advantage during growing-season burns (Brose et al. 2012) (Figure 5).



Figure 4. Prescribed burning top-kills undesirable species. Photo courtesy of Terry Price, Georgia Forestry Commission.



Figure 5. Spring or late summer prescribed fires are very effective for promoting oaks because of their greater survival at these times. Photo courtesy of Gerald J. Lenhard.

Winter fire, on the other hand, is not as effective, and most species sprout prolifically following such burns. Spring and summer fires produce comparable results, but summer fires are generally more difficult to implement because of more humid conditions. However, summer fires are disproportionately more effective at killing the rootstocks of competition than spring fires.

A spring fire should occur when new leaves have expanded to about half, or slightly more, of their full size. Typically, this expansion will happen in April but will vary by latitude and altitude. Summer fires should occur any time from mid-August through September when relative humidity is low enough to allow a fire to carry through the understory, typically between 20 and 35 percent.

During spring or summer, choosing weather conditions carefully is critical because of their influence on fire intensity and behavior. If you are not experienced in using prescribed fire, consult with someone who is when planning this burn. Weather conditions should include moderate relative humidity and a moderate in-stand breeze (about 3-8 mph) to dissipate heat from below the canopies and to be able to control fire behavior. In the case of summer burns, avoid excessive heat if possible (more than 90 F). Moisture of fine fuels (leaf litter) will often be favorable for conducting a burn two to three days after a rain, but in any case, must be dry enough to carry the fire easily. Avoid burning when fine fuels are exceptionally dry down to mineral soil. Such conditions are typical of droughts and may create fires that are too intense.

A moderately intense fire will top-kill all of the regeneration on the site without significantly damaging the large residual oaks (Figure 6). Flame lengths of 2 to 3 feet moving at 2 to 5 feet per minute are desirable. A fire with these flame lengths is hot enough to

kill the regeneration but also is unlikely to result in escapes or damage to overstory stems (Keyser et al. 1996, Brose and Van Lear 1998). A hot, slow-moving fire is best, and it should burn up most leaf litter and small fuels. An extremely hot fire that exposes a great deal of bare ground or with flame lengths more than 5 feet is not desirable. Such fires can completely kill any regeneration, including the root and the large residual trees and can pose a risk of escaped fire.

The amount of desirable (vigorous with a dominant terminal leader) advanced oak regeneration present on the site two to three years post-burning is the measure of success. The oak resprouts at this point should be about 4 feet tall and growing vigorously. Ideally, they also will have little competition from overtopping stems of undesirable species (e.g., red maple or yellow poplar) close to them. The term “free-to-grow” applies to such competition-free, quality regeneration. Approximately 400-500 of these stems per acre should lead to an oak-dominated stand in the future. Even

if this target is not met, even a small amount of advanced oak regeneration may produce a high-quality mixed hardwood stand, which also may accomplish the landowner’s ultimate goals.

## Step Four — Final Harvest

Following the burn and suppression of the competition, the developing oak seedlings should be allowed to grow for another four to five years or until regeneration is about 10-15 feet tall. Such regeneration will be large enough to respond favorably to full sunlight and small enough to still be flexible and not seriously damaged by logging equipment. At that time, the residual canopy left after the first harvest should be removed. This harvest should generate as much or even more income than the initial cut, because it will consist of mostly high-quality oak stems that have continued to grow (Figure 7). After a final harvest, a new even-aged stand dominated by oak should develop and eventually mature into a stand similar to the original one (Brose et al. 1999).



Figure 6. Oak regeneration one year following a prescribed burn. Most of the yellow poplar sprouts are dead; most of the new sprouts are oak. Photo courtesy of Patrick H. Brose, Clemson University.

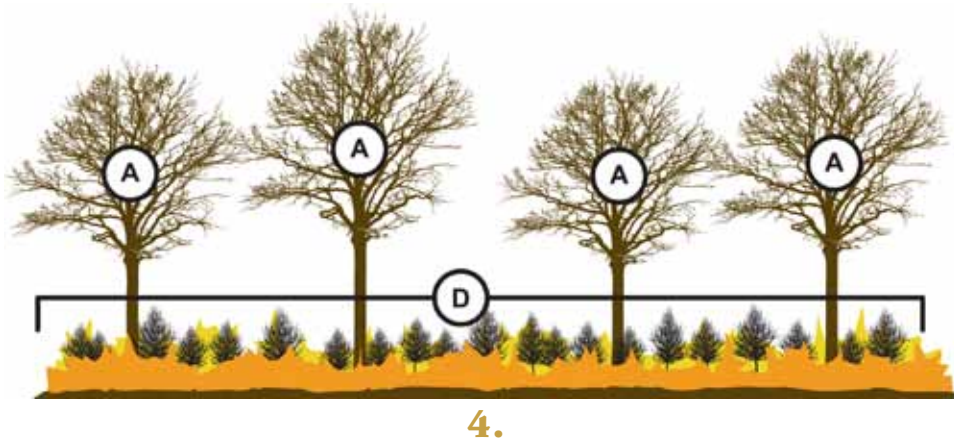
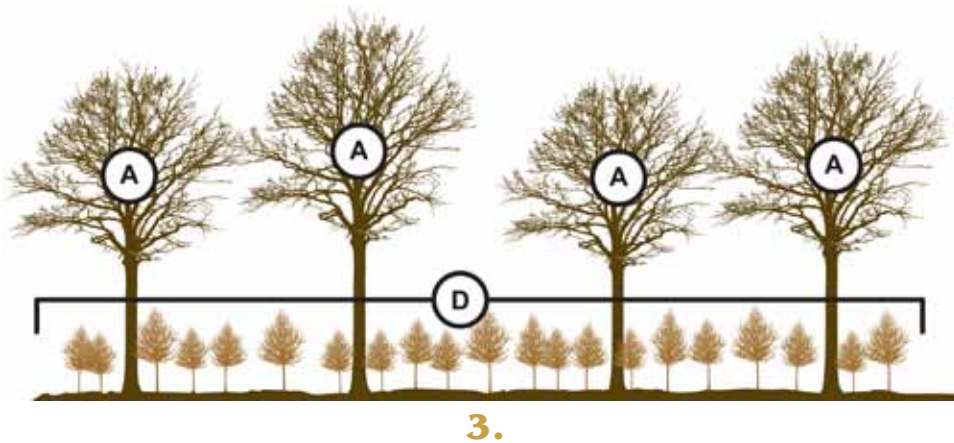
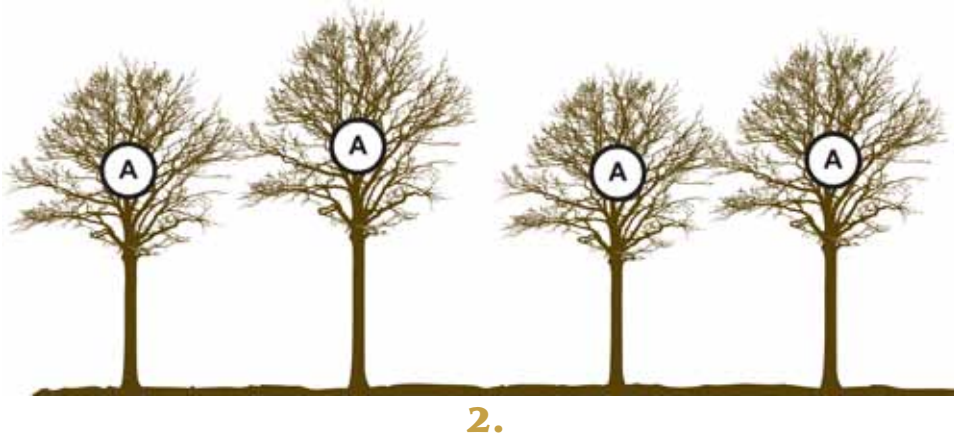
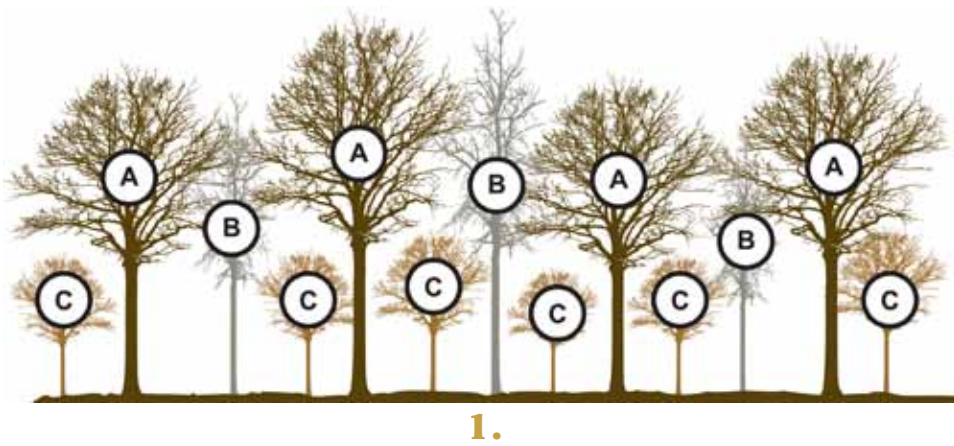
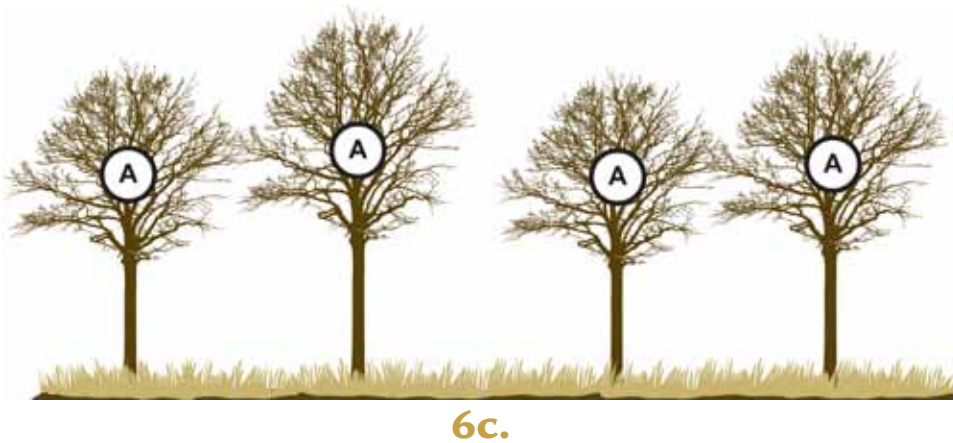
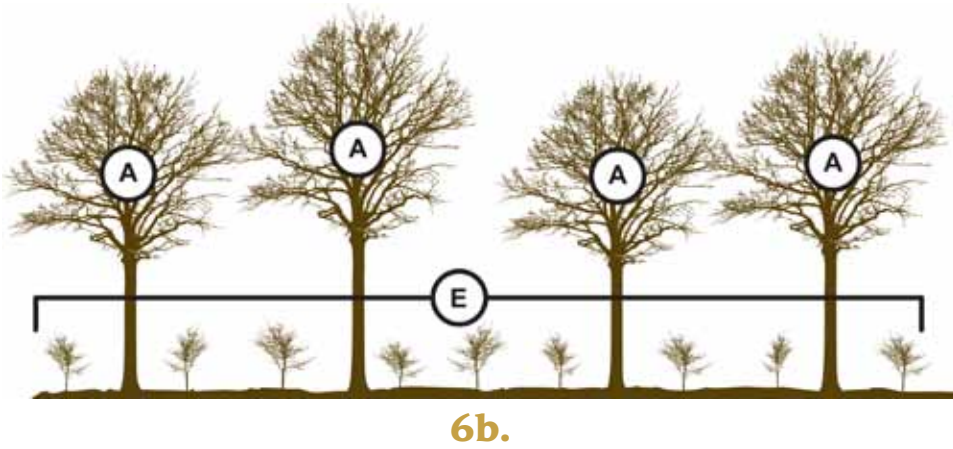
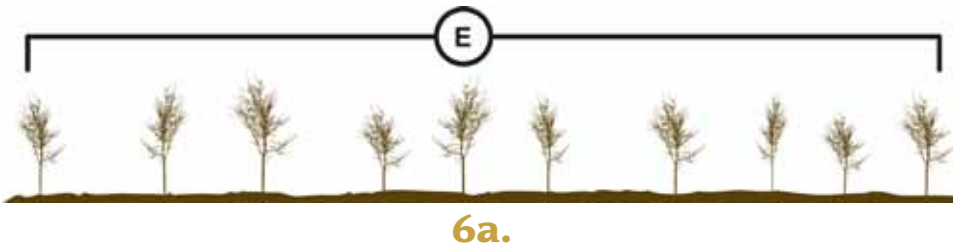
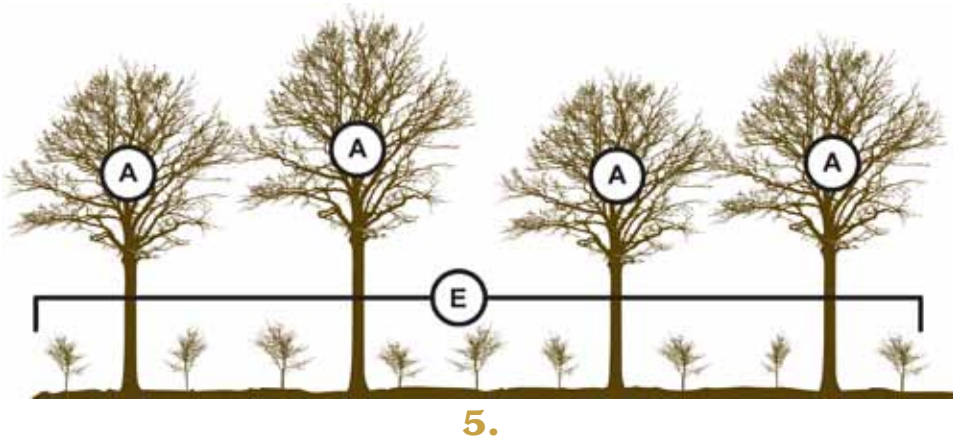


Figure 7. Schematic diagram of shelterwood-burn technique for regenerating oak stands on upland sites. A = High quality dominant oaks; B = Hickories, poor-quality oaks and yellow poplar; C = American beech, flowering dogwood and red maple; D = Mixed hardwood regeneration dominated by yellow poplar; E = Mixed hardwood regeneration dominated by oak.

1. Typical upland mixed hardwood.
2. Initial cut to shelterwood (40-60 percent basal area reduction).
3. After three to five years, yellow poplar dominates the advanced regeneration pool.
4. Prescribed fire top-kills the advance regeneration, forcing rootstocks to sprout. Overstory damage and mortality limited to trees with slash at their bases.



**5.** Oak now dominates the advance regeneration pool. Three management options are available.

**6a.** Overstory harvested and additional fires withheld creates a new oak forest.

**6b.** Overstory retained and additional fires withheld create two-age stand.

**6c.** Repeated burning either stockpiles oak sprouts or creates an oak savannah.

## Some Management Options

If the advanced oak regeneration on the site is insufficient, or if the landowner is interested in managing the residual stand for wildlife, additional fires are an option. Repeated fire after an initial thinning can further enhance the domination of oak regeneration. Alternatively, without a final harvest, the regeneration can develop (albeit more poorly) under the residual oak stand, creating a two-age stand structure. This is a great option for wildlife management, because the large mast-producing oaks are retained, and the potential for snag creation and woody debris is enhanced. Wildlife benefits for cavity-nesting birds are increased. Upland game species, such as wild turkey, white-tailed deer and squirrels, are provided supplemental food sources from continued acorn production. Repeated fires over time will stockpile small oak regeneration. Releasing it over time in patches of varying size will create a mosaic of different age classes. More frequent (one- to two-year interval) growing-season fires will reduce the amount of woody stems in the understory altogether and eventually create an oak savannah. Such open oak savannahs with grassy herbaceous understories are some of the rarest ecosystems in the United States. They have declined dramatically due to fire suppression and the lack of natural fire and can provide excellent wildlife habitat and encourage many rare native plants.

## Some Limitations

As with any land management practice, the success of the shelterwood-burn technique is dependent on a number of factors. First, as mentioned above, excessive deer populations can be a major threat to any form of forest regeneration, including this one. If a browse line is visible, reduce the deer herd before implementing any forest regeneration activities. Second, site

quality can play a major role in the level of competition that oaks encounter. On poor sites, those with site indices below about 60-65 (often characterized by the presence of an understory dominated by species such as mountain laurel or huckleberry), oak will almost always outcompete other tree species during the regeneration cycle. Stocking of timber also is not typically great enough or of high enough quality on such sites to support two entries.

On very high-quality sites — those with site indices above 80 — oaks are often not a major component of the canopy, and shifting the future stand to one dominated by oaks will not be accomplished easily. Stands where northern red oak (*Quercus rubra*) is the only oak species present are typical of such high-quality sites. In the Appalachians where fire cherry is common, burning may result in an increase in competition from that fire-adapted species. Always seek the involvement of a professional forester or wildlife biologist who is familiar with the area where you are working when deciding to implement a shelterwood-burn or other forest or habitat management.

## Conclusions

The shelterwood-burn technique is an effective method for landowners and managers to perpetuate oak forests in the eastern United States. The technique mimics the natural processes of disturbance and fire that are believed to have maintained these forests historically. The shelterwood-burn method also is attractive due to its cost effectiveness. The first step, a shelterwood cut, generates income. Only a small portion of this income is needed to complete the prescribed burning. Little upfront expense and the option of a high-value final harvest are great motivators for landowners who want to maintain their oak forests. The shelterwood-burn technique offers a practical and reliable method for maintaining the oak forests that, historically, have provided so many valuable benefits to the wildlife and people of eastern North America.



## Literature Cited

- Abrams, M.D. 2005. Prescribed fire in eastern forests: Is time running out? *Northern Journal of Applied Forestry* 22:190-196.
- Barnes, T.A., and D.H. Van Lear. 1998. Prescribed fire effects on advanced regeneration in mixed hardwood stands. *Southern Journal of Applied Forestry* 22:138-142.
- Brose, P.H. 2008. Root development of acorn-origin oak seedlings in shelterwood stands on the Appalachian Plateau of northern Pennsylvania: 4-year results. *Forest Ecology and Management* 255:3374-3381.
- Brose, P.H., and D. Van Lear. 1999. Effects of seasonal prescribed fires on residual overstory trees in oak-dominated stands. *Southern Journal of Applied Forestry* 23:88-93.
- Brose, P., and D. Van Lear. 2004. Survival of hardwood regeneration during prescribed fires: The importance of root development and root collar location. In M.A. Spetich, ed. *Upland oak ecology symposium: History, current conditions, and sustainability*. General Technical Report SRS-73. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 123-127.
- Brose, P.H., D.H. Van Lear, and R. Cooper. 1999. Using shelterwood harvests and prescribed fire to regenerate oak stands on productive upland sites. *Forest Ecology and Management* 113:125-141.
- Brose, P.H., D.H. Van Lear, and P.D. Keyser. 1999. A shelterwood-burn technique for regenerating productive upland oak sites in the Piedmont Region. *Southern Journal of Applied Forestry* 23:158-163.
- Brose, P.H., D.C. Dey, R.J. Phillips, and T.A. Waldrop. 2012. A meta-analysis of the fire-oak hypothesis: Does prescribed burning promote oak reproduction in eastern North America? *Forest Science*. Published online August 16, 2012 at <http://dx.doi.org/10.5849/forsci.12-039>.
- Carvell, K.L., and E.H. Tryon. 1961. The effect of environmental factors on the abundance of oak regeneration beneath mature oak stands. *Forest Science* 7:98-105.
- Gottschalk, K.W. 1985. Effects of shading on growth and development of northern red, black oak, black cherry, and red maple seedlings. I. Height, diameter, and root/shoot. P. 189-195 in *Proceedings of Fifth Central Hardwood Forestry Conference* Dep. For. Univ. of Illinois, Urbana.
- Hutchinson, T.F., E.K. Sutherland, and D.A. Yaussy. 2005. Effects of repeated prescribed fires on the structure, composition, and regeneration of mixed-oak forests in Ohio. *Forest Ecology and Management* 218:210-228.
- Keetch, J.J. 1944. Sprout development on once-burned and repeatedly burned areas in the Southern Appalachians. Tech Note 59. U.S. Forest Service, Appalachian Forest Experiment Station. 3 pp.
- Keyser, P.D., P.H. Brose, D.H. Van Lear, and K.M. Burtner. 1996. Enhancing oak regeneration with fire in shelterwood stands: Preliminary trials. In: Wadsworth, K., and R. McCabe, eds. *Transactions North American Wildlife Natural Resources Conference*: 215-219.
- Korstian, C.F. 1927. Factors controlling germination and early survival in oaks. *School of Forestry Bulletin* 19. New Haven, CT: Yale University. 115 pp.
- Little, S. 1974. Effects of fire on temperate forests: Northeastern United States. In: Kozlowski, T.T., and C.E. Ahlgreen, eds. *Fire and ecosystems*. New York, NY: Academic Press: 251-277.
- Lorimer, C.G. 1993. Causes of the oak regeneration problem. In: Loftis, D.L., and C.E. McGee, eds. *Oak regeneration: Serious problems, practical recommendations*. General Technical Report SE-84. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 14-39.
- Miller, G.W., J.N. Kochenderfer, and K.W. Gottschalk. 2004. Effect of pre-harvest shade uncut and fencing on northern red oak seedling development in the central Appalachians. In: Spetich, M.A., ed. *Proceedings of the upland Oak Ecology Symposium: History, current conditions, and sustainability*. General Technical Report SRS-73. U.S. Department of Agriculture, Forest Service: 182-189.
- Sander, I.L. 1971. Height growth of new oak sprouts depends on size of advance regeneration. *Journal of Forestry* 67:809-811.
- Sander, I.L., C.E. McGhee, K.G. Day, and R.E. Willard. 1983. Oak-hickory. In: R.M. Burns, compiler. *Silviculture systems for the major forest types of the United States*. Agricultural Handbook 445, Washington, D.C. US Department of Agriculture, Forest Service: 116-120.
- Sander, I.L. 1988. Guidelines for regenerating Appalachian oak stands. In: *Proceedings Guidelines for Regenerating Appalachian Hardwood Stands*. Morgantown, WV: West Virginia University Book, Office of Publications: 189-198.
- Van Lear, D.H., and T.A. Waldrop. 1989. History, uses, and effects of fire in the Appalachians. General Technical Report. SE-54. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Experiment Station. 20 pp.
- Van Lear, D.H., P.H. Brose, and P.D. Keyser. 2000. Using prescribed fire to regenerate oaks. In: Yaussy, D.A., (comp. 2000). *Proceedings: Workshop on fire, people and the central hardwoods landscape*. General Technical Report NE-274. Newton Square, PA. U.S. Department of Agriculture, Forest Service: 97-102.

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