THE DEVELOPMENT OF OAK REPRODUCTION FOLLOWING SOIL SCARIFICATION—IMPLICATIONS FOR RIPARIAN FOREST MANAGEMENT

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ABSTRACT.—With the current emphasis and interest in riparian forest management, it is necessary to develop management strategies that enhance and regenerate bottomland hardwoods in these biologically important areas. However, the regeneration of bottomland oaks has been problematic across much of the eastern United States. Two ongoing studies presented in this paper suggest that soil scarification, in the presence of abundant acorns, can increase the initial establishment of oak. One study assesses the effects of disk scarification on first year seedling establishment in a mixed-oak bottomland forest. The second study was conducted on an upland site within a fenced shelterwood and assesses the effects of bulldozer scarification on the development of seedlings 5 years after treatment. In both studies, the initial density of oak seedlings was greater and density and height of competitive tree species was reduced in the scarified areas than in the controls. Furthermore, the upland study showed that the benefits of scarification could be carried through year 5. From these studies, management recommendations have been developed and the implications of these recommendations for riparian management are presented. Finally, these studies suggest that soil scarification may be a useful tool for augmenting oak seedling reproduction in poorly regenerating riparian forests.

Riparian forests are some of the richest and most biologically diverse areas in the continental United States. They are home to a wide variety of plant and animal species, provide flood, erosion, sediment control, and function in nutrient cycling. In addition, these areas contain some of the most productive forest land in the United States and provide the forest products industry with several of the most economically important tree species (Kellison and Young 1997).

The vast complexity of site-species interactions in riparian forests makes the management of these forests difficult (Hodges 1997, Meadows and Stanturf 1997). As a result, the regeneration of many of these forests can be problematic. Likewise, past exploitive management practices employed in many of these areas have resulted in undesirable stand conditions (Meadows and Hodges 1997). Because of the diversity of benefits these systems provide, restoration or maintenance of riparian ecosystem health is of great importance.

To achieve a favorable species composition and structure in bottomland stands, the shelterwood system followed by appropriate intermediate stand treatments has been recommended to enhance seedling reproduction (Hodges and Janzen 1987, Loftis 1990, Meadows and Stanturf 1997). Treatments involving stand disturbance such as fire or soil scarification have been suggested as supplemental treatments to increase the establishment of oak reproduction (Scholtz 1959, Crow 1988, Barry and Nix 1993).

The principle behind soil scarification is that it improves germination and seedling establishment by incorporating acorns into the upper soil horizon(s). Studies have suggested that buried acorns are less susceptible to predation and have higher germination rates than acorns located on the soil surface (Griffen 1971, Janzen 1971, Auchmoody and others 1994, Nilsson and others 1996, Guo and others 1999). Soil scarification may also be useful in controlling competing understory vegetation, which may play a role in seedling development.

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Soil scarification has been tested, with favorable results, in both upland and bottomland oak forests under a variety of stand conditions and involving a diversity of species (Scholtz 1959, Zaczek and others 1997, Lhotka and Zaczek 2002). These studies suggest that soil scarification can enhance the initial establishment of oak seedlings in riparian forests. This paper highlights the effects of two recent scarification studies on the development of oak reproduction and their implications for riparian forest management.

ONGOING STUDIES

A soil scarification treatment was applied in 1993 on a poorly regenerating upland fenced shelterwood dominated by red maple seedlings and relatively few small oaks in central Pennsylvania. Results suggest that soil scarification in the presence of abundant viable acorns can increase the initial establishment and competitive position of oak and that the advantage is apparent through year 5 (Zaczek and others 1997). This upland study used a 78-hp crawler tractor with a 1.8-m wide brushrake to perform the scarification in autumn after mast dissemination.

One year after scarification, 32,618 oak seedlings ha^{-1} (78 percent of total seedlings) were found in the scarified plots while only 9,435 oak seedlings ha^{-1} were located in the control. The shelterwood overstory and fence was removed at year 3. Five years after treatment, a greater number of oaks (39,432 seedlings ha^{-1}) were still found in the scarified plots when compared to the control (12,971 seedlings ha^{-1}). Additionally, scarified areas had more oaks that tended to be in larger size classes compared to other species including red maple.

A second scarification study was conducted in the fall of 1999 mixed-oak bottomland forest in southern Illinois (Lhotka and Zaczek 2002). Primary oak species in the overstory were cherrybark oak (*Quercus pagoda* Raf.) and post oak (*Quercus stellata* Wangenh.). The understory had scant tree regeneration and was dominated by poison ivy (*Toxicodendron radicans* L.). A 42-hp wheeled tractor and 2.44-m wide field disk was used to complete the soil scarification treatment. One year after scarification, scarified plots had a greater density of oak seedlings (7,243 seedlings ha^{-1}, 42 percent of total seedlings) than did control plots (453 seedlings ha^{-1}, 9 percent of total). At the same time, poison ivy cover in the scarified plots (7 percent) was reduced compared to the control (35 percent). Results suggest the use of disk scarification has the potential of increasing the establishment and competitive position of desired oak species in riparian forests.

MANAGEMENT IMPLICATIONS

While soil scarification can increase the initial establishment of desired oak species, operational and biological influences may control the success of an operation. First, abundant viable acorns must be present at the time of scarification, for without the necessary seed, the success of a soil scarification operation can be severely limited. Extremely wet or dry conditions at the time of treatment may also influence the success of the operation. Extremely dry conditions may cause acorns to desiccate and loose their ability to germinate (Olson and Boyce 1971) and the depth of penetration by a disk in dry soils is limited. On the other hand, wet conditions may cause operational problems especially in riparian areas. With the soil excessively wet, scarification should not be implemented as the operation because it may compact soils and may bury acorns too deeply resulting in decreased seedling emergence.

Another important condition influencing a scarification operation is the presence of a dense midstory and understory. Stand density may limit the amount of space that machinery has to maneuver. The small-wheeled tractor with disk, small crawler tractor with brushrake or Salmon blade, and a modified drag-chain scarifier pulled by a small crawler tractor are three methods that may be used for scarification in partial harvests (Karsky 1993, Zaczek and others 1997, Lhotka and Zaczek 2002). These systems have the size and maneuverability to operate in a partially harvested stand without damaging residual trees, but still have sufficient power to complete the operation (Karsky 1993).

The disking and drag-chain method may be preferred in open stands, but the mobility of the equipment may be severely limited in dense stands or stands containing large amounts of downed slash. Therefore, it may be necessary to thin and/or remove slash prior to implementing the disk or drag-chain method. In contrast, the bulldozer/brushrake method has the ability to operate in dense and recently harvested stands, while still providing scarification benefits (Zaczek and others 1997, Zaczek in press). Damage to residual crop trees is possible so careful operation of equipment is necessary. For these reasons, it is important to consider stand conditions prior to planning a scarification operation.

Precision application of disturbance is another benefit that scarification can provide. Other oak regeneration enhancement treatments such as prescribed fire may be difficult or impractical to apply precisely in small or irregular-shaped patches and exclusion from sensitive areas may be problematic. With the ability to pinpoint treated areas, a manager could scarify poorly regenerating areas, while avoiding streamside buffer zones, temporal ponds, or other unique habitats. This flexibility makes the treatment useful with the complex variability in site conditions that occurs in riparian forests (Hodges 1997).

Soil scarification may enhance the establishment phase of a regeneration system, but this silvicultural treatment alone may not create appropriate growth conditions for the development of large, vigorous seedlings. Without the necessary cultural conditions in place, the continued growth and survival of seedlings produced after scarification may be limited. Therefore, it is recommended that soil scarification operations be implemented into a silvicultural system, such as a shelterwood, that provides the appropriate environmental conditions for the development of vigorous advance reproduction of oak.

CONCLUSION

Shallow soil scarification has been shown to enhance the density and competitive position of oak reproduction when applied during the fall after mast dissemination. It is cautioned that scarification should not be used during extremely wet conditions, on steep highly erodable slopes, or in sensitive habitats. Finally, soil scarification should be conducted along with a cutting prescription that promotes the development of advanced oak reproduction for without appropriate understory conditions seedling survival and growth may be limited.

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