Soil Scarification to Enhance Oak Seedling Establishment

by John M. Lhotka and Jeff Stringer

What is Soil Scarification?

Oak species play important economic and ecological roles in Kentucky's forests. Acorns provided by oak trees are important food sources for game and non-game animal species. However, acorn production and germination are needed to establish new oak seedlings. These new oak seedlings are important, because they are necessary for the regeneration of oak forests. One challenge to establishing new oak seedlings is the high year-to-year change in the number of acorns produced by oak trees. In years when acorn crops are small, almost all the acorns are eaten by animals or destroyed by insects and few acorns are left to germinate into seedlings. Large crops are needed to establish oak seedlings, allowing the oaks to win the battle versus the critters that feed on acorns.

To increase oak seedling numbers in a forest and improve chances for successful oak regeneration, researchers have looked for methods that increase acorn germination rates. Soil scarification, the mixing of acorns into the upper layers of soil, has been one method tested to help increase the number of oak seedlings that establish following a large acorn crop. Soil scarification is accomplished with the use of mechanized equipment to create a shallow soil disturbance in desired areas that mixes acorns into the soil. It also provides control of small trees and other plants that could compete with the newly established oak seedlings. Studies on scarification suggest the mixing or burying of the acorns in the soil reduces the acorns that are eaten or killed by excessive drying or cold temperature compared to acorns located on the soil surface. Soil scarification has been completed using equipment such a root rake on a bulldozer or a farm tractor and disk.

Does Soil Scarification Enhance Oak Seedling Establishment?

The short answer to the question is yes. Soil scarification and its influence on oak seedling establishment has been studied in a number of locations and conditions, including an upland oak forest in central Pennsylvania, upland oak forests in southern Illinois and Indiana, two bottomland stands in southern Illinois, and in upland stands in Eastern Kentucky. In each of these research trials, soil scarification, regardless of the machinery used and oak species involved, resulted in more newly established oak seedlings compared to areas where no scarification was used.

Photo courtesy: Chris Osborne

To highlight the patterns seen in these soil scarification studies, we present the findings of the most recent study, which was completed by the authors on the University of Kentucky Robinson Forest. The Robinson Forest study was established in five upland oak sites ranging from 0 to 40 percent slope. Within each site containing scattered northern red oak trees, paired experimental areas were established; one that was scarified and the other was not. Treatment was completed in November 2011 after the fall of a bumper crop of acorns. Scarification was implemented using a single pass of an 80hp John Deere 550G bulldozer with a mounted 8-foot wide, seven tine root rake. The operator followed winding paths through the stands, ensuring that the tines of the root rake were kept approximately 4 to 6 inches deep. The intent was to mix acorns into the top of the soil. The rake was lifted periodically to avoid rocks and stumps or to dislodge accumulated woody debris from the rake.

Photo courtesy: John Lhotka

Bulldozers equipped with a tine root rake can be used in soil scarification practices. One advantage that bulldozers have over farm tractors is that they can be used on steeper terrain.

After one growing season following the soil scarification treatment (fall 2012), more newly established oak seedlings grew within the scarified areas than the non-scarified areas. In the scarified areas 2,806 new oak seedlings per acre were established. These seedlings, along with the 1,915 small oak seedlings per acre that were there prior to the treatment, resulted in a total of 4,721 oak seedlings per acre one year following soil scarification. In the same time period, a loss of 702 oak seedlings per acre occurred in the non-scarified areas. When comparing the findings of this study conducted in Eastern Kentucky to those completed elsewhere, the 2,806 oak seedlings per acre gained one year after the scarification is similar to the results found in other studies where soil scarification resulted in 3 to 16 fold increases in oak seedlings (Table 1).

Implementing a Soil-Scarification Treatment

Research indicates that soil scarification can be used on a wide range of upland oak species, including northern red oak, white oak, black oak and those oak species that occur with them. Research also indicates that this technique can work over a range of soil and topographic positions as long as the equipment can operate safely. Soil scarification has been shown to increase the establishment of oak seedlings however operational and biological factors control the success of a scarification treatment. The following are the steps and details involved in helping ensure successful establishment of oak seedlings through soil scarification.

1) **Acorn Presence** - First, a large acorn crop must be present. While no recommendation on acorn numbers is available, it is important to know the acorn crop is larger than average. This requires a little knowledge of acorn production and commonsense observations of the number of acorns on the trees in late summer and fall.
2) **Timing** - Timing of soil scarification is also crucial. It is recommended that areas be scarified in the autumn following acorn drop, but before leaf fall. This timing allows the leaves to cover the scarified soil, providing protection for the acorns that are buried or partially buried. Extremely dry or wet conditions at the time of treatment also may influence its success. Extremely dry conditions may cause acorns to

Photo courtesy: Chris Osborne

Oak acorns that are on top of the leaf litter are subject to drying out and predation from insects and animals before they have the opportunity to germinate into oak seedlings.

Study	Site	Scarification Equipment	Oak Seedling Density	
			Non-scarified	Scarified
Zaczek 2002	Pennsylvania, upland oak	Bulldozer/Root rake	1,002	11,596
Lhotka and Zaczek 2003a	Illinois, upland oak	Bulldozer/Root rake	515	2,272
Lhotka and Zaczek 2003b	Illinois, bottomland oak	Farm Tractor/Disk	183	2,931
Rathfon, et al.2008	Indiana, upland oak	Farm Tractor/Disk	3,397	9,300
Parrott, et al. 2013	Kentucky, upland oak	Bulldozer/Root rake	1,592	4,721

Table 1. Comparison of oak seedling densities (number per acre) following one growing season between areas receiving soil scarification and non-scarified reference areas by research study, location, and scarification equipment type.

dry out and fail to germinate. On the other hand, doing soil scarification when conditions are too wet may compact or displace soils and may bury acorns too deeply.

3) **Equipment** - A variety of equipment including small farm tractors pulling disks and dozers with root rakes have been used for soil scarification. These equipment types have the size and maneuverability to operate in forests without damaging large trees, but still have sufficient power to complete the operation. Selection of appropriate equipment must balance traction, soil scarification, maneuverability, and safety. The farm tractor with disk method may be preferred in open stands on flat ground, but the mobility of the equipment may be limited in dense forests or those containing large amounts of deadwood. In contrast, the bulldozer and root rake method has the ability to operate in dense and recently harvested stands, while still providing scarification benefits. Also bulldozer and root rake scarification can operate on steeper slopes than farm tractors; work in Kentucky suggests that the bulldozer method can be effective on slopes up to 40 percent.
4) **Scarification Pattern** - Scarification of every square foot is not necessary, and scarifying multiple paths through stands is adequate. Equipment cannot easily access certain areas, and other areas do not contain acorns or oak trees. This treatment can also be used to target areas in and around a cluster of oak trees while leaving the rest of the stand unscarified.
5) **Technique** - Typically scarification should disturb the upper 4 inches of leaf litter and soil which is easy to achieve with a farm tractor and disk. Operators of bulldozers must be careful not to dig too deeply. Also bulldozer root rakes can accumulate large amounts of dead branches and rocks and the operator must clear these periodically.

Follow-up Treatments – While the scarification will increase the number of oak seedlings it is important to ensure that the right conditions are present to grow the seedlings. The most important of these conditions is light. Therefore, we stress that you consider a treatment to provide forest light conditions known to increase the survival and growth of newly established oak seedlings. Typically this is done with what is called a mid-story removal, refer to the article entitled "Using Midstory Removal to Enhance Oak Development" in the December 2012 issue of the Kentucky Woodlands Magazine, www2.ca.uky.edu/KYWoodlandsmagazine/Vol7_No2/Research_Brief-pg16_17.pdf for more information and ask your forester about these practices.

Soil scarification can enhance oak seedling establishment following a large acorn crop and can serve

Photo courtesy: John Lhotka

Farm tractors with disks work well on areas that are not too steep and are relatively open. Caution should be used as the slope of the area increases.

Photo courtesy: Chris Osborne

When using a bulldozer and a root rake it is important to not go too deeply. Operators should aim for disturbing the top four inches of leaf litter and soil.

Photo courtesy: Chris Osborne

Depending on the area being treated bulldozers using a root rake can accumulate a large amount of dead woody material that will require occasional clearing.

Photos courtesy: Chris Osborne

This series of images shows how soil scarification can be an effective management practice in the establishment of large numbers of oak seedlings. The top image shows the scarified path created by a bulldozer using a root rake. The middle images shows the increased contact the acorns have with the soil following scarification. The bottom image shows how competing vegetation is reduced and oak seedling establishment is greatly enhanced within the scarified path.

Photo courtesy: John Lhotka

as an important tool in the "toolbox" of woodland owners. This tool is one that is particularly helpful where oak regeneration is currently lacking. Contact your local forester for assistance in scoping your property for the applicability of a soil scarification treatment.

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