Soil Scarification for Upland Oaks

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Practice Objective and Description

Soil scarification is a silvicultural practice applied in stand that lacks sufficient density of oak advance reproduction and where the lack of oak seedling establishment is, in part, attributed to thick litter layers. The practice involves the use of mechanized equipment to create a shallow soil disturbance that incorporates acorns into the upper soil horizons to increase acorn germination. This practice is thought to decrease predation and desiccation of acorns by protecting them within the soil and under the leaf litter. Soil scarification has also been shown to decrease competition from understory plants and reduce midstory tree density, the latter aiding in improving light conditions to encourage oak seedling development.

When to Apply

The practice requires the following conditions:

- Stands that can be regenerated in the next 5 to 15 years
- Stands dominated by, or having a presence of, acorn-producing oaks of the appropriate species
- Presence of abundant viable acorns in the forest floor at the time of treatment
- Topography and site conditions that allow for the use of tractors or bulldozers to navigate the stand
- Stands that have sufficient light conditions at the forest floor for oak seedling development. The latter can occur naturally or can be generated with a mid-story removal or similar treatments aimed at increasing diffuse light without increasing the light enough to encourage shade-intolerant competitors.

The abundance of acorns sufficient for this practice generally occurs during "bumper crop" years. The artificial seeding of acorns can be accomplished, however there is a risk of predation of the added acorns if little naturally occurring hard mast is available.

Other potential practices for supplementing oak seedling density include underplanting and prescribed fire. Precision application of disturbance is a benefit that soil scarification can provide. In contrast, other oak regeneration enhancement treatments (e.g., prescribed fire) may be difficult or impractical to apply in small or irregular-shaped patches, and exclusion from sensitive areas may be problematic. The ability to pinpoint treated areas allows the treatment to occur under scattered oak trees in a mixed species stand and scarify poorly regenerating areas, while avoiding streamside buffer zones, temporal ponds, or other unique habitats.

Common Examples of Where the Practice is Applied

The primary application of soil scarification would be in mature stands where regeneration practices are planned but density of advance oak reproduction is insufficient. Soil scarification has been effective across a wide geographic range within the Central Hardwood Forest Region and in stands dominated by an array of upland oak species including white oak (*Quercus alba L.*) and northern red oak (*Quercus rubra L.*). Flat to gently sloping topography provides ideal operational conditions for soil scarification equipment. However, bulldozers and brush rakes can be used to implement practices with steep terrain, within safe operating limits.

Examples of Conditions or Situations that Limit Effectiveness

While the practice can be used over a range of sites, it should not be used

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where:

- extremely steep slopes limit safe equipment operations,
- significant large surface rock or woody debris prevents efficient disk or brush blade use,
- viable acorn production is limited,
- forest floor light regimes are not adequate or cannot be increased to facilitate oak seedling growth.

Post-implementation Conditions

The treatment should disrupt the forest floor litter layers and result in a higher number of acorns embedded and buried within upper soil horizons to increase the probability of successful germination and seedling establishment. After treatment, there should be readily apparent scarified lanes where the top soil, duff layer, and acorns are mixed into the litter layer or upper mineral soil horizon with a goal depth for acorn incorporation of approximately 1 to 3 inches.

Practice Use Within a Silvicultural Framework

Soil scarification is a mechanical site preparation treatment. Typically, it is associated with the shelterwood regeneration methods. It can be performed prior to shelterwood implementation and following preparatory cut and/or establishment cut phases of a shelterwood. The practice may be required 5 to 15 years prior to an overstory removal to ensure adequate oak advance regeneration development (11) (12).

Data and Observations

The following questions (and associated data) are relevant to evaluating the use of soil scarification for oak regeneration:

- Are oak regeneration densities currently sufficient in the stand? If so, soil scarification may not be needed.
- Are abundant, viable acorns present in the stand? Soil scarification has been effective in years with above average acorn production but most successfully applied in “bumper crop” acorn years. Binocular survey of oak crowns in the late summer or early fall can give an indication of the year’s potential acorn crop (9) (2).
- Do current stand conditions (density of understory/midstory trees, amount of slash and downed woody debris) or topographical characteristics alter the feasibility of scarification equipment type? (see discussion below)
- Are current understory environmental conditions conducive to the growth and survival of newly established oak reproduction? In stands with dense midstory canopies and low understory light availability, soil scarification should coincide with stand manipulations such as a shelterwood preparatory cut (midstory removal) or establishment cut.

Planning and Marking

Areas to be scarified are opportunistic based on where acorn abundance occurs. It may be appropriate across an entire stand, in sections, or potentially under individual trees or small groups of them. Because of this variability, there is no set method of marking. In most cases, the area to be scarified is delineated and adequate instructions are provided to operators to ensure effective equipment oper-

Figure 1. Brushrake scarification conducted in a mature upland oak stand.

Figure 2. Disk scarification operation in a bottomland oak stand.

Figure 3. Forest floor disturbance created by scarification (A) seedbed conditions immediately following brushrake operation, (B) reduction of competing vegetation within disked transect - one year after treatment.

ation. Scarification paths or lanes can also be designated, typically with degradable flagging, and the operator follows the flagging to establish lanes. These can be straight, but typically meander through the stand, avoiding large trees and other obstructions while maximizing the treatment of areas where acorns are prevalent.

Implementation, Timing, and Other Considerations
Operational and biological influences may control the success of a soil scarification operation.

<u>Presence of Acorns and Timing</u>
First, abundant viable acorns must be present at the time of treatment, for without the necessary seed, a soil scarification operation will only serve to disrupt the existing vegetation and fail to develop new oak germinants. Thus, sampling for viable acorns by float testing and/or cutting open a sample of fallen acorns after most have hit the ground to check for rampant acorn weevil (*Curculio spp.*) damage is important to estimate the viability of the acorn crop. Weevil infestation rates can be higher in acorns that drop earlier than ones that fall later (7). Timing of scarification operation is also crucial. It is recommended that areas be scarified in the autumn of an abundant mast year following drop of the vast majority of acorns, but just before leaf fall. This is important, because it is suggested that the litter accumulation after leaf fall may provide additional protection against acorn predation (1). Additionally, scarification should be implemented soon after majority acorn drop to limit acorn predation from animals such as white-tailed deer, which can rapidly deplete fallen mast.

<u>Equipment and Site Conditions</u>
A wide array of power sources and implements have been used for scarification in forest operations. Selection of an appropriate system must balance traction, soil scarification, and maneuverability. An important factor influencing a scarification operation is the presence of a dense midstory and/understory. Density is important, because it may hamper machinery maneuverability. The small-wheeled tractor with disk, small crawler tractor or bulldozer with brush rake 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 (3) (10) (4) (6). 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 (3). 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 those containing large amounts of 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 and brush rake method has the ability to operate in dense and recently harvested stands, while still providing scarification benefits (10) (5) (6). Damage to residual crop trees is possible so careful operation of equipment is necessary. The intent of a bulldozer and brush rake soil scarification treatment is to incorporate acorns into the mineral soil by shallowly inserting (approximately 2-4 inches deep) the rake tines into the upper soil horizons while the machine is moving forward. The rake must be lifted periodically to avoid rocks and stumps or to dislodge accumulated woody debris from the rake.

Site Considerations
Scarification can be used in any oak stand assuming that the topography and stand conditions allow for equipment access and safe operation. Obviously, excessive slope percent above what can be safely navigated with tractors or conditions that make it dangerous for bulldozers to work are not suitable. Significant woody debris or large rocks can also cause the practice to be difficult to implement. However, a study conducted in the Northern Cumberland Plateau within stands possessing steep topography found that the range of slope steepness observed (0 to 49% slope) and the presence of small rocks did not prevent use or appear to limit efficacy of the bulldozer and root rake scarification treatment (8).

Barriers to Success
Soil scarification may increase initial establishment, but this silvicultural treatment alone may not create appropriate conditions for the development of large, vigorous oak seedlings. Without the necessary environmental conditions in place, continued growth and survival of scarification produced seedlings may be limited. Many factors can influence further development of understory reproduction. A well-developed midstory and associated low light levels will greatly hinder the development of oak seedlings. The intolerant to mid-tolerant oak species are especially harmed and cannot survive over a long period in low light levels. Competing vegetation, deer browse, insects, disease, and other environmental variables may also add to seedling mortality. It has been suggested that a manipulation of the midstory or overstory may help alleviate some of the problems created by low light levels. Without release, seedling survival will be limited. This resulting mortality may leave the stand in a condition similar to that which is present prior to the scarification treatment. Silvicultural practices such as an oak shelterwood should be applied prior to or in concurrence with scarification to help enhance the survival, growth, and development of newly established oak seedlings.

Soil scarification may provide some control of competing midstory and understory vegetation (4) (5). However, scarification may also promote sprout development and therefore the response of competing vegetation should be evaluated prior to scarification.

Conducting soil scarification in years when a bumper crop is expected will yield the best results. It can also be used in oak stands with limited natural acorn production or in mixed hardwood stands where little oak is present. In the latter two cases, additional acorns will need to be scattered on the site and scarified directly prior to leaf fall. It is difficult to collect and scatter enough acorns to match the number of naturally produced acorns present across a stand during an abundant seed year. A practical solution to this problem is to focus acorn scattering and soil scarification in transects or small patches and to target this effort in poorly regenerating areas of a stand. This approach increases the likelihood that oak seedlings become established where they are most needed and ensures that acorn collection and scarification efforts are utilized effectively.

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 fail to germinate and the depth of penetration by a disk in dry soils is limited. On the other hand, scarification may compact or displace wet soils and may bury acorns too deeply, resulting in decreased seedling emergence.

Monitoring

Measures
Fixed-radius regeneration survey plots are needed to determine the effect of soil scarification on the density of oak reproduction and that of competitor species.

When to Monitor
Pre- and post-treatment surveys are recommended and best practice would be to utilize the same sample points at both survey periods. The effect of soil scarification on seeding densities can be determined at the end of the first growing season after treatment.

Costs
The cost of a soil scarification treatment depends on the type of scarification equipment utilized (see above discussion), the size of the stand area (or portion of the stand area) to be treated, and stand conditions that influence the productivity rate of machine work including the amount of downed debris, understory/midstory tree density, and the slope steepness. An important cost consideration is that the entire stand does not have to be treated. Typically, soil scarification is completed on only a portion of a stand and done in treatment transects within areas that are lacking desirable oak seedling densities and where acorn producing trees are present. Ultimately, the cost would be dependent on the amount of machine time needed and the equipment and labor cost of the given machine type (i.e., bulldozer and brush rake or tractor and disk methods) selected.

White Oak
Species within the white oak group exhibit radicle (root) emergence in the fall. It is recommended that soil scarification be promptly implemented following drop of the vast majority of acorns, but just before leaf fall in order to enhance treatment effectiveness and avoid potential damage to the emerging radicles. Soil scarification research has shown the treatment to be similarly effective for species in the white oak and red oak groups.

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NRCS Conservation Practices

- Core Conservation Practice: Site Prep (Code 490)
- Supporting Conservation Practice: Herbaceous Weed Control (Code 315)

"Caring for Your White Oak Woods" USDA Natural Resources Conservation Service, 2p.

The selection of prescriptions included in the Upland Oak and White Oak Silviculture Practice Series were established through consultation with silviculture researchers and state forestry management personnel across the region. The peer reviewed individual silvicultural prescriptions were authored by research silviculturists with significant experience in oak management. This series was designed to provide silvicultural guidelines that be used by practitioners and managers along with their knowledge and familiarity with local stand conditions, markets, and contractor expertise to make decision enhancing regeneration, recruitment, and growth and development of upland oaks with a special emphasis on white oak. Other publications in the Series and information on white oak sustainability can be obtained at www.ukforestry.org and www.whiteoakinitiative.org.

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