UPLAND OAK AND WHITE OAK SILVICULTURE PRACTICES SERIES FOR-164

Site Preparation for Regeneration of Upland Oaks

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Practice Objective and Description

The practice is designed to aid the growth of a developing age class resulting from a regeneration harvest (cut). Specifically, site preparation includes removal of residual unwanted trees, left after a harvest that are present in sufficient density to reduce the growth of the new regenerating age class. Typically, this practice is completed in conjunction with a regeneration cut directly before, during, or after the harvest. There are several methodologies for conducting a site preparation treatment. For naturally regenerating hardwoods the practice is typically completed through individual tree treatment of overtopping residuals either through mechanical or chemical treatments or a combination (2). Chemical treatments are the most common and effective. As the amount of residuals present after a harvest varies widely depending upon the characteristics of the timber, local markets, and the type of harvest, cost varies widely as well. Prescribed fire is an option under some stand conditions and regeneration methods (17). A number of elements of this practice can also be applied to a liberation treatment, which is functionally a site preparation treatment delayed for a number of years after the cut.

When to Apply

Site preparation is most advantageous when the post-harvest residual basal area of unwanted trees will impact the height growth of oak reproduction in the newly developing age class. The need for and intensity of this practice varies significantly based on a number of factors. One of the most important is a local market for small diameter material. There is an inverse relationship between market strength for smaller diameter material and the density of unwanted residual stems. As markets decrease, unwanted residuals increase. When there are strong markets for hardwood pulpwood or other markets for small diameter hardwoods, there may be regeneration harvests where little unwanted residual basal is left and site preparation is not warranted. When markets for small diameter material are wanting and merchantable minimum diameters increase, there can be a substantial basal area of unwanted residuals that can create problems for the development of a regenerating age class (Figure 1). While there is a focus on the retention of small diameter trees, there can also be unwanted sawtimber-sized residuals that need to be removed as well. As was the case with small diameter trees, this retention is often based on characteristics of local markets.

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FORESTRY AND NATURAL RESOURCES - EXTENSION

Figure 1. (A) Strong markets for sawtimber and pulpwood leaving few residuals in a patch clearcut where no site preparation treatment is needed. (B) Residuals left after a group opening regeneration harvest of sawtimber-sized trees resulting in a significant amount of unwanted residual stems that have been treated as part of a site preparation treatment.

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Common Examples of Where the Practice is Applied
This practice is often required in association with a regeneration harvest conducted in a sawtimber-sized mixed upland hardwood stand with a significant mid-story of shade tolerant oak competitors. These mid-story trees, if retained, can overtop the regenerating age class to the extent that it reduces height growth of the oak reproduction (5) (20).

An important part of oak management focuses on controlling light regimes to aid in the growth of newly established oak seedlings into larger advance reproduction, i.e. large seedlings and saplings (5). The shade from the mid-story can negatively impact this from occurring in undisturbed stands and likewise this mid-story, if retained after a harvest, can impact the growth and develop of oak reproduction in the regenerating age class. There are instances, as mentioned in the previous section, where unwanted residual sawtimber-sized trees may also be retained and need to be addressed along with the smaller mid-story.

The practice is often required after regeneration cuts such as group openings (6), clearcuts (patch or larger), and two-age deferment cuts (21) when substantial mid-stories are not removed during the harvest. The practice is also commonly used in association with a shelterwood establishment cut where approximately 50% of the overstory is removed to provide increased light to the emerging oak reproduction (18). If a robust mid-story is not removed in the establishment cut, a site preparation treatment is required to eliminate it to ensure that the regenerating age class is receiving the appropriate amount of light.

It may also be appropriate to plan for the removal of invasive and/or exotic plants during a site preparation treatment. Even if these trees don't necessarily impact the regenerating age class directly after a harvest, it might be prudent to treat them at this time to support overall forest management goals.

Examples of Conditions or Situations that Limit Effectiveness
The practice is not required when the post-harvest density of unwanted residual trees will not negatively impact the regenerating age class, or in the case of oaks including white oak, will not negatively impact their growth and development. This condition may exist because there was an absence of the mid-story in the stand before harvesting or it was removed during harvest. The former may be a result of the natural stand structure, a consequence of a previous mid-story removal treatment, or other disturbance such as repeated severe fires or grazing that have eliminated the mid-story. There may also be instances where the oak regeneration potential is low and a limited number of oak seedlings of sufficient size are present (16) or oak reproduction has not survived a harvest (19). If either is the case, then use of a site preparation treatment should be critically evaluated.

Post-implementation Conditions
To maintain maximum regeneration height growth for regeneration treatments the density of residual live trees should be below the basal area per acre that would negatively impact regeneration height growth. This density will vary depending upon the regeneration harvest used (shelterwood establishment cut, two-age deferment harvest, clearcut or group opening). The appropriate maximum residual basal area may also be influenced by residual DBH and species and the productivity of the site. (See Implementation Procedures and Timing Section for guidelines associated with maximum residual basal areas.) Regardless, in harvested areas after the site preparation treatment, there should be only a few overtopped or intermediate crown class living trees present. Standing dead trees are not problematic.

Practice Use Within a Silvicultural Framework
This practice is used in association with a regeneration harvest, typically completed at the end of a sawtimber rotation. It can be completed directly before, during or after the harvest, but in all cases it is associated with a regeneration harvest. For practical purposes, site preparation can also encompass liberation treatments that may occur a number of years after the harvest but still aligned with and implemented to deal with the results of a regeneration harvest.

Data and Observations
Pre-harvest Planning
Determination of the need for a site preparation treatment can be made pre-harvest if both diameter limits for local markets are known and if a minimum tree diameter has been established for the treatment. For example, if a minimum harvest DBH is 10 inches and a decision has been made to treat trees over 1-inch in diameter then it can be assumed that trees between 1 and 10 inches DBH will need to be treated. After determining these two parameters pre-harvest prism plots can be used to determine the potential residual basal area per acre of unwanted trees, which are typically overtopped and intermediate crown class trees, and in some cases unmerchantable sawtimber-sized trees that will not be removed during a harvest. Collecting this data will indicate if a site preparation will potentially be needed or not, and if so, what basal area will need to be removed.

There is no rule for determining the minimum size of tree to be treated. Often a 1-inch DBH is prescribed. However, there is no data supporting this, and the smallest tree to be treated can be determined based on stand conditions, prescription experience, and costs. Obviously, the smaller the DBH being treated, the greater positive impact to the growth and development of preferred reproduction (7) (8), however, the higher the cost.

A 5-factor prism is recommended for use in point sampling, as the majority of the non-commercial trees retained after a harvest will be saplings and poles with smaller diameters. The 5-factor prism increases the number of these trees that will be detected using a prism plot. Determining the number and distribution of points should be the same as that used for other point-tallying needs, with points distributed to encompass the variation present and generate an acceptable degree of variance.

Post-treatment Data

Two determinations can be made with observations, or data collected, within a year after implementation. This includes determining 1) if the appropriate percentage of trees were treated, and 2) treatment effectiveness. To determine either, observation can be used to determine a percentage of trees treated and/or killed or point sampling, using a 5-factor prism as discussed for pre-treatment measures, can be used to provide basal area per acre data. To determine implementation thoroughness, observations or data can be taken directly after treatment installation. To determine treatment efficacy, observations or data collection need to be delayed until the effects of the treatment are clearly presented. The timing of the presentation of symptoms can vary significantly for chemical treatments, depending upon the chemical used and the time of the year when treated. For example, if an imazapyr-based herbicide is used, defoliation of treated trees may not occur until after leaf-out the year after treatment. For most situations, treatment implementation rates should be > 95%, and effectiveness should be expected to be > 80% to 85% (15). However, local experience with treated species and the herbicide and technique used is needed to establish appropriate targets for implementation and effectiveness.

Implementation, Timing, and Other Considerations

Residual Basal Area Targets

One of the important factors associated with this practice is to determine if a treatment will be needed or not. There is a point where the basal area of residual trees will not functionally impact the regenerating age class. Because of this, it is useful to establish a residual maximum target basal area. However, there is no universal target or rule for establishing it, and local knowledge is an option for establishing this target. Data from the Ozarks indicate that oak reproductive height growth is noticeably impacted as stand basal area is equal to or exceeds 20-40 ft^2 ba a^{-1} (3). See White Oak Section for specifics. Based on this and similar evidence, keeping a residual basal area per acre below 20 ft^2 ba a^{-1} would be reasonable for regeneration treatments designed to evoke maximum height growth. This basal area target ensures that there will be limited interference with the height growth development of the regenerating age class. For shelterwood establishment cuts, this target may need to be adjusted and in some cases all residual mid-story trees treated to provide the specific amount of light that the cut is designed to provide to regenerating oaks. One factor that may influence the 20 ft^2 ba a^{-1} maximum retention density is the presence of residual overtopped or intermediate white oaks. A determination may need to be made on whether to increase the maximum residual basal area to allow these trees to stand or whether they need to be treated. In the latter case, if they are a preferred oak species, this could mean cutting them and allowing them to sprout versus treating them with herbicides. The decision on how to treat these trees then depends upon their sprouting potential and, if left standing, their potential to respond positively after the harvest. (See White Oak Section for details.) Landowner objectives may also come into play. An example would be an interest in maintaining the production of acorns for wildlife food.

Marking

In most instances, marking trees to be treated is not warranted. Typically, a prescription establishes the minimum diameter of trees to be treated, how to handle special situations such as how to deal with residual oak species, and specifics associated with the type of treatment used. For chemical treatments, specifics might include the herbicide used, application technique, and issues associated with the site and/or environment. In some cases, there may be a need to mark trees not to be treated, for example white oaks or other trees that need to be retained to meet management objectives.

Treatment Type

Generally, individual tree treatments are the most commonly prescribed site preparation treatments for upland oak stands. Individual tree chemical treatments including hack and squirt, cut stump, and basal bark are the most common (4) (12) (13) (14). However, other treatments such as girdling and frilling are also possible with or without herbicides. However, the use of herbicides is generally preferred for treating unwanted species, so their sprouts do not interfere with the reproductive development of the preferred species. There are instances when preferred species, such as white oak, may be present as small diameter residuals. In this case, cutting them and allowing them to sprout to become a component of the regenerating age class would be appropriate (see White Oak Section). However, the herbicide used varies depending upon a variety of factors, including species mix being controlled and environmental and safety issues. Herbicides and application types and specifics are exhaustive and more than can be included here (11). Many references on these treatments and local expertise exists to help make decisions on individual herbicide treatments. While not common, mechanical treatments where small non-commercial trees have been removed by harvesting equipment has been attempted and herbicide applied to cut stumps or stumble (15).

Timing
Site preparation can occur prior to the harvest, during harvesting, or directly after (1,7,8,15). There are pros and cons to each. The efficacy of pre- and post-treatments is similar (1). While these timing options exist, site preparation treatments are typically completed post-harvest. Several factors affect the cost differential of post- or pre-harvest treatment, including the amount and distribution of slash, type of logging equipment used, and topography. The lowest implementation cost is associated with ground skidding operations on gently sloping ground, where a pulpwood or a pulpwood/biomass market exists. This situation reduces overall slash, and the gentle terrain allows the use of unconstructed skid trails and a skidding pattern that impacts a greater percentage of the land area than operations on steeper slopes where skidding is constrained to constructed skid trails. Unconstrained skidding eliminates a greater number of smaller diameter stems resulting in a lower site preparation cost (15). While the treatment is most commonly implemented after the harvest, there may also be opportunities to incorporate the treatment into the harvest. This can be accomplished using sprayer assemblies added to the felling heads of mechanical harvesters, specifically cut-to-length systems with processor heads. A logger can also implement the treatment as a separate operation from the felling operation. Technically, in this case, the site preparation treatment is a separate operation from the harvesting, but functionally, it is the same, because the logger is the contractor for both and they are generally accomplished while the harvest is still operational.

Treatment efficacy can be impacted by the type of herbicide application used and the time of the year completed. For example, hack and squirt, cut stump, and similar treatments involving a cut surface herbicide application have the least efficacy when implemented from late winter to leaf-out. This is due to the higher sap pressure at this time of year that can lead to less herbicide penetrating to the trees' transport tissues. Also, there are specific application windows for different herbicides that can impact effectiveness. The herbicide label provides this information along with recommended rates and application specifics. Adhering to the label is required and can help improve the effectiveness of the treatment.

Site Considerations
This treatment can be used over a wide range of site and topographic conditions. The latter includes all landscape positions found in oak dominated forests. Worker safety may present the most significant issue associated with site consideration. Of particular concern are steep slopes that increase worker hazards. The amount of slash accumulation, its size, and height distribution can also impact worker safety and compound issues associated with steep slopes.

Barriers to Success
Decreased treatment efficacy can be expected when timing and site conditions indicated in the previous section are encountered. Also, if regulations and/or guidelines are not followed for herbicide treatments, their efficacy can decrease. Not completing the treatment within the first year after harvest also can decrease efficacy primarily due to the difficulty in workers navigating the rapid regrowth that can occur after a regeneration harvest.

Monitoring
For individual stem treatments, monitoring can be employed during implementation to ensure that all stems needing treatment are receiving it. Similarly, implementation monitoring should be completed directly after treatment to ensure that any deficiencies in the thoroughness of application can be addressed as quickly as possible. Post-treatment monitoring after the appropriate herbicide activity interval is needed to determine the effectiveness of the herbicide treatment.

Costs
Site preparation prescriptions vary widely based on stand composition, size of tree treated, local markets, landowner objectives, silvicultural prescription, and implementation technique. Unfortunately, because of these variables, the implementation costs vary significantly and providing cost estimates per acre, basal area or number of stems treated is ineffective and potentially misleading. If specific cost data are not available, relative cost differences between treatment conditions can assist in making cost estimates. Studies have been completed to determine the effectiveness (1) (7) (8) and cost (15) of implementing individual tree site preparation treatments pre- and post-harvest as well as accounting for different market conditions and size of stems treated (15). For example, in administering a cut stump treatment the breakdown of cost between chainsaw felling, herbicide application, and herbicide cost was 60%, 29.5%, and 10%, respectively (15). As was the case for efficacy, there is no significant difference in cost between conducting the site preparation treatment pre- and post-harvest (15). However, there can be significant cost differences as local markets change, specifically the presences or absence of a pulpwood market. As would be expected residual basal areas are higher for sawtimber-only harvests (> 10-inch DBH trees harvested) compared to those where pulpwood is also removed (> 4-inch DBH trees harvested). This difference can result in an increase of 50% in site preparation costs for stands where only sawtimber was harvested compared to both sawtimber and pulpwood being removed (15). There also is a significant difference in site preparation costs depending upon the diameter of stems being treated. While treating the smallest sized stems are best for treatment efficacy (7) (8), there is a substantial cost for doing so. For example, studies have found an increase of between 15% and 55% when treating stems < 1-inch DBH to 4.5 feet tall compared to only treating stems > 1-inch DBH (15). There are no published cost estimates for using herbicide-capable cut-to-length harvesting equipment for administering a site preparation treatment. Also, the cost of using mechanized equipment to run over residual stems is relatively cheap. Administering herbicide to the residual stumps or stubble increases the cost above traditional individual tree treatments (15).

White Oak

There are several white oak dependent factors that should be considered for site preparation treatments including

- determining the maximum basal area of post-harvest overtopping residuals that results in minimal impact to oak reproduction in the regenerating age class,
- how to deal with residual overtopped and intermediate crown class white oaks, and
- what is the minimum residual size class that should be treated.

One factor that can impact these decisions is the conservative growth habit of white oak that unfortunately manifests itself in relatively slow height growth compared to some of its competitors. This factor is more pronounced as site index and competitor vigor increases. This becomes a functional disability on intermediate and high quality sites (> 70 to 75 feet upland oak site index) and is exacerbated in the presence of fast growing competitors such as yellow-poplar. This indicates that there may be a functional limit to the maximum site index that white oak can be expected to maintain in the canopy of a regenerating age class, regardless of the application of a site preparation operation. This maximum site index will be influenced by the competitive species present.Regardless, the relatively slow growth of white oak causes difficulty in successfully regenerating the species, and a site preparation treatment can impact the regeneration outcome.

One decision that needs to be made in any site preparation treatment is the minimum size of stem that needs to be treated. This factor may be critical for white oak due to the relative slow height growth of the species. Basically, the smaller size of residual tree that can be treated the better, and there is evidence that even treating competing trees as small as 1-foot creates an advantage for white oak (7) (8). However, there is a cost for treating trees this small, and a balance is required to justify the practice.

A second issue is associated with whether to cut or leave standing residual overtopped or intermediate crown class white oaks. If they are displaying natural apical dominance and a live crown ratio of 40 or greater, there is good chance they will respond to release (10). If their crown is naturally flat-topped and/or sparse, there is a good chance they will not respond to the release provided by the harvest. There also exists guidelines for whether these white oaks will successfully sprout or not. If they are over 65 years old or are over 10-inches DBH, they have significantly reduced sprouting capacity (9). If they meet these requirements, they possess good sprouting capacity, and if cut, the sprouts can contribute stems to the regenerating age class. All these factors should be considered when faced with residual sapling and pole-sized white oaks.

One issue discussed previously concerns what post-harvest residual basal area triggers the need for a treatment. There is also the aligned issue of the residual basal area that can be left after a site preparation treatment without impinging the height growth of white oak reproduction in a regeneration age class. Figure 2 provides some information from the Ozarks indicating that white oak reproduction increases in height growth when stands maintain less than 20 ft^2 ba a^{-1} (3) and continues to increase in response as residual basal area decreases. This provides a guideline that can be used to make several decisions. First, if a harvested area contains less than 20 ft^2 ba a^{-1} of residual stems, one can consider not treating, particularly if resources are not available to conduct the treatment. Second, if resources are available, treating these stands will result in an increase in white oak success and the treatment should be considered.

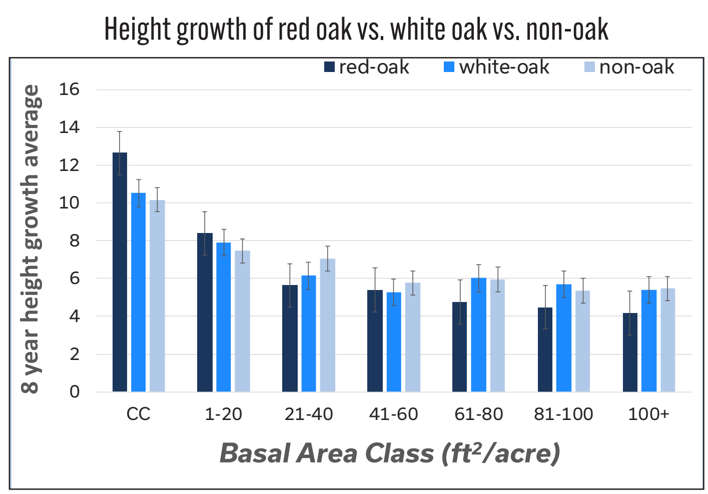

Figure 2. Data from the Missouri Ozark Highlands showing the height growth of white oak understory reproduction in relation to overall stand density.

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NRCS Conservation Practices

Implementing this practice, establishing group openings (gaps), is normally completed during a commercial timber harvest, and NRCS conservation practices would not be used to establish the gaps. However, after gap installation several subsequent practices may be required including:

- Core Conservation Practice: Forest Stand Improvement (Code 666)
- Supporting Conservation Practice: Brush Management (Code 314) and 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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