

Midstory Removal for Upland Oaks

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Practice Objective and Description

Midstory Removal is designed to eliminate all or a majority of intermediate and overtopped crown class trees (i.e., midstory) to increase size (height and ground-line diameter) and survival of oak reproduction (natural or planted seedlings established in advance of a regeneration event), by increasing light availability to the forest floor. This technique is intended to improve light transmittance by deadening or felling intermediate and overtopped crown class trees (Figure 1). Light transmittance within a mature forest with intact midstory is typically ≤10% of full sun conditions and increases to 10% to –20% full sun after midstory removal. Care should be taken to avoid removing trees in intermediate crown classes that would cause gaps in the overstory canopy. Gaps in the overstory will result in increased regeneration potential of competitors. Midstory removal is a suggested step in mature oak stands where a lack of adequate density of competitive advance reproduction yields concern that the overstory of the next rotation may not contain a dominant oak component.

For best results, a cohort of vigorous oak reproduction should be established in the stand prior to midstory removal. Oak seedlings persisting beneath low light conditions for long periods can have low vigor and exhibit poor growth responses upon release. For this reason, when oak seedling densities are low, midstory removal should be performed in the year following an acorn bumper crop and/or after a treatment intended to bolster germination (e.g., soil scarification). Underplanting oak seedlings will also augment regeneration potential in accordance with this treatment. Midstory removal is a technique often performed prior to overstory harvests (i.e., establishment cut) in the chronology of the oak shelterwood regeneration method.

Figure 1. An undisturbed upland white oak dominated stand (a) and the change in stand structure following complete midstory removal (b).

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When to Apply
Midstory removal is implemented in mature oak stands designated for regeneration but containing an insufficient density of competitive advance oak reproduction. This practice requires two conditions to warrant its application:

- The presence of oak advance reproduction, natural or established through the underplanting of seedlings or seed that requires improvement of its vigor (size) prior to a regeneration event.
- A midstory (overtopped and intermediate crown class trees) of significant basal area to limit light penetration to the forest floor.

The stand should contain a significant number of advance reproduction stems that once improved in vigor, (often indicated by a minimum height of 3 to 5 feet), have the ability to yield an appropriate number of dominant or co-dominant stems in a regenerating age class. Quantification of the required number is difficult and depends upon their size and the degree of competition they will face. The latter is often indicated by productivity of the site, and is an indicator of competitive pressure in a regenerating cohort. Small seedlings 0.5 to 3 feet tall may require 1000 or more per acre, while seedlings that are 3 to 5 feet tall (or taller) may only require 300 to 500 per acre.

It is assumed that the lack of vigorous advance reproduction is a result of significant shade that can be alleviated to an adequate degree by removal of the midstory, thus the requirement for its presence to warrant the practice. There could be other reasons for the lack of oak reproduction or the presence of only small oak seedlings including the absence of a viable seed source, inadequate forest floor conditions to promote acorn germination (e.g., very thick litter layers), seed predation, or intensive deer browse. However, in many upland stands the absence of adequate understory light due to a dense midstory is responsible for the lack of competitive oak reproduction.

Common Examples of Where the Practice is Applied
Midstory removal is recommended for mature oak-dominated forests containing a dense midstory and that have poor oak regeneration capacity due to limited large advance oak reproduction and/or stems capable of stump sprouting. Site productivity often plays a role in creating this condition. Low productivity sites (upland oak site index < 60 feet) may often have sufficient oak regeneration capacity due to limited midstory development and natural accumulation of larger advance oak reproduction. As site productivity increases so does the development of the midstory and shade that limits height growth of oak seedlings. Therefore, this practice is most often warranted on medium- and high-productivity sites with a significant midstory and small oak advance reproduction.

Examples of Conditions or Situations that Limit Effectiveness
The lack of naturally developed advance reproduction at the time of treatment, even if there is a potential of a significant acorn crop, can significantly limit the effectiveness of this practice. This practice alone does not increase seedling establishment, it improves the growth of seedlings. Conducting this practice in the hopes of naturally establishing seedlings after completing midstory removal is a significant risk. The practice can encourage the growth of shade tolerant and shade intolerant competitors, and oak seedlings that establish a year or two after practice implementation may suffer due to the increased competition. Underplanting may be attempted at the same time as the midstory removal, however there are risks as planted seedlings are susceptible to transplant shock and predation that may hinder their development, giving competitor species a height growth advantage.

Post-implementation Conditions
A stand would be characterized by the presence of dominant and codominant trees, with all non-oak intermediate and overtopped crown class trees deadened and/or removed with little evidence of root or stump sprouting from the treated trees. This condition typically improves visibility across the stand and an increase in light levels at the forest floor in comparison to the untreated condition. Oak reproduction should be easily seen scattered throughout the stand.

Practice Use Within a Silvicultural Framework
Midstory removal is recommended for mature oak-dominated forests. The treatment can be viewed as an intermediate treatment. However, midstory removal only makes practical sense in combination with an eventual partial or complete removal of the overstory. Therefore, it is more typically considered a part of a regenerate treatment, or a component of one (i.e., shelterwood system).

Data and Observations
The potential efficacy of a midstory removal treatment should be evaluated based upon the following criteria:

- What is the current density and size distribution of advance oak reproduction in the stand? Midstory removal is necessary only for stands lacking large advance oak reproduction. A shelterwood establishment cut or other overstory harvest method may be more effective for stands with well-developed (large) oak reproduction.
- Is there any oak reproduction in the stand? Although midstory removal can increase the survival and growth of established oak seedlings, a site preparation technique to improve acorn germination (e.g., soil scarification or prescribed fire) or underplanting oak seedlings should be performed prior to midstory removal in stands lacking dense oak reproduction.
- What is the site productivity of the stand? Oak reproduction in higher productivity stands will face greater competition and may require further competition control treatments to increase the competitiveness of the oak cohort.

Data collection

The protocol should begin with fixed-area sampling to estimate densities of 1) oak and competitor reproduction and 2) midstory stems. An adequate density of large advance reproduction may reduce the necessity for midstory removal, while the primary occurrence of small oak reproduction yields greater support for the treatment. If the tools are available, estimation of pre-treatment light levels, paired with knowledge of midstory density, can provide insight on potential treatment effects on post-treatment light transmittance and subsequent regeneration.

Planning and Marking

The prescription is designed to deaden and/or remove intermediate and overtopped crown class (midstory) trees. The size, basal area, or number of trees per acre requiring treatment is highly dependent upon stand structure. Midstory could be comprised of predominately overtopped crown class trees, 5 to 20 feet in height, or it could be comprised of 30 to 70 feet tall intermediate crown class trees. Each would have a vastly different range and average diameter at breast height (DBH), therefore providing a universal guideline using DBH or height is not possible. However, for any given stand, these elements can be determined. Also at the stand level, treated tree basal area per acre could be determined and is particularly useful in determining treatment cost estimates for program payments and/or developing an agreement with a contractor. If point sampling with a prism is used for determining basal area, given the relatively small diameter of treated trees, a shift to a lower factor prism (e.g., 5 BAF) than is used for sawtimber sized trees is recommended.

Several approaches can be used to mark or designate how the treatment is to be applied. A knowledgeable operator may be able to work from descriptive treatment guidelines using crown class definitions or a dbh range. Providing a small area (100 feet by 100 feet), where flagging or paint is applied to trees that need to be treated, would be appropriate to ensure that the descriptive guidelines are understood. If midstory trees are abundant, which is usually the case, it is often more cost-effective to mark the overstory trees that are not to be treated rather than marking the midstory trees. The latter can also be done, but marking costs would be above that of the other methods outlined above.

Treatment intensity

Midstory removal intensity could vary to foster light environments for site-specific understory conditions. However, complete removal of the midstory canopy layer (i.e., overtopped and intermediate crown class trees) is generally needed to promote growth and survival of oak reproduction. Typically, diameter and/or height thresholds for determining the minimum size of midstory trees (e.g., ≥ 1 in DBH and ≥ 4.5 feet tall in intermediate and overtopped crown classes) are established above which competition is considered large enough to inhibit oak regeneration. On medium- to high-quality sites (upland oak site index of 65 feet to 75 feet and > 75 feet, respectively), it is important to remove as much of the midstory, including intermediate crown class trees, as possible as these sites generate more leaf area than lower quality sites and thorough removal is important to provide enough light to oak advance regeneration. It is however, important on these sites to not produce canopy gaps that can trigger and sustain the growth of shade intolerant species (ex. yellow-poplar).

Removal method

An array of chemical and mechanical methods (and combination thereof) are available and widely implemented for midstory removal treatments. Hack and squirt and stem injection of herbicide are the most frequently applied chemical methods of deadening midstory trees, while manual felling of midstory stems with brushsaws and chainsaws are common mechanical methods. Both methods exhibit practical concerns. Care should be taken when selecting an herbicide for a chemical treatment. Certain tree species exhibit an amount of tolerance to some herbicides, which would result in variable mortality rates among midstory stems. While mechanical treatments instantaneously remove stems, the smaller stems inherent in midstory size classes demonstrate moderate to high rates of stump sprouting, a vigorous form of advance reproduction which may grow and rapidly outpace the oak seedlings. A cut stump treatment in which herbicide is applied to the stump of a mechanically removed tree appears to offer a good balance of direct removal with reduced stump sprouting.

Implementation, Timing, and Other Considerations

Midstory removal can be completed at any time during the year but may be best performed during the dormant season to maximize light availability to oak seedlings across the entire growing season. Since treatments are typically performed during this period, strong identification skills for undesirable species are required, unless tree marking is used. It should be noted that cut-surface herbicide applications made during periods of heavy sap flow are largely ineffective particularly for diffuse porous trees like maple (*Acer spp.*).

Site Considerations

Research has shown that midstory removal is effective at improving oak regeneration potential in upland and bottomland forests across a range of geographies. This practice can be performed within forests of any aspect and slope, although gentler slopes may improve operational efficiency. On higher productivity sites, a lower intensity midstory removal treatment may reduce competition from shade intolerant species.

Site productivity plays a direct role on stand structure, and higher productivity sites have the potential for denser midstory canopies and lower understory light availability. Medium- to high-quality oak sites also have a larger suite of competitor species and faster tree growth rates that result in more difficulty regenerating oak. Lower quality sites (upland oak site index < 65 feet) generally have fewer competitor species, sparser midstory canopies, and more available understory light.

As a result, advance oak reproduction can naturally accumulate on lower quality sites. These site quality trends mean that midstory removal is commonly necessary on medium- to high-productivity sites to develop competitive advance oak reproduction in sufficient densities.

Barriers to Success

A midstory removal treatment is designed to encourage development of oak reproduction by increasing light transmittance to the understory. While oak seedlings often do respond positively to this treatment, responses to treatments of varying intensity have been reported. Full midstory removal appears to significantly improve both light availability and oak growth over other treatments. However, light environments resulting from midstory removal also augment growth of competitors on medium- and high-productivity sites. Oaks face a two-pronged assault from competitors after midstory removal. Shade tolerant species, such as American beech (*Fagus grandifolia*) and maple, regenerate readily in the low-light conditions beneath the intact midstory. Upon release, these stems can maintain dominant height positions within the regenerating cohort. Reproduction of shade intolerant species are rare within the low-light understory of a mature forest unless they are within the vicinity of a recent or large canopy gap. However, midstory removal treatments can promote regeneration of shade intolerant species, such as yellow-poplar (*Liriodendron tulipfera*), whose rapid height growth can quickly overtop the slower-growing oaks. Since midstory removal is recommended as an initial step in a larger series of silvicultural activities, such as the shelterwood method, release of a cohort dominated by shade intolerant and large shade tolerant competitors via subsequent overstory harvest(s) will result in restriction of oaks to lower crown classes, from which crown ascension is difficult. In stands containing abundant overtopping competitors, competition control treatments should be explored prior to or in occurrence with overstory disturbance to improve oak competitiveness.

Midstory removal can improve a stand's oak regeneration potential only in the presence of an existing cohort of oak seedlings. Stands lacking sufficient density of oak seedlings can be treated with a prior site preparation technique (e.g., soil scarification, prescribed fire) to improve acorn germination toward bolstering oak seedling numbers; however, site conditions may limit the applicability of these treatments. For example, an important caveat on the use of prescribed fire is that a single burn (or series of low intensity burns) could induce more competition by creating a seedbed that promotes the germination of competitor species or by increasing root sprouting of some species topkilled by fire. Underplanting is another option for supplementing density of advance oak reproduction. Although oak seedlings may be present in the understory, seedlings persisting for long periods within low-light conditions can demonstrate low vigor and poor response to release. A sufficient number of young, viable seedlings will likely demonstrate the greatest competitive source for regeneration.

Monitoring

Measures

Regeneration sampling via fixed-area plots are critical for evaluating the relative effects of the treatment on oaks and competitors. Tallying reproduction by species and height will provide a means of evaluating oak competitiveness within the regenerating cohort. While the size and density of oak reproduction needed to successfully regenerate an oak-dominated stand can vary widely, an approximate target might be 300 to 500 oak seedlings per acre that are at least 3 to 5 feet tall.

When to Monitor

Regeneration surveys should be completed prior to and after treatment. Establishing permanent plot centers at which pre- and post-treatment surveys can be implemented will yield the best estimates of reproduction response to treatment. Midstory removal is often a preliminary phase in a larger silvicultural chronology, and the decision of when to proceed with subsequent phases is determined by the relative size and competitiveness of the oak advance reproduction within the cohort. Therefore, post-treatment surveys should be completed every 3 to 5 years to monitor regeneration. Monitoring will also allow for rapid intervention in case of high oak mortality events (e.g., disease, insects, weather) or apparent oak subjugation by competitors that requires further competition control.

Costs

Since midstory removal is a stand-level practice performed manually by a field crew, costs are determined by treatment-specific productivity metrics, including area to be treated, removal method (chemical vs. mechanical) and treatment intensity, midstory basal area to be removed, and crew operational efficiency (e.g., slope and soil conditions affect footing). Choice of removal method also entails separate material costs. Chemical methods may prove more cost-effective than mechanical treatments. A hack-and-squirt chemical removal can be performed with hatchets, spray bottles, and herbicide; stem injection can also be effective for larger midstory trees. Pre-treatment sampling data will identify the species composition and size distribution of the midstory, which can be used in the selection of an appropriate herbicide and application method. Review of herbicide labels is critical in identifying 1) appropriate application settings (e.g., near waterways), 2) species against which an herbicide is effective, 3) maximum areal application rates, 4) application rates for specific treatments, and 5) personal protective equipment (PPE) requirements for application. State and local regulations for herbicide applications should be reviewed prior to treatment implementation to ensure legal compliance. Mechanical removal treatments are often implemented via manual felling of midstory stems with brushsaws/chainsaws but may prove expensive if this equipment is unavailable institutionally and would require purchase. Current local fuel costs should be considered when estimating total treatment costs. Appropriate PPE for this treatment should be acquired.

White Oak
Midstory removal has been used successfully in oak-dominated stands to help enhance pools of competitive white oak advance reproduction. However, a challenge with regenerating white oak is its relatively slow growth compared to other oak species (i.e., red oak group and chestnut oak) as well as common competitor species like yellow-poplar. White oak's slower growth potential can exacerbate oak regeneration issues on medium- to high-quality sites associated with greater densities of faster growing competitor species. As a result, the use of understory competition control treatments in combination with midstory removal may be more warranted when faced with the need to increase the competitiveness of white oak reproduction on medium- to high-quality sites.

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NRCS Conservation Practices
- 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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