

Group Opening (Gap) Harvest for Upland Oaks

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Practice Objective and Description

Creation of canopy openings (i.e., silvicultural gaps), typically < 1.5 acres, where all or the majority of the overstory is removed and removal of midstory is sufficient to allow for the unhindered development of a new age class. These gaps create a range of light availability across the gap, from the edge to the center, and into the adjacent forest area surrounding the gap. These varying light conditions provide opportunities for a range of species to perpetuate based on their shade tolerance and where they occur in the gap. Gap-based regeneration provides a regeneration option for small tracts and/or where ownership is hesitant or resistant to significant harvest disturbance, and for stands where the potential for oak regeneration occurs in relatively small areas within a stand.

When to Apply

Recommended for mature oak-dominated stands that have a patchy distribution of advance oak reproduction or when a stand-wide regeneration treatment is not desired for wildlife, aesthetic, or other reasons. Ideally, the placement of silvicultural gaps should coincide with areas containing large density (300 to 500 per acre) of competitive (at least 3 to 5 feet tall) advance oak reproduction ready for release. An example would be locations that have experienced a disturbance in the recent past that has killed or significantly damaged one or more overstay trees

Gap harvests within sites of medium and high productivities will foster a rapid response from intolerant competitors within the gap, reducing oak's competitiveness within the regenerating cohort. Research on gap-based methods within xeric sites is limited, but clearcutting can be effective for oak regeneration within oak-dominated forests on these sites, indicating the potential efficacy of gap harvests on similar xeric sites. Terrain factors (aspect and slope) interact with gap characteristics (shape, size, and orientation with regard to terrain aspect) and adjacent forest conditions (total height, canopy density, and canopy thickness) to determine the amount and spatial pattern of light within the harvest area.

Common Examples of Where the Practice is Applied

Gap-based silviculture can be an effective technique for regenerating a diversity of tree species including oaks. Dense midstory and overstory canopies reduce light availability to the understory in many eastern hardwood stands, limiting the natural regeneration potential of oaks. Creation of canopy gaps creates a gradient of light levels within and around the gap. As a result, some locations will be more conducive for regeneration of competitive oak reproduction (light availability = 20 to 50% of full sun), while others will host greater densities of competitors (predominantly shade tolerants in < 20% full sun and shade intolerants in > 50% of full sun). Gap harvests may also be performed strategically as an overstory release treatment within areas of dense advance oak reproduction, depending on both the mean stature of oak reproduction relative to that of competitors and the site productivity.

Gap-based silviculture is a versatile technique that can be used in an array of management situations and meet a diversity of landowner objectives including natural regeneration of oak-dominated stands, creation of variability in stand structure and age classes, continuous canopy conditions for landowners not wanting to regenerate the whole stand at one time, wildlife habitats that vary over space and time, and generation of periodic income. Additionally, gap-based approaches can be combined with many supplemental treatments like prescribed fire, chemical/mechanical site preparation, and underplanting to overcome a number of oak regeneration

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barriers. Recent research has identified the potential efficacy of the expanding-gap, irregular or extended shelterwood for oak regeneration in eastern hardwood forests. In this system, a gap harvest is performed, creating locations within and around gaps with enhanced oak reproduction that can be nurtured until timely release by subsequent harvests to expand the original gap.

Examples of Conditions or Situations that Limit Effectiveness

As this is a regeneration practice, it would be unsuitable for stands with insufficient oak regeneration potential. Treatments to develop oak reproduction would be required in this condition to help ensure that advance oak reproduction is present ahead of gap creation. As this practice is generally implemented with a timber harvest that results in retention of surrounding overstory, there may be a financial impediment to using this technique when all merchantable timber must be removed to meet merchantability standards. As a regeneration treatment installed using a harvest, there may be site preparation or other silvicultural treatments required in association with a harvest to ensure unhindered development of the new age class and funding for these practices may not be available.

Post-implementation Conditions

The post-treatment stand will comprise a gap of a targeted shape and size surrounded by forest. Forest adjacent to the gap may be left undisturbed or treated with other practices depending on forest conditions and silvicultural planning. Together, the gap design and manipulation of the adjacent forest will result in a gradient of light levels within and around the gap. Optimal light conditions in some locations within and adjacent to the treated area will foster oak seedling development while inhibiting growth rates of some competitors (e.g., yellow-poplar *Liriodendron tulipifera*).

Practice Use Within a Silvicultural Framework

Similar to other regeneration treatments, this practice is used in economically or biologically mature upland oak forests and may require other practices associated with regeneration treatments.

Data and Observations

Data and observations are needed to both aid in decision making associated with implementation of the treatment as well as post-harvest monitoring. The effectiveness of a gap-based harvest for oak regeneration can be evaluated using the following criteria:

- Is there any oak reproduction in the stand? A site preparation technique (e.g., prescribed fire or soil scarification) to improve natural regeneration or underplanting of oak seedlings can be performed prior to harvest in stands lacking oak reproduction.
- What is the current density and spatial distribution of advance oak reproduction in the stand? While a gap harvest can increase the density and height of oak reproduction adjacent to the gap edge, the treatment will likely prove more effective when gaps are placed in portions of a stand containing a large density of advance reproduction. Thus, application of shelterwood practices, such as midstory removal prior to gap creation, may enhance the size and density of oak reproduction and result in a more successful oak recruitment.
- What is the site productivity of the stand? Oak reproduction in higher productivity stands will face greater competition than on poorer sites. Further silvicultural intervention (e.g., competition control) will be required to increase competitiveness of the oak cohort in certain locations within the harvest area (e.g., near the gap center).

Data collection includes the assessment of the oak regeneration potential that would include fixed-area sampling to determine the size and density of existing reproduction. Permanent plots could be installed and used for post-treatment monitoring (see below). The relative densities and height disparities between oaks and competitors will indicate the potential effectiveness of the treatment. A large density of advance oak reproduction prior to gap implementation will result in a more effective treatment, while smaller oak regeneration compared with larger competitors will likely indicate the need for further competition control treatments. Overstory sampling should be performed to estimate potential forest product value and revenue.

Post-treatment monitoring is required to determine treatment effectiveness in establishing a regenerating age class of oaks. Regeneration sampling via fixed-area plots should be employed to monitor the treatment's relative effects on oaks and competitors. These can be accomplished using permanent plot centers established for collecting pre-treatment data. These will yield the best estimates of reproduction response to treatment. Post-treatment surveys should be completed every 3 to 5 years to monitor regeneration. Tallying reproduction by species and height will provide a means of evaluating oak competitiveness within the regenerating cohort. Since this treatment takes advantage of spatial light gradients associated with a harvest gap, a spatially explicit sampling method that accounts for plot location with respect to gap centers and edges within the larger stand area may prove more advantageous than more conventional systematic sample plot grids. See (7) and (3) for more information on spatially explicit sampling.

Post-treatment 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.

Planning and Marking
Gap harvests can be performed in a manner similar to a silvicultural clearcut, resulting in the removal of all merchantable trees and any other stems that would significantly impede oak regeneration. However, in larger gaps (> 1.5 to 2 trees heights), a limited number of residual overstory trees (< 10-15 ft^2 ac^{-1} in basal area) could be retained based on landowner objectives. There are several methods of marking this treatment. Marking all the trees to be cut in the gap can be done but does require significant time. As an alternative, only the edge trees can be marked, including a stump mark, on two sides of the edge trees, one mark facing out and the other facing in towards the center of the gap. Harvest guidelines would indicate what needs to be harvested within the gap. If the operator is capable, the center tree of the gap could be clearly marked on several sides with harvest guidelines indicating the distance of removals from the center tree. The latter requires appropriate monitoring and oversight.

Implementation, Timing, and Other Considerations
A gap-based harvest requires determination of the gap size and shape. Circular gaps have been most studied for oak regeneration, but gap size, rather than shape, appears to be the more important factor. Intermediate-size circular gaps (e.g., 1 to 2 tree heights) have yielded high relative densities of oaks in a few studies. Smaller gaps will restrict light availability and favor regeneration of shade tolerant competitors (e.g., maples), while larger gaps will simulate clearcut conditions and result in regeneration of shade intolerant competitors (e.g., yellow-poplar). However, a wide range of gap sizes are also capable of regenerating yellow-poplar on intermediate to high productivity sites.

Research documenting forest development following various gap sizes has also provided important management guidance relating to long-term growth and yield. In Lhotka et al. (2018), a stark contrast was present among the species composition and growth trends in 50 feet diameter gaps versus two larger sizes tested, 150 feet and 250 feet diameter. The 50 feet diameter gaps did not promote the recruitment of oak, and the forest environment created by these small gaps reduced overstory tree growth in the gaps; mid-rotation data suggest that the future sawtimber yield potential in these small gaps will be poor. In the larger openings, reductions in maple were balanced by an increase in oaks and intolerant yellow-poplar. While the relative density of oak was highest in the 150 feet diameter gaps, oak had significantly higher mean per tree volume in the largest gap size. Whereas the per tree volume of yellow-poplar did not differ among the two larger gap treatments, yellow-poplar accounted for a significantly higher relative density of sawtimber-sized trees in the 250 feet gaps. Increased sawtimber volume in the 250 feet diameter opening was , therefore, likely a function of the combined effect of increased oak per tree volume growth along with the increased proportion of the fast-growing, shade-intolerant yellow-poplar.

Site Considerations
If a dense midstory or density of large non-oak reproduction is present within the planned gap, an additional chemical or mechanical site preparation treatment may be required to remove the subcanopy. Shelterwood treatments to the forest surrounding the gap (e.g., midstory removal, establishment cut) can be utilized in preparation for subsequent harvests (e.g., ahead of gap expansion for an expanding-gap irregular shelterwood).

Site productivity plays a direct role on canopy structure, and higher productivity sites have the potential for denser midstory canopies and lower understory light availability in undisturbed stands. 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 medium to high-productivity stands will likely have low densities of competitive advance oak reproduction prior to gap establishment and oaks will face increased competition within gaps following harvest. Therefore, the use of understory competition control and or/release treatments may be more warranted to help increase competitiveness of the regenerating oak cohort.

Barriers to Success
Gap-based silviculture leverages the gradient of post-treatment light levels present within and adjacent to the gap. The range of light transmittances provide versatility to the forest manager in targeting species for regeneration. For oaks that have intermediate tolerance to shade and grow slower than co-occurring species, research has identified specific locations within the gap and near the gap edge where oak regeneration potential is highest. Post-harvest growing conditions within stands of medium and high productivities facilitate regeneration of shade intolerant species and large reproduction of existing shade tolerants within the gap that can quickly overtop oaks. Moreover, the zone for enhanced oak regeneration outside the gap margin is within 50 to 75 feet from the gap edge, after which light availability is reduced to levels conducive for growth of shade tolerant competitors. Following gap establishment, overtopped oak reproduction may need subsequent competition control or release treatments (i.e., crop tree release) to ensure successful overstory recruitment.

Whereas many oak regeneration techniques seek to achieve densities of competitive advance oak reproduction at the stand-level, gap-based harvests can increase diversity of residual stand conditions and accomplish regeneration goals at specific within-stand locations. It would be typical for managers to implement several gaps within a stand. However, more research regarding optimal gap size, placement, and spacing is needed. Managers may seek to improve the chances of oak regeneration within the gap harvest area by enacting site preparation techniques (e.g., soil scarification, prescribed fire) to improve acorn germination; however, site conditions may limit the applicability of these treatments. Underplanting is another option for supplementing density of advance oak reproduction, but the feasibility of this option can vary significantly depending on local herbivore populations. For these supplementary treatments to improve regeneration success, sufficient time is needed before gaps are created so establishing oak reproduction can reach a competitive size. The smaller revenues received from gap harvests relative to larger harvests may restrict the method's utility if additional compensation is required to contract loggers or if revenues are the primary means of funding additional treatments (e.g., competition control, midstory removal).

As with any partial harvesting system, logging damage to residual trees is a concern for stand health and value potential. Up-front planning related to skid trail and road networks can help minimize damage to regenerating gaps during subsequent harvest entries. Overstory trees at the edge of harvest gaps may also be prone to epicormic branching and possibly reductions in future tree grade (and value). However, there is also evidence that these edge trees may have enhanced growth rates due to increased growing space availability created by the gap. One final caveat is that trees around harvest gaps may be more sensitive to windthrow.

Costs

Since this method will typically result in harvest of merchantable wood products, revenues will be generated that can be used to offset any management costs that may be required in the implementation of the system. Given the size of harvest gaps, contracting loggers may require additional compensation aside from traditional apportionment of harvest revenues. This potential compensation will depend on several factors, including value of harvested forest products, terrain, and other features that may restrict operations (e.g., seasonal weather, regulations). Costs for co-occurring treatments (e.g., site preparation to remove saplings and/or pole-size trees within the gap as part of the harvest or within the adjacent forest as part of a preparatory treatment for a subsequent harvest) should also be considered. Costs for these treatments will depend on removal method (chemical vs. mechanical), as well as density of trees to be removed, treatment area, terrain, and several other factors.

White Oak

Gap-based regeneration practices have been used to enhance the development of advance reproduction for a variety of oak species including white oak. Several of the existing research projects on gap-based regeneration methods for oak were initiated in stands with a large white oak component. However, these research efforts have not yet yielded species-specific recommendations on how best to implement gap-based regeneration practices for white oak. One known 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 or release treatments in combination with (or following) gap-based regeneration practices may be more warranted when managing for white oak on higher quality sites.

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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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