

Crop Tree Release for Upland Oaks

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Practice Objective and Description

The objective of crop tree release (CTR) is to ensure that specific highly valued trees sustain themselves and provide defined attributes to aid in meeting objectives. CTR is a variant of free thinning that focuses on increasing crown growing space of specific main canopy trees (crop trees). The release is applied by deadening trees that are touching and horizontally limiting the development of crop tree crowns (crown touching release). The aim is to provide crop trees ample room to expand their crowns thus improving their growth and helping maintain their position in the main canopy.

When to Apply

The practice can be most effectively used when the following stand and site conditions are met.

- There is a value differential (species and form) based on management objectives, among main canopy trees (dominant, co-dominant).
- The growth and/or survival of high valued trees is being negatively impacted by crowns of adjacent trees,
- The vigor of high valued main canopy trees is sufficient to result in response to a crown release.
- While CTR can be applied over a wide range of site indices, it is most effective when the site is well suited to crop tree species, helping to ensure that the crop trees can maintain canopy dominance once released.

Several, or all, of these characteristics are present in many upland hardwood stands, particularly those where oak is an important component, making CTR one of the more important and widely used intermediate practices to facilitate the maintenance and growth of oaks.

Common Examples of Where the Practice is Applied

This practice is most effective when highly valued trees (based on objectives) are at risk, and/or experiencing reduced growth, due to crown competition from adjacent trees including:

- Regenerating stands at canopy closure (stem exclusion) or in the early stages of development, where oaks are being over topped by competing species, or when preferred oaks are becoming overtopped by lower valued oaks. The latter can include lower valued species or poorly formed trees where there is a timber objective. The risk of losing oaks is generally more significant on higher quality sites.
- Pole-sized stands where oaks with high value potential are becoming overtopped and/or are losing live crown ratio needed to maintain adequate diameter growth (typically 40 to 50 percent).
- Small and medium sized sawtimber stands where diameter growth of oaks, and their potential value, is being significantly restricted due to crown competition.

Examples of Conditions or Situations that Limit Effectiveness

There are several conditions that will limit practice efficacy or make it difficult to administer including:

- Developmental stages prior to stem exclusion (canopy closure) where competitive positions among trees and species are highly dynamic and predicting those that will need assistance at canopy closure can be problematic.
- If all canopy trees are similar in value and condition an area wide thinning, without regard for individual tree condition, would be a more cost-effective treatment than a CTR, particularly if the thinning was commercial.

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- High-value trees have competitive positions (dominant crown class) where their horizontal crown expansion is not limited by competitors and thus not needing release.
- Degraded stands containing few potential crop trees.
- Stands where potential crop trees do not possess the physiologic vigor necessary to respond to release because they have been in sub-dominate canopy positions, as indicated by loss of apical dominance, or due to ages nearing or at biologic maturity. Some oaks are short-lived, ex. scarlet and black oak (90 to 120 years), while others are significantly longer, ex. white oak (200 to 400 years old).
- Stands on low site indices that would limit growth response.

Post-implementation Conditions
Directly after treatment, the stand contains 10 to 150 (depending upon average stand size), evenly spaced, highly valued dominant, co-dominant, or strong intermediate crown class trees with one crown width of open space on three or four sides of their crowns.

Practice Use Within a Silvicultural Framework
CTR is an intermediate treatment that works well from stem exclusion (sapling sized) through small to medium sawtimber sized stands. It is therefore compatible with a number of regeneration treatments and can be used in even and uneven aged stands and two-age stands in the regenerating age class.

Data and Observations
CTR is a flexible and relatively simple treatment and there are many instances where rigorous data collection is not required to decide whether to use CTR or not. However, data is particularly useful in estimating treatment costs or if a large number of stands need to be evaluated and prioritized for treatment.

<u>Commonly Collected Data</u>
- It is useful to define crop trees to facilitate accurate communication to help ensure efficient and effective prescription, marking, and implementation. Based on ownership objectives determine:
    - species
    - stem and/or crown criteria, especially important for timber objective, or mast production
    - dbh range (useful in assisting with selecting crop trees and marking)
- Number (or basal area) per acre of crop trees whose horizontal crown development is being impeded by adjacent trees. Also, species, average dbh, and crown position relative to competitors (relative crown position). The latter can be used to describe whether the crop trees are in co-dominant position relative to competitors, crowns slightly smaller than competitors, or are in the process of being overtopped. The relative crown position provides information that might be useful in prioritizing or emphasizing need for this treatment.
- Number (or basal area) per acre of treated trees, average dbh, and species. Treated tree density and dbh provides information useful in estimating treatment costs. Species of treated trees can also be important in determining how to implement chemical treatments when crop tree and treated trees are of the same species or genera.
- Stand or site conditions that could impact the development of crop trees, examples include presence of vines, previous storm or logging top or stem damage.

To use this data for prioritizing need when dealing with numerous stands see Appendix 1 "Crop Tree Assessment Guidelines".

<u>Additional Data for Monitoring</u>
If trees are to be monitored for treatment efficacy additional data may be useful. Monitoring can be accomplished on a subset of randomly selected crop trees encompassing the variability in species, size, and attributes present. Variables to be recorded can include crown class (or relative crown position), number of sides released, dbh, and attributes associated with specific objectives. For example, a timber objective might include the number of branches on the butt log, or tree grade. Mast production objectives could include information on crown size or other crown, flower, or fruit attributes.

Planning and Marking

<u>Target Number of Crop Trees per Acre</u>
CTR can be implemented over a wide range of stems per acre. While the minimum number can be one tree per acre (or less), there are often questions on the upper limit of crop trees per acre. This can vary considerably based on species and stand conditions. While variability exits, there is an upper limit of large upland hardwood sawtimber sized trees that an acre can contain, typically between 35 to 50. This can help inform a decision on how many trees should be selected per acre for CTR. However, it is prudent to select more crop trees per acre in smaller (younger) stands to ensure against risk (insect and disease issues impacting a species or genera, storm damage, market shifts). If initially selecting a higher number in smaller sized stands, investment in CTR for some of the "excess trees" may be recouped in a subsequent commercial release. The following provides a guideline for the number of crop trees for typical upland oak stands:
- 50 to 100 (20-30 ft spacing) in sapling sized stands
- 30 to 70 (25-40 ft spacing) in pole stands,
- 10 to 50 (30-66 ft spacing) in small and medium sized sawtimber sized stands.

Note: in stands with few oaks, releasing all oaks with potential to respond to CTR release may be desirable to maintain an oak component for wildlife, seed source, or other management objective.

<u>Crop tree selection</u>
Using the crop tree definition established above ensure that crop trees are:

- co-dominant or strong intermediate crown class trees (see cautionary note below on the selection of intermediate trees)
- have crowns indicating the ability for the tree to respond to release, live crown ratio's 40 to 50 percent, apical dominance for sapling and pole sized trees, reasonable crown balance,
- possess appropriate crop tree attributes based on ownership objectives,
- where appropriate, spaced as evenly across the stand.

Note: Critically evaluate all intermediate crown class trees. Typically, intermediate trees do not respond well to release, problematic for many ownership objectives, and issues like epicormic branches, often prevalent in intermediate oaks, can be problematic for timber production.

<u>Identifying Treated Trees for a Crown-touching Release</u>
Crowns of each crop tree need to be evaluated to determine proper degree of release.

- Determine the optimum number of sides that the crown of each crop tree should be released based on species and stand conditions. Typically, release oak crop tree crowns on at least three sides (see white oak section for further information), including a side that may already be released and species like yellow-poplar, that have exhibit rapid height growth, on 4 sides (Figure 1).
- Divide the crop tree crown into quadrants (sides) and locate competing trees that have crowns that are touching or directly adjacent (almost touching) to the crop tree crown, thus impeding the horizontal crown development of the crop tree, or close to doing so (Figure 2). Determine which of these trees needs to be treated based on the number of sides targeted for release (unless they are another crop tree). For a timber objective, if there is a choice of sides in a 3 side release, leave an adjacent tree on the south side to help reduce the development and retention of epicormic branches. See White Oak Section for more information on intensity of release relative to site productivity and other factors.

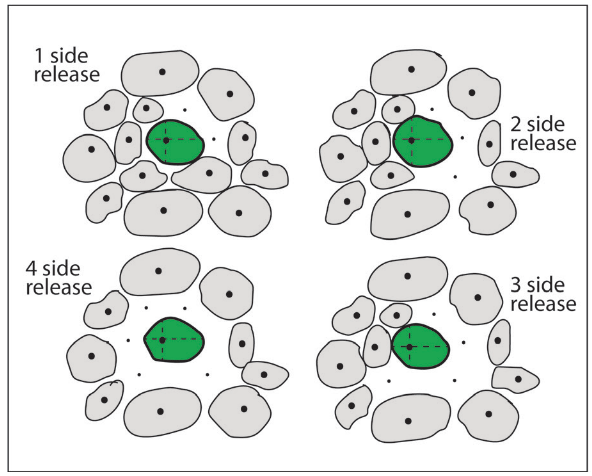

Figure 1: 1 to 4 side crown-touching release.

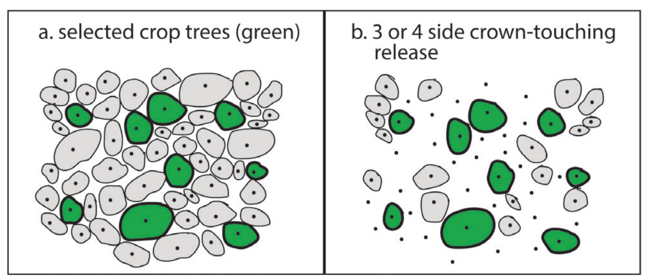

Figure 2: Diagram showing a 3 or 4 side crown touching release.

<u>Treated Tree Number per Crop Tree</u>
In stands that have significant number of crop trees present there are typically between 2 and 3 treated trees per crop tree, assuming a 3 to 4 side release. When crop tree numbers are limited, expect a range of 3 to 4 treated trees per crop tree.

<u>Marking</u>
There are a number of ways to mark CTR. The detail of the marking (and thus time and cost) can be adjusted based on the expertise of those conducting the practice. CTR implemented with a harvest warrants a special note. Regardless, of the specific method outlined below, crop trees need to be clearly marked or designated to help ensure that harvest operations do not unduly injure crop trees.

- Marking all trees- For applicators having little experience, both crop trees and treated trees should be marked with different colored flagging or paint. In the case of harvesting operations, marks at the base and on the stem may be required.
- Marking only treated trees- For use in non-commercial operations where there is little chance of crop tree damage and there is a lack of technical expertise or willingness to identify crop trees and treated trees. This approach is not recommended for applications involving a harvest.
- Marking crop trees- For experience applicators that are able to properly identify treated trees for crown-touching release, only the crop trees need to be marked, reducing administrative costs. Marking the base as well as the stem may be required to determine if crop trees were cut, recognizing and providing allowance for the removal of severely damaged crop trees (see Commercial – Crop tree Damage)
- No marking- To limit administrative costs, it may be possible to train those involved with both non-commercial and commercial operations to identify crop trees and learn to identify trees to be treated based on a crown-touching release. If training is needed, one useful exercise is to identify a 100 ft by 100 ft area (roughly 0.25 acre) and go through the process of identifying and flagging crop trees and the treated trees with different color flagging. It may be helpful

to use the spacing guidelines in section 10.a. The use of a fixed “demonstration” area allows one to easily express numbers on a per acre basis.

Treatment Application

The focus is to either deaden, top-kill, or weaken treated trees so that they will not continue to restrict the horizontal crown expansion of crop trees. The application should also not harm or degrade important attributes of the crop trees. Treatment selection is based on stand and tree conditions, constraints on application techniques, and economics.

Non-commercial

- Mechanical – Felling and girdling can both be used effectively. These techniques do not typically kill trees, especially sapling, pole, and small sawtimber sized trees that will sprout. However, the purpose of a crown-touching release is to remove crown competition and mechanical treatments can meet that objective. However, there may be secondary objectives that might require killing trees. Examples include invasive species eradication or removal of native species that will cause a problem with future regeneration or stand development.
- Felling – Felling can be used in all size classes but is most often used on sapling sized trees. When felling larger trees ensure that you minimize felling damage to crop trees. High stumps can be left if consistent with management objectives and future operations.
- Girdling – Girdling is normally reserved for pole or small sized sawtimber trees. Girdles should extend into the sapwood for all species. For vigorously growing and/or young trees, a double girdle is recommended. With girdling there is the risk of diffuse porous species callusing over girdles and rebuilding phloem connectivity quickly, thus regaining overall tree vigor. In contrast, some ring porous species, especially oaks, can be effectively controlled with a single girdle, as the majority of the water transport to the top is contained with the last few growth rings.
- Chemical – A number of individual tree chemical application techniques are appropriate for CTR. Follow directions on herbicide labels, and follow implementation guidelines found in the references, paying attention to size, species, timing, and legal use requirements. Herbicide applications appropriate for CTR include:
    - Hack and squirt (where slits are spaced around the stem) is often the preferred technique, often requiring less time than other treatments.
    - Frill and squirt (where a continuous girdle is created around the stem) is used for hard to kill species (as specified on the label).
    - Girdle and squirt, using only a single girdle typically created with a small chainsaw can also be used, but treatment times are higher than hack and squirt.
    - Tree injection can be used as well, however newer injectors featuring granulated formulations have been found to be slower, more expensive, and can lead to more sprouting and suckering that than hack and squirt or liquid tree injections on some competing species.
    - Cut stump can be used on all size classes.
    - Basal bark treatments were developed for use on relatively small thinned barked species. See labels and references for different basal bark techniques. Generally, one of the full basal techniques, involving the application of a continuous band of herbicide applied around the circumference, is preferred over streamline or thin line techniques to ensure that herbicides are kept on trees targeted for treatment.
- Timing- As indicated above season of year needs to be considered. See Timing and Seasonality Section below.
- Crop tree Damage- Back-flash (or flash-back) damage is the direct transfer of herbicides via root grafts or shared root systems from a treated tree to a crop tree. This can occur when the treated tree is the same species (or species within a genus that are known to cross). For oaks, root grafting can occur among species within the white oak group and likewise red oak species can root graft with one another. Rocky soils and/or soil with restricted rooting depth can exasperate the problem. Also, some herbicides exhibit a higher degree of systemic movement and are thus more prone to root transfer. While back-flash damage is not a concern in most diverse upland hardwood stands, mechanical treatments should be used to treat trees that are the same species and in close proximity to a crop tree while using herbicides for other treated trees. For beech, delay herbicide treatments until mid-summer to ensure herbicide is translocated to roots. Also, while uncommon, there can be instances were herbicides delivered to treated trees moves into the soil and are taken up by adjacent crop trees. This requires the use of an herbicides that maintains soil activity for a period to time. Regardless of these issues herbicide treatments remain some of the best options for implementing CTR.

Note: To limit potential legal liability, mechanical girdling and chemical control should be used on trees adjacent to, or capable of falling on, roads, trails, or similar infrastructure.

Commercial

In large pole-sized or sawtimber sized stands, harvesting can be used to implement the practice. Strong pulpwood and small diameter and low-grade markets are generally needed to facilitate the use of a timber harvesting to implement a CTR. Skidding and felling damage to crop trees and potential soil disturbance and compaction are the most common factors that need to be addressed. The potential for skidding and felling damage is directly related to time of year, type of equipment, and most importantly operator skill, awareness and concern. Research has shown the damage can be limited to less than 10% of crop trees regardless of topography, average stand diameter, and harvesting equipment used.

- Felling – Equipment must be suited to selective harvesting in stands with high stem density. Manual felling requires operator skill in directional felling techniques, especially on steep slopes where the majority of damage comes from felling. Skidding damage is more prevalent on flat or moderate terrain. Mechanized harvesting requires the use of equipment that can reach treated trees and limit contact with crop trees and soil compaction around crop trees. Typically, small three-wheeled feller-bunchers, swing-arm tracked and wheeled feller-bunchers, and cut-to-length machines are preferable to fix head feller-bunchers. The latter lacks the flexibility of easily maneuvering through natural hardwood stands without damaging crop trees. As is the case with manual felling, mechanized felling must proceed without inflicting damage to crop trees and equipment selection, especially related to tree size and topography should be considered.
- Skidding and Forwarding- Limiting damage requires planning and provisions for skidding and forwarding. Seasonality is important (see Timing and Seasonality Section). Reducing the potential for loads hitting crop trees is critical. Damage can be reduced by:
  - Use of defined skid trails in areas containing a high density of crop trees
  - Use of skid trail bumper trees
  - Reduction in length of material being skidded when crop trees cannot be protected using bumper trees
  - Use of cut-to-length systems and forwarders can limit crop tree damage. The combination reduces the potential for both felling and skidding damage.

<u>Timing and Seasonality</u>

- Girdling and Felling (non-harvest) – Mechanical treatments that do not involve a harvest can be completed at any time of the year. If there is an interest in reducing sprouting (stump sprouts or for appropriate species root suckering) treating directly after full leaf out can minimize sprouting vigor.
- Chemical – Any treatment requiring cutting through the bark (hack, frill, girdle, injection, cut stump) should avoid periods of high sap pressures, typically mid to late winter and spring prior to leaf out. The high sap pressures can result in sap running from the cut bark, decreasing the amount of herbicide entering the tree.
- Chemical (basal bark) – Basal bark treatments are not susceptible to heavy sap flow as are other chemical treatments. Basal bark treatments can be used throughout the year. Avoid applying during or directly after a rain, when the stems are wet or when snow or ice is present.
- Timber Harvest – Felling and particularly skidding damage can be reduced by avoiding late winter and spring when the bark can easily be stripped from the stem. The latter is particularly important for timber objectives. When operating during this sensitive period, specific practices to avoid skidding damage should be used. Examples include establishment of defined skid trails, use of bumper trees around crop trees, flagging crop trees, and limiting load length.

Site Considerations

Fortunately, CTR can be implemented over a wide range of sites. Site productivity often plays a role in the number of crop trees available (see White Oak Section) and growth response. Lower quality sites (upland oak site index < 65 feet) commonly result in a lower number of desirable crop trees, especially for a timber objective, and less response than medium or high-quality oak sites (65 to 75 feet and > 75 feet respectively). Lower quality sites may also have lower stocking level, and oaks may already be in dominant canopy positions, thus not requiring release.

Barriers to Success

CTR is one of the least problematic silvicultural treatments to implement. Barriers typically relate to the issues presented in the "Examples of Conditions that Limit Effectiveness" section and on the following issues:

- Stem Degrade for Timber Objectives – Oaks are susceptible to the development of persistent epicormics branches, as are other hardwood species, potentially limiting timber quality development. Epicormic branches arise from suppressed buds found on the bark, the majority (but not all) associated with bark defect indicators that are indicative of the previous location of a branch. Exposing stems to sunlight often leads to the release of the suppressed buds forming epicormic branches, thus perpetuating the defect. Selecting crop trees that have limited defect indicators (see White Oak Section) that harbor buds and/or limiting exposure of stems particularly on south facing sides of stems can help reduce epicormic branch development. Pruning has not been shown to be effective in reducing this issue.
- Ring Width and Veneer- In sawtimber stands, the increase in ring width after CTR may decrease value of veneer logs. Typically, this is not realized until harvest.
- Wind and Ice – Released trees can be more vulnerable to severe wind and ice damage, as typified by large branch loss, main stem breakage, and wind-throw, the latter an issue for shallow to bedrock or seasonally wet soils. The greater the exposure the greater the issue for all of these issues and maintaining minimum full-stocking levels can help limit damage (see Stand Stocking section).
- Stand Stocking – While CTR is an individual tree treatment, stand conditions, particularly stocking levels should be considered. Ensure that release does not result in the stocking levels significantly below minimum full stocking (ex. B line on the Gingrich upland oak stocking chart). Maintaining adequate stand level stocking helps ensure fiscal effectiveness as well as helping to prevent potential crop tree degrade as discussed above.
- Vines – Increased sunlight entering crop tree crowns from release, can exacerbate problems with existing crown vines or the movement of vines into crowns. For wildlife objectives this may not pose a significant issue if the vine provides

soft mast (ex. wild grape), unless it results in the demise of the crop tree. For timber objectives, vine control is often warranted.

Monitoring

To determine effective implementation of CTR there are several issues that need to be assessed including:

- Ensure that treated trees were appropriately treated. This is easy to assess for mechanical treatments. The appropriate application of herbicides is slightly harder as evidence of proper herbicide application and dosing is not immediately evident.
- While CTR has been shown to work effectively when applied correctly it is also prudent to monitor the stand to determine if the desired crop tree response occurs.

<u>When to Monitor</u>

To evaluate CTR for each of these, assessment at different times is required.

- Initial – Monitoring of mechanical applications (non-commercial and harvesting) can be completed directly after treatment. For harvesting damage can also be assessed during and directly after treatment. Evidence of chemical applications can be determined directly after treatment. However, proper determination of correct chemical application my require observation several months to a year after treatment.
- 1 to 2 years – Chemical treatment efficacy, based on top kill, is required during the first or second growing season after treatment. It may be possible within 1 or 2 years to determine back-flash damage, however longer intervals may be required.
- Periodic – Periodic monitoring is required to determine CTR response. Three to five years should be viewed as reasonable time to assess dbh response. Initial crown response, especially for oaks is a thickening of the leaf areas within the crown (decrease in crown transparency) followed by crown expansion a number of years later.

<u>Treatment Assessment</u>

Assessment of treatment implementation is appropriate for all CTR applications and includes assessment of correct application technique and for harvest a damage assessment.

- Typically, implementation assessment is based on the percentage of treated trees where treatments were correctly implemented. How this is assessed is based on the marking strategy that has was used.
- Treated Tree Marking – Application percentage can easily be determined for mechanical treatments using plots or transects. The determination of adequate chemical applications can be aided by the use of dye and an assessment that is completed as soon as practical after application.
- Crop tree Marking – As crop trees are marked, implementation evaluation should focus on determining the percent of crop trees having competitors on 3 or 4 sides treated.
- No Trees Marked – Determination of the number of trees per acre that meet crop tree standards and are released on 3 or 4 sides should be determined and compared to the number of crop trees to be released from pre-treatment data. See above for monitoring information for mechanical and chemical treatments.

<u>Damage Assessment from Harvesting</u>

For all marking strategies, percent severely damaged crop trees must be determined, which can be critical for harvest treatments. Damage assessment should focus on impairment of the release treatment (ex. crown loss of over 25 percent) and/or the ability of the crop tree to meets intended value. In the case of timber, for example, are there bark wounds in excess of 100 square inches or major branch breakage in close proximity to the butt log. Damage assessment criteria should be established and communicated to applicators prior to release implementation.

<u>Chemical Treatment Efficacy</u>

For chemical treatments, the percent of top-killed or significantly weakened trees should be determined with efficacy rates above 80 percent expected. This requires adequate time to see herbicide activity. Most herbicides are active in the growing season they are applied in or directly afterwards. Imazapyr herbicides may require evaluation during a second growing season to assess efficacy. Methods for assessing this can differ depending upon marking strategy (see above).

<u>Medium-Long Term Response</u>

Ultimately the success of the treatment is based on the response of crop trees. This can be determined by assessment based on objectives for the CTR treatment. See Additional Data for Monitoring section.

- Increase in dbh of crop trees
- maintenance or improvement of crown class (applicable for all size classes)
- maintenance or improvement of specific attributes associated with the management objective. An example of the latter for an oak timber objective would be improvement of tree grade or product type, crown expansion/exposure important for acorn production.

Costs

CTR can generate revenue if a harvest is used. Other applications accrue a cost that can vary significantly.

Estimates
Because of the wide variance in CTR intensity, large number of treatment methods, and different administrative costs relative to marking technique, it is difficult to determine a useful average treatment cost for implementing pre-commercial CTR. Administration and treatment application cost estimates combined range from $255 to $500 per acre across the region, with most situations on the lower end of this range. The harvest treatments can yield revenue that also varies widely. Estimates from CTR harvest range from $400 to $1,200 generated in stumpage from application of the treatment in sawtimber sized stands.

How to Determine Costs
Cost associated with non-commercial treatments is most significantly associated with acreage, number of treated trees per acre and their average dbh, often expressed as basal area treated, and type of marking strategy used. For chemical application the average dbh allows determination of how much chemical is used per tree, which is brand dependent. This can be combined with the number of treated trees per acre and can be used to determine chemical volume needed per acre and stand. Application time varies considerably based on application method. Local experience is required to provide this information.

What Effects Costs
Costs are directly correlated to the basal area of treated trees. Topography, size class, access, understory obstacles (briars, vines, debris) and application technique also effects costs. Costs are highest if all treated trees are marked, higher if only crop trees are marked, and lowest if non-marking is used.

White Oak
CTR works well for most species including white oak (*Quercus alba*). The following provides information that is useful for implementing CTR in both white oak dominated stands and in releasing white oak trees as a component in mixed species stands.

Site Considerations (based on upland oak site index)

- < 75 feet – White oak tends to occur and maintain main canopy status best on intermediate or poorer quality sites and based on this CTR can be expected to maintain effectiveness longer on these sites compared to higher quality sites. A 3 or 4 side crown touching release of co-dominant trees should be adequate for treatment response. If the crop tree is a strong intermediate, it may be helpful to conduct a release on all 4 sides to help maintain the crop trees canopy position.
- 75 feet – White oak is a slower growing species than many competitors on higher quality sites, and will have difficulties in maintaining canopy dominance on these sites. However, the potential to develop high quality white oaks exists. To overcome competition on these sites, increasing release intensity is recommended. Ensure a full crown-touching release on 4 sides and treat other trees that are in close proximity to the white oak crop tree. A second CTR 10-years later may be required in sapling or poles stands.

Crop Trees per Acre
Figure 3 shows the number of trees that contribute to stand value in 60 to 80 year old, small sawtimber sized white oak dominated stands, on intermediate site qualities in eastern Kentucky. The data indicate that 20 trees per acre represented the maximum, or near maximum value, that could be obtained from potential crop trees in previously unmanaged white oak dominated stands. Increasing crop trees per acre above this resulted in minimal increases in stand value. While this study was conducted on 12 stands in a single physiographic region with upland oak site indices averaging 70 to 75 it does provide some evidence on the number of potential crop trees in marginally managed sawtimber sized white oak stands. Potentially, higher numbers of white oak crop trees could be expected in white oak dominated stands that had been managed at any earlier age.

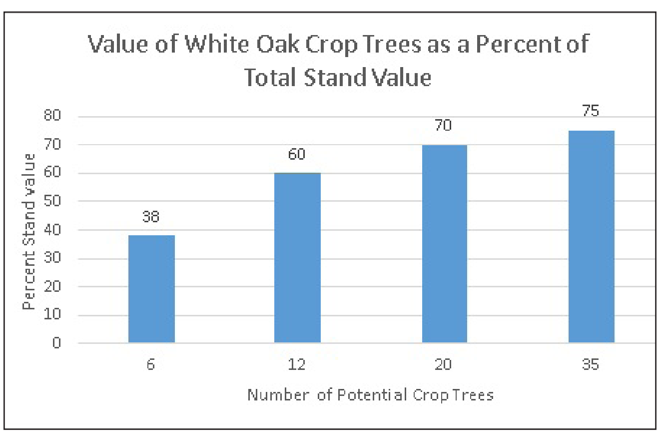

Figure 3.

Expected Growth and Quality Response
White oak responds positively in dbh and quality improvement over a wide range of ages. The table below shows average annual increment for released and unreleased white oak crop trees in a 15-year-old sapling sized stand and a small sawtimber 60 to 80 year-old stand.

Average Annual Increment (inches) of White Oak after Crown-touching Release		
	Sapling	Small Sawtimber
Released	0.27	0.19
Unreleased	0.16	0.14

CTR can also be expected to improve quality of white oak. The table provides changes in white oak quality over 30 years after a commercial CTR was applied in a small to medium sized white oak dominated stand providing a 3 or 4 side release.

Percent Quality Improvement		
	Percent of Trees with High Quality Veneer Butt Logs	Percent of Trees Reaching their Maximum Grade[1]
Released	20%	77%
Unreleased	7%	55%
[1] represents the percent of trees that reached the maximum USFS tree grade allowable for their diameter.		

Avoiding Epicormic Branching Problems
White oak is widely known for its propensity to develop epicormic branches. Research has shown that epicormic branch development is from suppressed buds on the bark and their presence and number is correlated with specific bark defect indicators. Data from this research can be used to select crop trees from pole or small sawtimber size stands in a manner that limits future epicormic branch development. Selection of trees that currently contain defects indicators with live suppressed buds (shaded defect indicators in the table) will continue to develop epicormic branches. Data from research as well as observation indicates that south facing portions of the stem tend to be subject to the greater release of suppressed buds forming epicormic branches than suppressed buds on the north side of the stem.

Acorn and Advance Regeneration Development
Production of highly digestible white oak acorns, is important for wildlife objectives where hard mast is important, as well as for silvicultural interests associated with the development of advance regeneration. Data indicate that individual trees that have been subjected to a four-sided crown touching release ultimately produce greater acorn yields than unreleased controls. Likewise white oak dominated stands that have undergone CTR result in greater development of advance regeneration. Data below are four averages for released and unreleased 60 to 80 year-old white oak trees 14 years after a crown touching release and the number of seedling per acre produced after release.

White Oak Suppressed Bud Number by Defect Indicator and Number of Epicormic Branches Produced 3 Years After Release		
Defect Indicator	number of suppressed buds	number of epicormic branches 3 years after release
live branch	10.0	2.5
epicormic branch cluster	9.1	1.1
individual epicormic branch	7.7	1.3
suppressed bud cluster	4.7	1.0
dead branch stub	3.9	0.7
epicormic branch distortion[1]	0.8	0.1
heavy branch distortion[1]	0.1	0.03
suppressed bud	0.04	0.01
medium branch distortion[1]	0	0
light branch distortion[1]	0	0
bird peck	0	0
surface rise	0	0
bump	0	0
seam	0	0
wound – old	0	0
wound – new	0	0

The Effect of Crown Touching Release on Acorn Production and Advance Regeneration Development		
	grams of acorns per tree	number of seedlings per acre
Released	1,424	690
Unreleased	689	227

References

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Appendix 1. Crop Tree Release Assessment Guideline[1]

The following guidelines can be used to determine the appropriateness of implementing a crop tree release.
Establish plots in each stand, any size will work. Recommendations are sapling size 1-3 inch dbh- 0.01-acre fixed area plot (11.87 ft radius), pole-sized- 0.02-acre (16.7 ft radius). Measure 1 plot for every acre up to 10 acres, then 1 plot for every other acre, highly variable stands may require more.

1. Data to collect includes:

Crop Tree Species	Dbh	Competitive Status	Competitor #	Remarks
____________	_____	____________	____________	_____________
____________	_____	____________	____________	_____________

Crop trees are defined according to management objectives.

Competitive Status designation is assigned as:

1. Dominant or strong codominant crop trees, crowns receiving no or very limited horizontal competition, thus are likely to survive without release.
2. Codominant crop trees that have horizontal crown competition but are not IMMEDIATELY threatened. These crop trees will become strong codominants if released.
3. Weak codominant crop trees that are threatened by adjacent trees that are larger and/or fast-growing trees. These crop trees can become strong codominants if released.
4. Desirable crop trees in the intermediate crown class that are capable of responding to release as indicated by still maintaining apical dominance, live crown ratios of >30 percent. After release, 20 to 25 percent of such trees can become codominant in the future. The proportion of successful trees depends on initial vigor and height differential when released. Competing Trees Definition- These trees are touching or directly adjacent to the crop trees. Their crown class is equal to or greater than that of the crop tree, and their crowns touch that of the crop tree. Competing trees are usually dominant or codominant. Record the number, species, and dbh of competing trees associated with each crop tree, but be careful not to double count competitors on the plot.

[1]Adapted from the training resource entitled "Example Crop Tree Management Assessment Data Sheet" by Dr. Gary Miller, USDA Forest Service, Northern Research Station, Morgantown, West Virginia.

Remarks
Record species and number of vines infesting the crown and any other observations about each crop tree. Record information about the competitors such as "old residual, or sprout clump" or other information needed to decide how to best treat (cut vs. herbicide) the residuals.

Analysis of Inventory Data
Convert plot data to per acre estimates to clarify composition of the overstory trees and the potential benefits of CTR treatments. Use Excel Spreadsheets or other similar tool to construct the following tables. Spreadsheets allow you to adjust survival probabilities and see the effect of CTR on long-term species composition, value, etc.

Table 1 is a general summary of the overstory trees you have, but it doesn't indicate the competitive status of the crop trees. For example, you have 63 red oak crop trees/ac, but you can't tell from Table 1 if they are all dominants, all weak co-dominants, or a mixture of both. Their status is important because crop tree release is intended to assist or improve the survival of crop trees. Note that red oaks make up about 11% of the overstory right now, but it's not clear if that percentage will hold over time. Table 2 helps clarify the potential benefits of crop tree release. Transfer the number of crop trees/ac to Table 2 and stratify them into competitive status for each species. For example, take the 63 red oak crop trees/ac and stratify them according to competitive status. Do the same for the 34 black cherry/ac and 51 hard maple/ac.

Table 1. Example overall inventory of crop trees and competing trees.

Category	Species	no/ac	% category	% total
Crop Trees	Black cherry	34	23	6
	Northern red oak	63	43	11
	Sugar maple	51	34	8
	Sub total	148	100	25
Competitors	Red maple	145	34	25
	Black birch	205	48	36
	Others	78	18	14
	Sub total	428	100	75
	Total	576	100	100

Table 2 shows your estimated survival of crop trees with and without release. The survival percentages are input by the user. There is not a lot of good data on such percentages, so use caution and experience to estimate survival. The red oak percentages are taken from Ward and Stephens (1994), but little is known about other species. In general, crop tree release raises long-term survival to over 90% for most species if they began as codominant trees. And 50% survival for codominant trees without release is a good starting point. Note that initial competitive status affects estimates of percent survival, both with and without release, thus it is important to collect good information during the inventory.

Table 2. Estimated effect of crop tree release (CTR) on long-term survival of crop trees.

Species	Competitive status	Crop Tree Inventory	Survival without CTR		Survival with CTR	
		no./ac	%	no./ac	%	no./ac
Black cherry	1	2	90	1.8	95	1.9
	2	6	50	3.0	90	5.4
	3	9	30	2.7	60	5.4
	4	17	0	0	0	0
	Sub total	34		7.5		12.7
Northern red oak	1	5	90	4.5	95	4.8
	2	12	50	6.0	90	10.8
	3	19	30	5.7	60	11.4
	4	27	5	1.4	20	5.4
	Sub total	63		17.6		32.4
Sugar maple	1	2	90	1.8	95	1.9
	2	10	50	5.0	90	9.0
	3	17	30	5.1	60	10.2
	4	22	5	1.1	20	4.4
	Sub total	51		13.0		25.5

Once Table 2 is complete, construct a new summary table to see how crop tree release affects species composition, value, etc. For example, the initial inventory indicated you have 63 red oak crop trees/ac, but Table 2 indicated that only 17.6/ac will survive without release and 32.4/ac will survive with release. Transfer the 17.6/ac and 32.4/ac from Table 2 into Table 3. Again, an Excel Spreadsheet would be helpful.

Table 3 shows the predicted effect of crop tree management on species composition. Table 3 assumes that the future overstory will contain 75 trees/ac, including the crop trees and their competitors. The projected number of crop trees/ac for each species came from Table 2. The projected number of competitors equals 75 trees/ac minus the projected number of crop trees/ac. The species composition of competitors is determined by applying the percentages in Table 1. For example, in Table 3 there will be 36.9 competitors/ac without release. From Table 1, 34% of competitors were red maple, so the same percentage is used in Table 3 to estimate the number of red maple/ac (.34 x 36.9 competitors/ac = 12.5 red maple).

Table 3. Projected long-term species composition with and without crop tree release.

Category	Species	Species Composition Without CTR		Species Composition With CTR	
		no/ac	%	no/ac	%
Crop Trees	Black cherry	7.5	10.0	12.7	16.9
	Northern red oak	17.6	23.5	32.4	43.2
	Sugar maple	13.0	17.3	25.5	34.0
	Sub total	38.1		70.6	
Competitors	Red maple	12.5	16.7	1.5	2.0
	Black birch	17.7	23.6	2.1	2.8
	Other	6.7	8.9	0.8	1.1
	Sub total	36.9		4.4	
	Total	75	100	75	100

Each stand is unique, so the improvement in composition or increase in stand value resulting from crop tree release will vary depending on the initial number of crop trees/ac and their initial competitive status.

The cost of crop tree release/ac varies within a small range, but the potential benefit can be extremely variable depending on initial conditions. A general rule is that priority should be given to stands with the maximum potential benefit.

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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