

Two-Age Deferment Harvest for Upland Oaks

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Practice Objective and Description

The objective of the two-age deferment harvest is to establish a two-age stand composed of scattered overstory trees (reserve trees) and a robust regenerating age class. The use of a deferment harvest has attributes that can address several economic, silvicultural, ecologic, and aesthetic objectives for both public and private forests (6) (11)(13). Appendix 1 provides a description of the two-aged system and the deferment harvest that establishes the two age classes. One of the attributes of a deferment harvest and the two-age stand that is created is its ability to "life boat" oaks in stands that will be subjected to a regeneration harvest, even when the oak regeneration potential is inadequate or non-existent (15) (16). In this instance the newly regenerating class will contain little or no oak. However, retaining oak reserve trees provides the stand with the ability to continue to produce acorns that will eventually result in advance reproduction needed to regenerate oak in the next rotation (Fig. 1) (14). This practice is valuable for retaining ("life boating") oaks in stands that will be subjected to an intensive harvest establishing a new age class, but where the oak regeneration potential is negligible. The practice is often viewed as a practice of "last resort" for oak management. However, the practice can also be used even when the oak regeneration potential is good but a limited amount of overstory retention can be used to meet aesthetic, wildlife, or other objectives (12).

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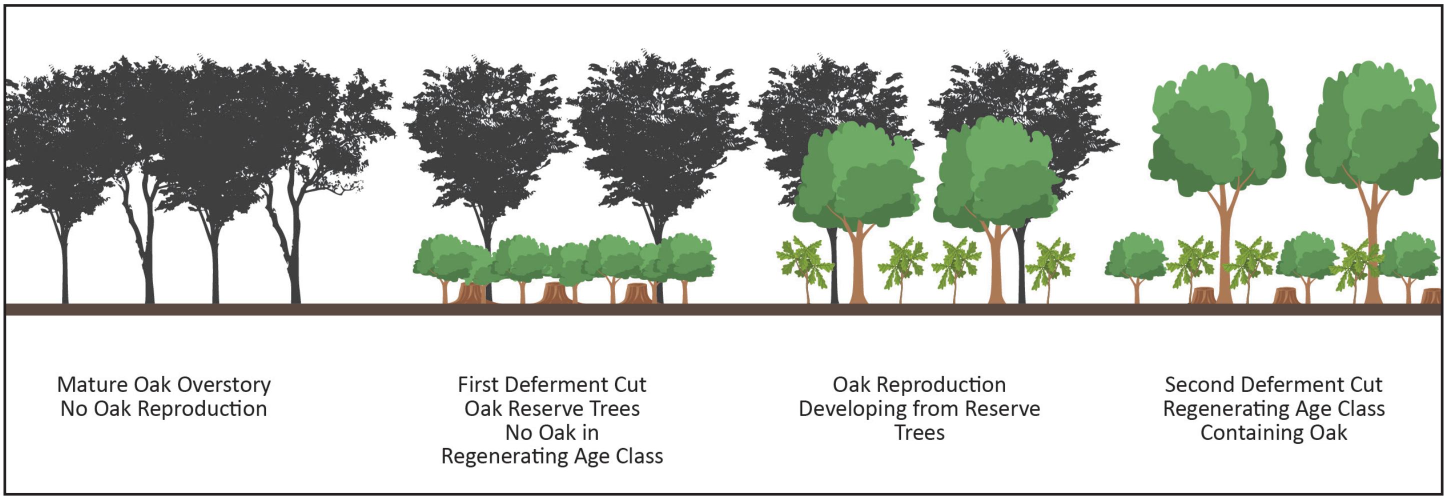
Figure 1. Diagram showing the use of deferment harvesting and the two-aged system for life boating oaks



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When to Apply
The practice is most valuable for oak stands where the following conditions are met.

- A harvest capable of initiating a regenerating class is imminent.
- There is little or no oak regeneration potential (lack of advance reproduction and stump sprouting capacity).
- There are dominant or co-dominant oak species present that are long-lived (> 200 years) having the ability to easily persist for two rotation lengths.

Figure 2. Simulated comparison of a clearcut and a deferment harvest showing the aesthetic differences between the methods (G. Miller, US Forest Service, Northern Research Station).

This practice is one of the most useful tools to retain oak in a stand when an intensive harvest that removes the majority of the merchantable volume is required by the owner and the stand does not have the oak regenerative potential to provide oak in the regenerating age class.

Common Examples of Where the Practice is Applied
This practice is applied in sawtimber-sized stands that are commercially mature and contain oak in the overstory. This practice establishes silvicultural attributes in oak stands (i.e. retaining oak) that will be subject to an intensive harvest without significant oak regeneration potential or where variable retention goals are required, including:

- economically mature oak stands possessing little or no oak regeneration potential where ownership objectives or interests will result in an intensive harvest,
- damaged or degraded oak stands where silvicultural options are limited and a regeneration harvest is required,
- oak stands where retention of older overstory oaks is advantageous to meet habitat/retention with little regard to characteristics of the regenerating age class,
- objectives include aesthetic values (12).

Figure 3. Deferment harvest used in a stand that was heavily damaged by ice. Reserve trees while damaged still possessed enough crown and vigor to respond to the practice.

Examples of Conditions or Situations that Limit Effectiveness
There are several stand conditions that limit the effectiveness or the feasibility of implementing this practice.

- Overstory oaks (dominant, co-dominant, or strong intermediate crown class) composed of relatively short-lived species, such as scarlet and black oak (90 to 120 years) are present, precluding retention of reserve trees to the end of a second rotation length.
- Overstory oaks of appropriate long-lived species are present, but their crown condition indicates limited ability to respond to release or maintain significant acorn production.
- Site conditions, such as thin soils or exposed positions, leave the scattered overstory oak reserve trees subject to windthrow or other similar damage.
- Ownership objectives require that all commercially viable trees are harvested therefore eliminating the ability to retain even a modest amount of reserve trees.
- Harvesting constraints or lack of harvesting expertise will result in significant damage to scattered reserve trees.

Figure 4. Recent deferment harvest retaining 15 square feet of basal area per acre in long-lived oak reserve trees.

Post-implementation Conditions
Directly after treatment, the stand contains 15 to 20 square feet of basal area per acre (15- 20 ft^2 ba a^{-1}) of scattered long-lived dominant or co-dominant oaks exhibiting good crown balance and adequate live crown ratios. The remaining overstory and mid-story trees are removed or treated to ensure adequate development of the regenerating age class.

Practice Use Within a Silvicultural Framework
This practice includes elements associated with both intermediate and regeneration treatments. The practice requires culturing reserve trees at the midpoint of their life span, as an intermediate practice would, and a regeneration concern associated with developing a new age class. It is generally considered a regeneration treatment and implemented at the end of a rotation. However, unlike other regeneration prescriptions that consider attributes of the regenerative potential of the stand, this practice can be implemented with little concern for the characteristics of the regenerating age class.

Data and Observations
Planning
Information is required to determine if appropriate overstory trees are present to meet reserve tree requirements. In the case of long-term oak management, are 15-20 ft^2 ba a^{-1} of long-lived overstory oak reserve trees present. See Reserve Trees section below for reserve tree attributes and characteristics. Typically, stand data collection for a timber harvest, basic inventory data, or observations can be used to determine if the density of potential reserve trees is adequate for prescribing this practice. Providing for two age classes requires the development of a vigorous new age class and an assessment of interfering vegetation such as overtopped and intermediate crown class trees that will be left after a harvest and hinder regeneration if not addressed in the harvest. This data will indicate whether a site preparation for natural regeneration practice is needed to remove this interfering vegetation to ensure unhindered development of a regenerating age class, even though little or no oak is present (17). If this data is not available from existing sources see Overstory and Understory Data Collection sections below for appropriate methodologies. Since this practice can be prescribed without the presence of oak reproduction, assessing the stand for this is not required. However, it is appropriate to have some information on the presence of oak advance production and stump sprouting capacity to determine if another prescription may be warranted. Having data or observations of the regeneration potential helps in this decision. If there is an interest in gauging oak regeneration potentials, see Regeneration Data Collection section below for methodologies.

Table 1. Estimated life expectancies (years) of common species in the eastern U.S.[1]

Species	Mean	Range	Species	Mean	Range
American beech	168	100-250	**black walnut**	131	75-200
white ash	129	80-150	**sassafras**	69	30-175
black cherry	115	70-175	**black locust**	75	15-150
bitternut hickory	133	100-150	**nuttail oak**	125	80-163
mockernut hickory	127	75-175	**southern white oak**	127	80-150
shagbark hickory	137	80-200	**pin oak**	116	80-170
pignut hickory	117	60-200	**water oak**	130	80-200
sugar maple	162	75-225	**swamp white oak**	157	100-200
red maple	106	50-175	**overcup oak**	135	80-165
northern red oak	151	90-200	**cottonwood**	79	50-100
scarlet oak	105	65-150	**black willow**	65	40-100
black oak	129	75-200	**pecan**	117	60-200
chestnut oak	141	75-200	**green ash**	98	60-150
white oak	194	90-250	**silver maple**	78	50-100
cherrybark oak	139	90-200	**water tupelo**	123	90-175
post oak	137	70-190	**baldcypress**	264	150-500
bur oak	181	125-250	**Virginia pine**	76	40-125
sweetgum	112	80-125	**shortleaf pine**	110	75-150
blackgum	116	80-150	**pitch pine**	110	75-200
yellow-poplar	136	80-300	**eastern white pine**	140	75-200

[1]Ages developed from a survey of silvicultural experts in the eastern U.S. by Dr. George Hopper at the University of Tennessee, Department of Forestry, Fisheries and Wildlife

Figure 5. Examples of oak reserve trees possessing crown attributes and the potential for significant future timber values.

<u>Reserve Trees</u>

Reserve trees must have the ability to withstand harvesting, maintain post-harvest growth and development, produce acorns needed for developing future oak regeneration potential, and meet landowner objectives. The following are attributes and characteristics that should be considered when selecting oak reserve trees.

- Crown class: dominant, co-dominate, or strong intermediate. These classes are recommended to help ensure that reserve trees possess the ability to respond to the release created by the practice, and because these crown classes will contain trees with a relatively large dbh they are less prone to felling damage associated with the harvest.
- Crown architecture: horizontally well-balanced crown, approximately similar horizontal projection on at least three sides for trees on significantly sloping sites and four sides for trees on gently rolling or flat ground
- Live crown ratio: > 40%
- Longevity: long-lived species, having a life span of at least two rotation ages (Table 1)
- Acorn production: acorn production from the reserve trees is required to establish advance reproduction at the end of the upcoming rotation. This can be difficult to ascertain with typical timber cruising or stand inventory data. For many oak species a few trees produce the majority of acorns (4), often without a direct correlation to crown size (see White Oak Section). Scouting for mast producing trees prior to implementing this prescription can help define reserve trees with this attribute.

Merchantability attributes for reserve trees with a timber objective:

- Main stem straightness
- Limited indications of internal rot and defect
- Butt log (1 ft to 17.3 ft above ground) free of bark defect indicators that will result in significant epicormic branching (see White Oak Section). Merchantable height is less of a factor, as the majority of value is in the butt log and maintenance and growth of the lower stem is the most important concern. Also, the significant reduction in stand density may result in epicormic branching of upper logs, and the continued growth of branching in these upper logs may hinder clear stem development.

<u>Overstory Data Collection</u>

Typically, fixed area (1/10 acre) or prism plots can be used, with a preference for prism plots using a prism factor of 10 or greater. The latter is appropriate when large trees are widely spaced. Collect data elements for overstory trees outlined in the Reserve Tree section above. Overstory data allows for determining if 15-20 ft^2 ba a^{-1} of oak reserve trees are present. Plot distribution and number should encompass the topographic and tree diversity found in the stand.

<u>Understory Data Collection</u>

The basal area per acre of intermediate and overtopped crown classes should be collected to determine the extent of non-overstory vegetation that can impact regeneration development. This is typically basal area per acre of these crown classes that will be left after the harvest. Understory data can be determined if these crown classes are included in the overstory data collection. If this is not possible an inventory can be established for this purpose. For fixed area (1/20 acre) or prism plots, with a preference for prism plots, using a prism factor of 5 or 10 is appropriate for these smaller diameter trees. Plot distribution and number should encompass the topographic and tree diversity found in the stand. Generally, if over 20 ft^2 ba a^{-1} of understory is present, removal may be required.

<u>Regeneration Data Collection</u>
Use small (ex. 1/100 acre) fixed-area plots or fixed-width (ex. 2- to 6-foot wide) transects for determining the abundance of advance oak reproduction and/or potential stump sprouts (1.5 to 10 inches in stump diameter) (3). Tally the number of oak seedlings by height classes (ex. < 2 ft, 2 to 3 ft, 3 to 4.5 ft), number of stems between 4.5 feet tall and 1.5 inches in dbh, and stems between 1.5 and 10 inches dbh, the latter for indicating the potential for stump sprouting. A measure of the age of the 1.5- to 10-inch dbh stems is required to ensure they have the potential to sprout (30- to 40-year-old maximum for red oaks and a maximum of 65 for white oak). The target amount of advance reproduction or stump sprouters needed to ensure oak presence at crown closure in the regenerating age class is highly dependent on both the oak competitors present and site productivity. If appropriate information is available for this assessment, it should be used. If not, use 200 to 300 seedlings per acre over 4-feet tall and/or 20 to 50 trees 1.5 to 10 inches dbh as the amount needed to provide for oaks becoming established in the new age class.

<u>Reserve Trees After Harvest</u>
Data is required to determine reserve tree density directly after the harvest. The same methodology options available for overstory data collection prior to the harvest can be used. Determining reserve tree basal area per acre at this time allows for easy monitoring of reserve trees in subsequent years. See Monitoring section for data collection required to estimate harvest and post-harvest damage.

Planning and Marking
<u>Reserve Tree Density</u>
To account for mortality from natural causes or harvesting, 15 to 20 ft^2 ba a^{-1} of reserve trees is required to provide sufficient occurrence to ensure a final reserve tree density of 10-15 ft^2 ba a^{-1}. Providing this relatively low density is required to ensure that reserve trees do not interfere with the development of the regenerating age class (9). The minimal number of reserve trees also helps reduce the value left standing after harvest. This provides less financial burden than a traditional shelterwood or other regeneration prescriptions other than a clear cut (13). For ensuring future development of oak advance regeneration, reserve trees should be evenly distributed to help ensure acorns deposition across the stand. This can be done by leaving an even distribution or small groups of reserve trees across the stand.

<u>Reserve Tree Attributes</u>
Each stand and ownership may require differing reserve tree characteristics. While common attributes such as crown balance, live crown ratio, and longevity are required regardless of site or ownership, other characteristics are determined based on objectives. Refer to the Reserve Tree section to aid in establishing reserve tree characteristics.

<u>Reserve Tree Selection</u>
Selecting reserve trees can be accomplished by using a prism during marking to ensure that basal area targets are being met. If reserve tree dbh is relatively consistent across the stand, Table 2 can be used to provide spacing rather than using a prism. Avoid selecting reserve trees that occur on landscape positions where thin soils or other site characteristics limit rooting depth or other conditions that might exacerbate wind throw. Table 3 and Figure 7 provide information on landscape positions susceptible to post harvest wind-throw in two-age stands in eastern Kentucky. These sites also were more prone to knock-down from harvesting operations. On sites that are at risk for this type of damage it may be prudent not to mark reserve trees on these landscape positions.

Figure 6. Examples of even distribution (top) and grouping (bottom) of oak reserve trees.

Potential damage from harvesting activities should also be considered when selecting reserve trees. While the low density of reserve trees indicates that harvest damage should be minimal, their limited number also indicates the importance of ensuring their protection. The following recommendations are provided to aid in protecting reserve trees from harvesting operations.

- Avoid selecting reserve trees directly downslope from large trees that will be harvested. This is especially critical in steeply sloping terrain where tree crowns are often more pronounced on the downhill side and directional felling may be difficult to effectively achieve. On steep slopes, felling damage is more prevalent that skidding damage.
- Special care associated with directional felling is warranted if reserve trees are retained on areas with shallow soils that are at risk for wind-throw (see above).
- On gently sloping ground, most damage is a result of skidding, with basal wounding occurring much more frequently than felling damage. The following will help minimize basal wounding:
    - keep skidding and skid trails away from reserve trees,
    - minimize merchantable lengths (thus reducing the length of material being skidded),
    - use bumper trees around reserve trees to protect them and remove bumper trees at the end of skidding operations,
    - using forwarders.
- Avoid harvesting around reserve trees when the bark is most easily stripped from trees, typically late winter through late spring (see Timing and Seasonality section below).

Marking

Compared to many prescriptions, marking of this practice is relatively easy. Because of the high value of the limited number of reserve trees, marking protocols need to ensure that the reserve trees are clearly identified.

- Reserve trees should be marked in a manner easily seen by fellers as well as skidder operators. Band the entire circumference or place spots around the circumference with a paint color unique to reserve trees. Place paint high enough to be readily seen by operators. Also place paint below the stump to identify reserve trees after harvest. The permanency of paint is warranted, however also using flagging in addition to paint (never by itself) might also be warranted.
- Stipulating what needs to be cut (ex. species, diameter) in a contract or similar type of agreement normally requires that only reserve trees need to marked reducing administrative costs.

Contract Damage Provisions

Because of the limited number and the value of the reserve trees, it is prudent to consider using a clause in contracts to help ensure their protection. This can include payment for reserve tree damage that exceeds a threshold. While accidental damage is to be expected, data indicates that operators can easily achieve a mortality/damage loss of < 10 percent. It is advisable that contractual requirements for reserve trees should be discussed with the timber purchaser and the operator, if the latter is a contractor. This is particularly important as there can be a disconnect between timber buyers and contractors at times, and the limited number of reserve trees indicates there is little room for error when it comes to protecting them. Further, the timber buyer and contractor should be made aware of communicating issues associated with reserve tree damage so adjustments can be made to help ensure the proper retention targets are met.

Table 2. Spacing (feet) between scattered reserve trees.

Reserve tree dbh	**ft² basal area per acre of reserve trees**		
	10	**15**	**20**
6	29	24	21
8	39	32	28
10	49	40	34
12	58	48	41
14	68	56	48
16	78	64	55
18	88	72	62
20	97	80	69
22	107	88	76
24	117	96	83
26	127	103	90
28	136	111	97
30	146	119	103

Table 3. Post-harvest wind-throw of upland hardwood reserve trees in eastern Kentucky based on topographic position.

Topographic position	**Wind-throw percent**
cove/hollow	4.34
lower slope	5.00
upper slope	10.31
Ridge	7.69
Nose	40.01

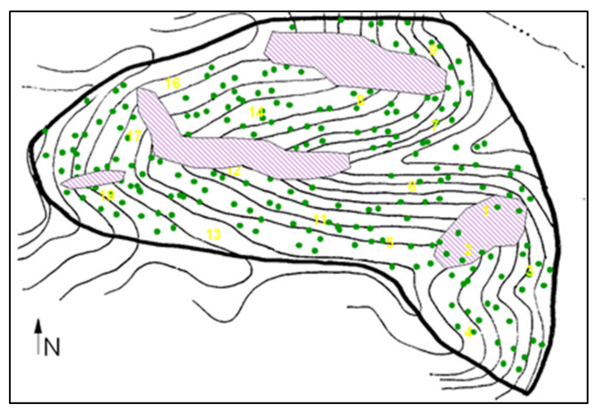

Figure 7. Topographic map of thirty-acre deferment harvest in an upland oak tract in eastern Kentucky. Hatched areas indicate topographic positions associated with high wind-throw of reserve trees.

Table 4. Reserve tree damage percent by operator and statistics on average dbh, slope percent, and skid trail density for the three tracts that each operator harvested.

Operator	Damage %	Mean dbh	Slope %	Trail Density
1	9	13.3	41.6	786
2	22	13.8	47.6	154
3	20	14.1	50.55	485
4	12.5	12.2	32.5	338

Harvest Equipment and Operators

It is important to use operators with harvest equipment that can both efficiently harvest large volumes, including extraction of smaller diameter trees, and protect reserve trees. . While the limited number of reserve trees per acre reduces concern associated with their damage, operation experience indicates that problems in retention of reserve trees can occur. Table 4 shows damage percentage to reserve trees in a replicated study of logging operators in eastern Kentucky undertaking deferment harvests for the first time under similar topographic and stand conditions. Results showed a wide range of reserve tree damage by operator. As is the case with proper selection of reserve trees to minimize harvest damage and contract provisions, the selection of harvest equipment and operator competency is also important and should be considered.

Timing and Seasonality – Limiting Reserve Tree Damage

Seasonality can play a part in limiting harvest damage. The following should be considered when timing a deferment harvest.

- Excessively wet soils producing increased pore pressures may lead to increased instances of knock-down.
- Where timber objectives are important for reserve trees, avoid harvesting during periods where the bark is loose (late winter/early spring). This will help to limit bark stripping associated with both felling and skidding damage that can create long-term rot issues, impacting timber value and potentially tree longevity (Fig 8).
- Soil compaction, while a broad concern for harvesting operations, potentially has ramifications for reserve tree longevity, especially for white oak. There is significant antidotal evidence, albeit not supported by research, that white oak can be negatively impacted by intensive equipment activity, resulting in soil compaction within close proximity (ex. within the dripline) of overstory white oaks, including reserve trees in two-age deferment harvests. It is prudent to consider this when marking reserve trees and conducting operations.

Figure 8. Basal bark damage directly after ground skidding (left) and resulting rot 15 years after injury (right). Photo credit: Steve Gray, Kentucky Division of Forestry)

Non-reserve Trees

The objective of this practice, along with retaining reserve trees, is to ensure the development of a new age class. As indicated above, determination of interfering trees and vegetation to regeneration development is important. Stipulations should be provided in the harvest contract/agreement to remove interfering vegetation or, if necessary, administer a site preparation for regeneration treatment (17).

Site Considerations

Two-age deferment harvests can be used over a wide range of sites and topographic conditions. The latter includes all landscape positions found in oak dominated forests. As indicated previously, leaving exposed reserve trees on sites with limited rooting depth can lead to an increase in knock-down from harvest and post-harvest wind-throw or downing due to ice. As discussed previously, steep slopes also increase the risk of felling damage to down-slope trees.

Barriers to Success

Two-age deferment harvests are relatively easy to prescribe and implement. Along with barriers discussed in the "Examples of Conditions that Limit Effectiveness" section, the following issues can also reduce success of the practice.

Fiscal Constraints

As is the case with any harvest that retains standing volume and value, fiscal issues can arise with deferment harvests. While this practice leaves little retention compared to other regeneration treatments such as a traditional shelterwood, some reduction in harvest revenues can be expected. Selecting the reserve trees with smaller diameters reduces volume, and typically value, left in the reserve trees. However, it is imperative that in selecting smaller trees, one does not sacrifice reserve tree attributes. Research has provided average minimum dbh for reserve trees based on the average dbh of overstory (dominant and co-dominate) trees in upland hardwood stands (13). Figure 9 provides examples of potential minimum dbh for reserve trees of white and chestnut oaks. The individual points are minimum dbh of reserve trees in upland oak stands. Note the wide range of dbh's for both species at a given average stand dominant and co-dominant dbh. For example, white oak reserve trees ranged from 12 to 17 inches (left axis) for stands with an average dbh of 16 inches (bottom axis). The lowest average dbh for chestnut oak reserve trees was 10 inches in stands with an average dbh of 16 inches. This shows there is variability that can be considered in reserve tree size within a stand. This is particularly useful if you have timber cruise data that includes dbh and the merchantable trees are sawtimber sized and primarily composed of dominant or co-dominant crown classes. Using minimum dbh trees reduces the dollars retained in the reserve trees compared to the dollars left if reserve trees were the average size of the dominants and co-dominants. Table 5 provides information on the reduction in dollars left in reserve trees using the minimum dbhs compared to the average of the dominants and co-dominants.

Epicormic Degrade for Timber Objectives

Along with the degrade from logging wounds, oaks and other hardwood species are susceptible to the development of persistent epicormics branches potentially limiting timber quality development (2). Epicormic branches arise from suppressed buds on the bark, the majority associated with bark defects that are indicative of the previous location of a branch. Exposing stems to sunlight often leads to the release of the suppressed buds, 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, can help reduce epicormic branch development.

Wind and Ice

Deferment harvests produce open canopies where reserve tree crowns are exposed on all sides. Operational experience has shown that harvests that left scattered overstory trees has resulted in increased damage to residual trees from ice accumulation and high winds. This indicates that reserve trees may be subject to similar damage. Both can increase the likely hood of large branch loss, main stem breakage, and wind-throw, the latter a particular concern in shallow soils (see Selecting Reserve Trees section above). Avoiding problematic topographic positions and soils that would exacerbate wind-throw can help. Selecting reserve trees that have adequate live crown ratios and balanced crown architecture and marking slightly more basal area per acre (15-20 ft^2 ba a^{-1}) than the 10-15 ft^2 ba a^{-1} that is ultimately required, can all work together to limit the effects of storm damage. However, all these precautions cannot eliminate risk associated with severe ice and wind.

Table 5. Percent of stumpage value per acre of reserve trees (20 ft^2/acre basal area) of average dominant and co-dominant dbh compared to reserve trees of minimum dbh to meet criteria for timber objective.

Tract	Dominant and Co-dominant dbh	Minimum dbh
1	23.0	18.4
2	32.1	16.9
3	22.6	20.2
4	22.5	22.5
5	17.9	14.6
6	23.3	20.7
7	32.5	13.9
Mean	**24.8**	**17.1**

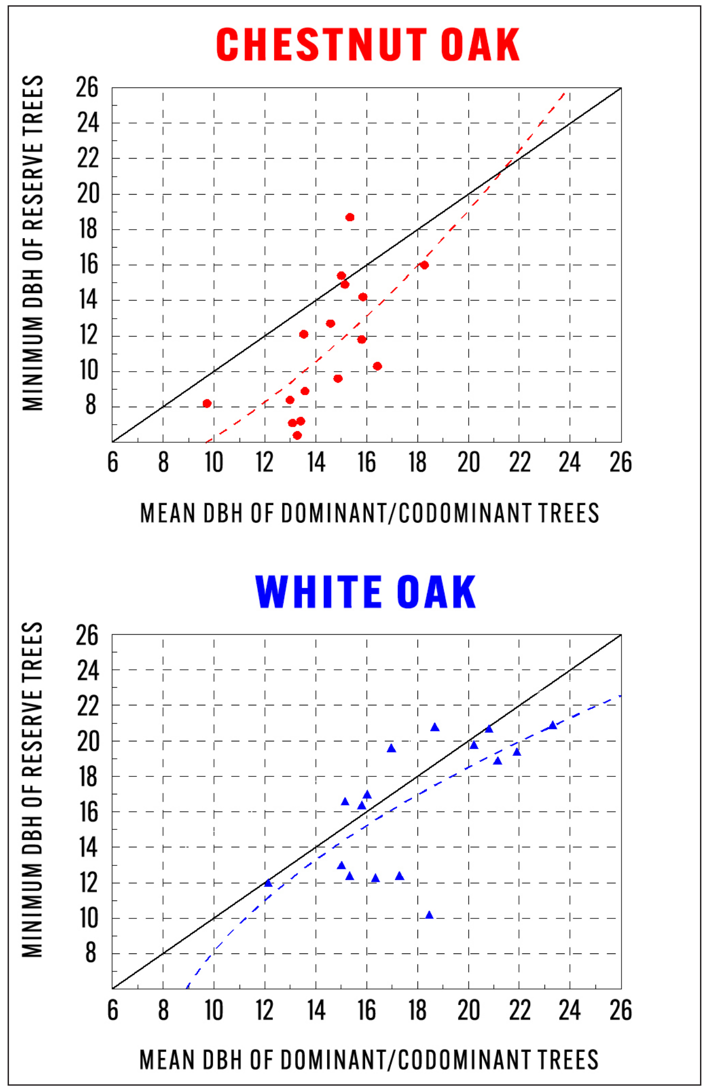

Figure 9. Minimum average dbh for two species of oak reserve trees based on the average dbh of dominant and co-dominant trees in each stand for seven tracts on the Cumberland Plateau in eastern Kentucky. The diagonal line shows a 1:1 relationship and the dashed line represents the best fit regression for the oak reserve trees.

Monitoring

Monitoring of reserve tree integrity is required for the first several years after harvest to determine initial treatment success.

Harvest Monitoring

Monitoring is required during the harvest to determine if reserve trees have been adequately protected as previously discussed. This would be accomplished as part of harvest inspections typical for timber sale administration. If damage provisions are included in timber sale contracts, the methodology used for monitoring must provide data that can be used to assess adherence to contract provisions (see Contract Provisions section).

Post-Harvest Monitoring

Post-harvest monitoring should occur at least once in the first three years after harvest and periodically thereafter. If the basal area per acre of reserve trees has been previously established, rather than taking plots, monitoring can be accomplished using observation transects and damage expressed as a percent of the total number of reserve trees observed. The number of assessed reserve trees and their location should represent the range of topographic variation found in the stand, and reserve tree dbh. It would be useful to record the types of damage that would result in mortality or significantly degrade future merchantability if there is a timber objective. If there are data or guidelines to assist in determining damage assessments, use them. If not available, the following common-sense measures can be used, indicating current or future mortality.

- Dbh and species
- Knock down, loss of > 50% of the top, mainstem bend or lean of >30% from horizontal, major stem damage leading to loss of stem integrity (either immediate or future from decay)
- Harvest damage resulting in loss of merchantability of the butt log (for a timber objective)

With this information, specifying dbh, determining the basal area per acre of undamaged reserve trees can be easily calculated.

Costs

This treatment is implemented using a commercial harvest with a significant timber volume removed and thus has the potential to generate income. The costs associated with treatment are the typical administrative costs associated with timber sales. Marking only the reserve trees could lead to a reduction in timber sale administration costs (see Marking section) compared to the common practice of marking cut trees. Costs associated with pre-harvest data collection could be combined with the timber sale inventory, reducing this cost significantly. Similarly, reserve tree damage assessment associated with the harvest could be combined with timber sale monitoring. The remaining cost would be for monitoring post-harvest damage to reserve trees.

White Oak

White oak is well suited to the two-aged system as it is long-lived, has historically sustained commercial value, and produces habitat and food attributes for wildlife (10). As is the case with all species used for reserve trees, selecting white oak reserve trees that have the minimum impact on harvest revenues may be important for some ownerships. Figure 9 provides examples of the minimum average dbh. Selecting white oak reserve trees that can produce acorns is important for establishing future advance reproduction so white oak will be a component in the regenerating age class in the next rotation (see Section 10). These acorns are also a highly palatable hard mast for wildlife. Research has indicated that fully released white oak reserve trees have the capacity to increase acorn production over white oaks growing in intact forests (Table 6). This same research has shown that this acorn production over time can initiate the development of oak advance reproduction (Table 6). It is also important, as indicated previously, that there are trees that inherently produce more acorns than others, irrespective of crown size (Fig. 10). Finding these trees can be difficult, but they can be extremely valuable as reserve trees.

White oak is widely known for its propensity to develop epicormic branches. Understanding which defect indicators hold suppressed buds can aid in selecting reserve trees that limit the chance of developing epicormic branching

Table 6. Average acorn production per tree and seedling establishment 13 years after crowns of sawtimber sized white oaks were fully released.

	Average grams of acorns per tree	Number of seedlings per acre 13 years after release
Released	1,424	690
Unreleased	689	227

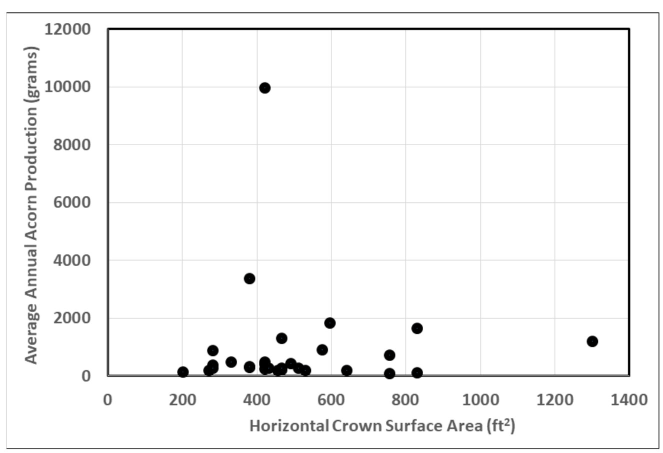

Figure 10. Four-year average annual acorn production for 29 white oak trees 13 years after a full crown touching release. Data indicates no relationship between crown size and acorn production.

after exposure from a deferment harvest. This is particularly useful when there is a timber objective for reserve trees. Table 7 provides the number of suppressed buds associated with bark defect indicators and the number of suppressed buds ultimately resulting from them three years after a deferment harvest. Note how few of the defect indicators hold suppressed buds. Avoiding these specific defect indicators will lessen the chance of developing epicormic branching.

The relative shade tolerance of white oak compared to other co-occurring upland oak species allows white oaks to persist as intermediate crown class trees much longer than other oaks. It is not unusual to find sawtimber stands containing pole-sized intermediate crown class white oaks. Normally intermediate crown class trees would not be selected as reserve trees unless they are very strong intermediates that have balanced crowns and > 40 percent live crown ratios. This can occur with white oak, especially if stands have been subjected to selective harvests in the past allowing for intermediate crown class white oaks to maintain vigor. The latter is indicated by the crown characteristics mentioned above and the presence of a main leader showing that apical dominance has not been lost. If these intermediate crown class white oaks have naturally lost their leaders and the crown is flat-topped, these trees typically will not respond well to release and should be avoided as a reserve tree.

Table 7. White oak suppressed bud number by defect indicator and number of epicormic branches produced three years after release

Defect Indicator	Number of suppressed buds	Number of epicormic branches three years after release
live branch	10.02	2.50
epicormic branch cluster	9.14	1.14
individual epicormic branch	7.67	1.33
suppressed bud cluster	4.73	0.95
dead branch stub	3.94	0.74
epicormic branch distortion[1]	0.80	0.13
heavy branch distortion[1]	0.12	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

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Appendix 1. Two-Aged System and Deferment Harvesting

The two-aged system is designed to maintain two distinct age classes. This system is generally initiated using a deferment harvest, sometimes referred to as a shelterwood or clearcut with reserves, or classically a high forest with reserves. The deferment harvest retains a limited basal area of canopy trees (reserve trees). The basal area retained should be low enough to ensure that the majority of the area vigorously regenerates in similar fashion to a clearcut. The harvesting of the reserve trees occurs at the end of the second rotation along with a younger regenerating age class except for those that will be the next reserve trees. At the end of a second rotation length, the stand contains a limited number of large reserve trees, two rotation lengths in age, and a larger number of trees that are one rotation length in age (7).

The two-aged system is a viable system for managing many hardwood stands where long-lived species are present. The system provides for vigorous regeneration and the development of average size and valued sawtimber trees and a significant component of older, larger and potentially higher value trees (5)(8). The system also provides for structural components that are lacking in even-aged stands. The two-aged system initiated by a deferment harvest provides a number of benefits including:

- development of old, large diameter sawtimber or veneer trees,
- production of a wide range of forest products with a significant value range,
- ability to regenerate shade intolerant and intermediate shade tolerant species,
- improved aesthetics compared to clear cutting,
- increased structural diversity and retention of habitat and potentially food components important to wildlife (3) compared to clear cutting,
- increased initial revenue compared to other types of non-clearcut regeneration techniques,
- development of old growth characteristics, and
- maintenance of sexual reproduction in reserve trees throughout the entire rotation and the ability to “life boat” species that would otherwise be eliminated if the area were clearcut.

While the two-aged system has benefits, it also has constraints and is not appropriate for every management objective or stand condition. Implementation must consider:

- lack of appropriate long-lived species to maintain the system,
- forest fragmentation and habitat effects similar to clear cutting,
- reduction in initial revenues compared to clear cutting and possibly diameter limit harvests,
- limited development of shade tolerant species, and
- damage to new age class trees if a portion of reserve trees are removed prior to the end of the second rotation length.

The two-aged system requires the long-term retention of reserve trees, and their characteristics and selection are critical for successful implementation of the system. Reserve tree characteristics can vary considerably and are based on management objectives. Regardless, the reserve trees must be able to maintain themselves when challenged with an open environment. The selection of the reserve trees, their individual characteristics, position in the landscape, number, and distribution must be carefully determined and managed.

Deferment Harvests

Two-age stands are typically developed using a single deferment harvest that establishes two age classes that are maintained and actively managed through rotations. This differs from an irregular shelterwood that focuses on the management of the regeneration and is implemented to ultimately establish an even-aged stand with overstory removals occurring over multiple harvests and the management focused on regeneration. Further the establishment cut that initiates an irregular shelterwood retains a higher basal area of overstory trees. This is designed to decrease the light regime provided to the regenerating age class, whereas retention levels in the deferment harvest are designed to minimally reduce light levels and have minimum impact on the regenerating age class.

One of the first uses of the two-aged system in the U.S. was to provide an aesthetic improvement over clearcutting (11). When used for this purpose reserve trees do not necessarily need to possess characteristics important for high value timber production. The same can be said for reserve trees where goals and objectives focus on wildlife and/or ecosystem diversity.

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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