United States
Department of
Agriculture

Forest Service

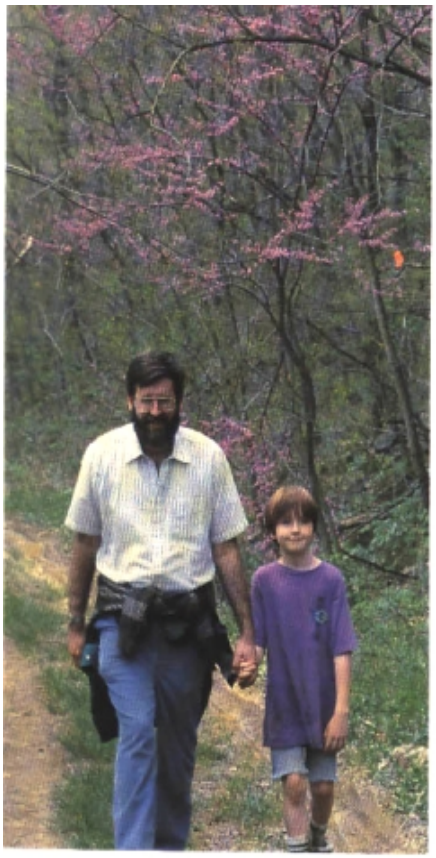
Northeastern Area
State & Private Forestry

Forest Resources
Management

Morgantown, WV

NA-TP-19-93

Crop Tree Management In Eastern Hardwoods



Much of the timber management information in this publication is based on long-term crop tree release research conducted by the Timber Management Research Project at the Fernow Experimental Forest in Parsons, West Virginia. This work was started in the mid 1960's.

Integration of wildlife and aesthetic concepts began in Morgantown in 1987 when Forest Resources Management personnel of the Northeastern Area, State and Private Forestry, were looking for a means of accomplishing multiple landowner objectives on the private, non-industrial forest. In 1990, the Crop Tree Management concept was expanded to include accomplishment of water-quality objectives.

It is our intent that this publication be used as a guide by forestland managers working on private, non-industrial forests in the eastern United States. We have written it, however, so that the information it contains may also be shared with landowners interested in the management of their woodlands.

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and
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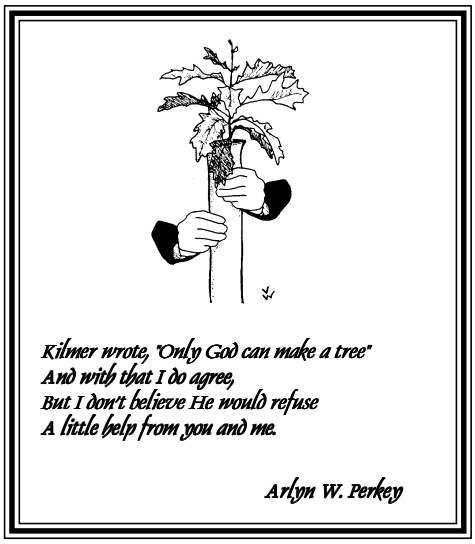

Kilmer wrote, "Only God can make a tree"
And with that I do agree,
But I don't believe He would refuse
A little help from you and me.

Arlyn W. Perkey

This publication is dedicated to all the service foresters and consultants who tirelessly work to manage the private, non-industrial forests of the eastern United States. It is our hope that it will help them better serve this landownership which is so critical to future generations of Americans.

Acknowledgments

We would like to thank several people for their assistance in making this publication possible. In our Morgantown Forest Resources Management Group, the combined skills of Nancy Lough, Vicky Watkins, and Jamie Knotts contributed greatly to the overall project. Nancy spent several hours at the computer assisting with desktop publishing and preparation of the camera-ready copy. She also did the computer graphics. Jamie organized and scanned all the photographs and helped edit text. Vicky designed the front and back covers, in addition to rendering some freehand artwork within the publication. Helen Wassick assisted with production of drafts, and Gretchen Hanna donated her time to provide valuable proofing assistance.

Watershed Planners in our Morgantown office, Karen Sykes and Roxane Palone, were contributing authors for Section VI, *Managing Water-Quality Crop Trees*. Karen also compiled the information contained in Appendix D, *Flood Tolerance of Specific Tree Species*.

Our thanks also goes to Toni McLellan from the Durham, NH, S&PF field office for providing input regarding management of wildlife habitat.

We appreciate all the time and hard work these devoted and talented professionals contributed to the finished product. Their help made our jobs easier.

Arlyn, Brenda, and Clay

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Childhood Memories

"Take my hand," my father said.
"Walk through the woods with me.
I'll show you things that other folks
Might never chance to see."

So I skipped along at Daddy's side,
And saw sights to behold.
The hoot owl with his eyes so wide,
And leaves of red and gold.

I saw bees and their honey tree,
We took a careful look.
We dug sassafras for tea, and
Watched deer by the brook.

We came across a tiny pine,
I said it was so small.
My Dad said in a few more years
It would be very tall.

He said, "You may be bigger now,
But that won't always be.
It will pass us up somehow,
Then dwarf both you and me."

We watched a squirrel on a limb,
Consume an acorn treat.
It didn't seem to bother him,
That we should watch him eat.

A rabbit jumped out of the brush,
I asked my father, "Why?"
"That hawk made the rabbit flush."
He pointed toward the sky.

"Nature has to balance things.
You'll understand some day.
That rabbit could be eaten,
If he doesn't get away."

I didn't want to leave that glen,
When Daddy said, "Let's go."
He promised we'd come back again.
So more that he could show.

Like the pine, I've now grown tall,
But I recall that wonderland.
And how I learned about it all
In the clasp of my father's hand.

Brenda L. Wilkins

Crop Tree Management prescriptions have been implemented on the hillside behind this abandoned farmhouse. The owner of this tree farm has a stewardship goal for the property.

I. Introduction

Because many of today's landowners are interested in stewardship of the forest resource, they need their woodlots managed with a system they can understand and one that will accomplish varied goals. Crop Tree Management was designed to facilitate communication with landowners and to fulfill a combination of stewardship goals.

This publication will guide you, the forestland manager, in applying Crop Tree Management on private, non-industrial forests of the East. It describes how to manage individual crop trees for timber production, fish and wildlife habitat improvement, aesthetic enhancement, and water-quality maintenance.

In contrast to traditional, single-purpose timber management practices, this system focuses on selecting and releasing trees that will yield ***multiple*** landowner benefits, including timber. It requires you to obtain a clear understanding of a landowner's property goals. Based on these, you establish objectives for each stand and develop criteria to guide your selection of individual crop trees. A crown-touching release is then applied to free the crop trees from competing trees. Once released, the crop trees respond with accelerated growth and production of landowner benefits.

Although the Crop Tree Management System focuses on selecting and releasing trees that will yield multiple landowner benefits, it can also be used to accomplish a single objective.

This versatile system, which can be applied in both commercially operable and precommercial stands, was designed to help landowners achieve their stewardship goals.

Although Crop Tree Management was developed for use in private, non-industrial forests where woodlot size is often 100 acres or less, its application is not restricted by the size of the forest to be managed. It can be used to do treatments in both commercially operable and precommercial stands.

This system also works well in riparian areas (streamside management zones). Some of the best sites for production of timber, wildlife, aesthetic, and water-quality benefits are found in these places. However, because certain aquatic and vegetative communities depend on these sensitive areas for existence, management of trees in the riparian zone requires a system that:

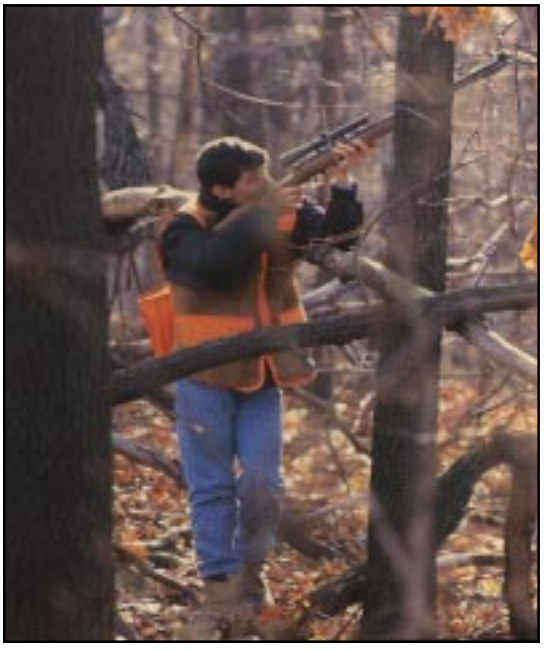
- helps maintain vigorous and diverse vegetation,
- regulates stream temperature, and
- traps sediments and filters pollutants.

Crop Tree Management meets these needs.

At a time when private, non-industrial forestland managers are being challenged to assist their clients in achieving multiple stewardship goals, Crop Tree Management offers an effective way to do so.

II. Crop Tree Management –The Process Defined

1.) Identify the Landowner's Property Goals



Talking with landowners to discover their interests helps you to develop a management plan that will satisfy their needs.

The first step in the Crop Tree Management process is helping landowners describe their property goals.

This can be done by asking what use the landowner intends to make of the forestland. You might suggest some possibilities and explain how current and future benefits can be obtained.

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This can be done by asking what use the landowner intends to make of the forestland. You might suggest some possibilities and explain how current and future benefits can be obtained.

For example, if there is a pole-sized hickory stand on the property and the landowner wants to improve squirrel habitat, you could suggest releasing trees with vigorous, healthy crowns to increase production of nuts.

Or, if the landowner wants to harvest firewood, you could advise cutting the poorest-quality trees. Explain to your client how retaining high-quality trees can yield a future harvest of valuable sawtimber.

Because clear communication between you and the landowner is vital, avoid use of technical forestry terms. Instead, ***use plain English*** to explain the benefits of forest management.

When technical terms must be used, restrict them to descriptions of things that can be seen in the woods. For example, it is all right to use terms like "epicormic branches," "stump sprouts," and "hard mast," **if** good examples of each are shown to the landowner at the time the term is introduced. However, abstract terms like "basal area," "stocking percent," and "rotation" should **not** be used because they can't be observed in a woodlot.

Don't use technical forestry terms to explain the benefits of forest management to landowners; use "plain English," instead.

Explaining what can be seen in the forest in easily understood terms is the best way to capture and maintain the landowner's interest in managing the resource.

By increasing the landowner's understanding of what can be seen in the forest, you are making your client more aware of the benefits that can be produced by managing individual trees.

2.) Establish Stand-Specific Objectives

After the overall property goals are identified, objectives for each stand can be established. Although some stands may provide little opportunity to accomplish a property goal, others might have great potential to do so.

For example, improving squirrel habitat by increasing hard-mast production can't be accomplished in a yellow-poplar stand. But, it ***can be achieved*** in a pole-sized, oak-hickory stand.

Squirrel habitat has been improved in this oak-hickory stand by giving selected hard-mast trees more room to grow.

Having stand-specific objectives focuses your attention, as well as the landowner's, on the portions of the property with the greatest potential to meet goals.

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3.) Develop Crop Tree Selection Criteria

Once you have established the stand-specific objectives, develop selection criteria for each crop tree category. Use these criteria to guide your selection of crop trees. Examples of selection criteria developed for timber, wildlife, aesthetic, and water-quality crop trees begin on Page 15. Explanatory information accompanies each set of criteria to help you understand the guidelines involved. ***Remember: These are only examples; you will need to develop selection criteria to match the specific objectives for each of the stands you will be working in.***

Some trees may satisfy multiple crop tree selection criteria, which makes them very desirable choices for management. For example, a sugar maple could be both a timber and aesthetic crop tree. If it had a cavity, it could also qualify as a wildlife crop tree.

This sugar maple is both a timber and aesthetic crop tree. It can provide valuable timber products and attractive fall foliage.

A red oak might be both a timber and wildlife crop tree because it can produce high-quality timber products and valuable mast for wildlife. Blackgum may serve as an aesthetic crop tree because of its attractive fall foliage. It also qualifies as a wildlife crop tree because of the soft mast it produces.

This red oak is both a timber and wildlife crop tree because it satisfies the criteria for both categories. For the landowner interested in accomplishing these objectives, this is a doubly important tree to release.

Crop Tree Management requires you to choose the trees that best meet the landowner's property goals. This often forces some tough decisions.

Applying this system means selecting crop trees that best meet the selection criteria and are, therefore, best able to accomplish the landowner's property goals. Frequently, there are conflicts among the criteria that require judgment to reconcile.

For example, black walnut may be found growing on abandoned pastureland in competition with sugar maple on a north-facing, well-drained, lower slope with moderately deep soil. When making a choice between timber crop trees of these two species on this site, you must consider:

- the quality of the future timber products,
- the potential growth rate of both trees in regard to the position and vigor of the crowns,
- the growth advantage of the sugar maple because it is better adapted to the site, and
- the probable higher per-unit value of the walnut.

The tree on the right is an off-site black walnut. The tree on the left is a sugar maple growing on a north-facing, well-drained , lower slope. Which tree would you select as a timber crop tree?

As you can see from this example, the Crop Tree Management System often forces you to make some tough decisions when selecting crop trees.

However, weighing the relative advantages and disadvantages of each potential crop tree provides the opportunity for sound judgment to produce the best possible results.

4.) Inventory the Property

After the crop tree selection criteria have been clearly established, inventory the property to estimate the number of trees that meet these guidelines. Appendix A, *Crop Tree Management Inventory and Marking Procedures*, describes an efficient means of collecting data that will help you make management decisions consistent with the landowner's property goals. The **Crop Tree Release Tally Sheet** (sample included in Appendix A) may be used to inventory and analyze the potential crop trees. You can also use it to record the number of trees to be cut. *(**Note**: A reproducible version of the tally sheet can be found in the back pocket of this publication.)*

The Crop Tree Release Tally Sheet may be used to inventory and analyze crop trees and to record the number of trees to be cut.

Remember, crop tree selection criteria may change from one stand to another, even if ownership is the same. Not only may there be different stand-specific objectives, but the quality of available crop trees can vary because of site or past management practices.

Trees that are considered poor-quality in one area may be the best available in another. For example, if you are selecting wildlife crop trees to produce hard mast, you may have plenty to choose from in one stand. In that case, you would select only dominant/codominant trees with good, healthy crowns for crop trees. In another stand where hard-mast trees are scarce, you may be forced to select trees with poorer crowns simply because that is all that is available.

Crop tree selection criteria may change from one stand to another, even if ownership is the same.

If you find small portions of the property where crop trees are lacking, you have two options. One is to do nothing. Simply allow that area to continue to mature without releasing any trees. The other option is to cut all trees that do not meet the crop tree selection criteria. This will create an opening that will permit establishment and development of regeneration.

5.) Explain the Proposed Treatment to the Landowner

Prior to marking any crop trees, demonstrate to the landowner how the Crop Tree Management System works. This will help your client understand the prescription and give you an idea of how many crop trees the landowner wants to release (Figure 1).

Establish a few one-fifth-acre circular plots. (Don't try to use variable radius plots for this exercise; keep things simple.) Select crop trees on these plots and temporarily identify them with a band of brightly colored flagging. Explain to the landowner how these crop trees will meet the property goals.

Simulating the proposed treatment on a small scale and discussing it with the landowner helps you get feedback on how well the prescription satisfies your client.

Figure 1. *Helping the landowner visualize the proposed treatment on a small scale is the best way to get your client's feedback. Here, the crop trees are identified with one band of ribbon, and the trees to be cut are double banded. If adjustments need to be made, now is the time to do so.*

After you have talked about the ribboned crop trees, walk around the plots again. This time, identify (with a contrasting color of flagging) all of the trees that need to be removed to fully release the crop trees. Be sure to explain that **only the trees in direct competition with the crop trees will be removed**; those with crowns that do not touch the crop trees will remain in the stand. This helps the landowner visualize what the proposed treatment will look like.

Simulating the proposed treatment on a small scale and discussing it with the landowner helps you get feedback on how well the prescription satisfies your client. If you need to make adjustments in the number of crop trees to be released, or the selection criteria to be used, now is the easiest time to do so because the crop trees have not yet been permanently marked.

6.) Decide How Many Crop Trees to Release per Acre

The number of crop trees to release per acre depends on how many trees meet the selection criteria and how many the landowner wants to release. The more crop trees that receive a crown-touching release, the heavier the cutting will be. When fewer crop trees are released, the cut is lighter (See fold-out on Pages 55 and 56).

When a low number of crop trees are released, the cut is lighter, leaving some areas of the stand relatively undisturbed.

Many commercially operable Central and Northern hardwood stands have only about 20 to 50 good-quality timber crop trees per acre. The number of crop trees in these previously unmanaged stands usually depends on site, species composition, stand history, and, most importantly, stand age. Younger stands, with more trees in smaller size classes, tend to have more crop trees per acre.

It is sometimes helpful if you can actually show landowners various intensities of cutting on other properties. This way, they can see what slash and regeneration look like and decide how much they are willing to accept in their own woodlots. Some landowners may be dismayed by the difficulty of walking through a lot of woody debris and thick regeneration. However, they must be able to weigh this inconvenience against the positive aspects of both.

Younger stands, with more trees in smaller size classes, tend to have more crop trees per acre.

Explain to landowners that regeneration often includes desirable species of trees that can effectively meet their overall property goals. Regeneration is also a valuable source of habitat for some species of wildlife. Slash usually decomposes in about four or five years, but until it does, it, too, provides a source of wildlife habitat. Walking trails can be established throughout areas of dense regeneration and slash to make access easier.

In this 55-year-old stand, all available crop trees were released (32 per acre), which initiated dense understory development. This photograph was taken during the fifth growing season following treatment. Trails were established during the cutting operation and have been maintained on an annual basis.

Regardless of the number of crop trees you decide to release per acre, be sure each of them receives a complete crown-touching release. For instance, imagine you survey a stand and find 30 trees per acre that meet the crop tree selection criteria. The landowner, however, is uneasy about the degree of cutting required to fully release that many trees. You discuss it, and both agree that releasing 20 trees per acre would be acceptable.

Regardless of the number of crop trees you decide to release per acre, be sure each of them receives a complete crown-touching release.

At this point, you must take another look at your 30 initial choices and drop 10 of them from consideration. Concentrate your attention on selecting the 20 trees per acre that you consider best for meeting your client's property goals, and fully release each of them.

In this 55-year-old stand, 20 crop trees per acre were released. The understory developing here (fifth growing season following treatment) is more patchy and less dense than that shown in the photograph above.

In other words, adjust the intensity of cutting by adjusting the number of crop trees selected for release. Don't be tempted to compromise the system by selecting more crop trees than you can fully release (Figure 2).

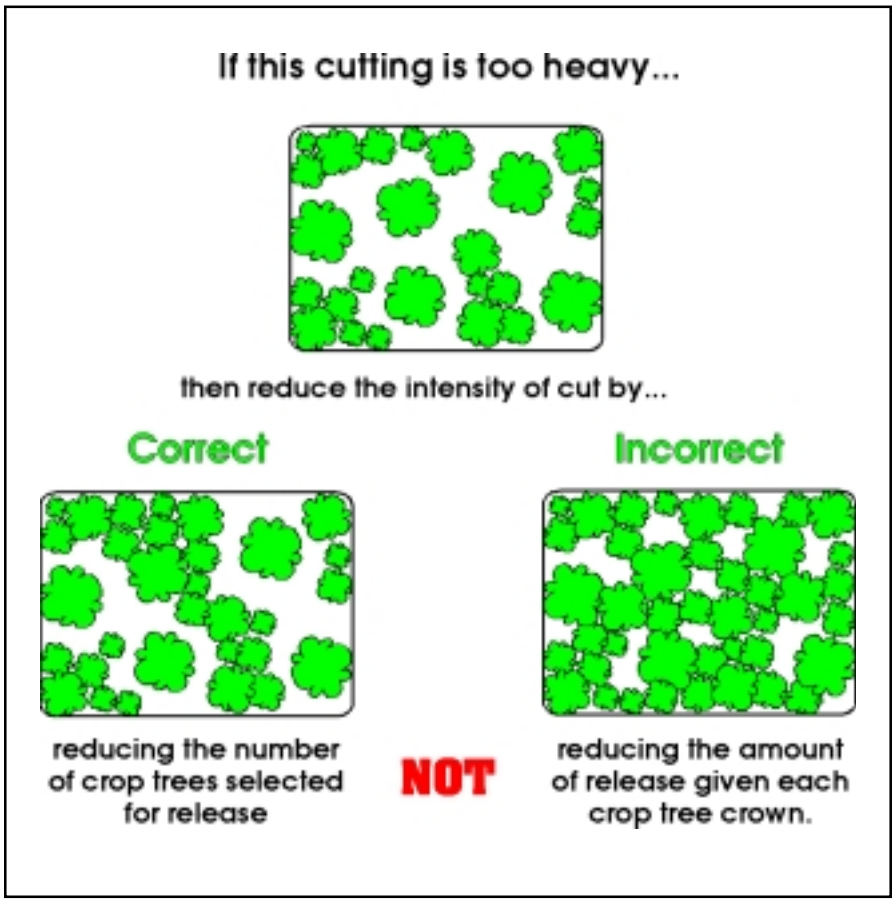

Figure 2. *If the landowner indicates that a lighter cutting is desired, adjust the intensity of cutting by releasing fewer crop trees.*

Adjust the intensity of cutting by adjusting the number of crop trees selected for release.

Keep in mind that only the trees in direct competition with the crop trees get cut; all non-competing trees remain in the stand. Although no consideration is given to releasing any of the trees in this second category, some may receive partial release because of their proximity to crop trees. This incidental release can help the residual trees produce timber, wildlife, aesthetic, or water-quality benefits.

What if the landowner indicates no concern about how heavy the cut is? Then you should feel free to release every crop tree that meets the established selection criteria. In a stand well-suited to accomplishing the overall property goals, this often means selecting as many crop trees as the crown-touching release guidelines will allow. Remember, however, that each crop tree must be given a complete release, unless two crop trees are adjacent to each other (See photograph on Page 13).

Free-to-grow rating of "0." *The crown of this tree is crowded around its entire perimeter.*

Free-to-grow rating of "2." *This crown has room to grow on two of its four sides.*

Free-to-grow rating of "4." *This tree has received a crown-touching release which gives it freedom to grow on all four sides.*

7.) Decide Which Trees to Cut to Release the Crop Trees

Our step-by-step explanation of the Crop Tree Management process concludes with a description of how to determine which trees must be removed to fully release the crop trees.

This is done by simply looking up into each crop tree crown and envisioning it divided into four separate quadrants, or sides (Figure 3). A determination is then made as to how many of the four sides are free from competition from neighboring crowns.

For example, a "0" classification means the crop tree crown has no room to grow. In contrast, a rating of "4" means the crop tree is free to grow on all of its four sides.

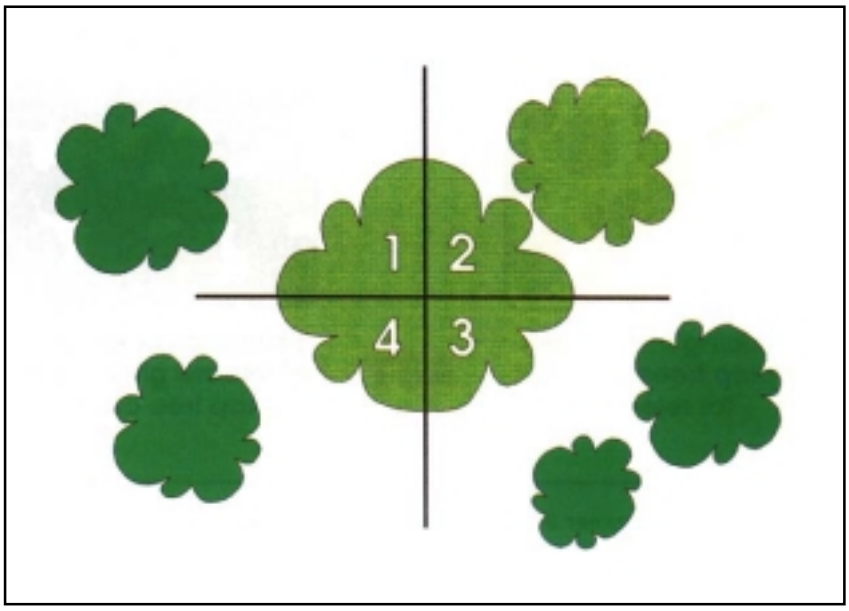

Figure 3*. The crop tree crown in the center of this illustration has been separated into four quadrants, or sides. A free-to-grow rating is determined by evaluating each side for competition from neighboring crowns. This crop tree is free to grow on three sides.*

Free to grow really means free to expand. A crop tree that has only one or two feet between its crown and a neighboring crown is not free to grow in that quadrant. If there is doubt about whether an adjacent tree is touching and competing, cut it.

Healthy crowns of immature hardwood trees generally expand at the rate of a foot per year. Therefore, the growing space between adjoining crowns decreases by about two feet annually. Consequently, 15 feet of space between crowns provides adequate release for about seven or eight years.

A crown-touching release essentially involves removal of all trees with crowns that interfere with, or touch, the crop tree. In the event of two crop trees occurring close together with adjoining crowns, it is acceptable to consider the two as one crown, and then release fully around the dual crown. This means the two crop trees each receive a three-sided release rather than a four-sided release, as otherwise recommended.

A complete crown-touching release is required for all crop trees unless two of them happen to have adjoining crowns. In this case only, a three-sided release is acceptable. Be sure, however, to fully release the entire dual crown.

Why is a complete crown-touching release so important? Many of the best crop trees in stands that have received area-wide thinnings have been released on only one or two sides of the crown. Research has revealed that this limited degree of release captures only about half of the diameter growth potential of the crop trees (Figure 4).

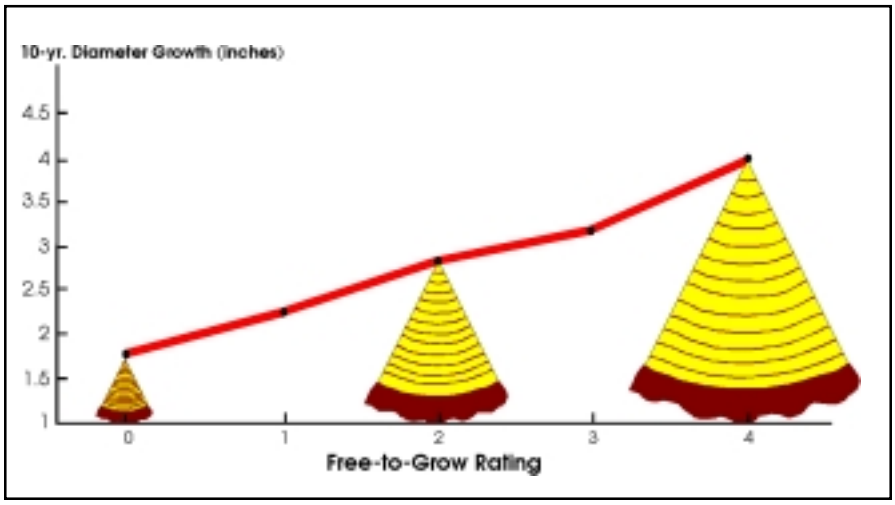

***Figure 4**. This chart shows the dramatic difference a complete crown-touching release makes in the growth of crop trees. Represented here is the 10-year diameter growth in inches for the 20 best crop trees per acre in a 54-year-old stand.*

Many of the best crop trees in stands that have received area-wide thinnings have been released on only one or two sides of the crown.

As you can see, giving a crown-touching release to selected high-value crop trees can greatly enhance the benefits they are capable of producing.

Nearly every timber crop tree available was released on this site. Rapid growth is being recorded as the trees respond to the crown-touching release they received.

Appendix B, *Applying Crop Tree Management in Specific Eastern Forest Types*, provides a brief synopsis of pertinent information you might find helpful when using this system to manage the various species of trees found in your area. White pine and hemlock are also included because managing these conifer inclusions may be critical to accomplishing the landowner's goals.

III. Managing Timber Crop Trees

Although today's landowners are interested in managing their woodlots for other benefits, timber production still remains an objective of many and an important source of public benefit. Often cited as a secondary rather than a primary objective, managing for timber has become a real challenge.

In Eastern hardwoods, we should consider concentrating our efforts on managing individual trees with the greatest potential for producing high-value products. The limiting factors are: 1) the number of trees we can find or get established per acre at a reasonable cost, and 2) our ability to grow them at a rapid rate while retaining the characteristics that make them valuable.

We should consider concentrating our efforts on managing individual trees with the greatest potential for producing high-value products.

It is value that counts; not volume. We have an excess supply of low-value volume and a shortage of potentially high-value trees. Doesn't it make sense to manage the good trees we do have to produce high-value volume in a shorter period of time? Crop Tree Management can provide high-quality timber products from individual trees growing at a rapid rate.

Following is an ***example*** of selection criteria developed for timber crop trees.

Nearly every timber crop tree available was released on this site. Rapid growth is being recorded as the trees respond to the crown-touching release they received.

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Following is an ***example*** of selection criteria developed for timber crop trees.

Timber Crop Tree Selection Criteria

- Dominant/codominant trees (at least 25 feet tall)
  - Healthy crown; large in relation to dbh
  - No dead branches in upper crown
  - Either low-origin stump sprouts (less than six inches at groundline) or seedling-origin stems are acceptable
  - U-shaped connections are acceptable; avoid V-shaped connections
- High-quality trees
  - Butt-log potential of Grade 1 or 2
  - No epicormic branches (living or dead) on butt log
  - No high-risk trees (leaners, splitting forks, etc.)
- High-value commercial species
- Expected longevity of 20+ years
- Species well-adapted to the site

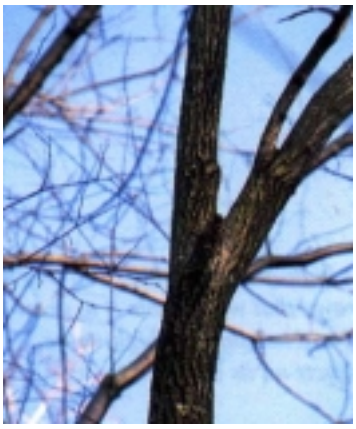
Select dominant/codominant trees, at least 25 feet tall, with large, healthy crowns. Trees of this height with these crown characteristics have already gained a good competitive position in the stand. They will also have developed to the point that approximately 17 feet of the bole should be clear. Such trees respond well to release, and they are less likely to epicormic branch than those that do not meet these guidelines.

Crop Tree Management places special emphasis on the crown as a tree characteristic that must be given serious consideration when selecting crop trees. In fact, when using this system a good rule of thumb is:

If you're not stumbling over debris on the forest floor . . . . You should be looking up at the crowns a lot more.

Trees with small crowns should not be chosen as crop trees. Also avoid trees that have dead branches in the upper crown.

When selecting timber crop trees, don't gamble on trees with evidence of epicormic branching on the butt log -- once released, they usually branch profusely.



High-risk trees, like this one, are not good timber crop tree choices. The seam below the fork increases the likelihood that this tree will split.

Stable, well-formed stump sprouts that originate close to the ground are acceptable choices for crop trees.

Following release, growth response rates of trees with large, healthy crowns can be quite dramatic.

Trees with a few dead lower-crown branches are often acceptable as timber crop trees. However, be cautious about trees with dead branches in the upper crown.

Stump sprouts that originate close to the ground are suitable crop tree candidates if they are stable and have good form. When choosing from multiple-stem sprouts on slopes, the stem that originates from the uphill side of the stump is often the most stable.

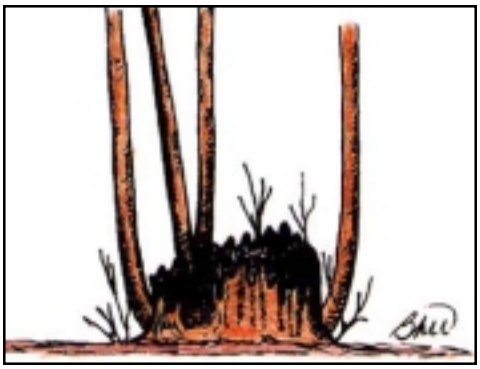


Figure 5. *The two sprouts in the center have grown together to form a "V-shaped" connection. The other two sprouts on either side of the stump represent a "U-shaped" connection.*

Stump sprouts join at the base in two forms (Figure 5). Trees joined with a "V-shaped" connection generally don't make good crop trees. In most cases, a decision must be made to either cut both or leave both. If one is cut and the other left, the decaying stump of the removed tree provides an entry for rot into the tree that remains.

Trees having a "U-shaped" connection may be considered individually as crop trees. Because their bases are independent of each other, they can be harvested at different times. This means that one can be cut without providing an avenue of decay into the other.

This high-quality timber crop tree has a crown that will enable it to grow well and accumulate high-value products on its bole.

High-quality crop trees with the potential to produce Grade 1 or 2 butt logs can give landowners a reasonable rate of return on their investment.

On good growing sites, crop trees with a growth response of one inch often earn a 4 percent real rate of return.

Skill in evaluating the probability of epicormic branching after release is especially important. You must be able to assess the likelihood of a tree developing epicormic branches, as well as the degree to which they might occur. With a little knowledge and some practice, you can do this with good success.

Epicormic branching following release is affected by several interacting factors. These are:

1.) crown position
2.) crown size relative to dbh
3.) tree vigor
4.) species
5.) genetics
6.) stress
7.) wounds

For most species, dominant/codominant trees with large crowns and good vigor are not likely to epicormic branch to any significant degree following release. When epicormic branching does occur, it usually happens on the upper, less valuable logs instead of the butt log. Contrary to what might be expected, there is no evidence to indicate that leaving midstory trees to provide shade to the bole of crop trees reduces epicormic branching.

Certain species have a greater tendency to epicormic branch than others. White oak, basswood, and elm are the most prone, followed by red oak, black cherry, chestnut oak, beech, hickory, yellow-poplar, red maple, sugar maple, sweet birch, and white ash.

Research from the Northeastern Forest Experiment Station in Parsons, WV, reveals that we can expect approximately 15 percent of dormant buds on the butt log of red oak trees to sprout. For yellow-poplar, only about 4 percent will sprout.

Neither of these two white oaks is a good choice for a timber crop tree. The one on the left is smaller than most trees in the stand, and it has a sparse crown. The tree on the right has many dormant buds that are likely to respond to any significant degree of release.

There is no evidence to indicate that leaving midstory trees to provide shade to the bole of crop trees reduces epicormic branching.

Markers must be careful to look for dormant buds or existing epicormic branches on the butt log of the tree. These are warning signs of a tree's potential for epicormic branching, which can lower the value of timber products.

The genetic make-up of individual trees also influences epicormic branching. Avoid selecting trees prone to this deficiency by looking for existing branches and dormant buds. The butt log of selected crop trees should be completely free of epicormic branches (living or dead).

A large branch was cut from this crop tree. This left a major wound which triggered development of epicormic branches.

Stress and wounds can also affect epicormic branching following release. Usually, these factors can be considered prior to cutting and mitigated to some extent. For example, if a stand has recently been defoliated by gypsy moth, cutting can be delayed until the trees recover from the stress of infestation.

It is important to minimize wounds on crop trees by exercising care during the cutting operation. Resist the temptation to trim off any large lower branches from crop trees. Doing so can leave a major wound that may stimulate epicormic branching on the butt log of the tree.

Avoid selecting trees that are high-risk because of characteristics like excessive lean and forks. The susceptibility of trees to damage from such characteristics varies by species. For example, a yellow-poplar or black cherry with a forked stem is more likely to break than a red oak with a similar fork.

The fork of this yellow-poplar was broken during a storm. Some species are more prone to this kind of damage than others.

Species that are valuable for commercial forest products, or those expected to become valuable, should be preferred as timber crop trees. Market preferences can and do change, so the future is certainly not entirely predictable. However, you must use your best judgment to make decisions that have the greatest probability of providing landowners with a good return on their investment.

Don't select trees with a short life expectancy. For example, in a 70-year-old, even-aged, Northern hardwood stand, it makes little sense to select a paper birch as a timber crop tree. This short-lived species isn't likely to respond well to release because it is already biologically old. However, sugar maple and yellow birch trees of that age can be expected to respond very well. Timber crop tree candidates should be at least 20 years younger than the normal biological maturity for that species.

Timber crop tree candidates should be at least 20 years younger than the normal biological maturity for that species.

Select crop trees that are well-adapted to the site. This is particularly important in stands that are succeeding from past agricultural use. These stands are likely to include trees that are not site-suitable because they were established by advantages such as seed size and dispersal rather than by site compatibility.

This can happen, for example, when there is a black walnut seed source available in an abandoned, upland pasture site with shallow soil. The large seed of the walnut gives it an advantage getting established in the grass competition.

It does not grow well, but it survives, and becomes part of the first stand established on the site. Even if walnut is selected and released on this site, it isn't likely to grow as well as other species better adapted to growing on upland slopes with shallow soils.

These black walnut trees have become established on a site not suited to the species. Consequently, although they survive, they will not produce valuable timber products.

Seed dispersal also contributes to trees becoming established in areas where they are not well-adapted. Consider a large, abandoned field situated on an upper slope. The only seed source is a drainage located upwind with a few large yellow-poplar and white ash in it.

Seed size and dispersal are two factors which can be responsible for trees becoming established in areas where they are not well-adapted.

The variety of species available to provide a seed source is limited. However, these few big trees produce a large quantity of wind-blown seed. This increases the probability of these few trees being the parents of the seedlings that occupy the field.

As a result, yellow-poplar and white ash become established on a site that is drier than these species need to grow well. Unless these trees die during periods of drought, they may occupy many growing sites because there is little competition from other species better adapted to the location.

Generally, timber crop trees can be grown along streams if the soils drain adequately. Riparian zones are often excellent growing sites for timber if the soils are deep, well-drained or moderately well-drained, and have good water-holding capacities.

Under these topographic and edaphic conditions, the riparian zone produces some very high-quality timber crop trees—provided the species selected for management are adapted to the moisture conditions.

Riparian zones are often excellent growing sites for timber if the soils are deep, well-drained or moderately well-drained, and have good water-holding capacities.

Important factors to consider in managing trees in riparian zones are flood frequency, flood duration, and high-water tables. Some excellent timber crop tree species growing in these areas are only marginally adapted to the conditions that exist there.

For example, black cherry may be found in riparian zones, but if drainage conditions are poor or if periodic flooding occurs, its potential to produce timber benefits is severely restricted. In fact, there is a good chance these trees will die. Therefore, you must not only consider the general timber value of a species, but whether or not it can survive and grow well under the conditions on the particular site where it is found.

Some good timber crop trees can often be found in riparian zones, especially on rises or terraces above the flood plain.

In the Appalachian and Central hardwood forest regions, high-quality timber crop trees are seldom found in riparian zones where recurrent flooding is common. Many of the species best adapted to these conditions are of low timber value.

However, some very productive growing conditions can be found on certain sites — if flooding is brief, infrequent, and occurs only during the dormant season. Usually, these locations are either on rises of the flood plain or on terraces above it. They are often the best places to look for good timber crop trees.

IV. Managing Wildlife Crop Trees

Fish and wildlife habitat improvement is important to many woodland owners. Often cited as a primary management objective, this area of technical assistance can be as complex as manipulating multiple vegetative communities to benefit turkeys or as simple as increasing hard-mast production for squirrels. Landowners whose properties include riparian areas are often interested in enhancing fish habitat and encouraging reproduction of desirable fish species.

Before you can develop a wildlife management strategy, you need to determine what type of wildlife your client is interested in. Is it game, non-game, or a combination of both?

Interests of the landowners you serve are as varied as the landowners themselves. For this reason, you should be prepared to determine the habitat requirements of a wide variety of wildlife species.

Some landowners are realizing they are not limited to managing the fin, feathers, and fur species. There are those who are interested in insects, like bees and butterflies, and still others who want to know how to favor such species as reptiles and amphibians.

Once you know the kind of wildlife the landowner wants to favor, determine if the property is capable of supporting it.

Once you know the kind of wildlife the landowner wants to favor, determine if the property is capable of supporting it. If it is, manage crop trees that will provide food and cover to satisfy the habitat requirements of the preferred species.

Following is an ***example*** of selection criteria developed for wildlife crop trees.

Wildlife Crop Tree Selection Criteria

Mast-producing species:

- Dominant/codominant trees
  - Healthy crown; large in relation to dbh
  - A few dead, upper-crown branches are acceptable
  - Stump-sprout or seedling-origin stems are acceptable
- Hard-mast producers preferred over soft-mast producers; strive for species variety
- Expected longevity of 20+ years
- Cavities and large, broken branches are acceptable

Cavity trees*:

- Trees of any species, size class, and crown position are acceptable
- Dead, upper-crown branches and cavities in the main bole are acceptable
- Expected longevity of tree isn't important

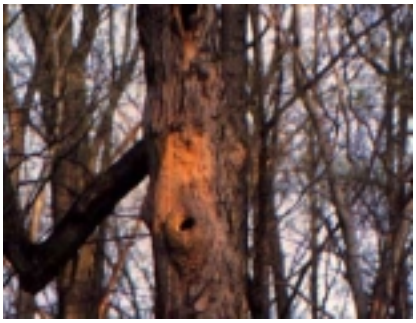
* If a cavity tree is also a mast producer, release it. Otherwise, it need not be released.

Crop Tree Management can benefit wildlife by increasing production of mast from individual trees. Important mast-producing indicators are:

1) size of crown relative to dbh
2) crown position
3) species
4) genotype

The greatest mast production within a stand comes from dominant and codominant trees.

Depending on the wildlife species being managed, hard-mast producers may be preferred over soft-mast producers. Sources of winter-storable food are critical for survival of some species of wildlife.



If a tree qualifies as a wildlife crop tree only because it can be used as a den, it doesn't need to be released.

One large, released crown produces more mast than two or three small crowns on trees of the same species.

Intermediate or suppressed trees produce very little mast because their crowns receive limited sunlight. By removing trees with small, sparse crowns, we allow trees with large, healthy crowns to expand and produce more mast.

The important thing to remember when releasing mast-producing trees is to expose as much crown-surface area to sunlight as possible. One large, released crown produces more mast than two or three small crowns on trees of the same species.

When releasing mast-producing trees, expose as much crown-surface area to sunlight as possible.

A study at the West Virginia University Forest near Morgantown compared acorn production of released trees to that of unreleased trees. In an average acorn crop year for white oak, the production of acorns from individual released crop trees was seven times that of unreleased trees.

For red oak in a poor year for acorn production, individual released crop trees produced double the acorns of unreleased trees. When the increased production for both species was evaluated on a per-acre basis, there was twice as much mast produced on the areas where the crop trees were released as there was where they were not.

Although soft mast, catkins, and buds are important sources of food for many species of wildlife, hard-mast producers are usually preferred for selection as crop trees over soft-mast producers. Hard mast is generally available for a longer period of time, and, because it is a winter-storable food, it is critical to some wildlife species.

White oak acorns are generally preferred over red oak acorns by many species of wildlife. However, they are available as food for a much shorter period of time. They germinate in the fall rather than in the spring, which limits their usefulness as a winter food source.

These red oak acorns are not as tasty to wildlife as white oak acorns, but they are often more abundant. They do not germinate until spring, so they are an available food source for a longer period of time.

Some species produce more mast than others. For example, on the average, red oaks produce more than either chestnut or white oaks—both of which produce more than black oaks. The average red oak between 14 and 16 inches dbh produces two or three times as much mast as the average black oak of the same size.

Some species optimize production at a larger diameter than others. For example, the average white oak will be 20 to 22 inches dbh before it produces as many pounds of mast as a red oak 16 to 18 inches in diameter.

If you are working with a young stand, remember that chestnut oak may start yielding acorn crops at an earlier age than many other oak species. Having a mixture of mast-producing species is the best way to minimize the probability of a total mast-crop failure.

Having a mixture of mast-producing species is the best way to minimize the probability of a total mast-crop failure.

Some trees habitually produce more mast than others of the same species, crown condition, and canopy position. This is probably because of genetic variation. If adequate management time is available, these historically-reliable mast producers can be found by visiting the woods during several successive seasons and observing which trees yield the greatest crops. These top producers can then be targeted for selection as wildlife crop trees. Unfortunately, this intensity of management for mast production usually requires more lead time than many landowners and foresters have available.

Frequency of good seed crops is another mast-production consideration. Red, black, and scarlet oak tend to have good seed crops more frequently than white and chestnut oak. Hickory has good seed crops more frequently than oak. Abundance of mast production can vary by species in different regions of the Country.

Frequency of good seed crops is another mast-production consideration ..... hickory has good seed crops more frequently than oak.

To help ensure long-term mast production, select wildlife crop trees with an expected longevity of at least 20 years. Cavities are acceptable. In fact, a good mast producer which can also provide shelter is a doubly important wildlife crop tree.

Den trees are another type of wildlife crop tree. Generally, a tree of any species, size class, and crown position can qualify as a den tree if it can fulfill the need for shelter. It can have dead branches in the upper crown, holes in the main bole, and large broken branches, and still be acceptable. In fact, even its expected longevity is not a limiting factor.

It is important to identify trees with cavities currently being used as dens. Scratch marks around the entrance of the cavity are an indication of present use. Also look for trees with developing cavities that have potential to become future dens.

The scratch marks around this cavity indicate it is being used for a den. Cavities are an important habitat feature that shouldn't be overlooked if the landowner is interested in managing wildlife species that utilize den trees.

To some degree, you can manage den and potential den trees to benefit whatever species of wildlife the landowner desires. The optimum size and location of the den vary with the wildlife species you are trying to favor. Certain species of trees tend to form cavities more readily than others. Beech, basswood, sycamore, black gum, ash, and the maples are particularly likely to develop good dens.

Den sites near water are especially valuable to wildlife.

Dens and potential den sites near water are very valuable to certain species of wildlife. Consequently, you need to be especially watchful for the opportunity to maintain cavity trees in the riparian zone.

Another consideration in managing habitat for wildlife is retaining dead trees for use by various species of wildlife. Dead-tree habitat provides an important source of food. For example, woodpeckers feast on insects found in standing, decaying wood. Snags are used by several species of wildlife as perches for resting and observation.

To create dead-tree habitat for wildlife, you may want to consider girdling a few of the trees that would otherwise be cut to release crop trees. Girdling some of the competing trees may not provide release as quickly as cutting them does, but the slight delay is often offset by the wildlife benefit gained. Appendix C, *Creating Snags for Wildlife*, contains specific information regarding this process.

You may sometimes find that coordinating silvicultural activities to benefit one wildlife species may hinder another species. For example, the number of crop trees released affects the density of the understory that develops. A dense understory may not be ideal habitat for an oven bird, but it can be very desirable to a red-eyed vireo. Therefore, some trade-offs may need to be discussed with the landowner.

Openings created in the canopy when crop trees are released allow sunlight to reach the forest floor. Understory vegetation response and regeneration are almost immediate. Of course, in some areas, high deer populations may inhibit such regeneration.

Maintaining various stages of reproduction and age classes throughout the forest provides habitat for numerous species of wildlife. Under proper management, this may enhance activities such as hunting, trapping, fishing, birdwatching, and photography.

Openings created in the canopy when crop trees are released allow understory vegetation to flourish.

You may sometimes find that coordinating silvicultural activities to benefit one wildlife species may hinder another species.

Frequently, the riparian zone is where many species of wildlife are more abundant and most active. Therefore, special attention should be given to helping this area reach its fullest potential.

If diversity of tree species is important to produce wildlife benefits, the riparian zone can often play a key role in maintaining those benefits. Because this zone is frequently topographically and edaphically different, it often contains tree species that may not be present elsewhere on the property. Even if the species are available for selection as crop trees on other sites, their presence in the riparian zone may enhance production of benefits such as food and shelter for preferred wildlife.

Along the water's edge, Crop Tree Management helps maintain the aquatic food source by favoring deciduous species for crop trees.

Crop Tree Management is also compatible with maintenance and improvement of fish habitat. In order to achieve and maintain productive fisheries in streams, suitable habitat for fish and their invertebrate food source must be maintained. The major source of food on which both vertebrates and invertebrates depend, the nearstream deciduous vegetation, may be managed to increase its productivity.

Leaves that fall into streams add organic material to the water, thus contributing to the energy source on which productive fisheries depend.

Leaves that fall into streams add a large quantity of organic material (detritus) to the water. This organic load is the basis of increased productivity. Invertebrate populations increase and, through the food chain, corresponding increases in fish growth and food production occur.

Along the water's edge, Crop Tree Management helps maintain the aquatic food source by favoring deciduous species for crop trees.

Both vertebrates and invertebrates favor deciduous vegetation over that of conifers because the leaves are thin and easier to consume. This doesn't mean, however, that all conifers should be ignored during crop tree selection. Conifers also provide wildlife habitat, year-round shade, and aesthetic diversity.

An additional benefit can be gained by retaining big, limby trees that lean out over the water. These trees may contribute to the energy source for many years as their leaves and twigs drop into the waterway. When the trees eventually fall into the water, they become large, woody debris which aids in development of excellent habitat for fish.

Large, limby trees that hang out over the water provide shade and add organic matter to the stream.

A bonus benefit is gained when these overhanging trees eventually fall into the water and provide habitat for fish. If the fallen tree has some large limbs, they may help keep the bole off the bottom of the stream, extending the useful life of the cover.

If shade is needed to keep water temperatures low for fish habitat, then a dense stand in the area adjacent to the stream must be maintained. When this is the case, few crop trees should be selected and released. For example, in most 40 to 60-year-old Eastern hardwood stands, no more than 20 crop trees per acre should be released.

Studies have shown that trees keep streams cooler in the summer months and warmer during the winter. This is important information to remember if fisheries are a consideration. If water temperatures are too warm, preferred fish species stop reproductive activities. On the other hand, cooler water temperatures prevent undesirable fish species from increasing in the aquatic community. Therefore, trees along a stream play a vital role in establishing and maintaining desirable fish habitat.

Some landowners may not realize the cooling effect trees along waterways can have on the water — and the beneficial influence that results for the aquatic life that inhabits the stream.

The cooling effectiveness of trees decreases with increasing stream size. However, if temperature control is accomplished in the smaller streams, it will help reduce temperature-associated problems in larger downstream locations.

If water temperature isn't a primary concern, there is more flexibility in the number of crop trees that can be released adjacent to waterways. In most Eastern hardwood forests, applying a crown-touching release to more than 25 crop trees per acre admits sufficient light to encourage patches of dense understory development.

If temperature control is accomplished in the smaller streams, it will help reduce temperature-associated problems in larger downstream locations.

V. Managing Aesthetic Crop Trees

Aesthetic enhancement is an idea that appeals to many private, non-industrial landowners. They may not want timber production as a primary objective because they know their forestlands can also produce non-priced benefits such as spring blossoms and colorful fall foliage. The beauty of the forest increases recreational enjoyment of the property, which encourages stewardship of the forest resource.

Following is an ***example*** of selection criteria developed for aesthetic crop trees.

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Following is an ***example*** of selection criteria developed for aesthetic crop trees.

Aesthetic Crop Tree Selection Criteria

- Species that produce attractive flowers or colorful foliage
  - Healthy crowns; large relative to dbh
  - A few dead, upper-crown branches are acceptable
  - Stump-sprout or seedling-origin stems are acceptable
  - Understory trees acceptable if release is not high risk
- Visible from travelways and adjacent to streams, when opportunity exists
- In many cases, expected longevity of 20+ years
- Unique trees (old pasture trees with spreading branches, unusually shaped trees, trees with attractive bark characteristics, etc.)

Although many of the flowering species are understory trees such as dogwood, serviceberry, and redbud, it is still important to make your crop tree selections from the trees that have the best crowns. Expose them as fully as possible to the sunlight for more abundant blossoms.

Species that provide pleasing fall colors, such as maples, sourwood, and black gum, should also have good crowns. When these trees exist in a dominant or codominant position, they are likely to have the best advantage for rapid growth following release. The better they are released, the more visual benefits they will produce.

If aesthetic crop tree release is to be done in conjunction with a harvesting operation, you may want to caution the land-owner beforehand that this is not an easy task. Understory trees are especially susceptible to damage from logging equipment and falling trees, sometimes making their release a high-risk activity that can result in loss of the tree.

Trees that provide fall colors and spring blossoms are especially attractive along streams and travelways where there is more opportunity to view them.

If the landowner enjoys spring blossoms, exposing the crowns of trees like this serviceberry to full sunlight will produce an abundance of beautiful flowers.

These old, open-grown sugar maples have been identified as aesthetic crop trees because the landowner likes their shape and size. They are also a reminder of the agricultural heritage of this landscape and the days when a farmer's children climbed on their branches.

The location of aesthetic crop trees can significantly affect their value and importance. When visible from travelways, they can be enjoyed by a greater number of people. Trees with attractive fall foliage or spring flowers are particularly desirable along streams where their reflections in the water add to the beauty of the landscape.

Because trees are phototropic and grow in response to varying amounts of light, those located along streams, lakes, and ponds can develop some interesting shapes. These unusual trees contribute to the aesthetic attractiveness of riparian areas and are frequently endearing to landowners.

Aesthetic crop trees that are visible from trails and waterways can be enjoyed by a greater number of people.

There may be a few trees that are considered special by the landowner, perhaps because of size, uniqueness, or other distinctive characteristics. Usually, managing these aesthetic crop trees is simply a matter of retaining them in the stand, regardless of their crown position or expected longevity.

Another consideration of special interest to landowners is the density of understory in the wooded area along waterways. Generally, landowners prefer a park-like environment near the water's edge so they can walk along unimpeded by thick brush.

This does not mean, however, that aesthetic crop trees near water can't be managed. When a relatively low number of crop trees per acre receive a crown-touching release, understory development is limited.

This small, blooming serviceberry has been released so its crown will expand. It is adjacent to a stream and visible from the road. Slash from the cut trees has been pulled out of the stream and piled to provide habitat and minimize the negative appearance of the debris.

VI. Managing Water-Quality Crop Trees

Crop trees in riparian zones can be managed to improve water quality by helping control non-point source pollution. Water-quality crop trees can absorb large amounts of excess nutrients that come from agricultural fields. These trees act as effective filters by intercepting and retaining runoff sediments and excess nutrient pollutants that would otherwise end up in waterways.

For example, nitrogen is a nutrient that is often leached from agricultural fields as nitrate fertilizer. Water-quality crop trees can absorb nitrogen in the form of nitrate and change it to an organic compound that is stored in their woody biomass. They also convert nitrate to nitrogen gas which is released into the atmosphere when organic matter like the annual leaf fall is decomposed. In this way, the nutrients that would otherwise find their way to water courses are instead harmlessly dispersed into the air.

Some landowners are very concerned about water quality, and they are interested in utilizing their woodlands to promote cleaner waterways. You may want to advise these landowners that some species of trees are more effective nutrient filters than others.

Following is an ***example*** of selection criteria developed for water-quality crop trees.

Water-quality crop trees provide a viable means of mitigating the influence that some agricultural practices have on water quality.

Water-quality crop trees are a new concept to many landowners, but there is increasing interest in managing these trees. Forestland managers need to know which species are the most effective nutrient filters.

These yellow-poplar trees, located between an agricultural field and a stream, are helping to keep excess nutrients from reaching the water.

Hardwoods along a stream course or in forested wetlands are more effective nutrient filters than most conifers.

Tree tolerance to flooding and high-water tables is a major consideration when selecting crop trees in riparian zones. Sycamore is well-adapted to such locations.

Water-Quality Crop Tree Selection Criteria

- Dominant/codominant trees
  - Healthy crown; large in relation to dbh
  - A few dead, upper-crown branches are acceptable
  - Stump-sprout or seedling-origin stems are acceptable
- Expected longevity of 20+ years
- Species that are good nutrient accumulators
  - Young trees
  - Deciduous trees
- Trees tolerant to flooding

Dominant/codominant trees with healthy crowns that are large in relation to their dbh are the best choices for water-quality crop trees. Generally, these trees that have already established good, competitive positions in the stand are the ones with the greatest capacity to absorb nutrients. A few dead, upper-crown branches are acceptable if they don't appear to be indicating a significant loss of vigor. Stump-sprout or seedling-origin stems can be chosen as crop trees; however, remember that sprouts that originate near groundline are the most stable.

When selecting crop trees, choose those with an expected longevity of at least 20 years. Nutrient uptake is most rapid in young trees, and it declines with increasing age. As trees mature or begin to die, their net annual nutrient uptake tends to drop.

Trees growing in riparian zones will not reach their full potential as long-term nutrient filters unless they are properly managed. If trees mature and die at the same time, their effectiveness for filtering nutrients is diminished. For this reason, it is important to maintain various age classes within the riparian zone to provide a continuous cycle of nutrient uptake.

Generally, deciduous trees have greater nutrient demands than conifers. For example, oaks require more nutrients, especially potassium and nitrogen, than spruce and pine. Therefore, if water quality is important to landowners, they should be advised that hardwoods between agricultural fields and water courses absorb more nutrients than most conifers. This "filtering" process captures as much as 89 percent of excess nutrients before they reach waterways.

Deciduous trees can filter as much as 89 percent of the excess nutrients from agricultural fields before the pollutants reach waterways.

Basswood, yellow-poplar, dogwood, and red cedar concentrate large amounts of calcium, phosphorus, and potassium in their foliage. Beech, red spruce, the pines, and hemlock are slower in their uptake of these elements.

Red and white oak, red maple, and quaking aspen do extremely well in nitrogen uptake, but only to a point. Once their requirements are met, their growth and absorption level off. White ash, basswood, and yellow-poplar also respond well if nitrogen levels increase.

Yellow-poplar and basswood absorb large amounts of nitrogen, phosphorus, and potassium (N, P, K)— the components of fertilizer commonly used on agricultural fields.

Although deciduous species provide successful avenues for improving water quality, do they have the ability to survive in riparian conditions? This introduces another consideration — tree waterlogging tolerance to various hydrologic regimes. Waterlogging tolerance refers to a species' ability to live from seedling to maturity in various soil saturation conditions during the growing season.

White ash is a "moderately water tolerant" species that can survive occasional periods of waterlogging during the growing season.

Tolerance to flooding depends on species, age, genetics, soil conditions, and time of year.

Some species survive well in conditions of frequent flooding or waterlogging, but others may die if waterlogged for even a short period of time. Generally, waterlogging tolerance of a species increases with age and size up to maturity, but it declines with decreasing crown position. Tolerance to flooding depends on species, age, genetics, soil conditions, and time of year (growing season or dormant season).

Basswood, a "*highly water tolerant"* species, accumulates large amounts of calcium, phosphorus, and potassium in its leaves. It is able to withstand flooding for most of one growing season. However, in contrast, yellow-poplar, which is a "*least water tolerant"* species, accumulates the same elements, but cannot withstand flooding for more than a few days during the growing season.

"Highly water tolerant" species, like basswood, can survive flood events during the growing season, while a "least water tolerant" species, like yellow-poplar, usually cannot.

High concentrations of some elements may be toxic to some plant species. Flooding, or high-water tables, results in many elements becoming more available to plants, potentially reaching toxic levels. This availability, however, depends on the chemical properties of the soil and the amounts of oxygen present during flooding.

Once water levels return to normal, most nutrients return to pre-flood concentration levels unless excessive leaching has occurred. For a complete listing of tree tolerance to flooding, please refer to Appendix D, *Flood Tolerance of Specific Tree Species.*

VII. Visual Effects of Treatment

When discussing the post-treatment appearance of the stand with the landowner, be sure to talk about what to do with the midstory trees. Will they be cut or knocked down during the treatment operation? Or, will they remain standing to provide foliage in the midstory?

Considering only the visual effects, to cut or not to cut the midstory is a decision that can be made based on landowner preference. Some landowners prefer the park-like appearance achieved when the midstory is removed. Others may want to leave the midstory trees standing to reduce the open appearance of the stand.

Another visual consideration affecting the decision is the high probability that residual midstory trees could epicormic branch profusely. Generally, these are low-value trees anyway, but the presence of many small trees with epicormic branches may be an aesthetic liability to some landowners.

Because most crop trees are in the main crown canopy, midstory trees are usually not serious competitors. However, if establishment and development of regeneration is part of the Crop Tree Management prescription, leaving midstory trees may critically affect the regeneration process.

Shade from midstory trees usually has an inhibiting effect on development of an understory layer of vegetation. This may be positive or negative, depending upon the prescription.

If establishment and development of regeneration is part of the Crop Tree Management prescription, leaving midstory trees may critically affect the regeneration process.

When this stand received a Crop Tree Management treatment, the midstory trees were cut. Some landowners prefer the park-like appearance obtained by removal of the midstory.

When midstory trees are not cut, the slash and other evidence of management is less visible.

How the work is done also has an effect on post-treatment appearance of the area. If competing trees are girdled instead of felled, there is less slash on the ground following completion of the treatment. However, if the trees are girdled too deeply, they may fall over and hang-up in standing trees. This creates an aesthetic liability more offensive than slash, not to mention the safety hazard it poses.

Girdling with a chainsaw to a depth of one inch is sufficient to kill trees. Cutting deeper, especially on small trees, increases the probability they will fall over soon after girdling.

Competing trees may be girdled instead of felled. This provides standing, dead, woody habitat for some species of wildlife. It also decreases the amount of slash on the ground right after treatment.

Timing of the cut is another consideration. If felling is performed during the growing season, there will be a brown-up effect that is very apparent. However, if competing trees are felled during the dormant season, there will be no leaves to turn brown. Consequently, there will be less contrast between the slash and the standing trees.

When competing trees are cut during the growing season, the leaves turn brown, increasing the visibility of the treatment.

If competing trees are girdled, the season when the work is done may have a significant effect on how quickly the trees die and how apparent their death is. Many ring-porous species die quickly if girdled between July 15 and September 15 (see Appendix C).

Although a "quick kill" may provide the desired timber and wildlife benefit, it could be visually offensive to some landowners.

Access trails through the woody debris can help make the treatment more acceptable to the landowner.

The appearance of treated stands changes rapidly with time. The following scenes show how quickly the slash loses prominence as it settles to the ground and understory vegetation grows through it.

The yellow-poplar stand pictured is being managed for timber production. It received a heavy dormant-season cut, which was financed with the assistance of a cost-share program. No timber products were removed from the area, so there was a dense concentration of slash immediately after cutting. Midstory trees were felled to achieve a park-like appearance in the stand.

Immediately after treatment slash is very prominent.

Near the end of the second growing season, the understory vegetation has reduced the visibility of the slash.

When autumn arrives and leaves begin to fall, the slash and understory blend together in appearance.

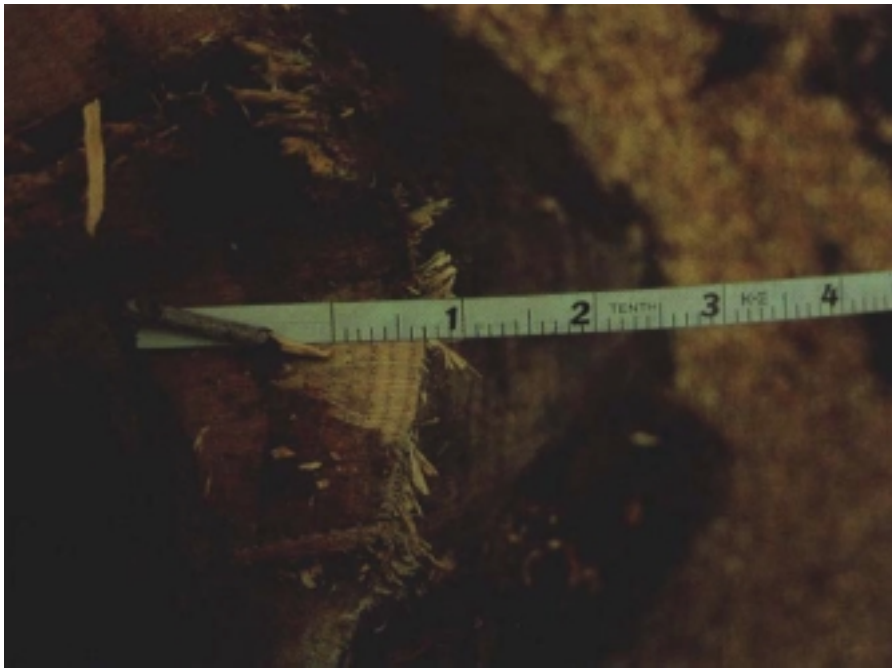
Winter snows tend to focus attention on the overstory where individual trees contrast with the white surroundings.

As you can see from the photographs, the season of the year can also affect how the landowner and other forest visitors may perceive a Crop Tree Management treatment.

VIII. Evaluating Growth of Released Crop Trees

Because Crop Tree Management focuses on individual trees, it is important for us to have an appropriate way of evaluating growth. Individual tree diameter growth expressed in inches per decade is a viable means of measuring growth rates and responses. It is also easy to explain to landowners.

One way to estimate the growth of various species in a general area is to look at stumps of recently cut trees. Select one, and measure the width of the last five growth rings. For example, if the five-year radial growth is 0.7 inches, then the diameter growth would be double that, or 1.4 inches for the five-year period. Because we want to express growth in inches per decade, we must multiply that figure by two to get an estimate of 2.8 inches overall diameter growth per decade. In other words, diameter growth in inches per decade can be estimated by simply measuring the last five growth rings and multiplying by four.



Another method of estimating growth is to establish permanent paint marks at dbh on 10 trees of the same species with similar diameter, crown size, and degree of release. Measure these trees before leaves appear in the spring and again after growth has ceased in the fall. The sum of annual growth for these 10 trees gives you an estimate of the per decade growth of individual trees for that species, size, and free-to-grow category.

Individual tree diameter growth expressed in inches per decade is a viable means of measuring crop tree growth rates and responses. It is also easy to explain to landowners.

One way to estimate crop tree growth is to measure the five-year radial growth and multiply by four.

A real advantage of this method of measuring crop tree diameter growth is that it is something landowners can do themselves. It gives them an accurate and easy way to monitor the progress of selected crop trees over time. Periodic remeasurement of these 10 trees by the landowner helps maintain interest and promotes a sense of stewardship as the crop trees grow and produce the desired benefits. *(**Note**: A form, **Crop Tree Growth**, has been developed for landowners to use to monitor how well their crop trees are growing. A reproducible copy of it is included in the back pocket of this publication.)*

An annual measurement of selected crop trees enables landowners to monitor the growth rate of released crop trees.

What growth rates can we expect from individual crop trees? As an indication of the upper limit of growth, we have recorded an open-grown yellow-poplar with a growth of five inches in diameter in five years. If this growth were projected for an additional five years, it would have an estimated growth rate of 10 inches per decade. This example is a yard tree with little crown or root competition. It is not expected that comparable growth could be obtained in the forest environment with a complete release.

The photograph on the left shows a red oak crown at the beginning of the first growing season after it received a crown-touching release.

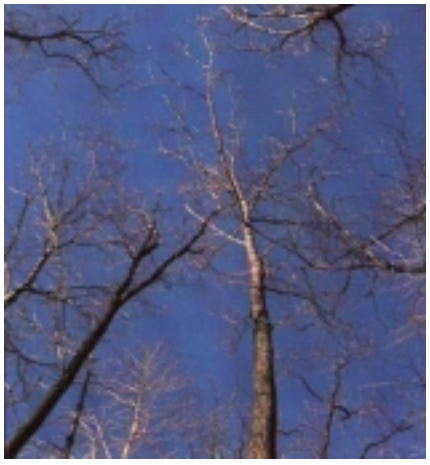
The picture on the right is the same tree at the end of the fourth growing season. Crop trees that develop deep, wide crowns like this are capable of rapid growth.

However, in another case, a forest-grown red oak in an unthinned stand was once growing at the rate of six inches per decade. That is certainly an indication that individual trees of the right species, with healthy crowns and a good release, can produce such growth.

What is a realistic average diameter growth we could expect? Research at the Fernow Experimental Forest near Parsons, WV, gives an indication of how fully released trees on good growing sites are likely to respond. We can expect 10-year growth rates of about 3.5 inches per decade for yellow-poplar and red oak, 2.8 inches for black cherry, 2.6 inches for white oak, and 1.8 inches for chestnut oak.

Both of these crop trees have good, healthy crowns and are well-adapted to the site. The smaller red oak on the left has grown at an average rate of 4 inches per decade. The slower-growing chestnut oak on the right has averaged 2.8 inches per decade.

What influence would this kind of growth have on the rate of return and crop tree income for an individual tree? Let's compare two 12-inch trees that are growing on the same one-half-acre plot.



The unreleased, 12.0-inch dbh red oak on the left has a growth rate of 2.0 inches per decade. Its rate of return is 14 percent and its income is $12.

The 12.2-inch dbh red oak on the right, which was fully released, has a growth rate of 3.8 inches per decade. Its rate of return is 20 percent and its income is $24.

Growth of the released tree is nearly double that of the unreleased tree, its rate of return is much greater, and its income is twice as much as the unreleased tree.

IX. Timber Crop Tree Investment Analysis

Techniques for estimating individual tree volumes with a calculator are explained in Appendix E, *Timber Crop Tree Investment Analysis*. Using the formulas given, a calculator with business analyst features, and appropriate local stumpage values, individual tree rates of return and income may readily be calculated.

The **Timber Crop Tree Investment Analysis Sheet** (sample included in Appendix E) is a useful tool for helping you evaluate the financial potential of an individual tree. *(**Note**: A reproducible version of the sheet can be found in the back pocket of this publication.)*

X. Crop Tree Management versus Area-Wide Thinning

Many area-wide thinnings simply take out the poor trees and retain the good ones.

What makes Crop Tree Management so different from an area-wide thinning? Crop Tree Management requires you to focus attention on retaining those trees with the greatest potential to produce specific benefits consistent with the landowner's property goals. You are forced to single out and release those "best" trees, which often means removing some trees that might ordinarily be retained when doing an area-wide thinning.

Crop Tree Management requires you to retain trees with the greatest potential to fulfill the landowner's goals. This often means removing competing trees that would be retained in area-wide thinnings.

Many area-wide thinnings simply take out the poor trees and retain the good ones. Frequently, marking rules for these treatments call for removing all high-risk and poor-quality timber trees as a first priority. No attention is given to the release of crowns. On the surface, these stands usually look very good to foresters, but can they produce optimum benefits consistent with landowner objectives?

With Crop Tree Management, the marking rules are changed. The distribution of the cut trees may be very different. The first priority trees for removal are those that are interfering with the development of selected crop trees (See fold-out on Page 56).

Consequently, from a timber production perspective, you may be leaving some undesirable or high-risk trees in the stand and removing some fairly good trees because they inhibit the ability of crop trees to produce benefits.

Implementing a Crop Tree Management prescription generally means cutting the trees with crowns that are competing with those of the crop trees. If enough of the trees that need to be cut are commercially valuable, the treatment can produce income for the landowner.

Because this system is quite different from traditional practices, it is extremely important that the logger and/or tree feller be part of the Crop Tree Management team. A clear understanding between the landowner, forestland manager, and tree feller is essential for successful application of the practice. This is especially true if you are doing "leave tree" marking rather than "cut tree" marking because many tree fellers are not currently experienced with this approach.

Using leave tree marking, crop trees are identified with paint. Trees to be cut are not painted. The tree feller applies a crown-touching release to each crop tree, cutting only those trees with crowns that touch and compete with the crop tree. Not all unmarked trees in the stand will be cut, especially if relatively few crop trees are designated. Any release these remaining trees receive is incidental, because it occurs only as a result of trees being cut to release the crop trees.

A clear understanding between the landowner, forestland manager, and tree feller is essential for successful application of the Crop Tree Management System.

XI. Regeneration

Obtaining and encouraging development of desirable regeneration is a management need that has not been adequately addressed on the private, non-industrial forest. This is primarily because of the rather intensive treatments, such as clearcutting, that are frequently associated with regeneration practices.

This 0.4-acre opening was made by cutting commercially removable trees. Openings of this size, and somewhat larger, are acceptable to many landowners.

Because many landowners are sensitive to these practices, doing regeneration work on large areas of an individual's property is often not an option.

However, addressing regeneration by treating one or more small portions of the property is sometimes acceptable. Many landowners will agree to openings of 0.4 to 1-acre in size.

The physiographic characteristics of a site and the successional stage of the vegetation found there are two major factors influencing the effectiveness of prescribed regeneration treatments. The two factors are interactive, so you need to consider the combined effects when prescribing management activities designed to meet the germination and early growth requirements of a desired species.

Many private, non-industrial forests are on land that was previously used to grow agricultural crops. As a result, these sites may be occupied by trees that are quick to capture open land, but may be poorly suited to growing well on the site.

First, evaluate the physiographic characteristics of the site. Is it a cool, moist, north-facing, lower slope, or a hot, dry, steep, south-facing, upper slope?

If the site is moist and very productive, there is a high probability of finding late successional species established in the understory just waiting to take the place of the present overstory. When this is the case, it may be more practical to direct management activities to the late successional species for the site instead of trying to maintain the present cover type.

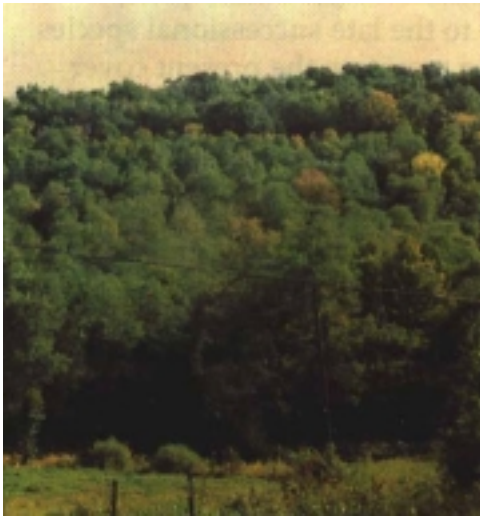
On this northeast-facing slope, the sugar maple understory is ready to replace the oak overstory. It would require an intensive understory treatment to establish oak regeneration and enable it to successfully compete with the sugar maple.

When the early successional species are preferred on mesic sites, intensive management activity may be necessary to perpetuate them. They require significant site disturbance to establish, and they receive tough competition from other plants.

Where growing conditions are less favorable because of factors like low available moisture, poorly drained soil, or shallow soil, it is often easiest to maintain early successional species. For example, a chestnut oak ridge may be easy to maintain in that species because there aren't many other species that effectively compete on that site.

Where growing conditions are less favorable because of factors like low available moisture, poorly drained soil, or shallow soil, it is often easier to maintain early successional species.

Think about the history of the area. How did the currently existing overstory and understory get there? Where on the successional scale is the stand currently located? For example, is the stand in an early successional stage after reverting from agricultural use, or is it a late successional forest with the most recent activity being a partial harvest 40 years ago?



The present species in the overstory is usually just one of several options you may have on the site. To evaluate how practical it is to regenerate any particular species, consider the natural dynamics of the site and how the species composition will change over time in the absence of any specific management activities.

The indications of past activities are on the landscape for those who learn to read the signs. An old fenceline, still visible from a distance, is a clue that past land use below the fence may have been different from that above it.

Within the constraints established by the physiographic characteristics of the site and the successional stage of the forest, there may be an opportunity to influence species composition with management activities.

For example, the size, shape, and directional orientation of the openings affect the light reaching the forest floor. Influencing light affects the temperature and moisture content of the soil, with subsequent effects on the establishment and early growth of regeneration. Creating light, temperature, and moisture conditions that favor one species over another is the primary means we have of influencing species composition.

Below this old fenceline was open field where hay was harvested. Tree species whose seeds are dispersed by wind or transported by small animals now occupy the site. Above the fence was pasture with residual trees. It is now a two-aged stand with the older residual trees having been the seed source for the immature trees.

Because many private, non-industrial ownerships in the eastern United States are old farms, agricultural land that is reverting to trees is a common forest condition encountered on this ownership category. Frequently, portions of these productive sites are occupied by commercial tree species that have poor form. These patches of poor-quality timber trees are good places to make openings where desirable regeneration can be established and developed.

It may also be appropriate to establish regeneration artificially. This can be done in openings or under canopies that have been opened to admit additional light to the forest floor. Artificial regeneration can be established by planting nursery stock. It can also be achieved by direct seeding with appropriate protection from predation. Tree shelters can be used to improve survival and early shoot growth of seedlings while protecting them from animal damage.

Tree shelters can be used to improve survival and early shoot growth of seedlings while protecting them from animal damage.

It may be desirable to use some artificial reforestation techniques to influence the species composition of the new stand. Tree shelters were used here on planted nursery stock to establish a component of black walnut.

In stands where the forest is more mature, openings can frequently be established using a commercial harvest. This may provide some income for the landowner. However, it can also affect regeneration conditions.

When equipment is used to remove timber products, there is usually disturbance to the duff layer of the forest floor. This exposure and mixing of mineral soil with partially decomposed organic matter provides seed bed conditions more favorable to some species than to others.

This area was old pasture that had succeeded to non-commercial and poorly formed commercial species. The trees in this opening were cut during the dormant season to encourage sprouting of desirable species and regeneration of a higher-quality stand of trees.

If advanced regeneration is an important part of a Crop Tree Management prescription, use six-foot radius plots to inventory existing regeneration. Follow procedures described in the SILVAH[1] manual (or other applicable guide for your region) to evaluate the adequacy of the established regeneration. Then determine the prescription that is appropriate for its stage of development.

If there is no place where desirable regeneration is established, select an area where it can be, and determine what is needed to accomplish it. If the species you want to regenerate is an intolerant with an adequate available seed source on the site, you may not need advanced regeneration. Just make the opening.

If there is no place where desirable regeneration is established, select an area where it can be, and determine what is needed to accomplish it.

For some species (such as oaks and hickories), establishing regeneration is more of a process than an event. Therefore, it may take several years to accomplish the task.

If the species you want to regenerate needs to be established as advanced regeneration on that site, you will need to create the conditions that favor its establishment. This may involve using management activities like treating midstory competitors with herbicides. At the appropriate time, you may also need to open the main crown canopy by deadening or felling some of the trees in the dominant and codominant crown classes.

Frequently, Crop Tree Management prescriptions that release a relatively large number of crop trees per acre admit sufficient light to encourage understory development that includes desirable species. When this is the case, you may ignore the understory if its development doesn't coincide with the maturity of the crop trees being managed in the main crown canopy.

1/ SILVAH (SILViculture of Allegheny Hardwoods) was developed by the Northeastern Forest Experiment Station to facilitate the inventory, analysis, and prescription writing for hardwood stands in the Northeast.

Another option is to manage the understory by maintaining sufficient light on the developing crop trees to keep them growing vigorously. This allows you to manage the unit as an even-aged stand by removing the overstory (in essence a two-cut shelterwood).

This Crop Tree Management prescription released the maximum number of available crop trees. It permitted enough sunlight to reach the forest floor to establish regeneration in the understory. This area can easily be managed as an even-aged stand by removing the overstory during the next 20 years. It could also be managed as a two-aged stand.

Two-aged management is another option in some eastern hardwood types. At different points in time, two-aged stands have immature crop trees in the understory, midstory, and eventually the overstory canopy. The immature crop trees need sufficient light and space to develop as they grow through these various canopy levels. When the older age class of overstory crop trees reaches maturity and the younger crop trees are in the main crown canopy, the older age class can be harvested. New reproduction in the understory occupies the space made available by the removal of the mature trees. This cycle is repeated, always maintaining two age classes of trees on the site. The younger age class is about one-half the age of the older class.

In this two-aged stand, the younger tree in the center has now reached the same height as the older age class of trees that border it on both sides.

Factors to consider in the location of regeneration areas are not limited to the present condition of the forest site. You must also weigh the aesthetic effects, both positive and negative, of a regeneration treatment. For instance, you might ask yourself where an appropriately designed regeneration treatment would be most beneficial to wildlife and the people who enjoy observing the wildlife.

Dealing with the social aspects of establishing and developing desirable regeneration is probably one of the greatest challenges facing managers of the private, non-industrial forest. Establishing small openings (0.4 to 1-acre) is a viable option that needs greater application.

Cutting 0.4-acre openings results in trees of different ages. Trees in the foreground of this photograph are four years old. The middleground trees are 14 years old, and the background trees are more than 80 years old.

To minimize the amount of treatment that must be carried out, be opportunistic. Carefully evaluate where openings will be made to take advantage of existing desirable reproduction. For example, if oak regeneration is desirable, look for portions of the property where it is already established.

If landowners are not concerned about applying a regeneration treatment on a stand-level basis, there is no reason to be artificially constrained to treatments of 0.4 to 1-acre in size. You may want to discuss with landowners the benefits of regenerating the species that will best accomplish their property goals. Showing landowners what prescribed regeneration treatments look like is probably the most effective way to help them decide if they are willing to manage crop trees for future generations.

Showing landowners what prescribed regeneration treatments will look like is probably the most effective way to help them decide if they are willing to manage crop trees for future generations.

XII. Conclusion

These are times of change and challenge. The majority of this Country's forests are in private, non-industrial ownership. This means that the future forest resource needs of our nation must largely be met by the people you advise.

As the demand for forest benefits grows and their availability from public lands is constrained, supply will depend more and more on private, non-industrial forests. Management of private ownerships must appeal to today's landowners by offering options that can produce a wide range of benefits.

Crop Tree Management is a system that can effectively fulfill multiple landowner goals. It is easy to explain and understand. Perhaps the greatest advantage of this system, however, is the opportunity it gives landowners to actually participate in managing their own crop trees.

Remember — communication is the key. Helping private, non-industrial landowners reach a forest stewardship goal by providing sound management advice can be a real challenge. However, if we are going to be effective at managing crop trees both now and in the future, we must meet that challenge by learning how to communicate well with our clients.

Management of private ownerships must appeal to today's landowners by offering options that can produce a wide range of benefits.

Managing private, non-industrial forests today presents new challenges and great opportunities. How well this vital segment of the forest resource produces benefits for society depends on our ability to meet those challenges.

I Can Wait

"I can wait," said the farmer,
When all the seeds were in the soil.
"I can wait until the harvest
To prosper from my toil."

He paused a bit to wipe his brow,
How fast had gone the morn.
"I'll work this plot all summer,
Then reap my crop of corn."

And so the farmer tends the field,
And as he works he knows,
He will see the harvest
From all the seeds he sows.

"I can wait," said the steward,
When the treatment was all through.
"I can wait to see the new stand,
It was time here to renew."

He thought about the work it took
To regenerate the stand.
He thought about the way it looked;
Some might not understand.

"It looks a little naked now,
But that won't last for long.
New growth will quickly fill the site,
With young trees growing strong."

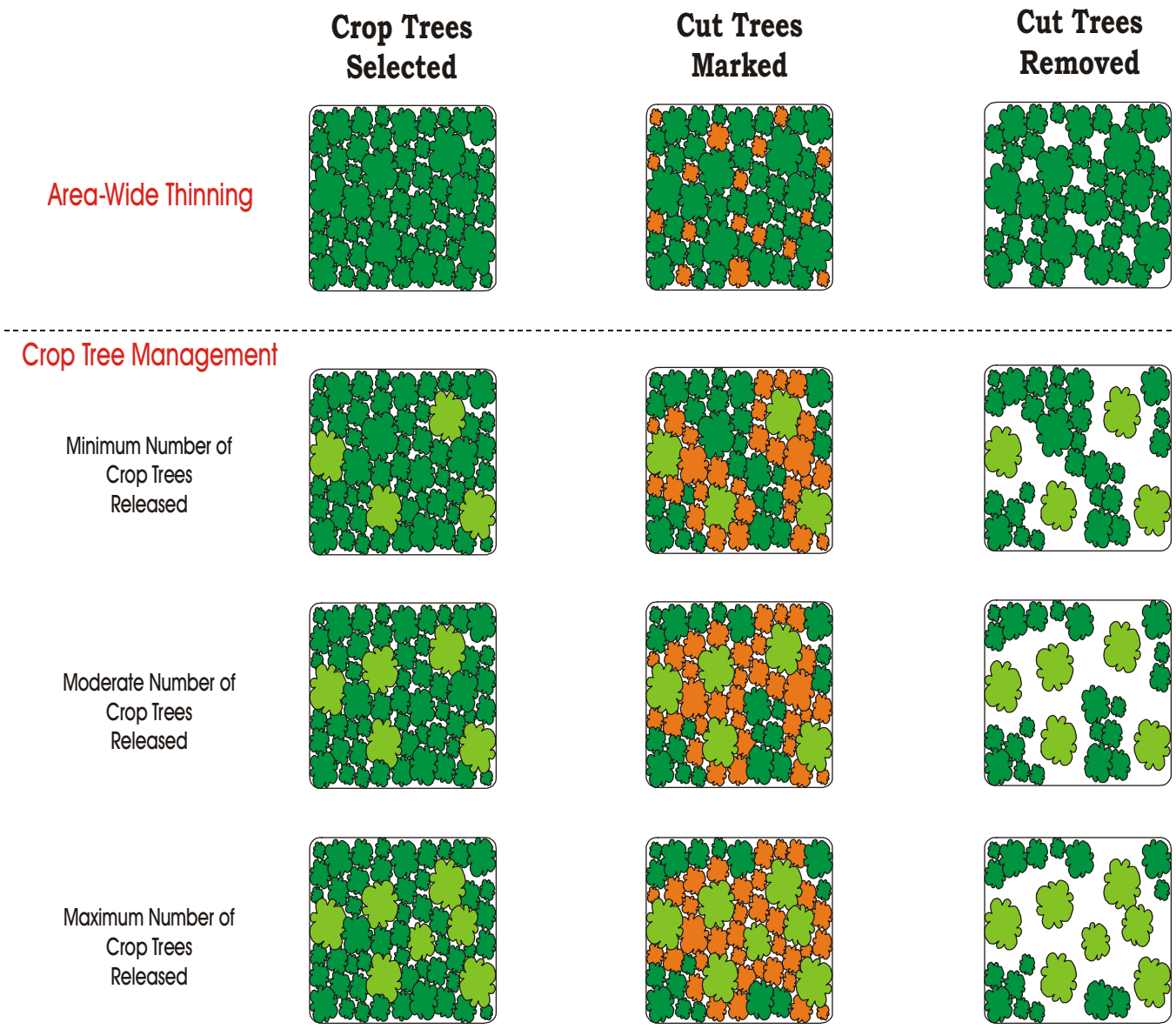
Unlike the farmer with his crop,
The steward cannot say,
"I can wait to reap the harvest
From what I've done today."

The steward starts the trees to grow,
Tending season after season,
While others question why he does,
What could be his reason?

Not for himself he does it,
No reward he'll likely see,
But for those who follow after,
He will leave his legacy.

Brenda L. Wilkins

	Original Stand (55 Years Old)	Immediately After Cutting	4 Years After Cutting
20 Crop Trees Released per Acre			
32 Crop Trees Released per Acre			

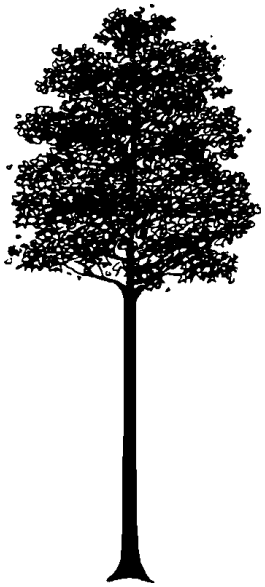

Crop Trees Selected
Cut Trees Marked
Cut Trees Removed
Area-Wide Thinning
Crop Tree Management
Minimum Number of Crop Trees Released
Moderate Number of Crop Trees Released
Maximum Number of Crop Trees Released

XIII. Appendices

The following appendices contain additional information regarding Crop Tree Management in Eastern Hardwoods. The data sheets included in the back pocket of the publication may be reproduced. Please feel free to use this publication and its contents to help your clients understand how the Crop Tree Management System works.

Crop Tree Management is easy to understand and easy to explain, which facilitates communication of the concept to others.

- **Timber Production**
- **Fish & Wildlife Habitat Improvement**
- **Aesthetic Enhancement**
- **Water-Quality Maintenance**



APPENDIX A

Crop Tree Management
Inventory and Marking Procedures

by

Arlyn W. Perkey & H. Clay Smith

Communicating with the landowner is a critical part of Crop Tree Management. Just as you inventory the forest, you must also inventory landowners' interests and feelings about their woodlots.

Crop Tree Management
Inventory and Marking Procedures

by

Arlyn W. Perkey and H. Clay Smith

These inventory and marking procedures are intended to help practitioners develop effective and efficient Crop Tree Management application techniques. Based on personal experience, these recommendations come from application in demonstration areas on public land and prescriptions administered on small, private woodlots.

The Crop Tree Management System involves careful identification of landowner property goals, establishment of stand-specific objectives, and development of crop tree selection criteria.

Look for clues that might reveal stand history, such as remnants of open-grown pasture trees, indications of fences, or old stumps.

Generally, objectives are accomplished by giving the crop trees a crown-touching release. This means the entire perimeter of each crop tree crown is freed from competing crowns. Neighboring trees are cut if their crowns touch or extend over the crown of the crop tree. It is not essential to cut trees that are clearly in the overtopped crown class position because they are well beneath the crop tree crowns and unable to compete.

To ensure a complete release, imagine the crop tree crown divided into four separate quadrants, or sides. Evaluate each side for competition from neighboring trees. A crop tree is not fully released unless it is free from crown competition on all four sides.

It is permissible to have two crop trees adjoining, in which case they each receive a crown-touching release on only three sides. However, their combined crown perimeter must be fully released. The intensity of cutting is adjusted by changing the number of crop trees to be released, not the number of sides of the crowns released.

We recommend the following steps:

1. Talk with the landowner to learn current and potential future uses of the property. Assist your client in articulating property goals.

2. Do a walk-through evaluation of the woodlot, making visual observations about species composition by size and crown class. Assess the history of each stand and its progression in terms of ecological succession. For example, is it an old field with pioneer species growing on it? Has it been forested for many years and had previous timber-cutting activity? Is it an even-aged stand or a two-aged stand?

3. Discuss the potential of each stand with the landowner. Describe how the individual stands can be managed to contribute to the overall property goals. Reach agreement with the landowner about what the stand-specific objectives are. If trade-offs must be made among multiple objectives, determine which of them will have the highest priority for accomplishment.

4. Draft crop tree selection criteria to meet the stand-specific objectives. The quality of crop trees varies from site to site and from stand to stand, so it is difficult to draft standards that have universal application.

A tree that would not qualify as a crop tree on a good site in an excellent stand may be the best tree available on a poorer, previously mismanaged site. When selecting crop trees, it will often be a matter of picking the best available.

If financial return is a primary objective, precommercial work should begin in stands with crop trees that have the best potential to provide the income desired in the anticipated time frame. Frequently, these opportunities occur on the best growing sites.

Crop tree selection criteria should be established for each stand to help you judge which trees are the best and to verbalize minimum crop tree standards. For example, to increase income from timber crop trees, the selection criteria should focus on the tree characteristics that indicate it is likely to grow rapidly and produce high-quality products.

When selecting timber crop trees, choose dominant/ codominant trees with no dead branches in the upper crown. Trees with large crowns relative to their dbh are much less likely to develop epicormic branches than trees with small, sparse crowns.

This stand has a history of high-grading and livestock grazing. The red oak in the center is one of the few crop trees available that will meet both the landowner's wildlife and timber objectives.

Look for indicators (i.e. dormant buds) of the tree's probability of degrading in quality because of epicormic branches. Don't select trees with existing epicormic branches (alive or dead) on the butt log. It is very likely these trees will have additional epicormic branching problems.

5. Take systematic points throughout each stand. Analyze this information to obtain an estimate of the number of trees per acre that meet the crop tree selection criteria. The species composition and size of the trees may also be relevant to the stand's capability for accomplishing objectives.

On Pages A9 and A10 is a tally sheet with sample inventory data recorded before implementation of a Crop Tree Management prescription. Crop trees are identified according to category ("T" for Timber, "W" for Wildlife, "A" for Aesthetic, and/or "WQ" for Water Quality) in the ***Crop Tree*** column.

The one-fifth-acre fixed radius plot is best to use when communicating with the landowner about the prescription. However, the variable radius plot is much faster to use for obtaining inventory information efficiently.

When doing pretreatment inventories, competing trees that will be cut to release crop trees can be identified on the tally sheet in the ***Other Tree*** column with a symbol like "C" for cut. Trees that are not competing with crop trees can be identified with an "L" for leave. This data can then be analyzed to provide a per-acre estimate of the number of crop trees to be released, the number of trees to be cut, and the total number of trees left in the stand.

6. Conversations with the landowner may give you an indication of how intensively your client is willing to cut the stand. This will help you judge the number of crop trees you can plan to release.

Using the stand-specific objectives, crop tree selection criteria, information from the stand inventory, and your preliminary assessment of the landowner's tolerance for degree of cutting, develop a Crop Tree Management treatment proposal. Identify the species, size class, and physical characteristics of the trees you propose to manage. These should be the trees identified using your crop tree selection criteria.

If possible, visit the woodlot with the landowner. Using a one-fifth-acre circular plot (52.7-foot radius), demonstrate what the treatment will look like. Designate the proposed crop trees with flagging. With a different color of flagging, identify trees that would be cut to release them. This exercise helps the landowner visualize how the area will appear after treatment. Explain how doing the work will accomplish the stand-specific objectives.

If the landowner indicates the proposed intensity of cutting is too heavy or too light, adjust the amount of cutting by decreasing or increasing the number of crop trees to be released. While on the plot with the landowner, thoroughly review the stand-specific objectives for each stand, the crop tree selection criteria, and the number of crop trees to be released. This is probably the best opportunity for the landowner to obtain a clear perception of what the proposed treatment is, what it will look like, and how doing it will accomplish the overall property goals.

Showing landowners an example of how the stand will be marked helps them see why cutting competing trees helps the crop trees accelerate their growth and subsequent production of benefits.

7. Decide whether the trees to be cut constitute a marketable volume of timber. In many instances this will be obvious without any additional detailed analysis of the inventory data. In other cases, it may be appropriate to not only further analyze existing plot data, but also to do additional cruising to determine if the trees to be cut are marketable.

8. If the cut trees are to be sold, determine if you should do "cut tree" marking as well as crop tree marking. If so, be sure to use a different color of paint to clearly differentiate the cut trees from the crop trees. It is easier and less time consuming to mark crop trees only. However, cut tree marking may make supervision of the cutting easier.

Cut tree marking is appropriate if the cutting crew has not been trained to do a crown-touching release on selected crop trees. It may also be advisable if trees in the stand are of high value. You need to be certain the cut tree volume estimate includes only competing trees. In lower-value stands, crop tree marking may be sufficient if cutting crews receive adequate training and supervision.

If cut tree marking is done with leaves on, it is often difficult to see all of the trees whose crowns are touching the crop tree. This is especially true if there are many midstory trees obscuring visibility of overstory crowns. Cut tree marking is easier and quicker to do during the dormant season.

It is preferable to do crop tree marking during the growing season. The crown vigor of potential crop trees can be more adequately evaluated during this period.

If, for efficiency or other reasons, it is necessary to do both crop tree and cut tree marking during the same season, it is usually more practical to do both jobs during the dormant season when leaves do not obscure the crowns.

This tree feller is working in a stand that has only the crop trees marked. He knows how to apply a "crown-touching" release.

Use paint to identify the crop trees. If properly marked, they will remain visible during and after the cutting operation. Flagging of crop trees is sufficient for purposes of staying organized during the marking process, but flagging will frequently be destroyed during cutting.

9. If the cut trees are not marketable, consider a precommercial treatment. If the stand is on private, non-industrial ownership, cost-share programs like the Forestry Incentives Program (FIP), Agricultural Conservation Program (ACP), and Stewardship Incentive Program (SIP) may be available to help pay the cost of doing the treatment. Compare the landowner's property goals and the stand characteristics with the available cost-share program objectives, and select the best match-up.

10. If a precommercial treatment is to be performed, evaluate the training and experience of the cutting crew. Determine if it is appropriate to do cut tree marking, crop tree marking, or both.

With precommercial treatments, crop tree marking will often be sufficient, and identifying crop trees with flagging may be adequate. However, if flagging is used, the treatment should be done soon after the crop trees are identified. Because flagging can fall off or be removed, it is not a good idea to rely on it for any long-term identification of crop trees.

11. Some landowners may be willing to release the maximum number of crop trees that meet the selection criteria. Applying a complete crown-touching release to each will often result in fairly heavy cutting. However, when this is the case, the designation of crop trees is fairly simple.

When you begin to mark, look for the best crop tree; the one that best meets the crop tree selection criteria for one or more of the stand-specific objectives. Designate it with flagging or paint.

Look for the next best crop tree and designate it. If its crown is touching the first one selected, you know you can't have a third crop tree touching either of those two crowns. Move through the stand designating as many crop trees as you can that meet the crop tree selection criteria. However, be careful not to allow occurrences of more than two crop tree crowns that touch each other. Each crop tree will have at least a three-sided release, and some will have a four-sided release.

When evaluating trees for selection as crop trees, you will often be forced to make difficult choices. Remember, crop trees are those that best meet the selection criteria. When you have multiple objectives, not every crop tree can meet the criteria for all objectives.

For example, some crop trees may qualify only as timber crop trees. Others may qualify just as wildlife crop trees. However, there may be some trees in the stand that qualify as <u>both</u> timber and wildlife crop trees. Therefore, if both timber and wildlife objectives are important to your client, these trees will be highly preferred for selection as crop trees. You must strive to select the combination of crop trees that best meet the objective or combination of objectives for the stand.

For stands with multiple objectives, selecting the optimum combination of crop trees to accomplish them is not an exact science. In mixed species stands, you may frequently be forced to place a priority on objectives and make trade-offs when selecting individual crop trees. An accurate assessment of what is most important to the landowner will make these crop tree selection decisions much easier.

Stands with a mixture of species provide excellent opportunities for accomplishing a combination of objectives.

12. The easiest way to release a specified number of crop trees per acre is to visualize the one-fifth-acre circular plot, and imagine how the proportional number of trees would fit on it. For example, releasing 20 crop trees per acre means there would be four on a one-fifth-acre plot.

If you picture yourself at the center of the plot, two crop trees would be within about 50 feet behind you and two would be within 50 feet in front of you. The exact location and spacing of these trees isn't critical. Locate the four best trees on the imaginary one-fifth-acre radius plot, and as long as no more than two of their crowns are touching, their spacing is not a major consideration.

In lighter cuttings, there will be more residual trees left in the stand. The trees pictured here were not in direct competition with the crop trees, so they did not get cut.

The lighter the cutting (low number of crop trees released), the more trees left in the residual stand. Trees with crowns that do not touch crop trees, don't get marked for cutting. You may choose to cut some of them if for any reason they are undesirable. However, if many additional trees are marked, it will affect the appearance of the stand with regard to how heavily it gets cut.

Using these procedures, the inventorying and marking process is drastically different from marking to a specified basal area. However, having done both crop tree marking and basal area cutting for several demonstration areas, we have found crop tree marking easier to do. In addition, there is considerable satisfaction that comes from knowing the crop trees selected for management are the ones with the greatest potential to meet the property goals important to the landowner.

CROP TREE RELEASE TALLY SHEET

LANDOWNER: ______________________ **DATE:** ______________

STAND HISTORY: ____

STAND NUMBER: ____________ **TYPE:** ____________ **AGE:** ____________

ACRES: ____________ **BAF:** ____________ **SITE:** ____________

LANDOWNER OBJECTIVES: ______________________________________

Spe-cies	DBH	Ht	Crop Tree			Other Tree	
			T,W, A,WQ	F T G	#/Ac	C,L	#/Ac

Spe-cies	DBH	Ht	Crop Tree			Other Tree	
			T,W, A,WQ	F T G	#/Ac	C,L	#/Ac

Species	DBH	Ht	Crop Tree			Other Tree	
			T,W, A,WQ	F T G	#/Ac	C,L	#/Ac

Crop Tree Categories:
- **T** - Timber
- **W** - Wildlife
- **A** - Aesthetic
- **WQ** - Water Quality

Other Tree Categories:
- **C** - Cut Tree
- **L** - Leave Tree

DBH - diameter breast high
Ht - Height
FTG - Free To Grow Rating (0-4)

#/Ac - Number of trees per acre represented by a tree of the measured DBH for the selected BAF. Obtain the number of trees/ac from the chart at right, or calculate it using the following formula:

$$\#/Ac = 43{,}560/[DBH(rf)]^2(3.14)$$

rf = 2.75 for 10 BAF
rf = 1.9445 for 20 BAF

Crop Tree Totals

Category	Total*	# Plots	Ave. No. Trees/Ac.**
Timber (T)			
Wildlife (W)			
Aesthetic (A)			
Water Quality (WQ)			
Total All Categories			

Non-Crop Tree Totals

Cut Trees (C)			
Leave Trees (L)			

* If a tree qualifies in more than one category (example: T & W), count it only once in the category where it makes the greatest contribution to accomplishing the primary landowner objective.

** Average Number of Trees Per Acre = $\frac{\text{Total}}{\text{\# Plots}}$

No. Trees/Acre by BAF and DBH

DBH	10 BAF	20 BAF
3	203.7	407.4
4	114.6	229.2
5	73.3	146.6
6	50.9	101.9
7	37.4	74.8
8	28.6	57.2
9	22.6	45.2
10	18.3	36.7
11	15.1	30.3
12	12.7	25.5
13	10.8	21.6
14	9.4	18.7
15	8.1	16.2
16	7.2	14.3
17	6.3	12.6
18	5.7	11.3
19	5.0	10.1
20	4.6	9.2
21	4.1	8.3
22	3.8	7.6
23	3.4	6.9
24	3.2	6.4

APPENDIX B

Applying Crop Tree Management in Specific Eastern Forest Types

by

Arlyn W. Perkey

This yellow-poplar stand received a dormant season Crop Tree Management treatment. During the spring the released trees will start expanding their crowns and accelerating growth.

Applying Crop Tree Management
in
Specific Eastern Forest Types

by
Arlyn W. Perkey

ALLEGHENY HARDWOOD CROP TREE MANAGEMENT

Crop Tree Selection

1. Commercial thinning can often begin when the stand is 40 to 60 years old. Black cherry and yellow-poplar are generally more responsive to release than white ash. Red and sugar maples, with good crowns and few epicormic branches, also respond well to release.

2. Timber crop trees should have clear, straight boles that are free of forks. Yellow-poplar and black cherry are especially susceptible to having forks that split open in wind and ice storms.

3. For timber production, avoid black cherry trees with black knot, particularly if the defect appears on the main bole. However, black knot that occurs in the crown can be accepted if less than 50 percent of the crown is affected (assume branch will eventually break off at the knot).

4. Black cherry, white ash, and yellow-poplar mature before maple. If these three intolerants are desired in the next stand, crop trees must be maintained as a seed source until it is time to establish regeneration.

5. Black cherry is very effective at compartmentalizing wounds. Consequently, V-shaped stump sprout connections are more acceptable with this species than with many others.

6. To reduce the probability of gum spots caused by bark beetles in black cherry, avoid operations between January and June that result in black cherry slash or standing, dead trees. Black cherry trees cut or deadened between July and January are much less likely to provide suitable habitat for bark beetles.

7. Black cherry is a good soft-mast producer, which makes it a desirable wildlife crop tree.

Residual black cherry trees are resistant to decay from cut V-shaped connected sprouts. This allows more choices when selecting crop trees from a population that includes stump sprouts.

8. White ash and beech have a greater tendency to form cavities than other associated species, increasing their probability of being potential den trees. Beech is also acceptable as a hard-mast producer.

Natural Regeneration

1. Assess the effects of deer on regeneration by estimating the density of the deer population and the quantity of food available within a three-fourths mile radius of the potential regeneration site.

2. Establish a minimum of 20 six-foot radius regeneration plots. Determine if at least 70 percent of them are adequately stocked with advanced regeneration of desirable species.

3. Assess the degree of interference from undesirable plants. Any six-foot radius plot that contains a total of eight stems of beech or striped maple is considered stocked with those competitors.

4. To determine interference by ferns and grasses and site limiting factors such as rockiness, expand the regeneration plots to a radius of 26.4' (0.05-acre). If more than 30 percent of any plot is covered with fern or grass, serious competition can be expected under partial shade.

5. Where desirable advanced regeneration is adequate and interfering understory plants are not extremely dense, remove the overstory.

Where advanced reproduction is inadequate and understory competition is severe, apply appropriate herbicides to the undesirable plants. (As a general guide, if there is less than 15 square feet of understory basal area, ignore it. If there is greater than 15 square feet of undesirable understory, consider a herbicide treatment.)

Where advanced reproduction is inadequate and interfering plants are sparse, apply a two-cut shelterwood.

6. If tolerant species such as sugar maple, beech, and hemlock are desired in the new stand, retain 30 to 80 good-quality stems per acre (3 to 10 inches dbh) with vigorous crowns and few epicormic branches.

A high deer population can affect the species composition of regenerating stands. When the number of deer is out of balance with the available habitat, regeneration may be eliminated.

NORTHERN HARDWOOD CROP TREE MANAGEMENT

Crop Tree Selection

When available, beech nuts are consumed by many wildlife species. Because beech trees are more likely to be hollow than many other species, they frequently become den sites for wildlife species that use tree cavities.

Birches that have grown around old, decaying stumps may be unique and, therefore, aesthetically pleasing to landowners.

1. Timber crop trees should have the potential of producing a Grade 1 or 2 log from the butt section of the stem. For yellow birch, sugar maple, and white ash trees with this grade potential and two logs per tree, financial maturity will often be reached at about 20 inches dbh. When sawlog height is one log, financial maturity frequently occurs at 18 inches dbh.

For paper birch, financial maturity may be reached at 16 inches, regardless of log height. Beech and red maple are often limited to medium grade potential and financial maturity of 14 to 16 inches. With all species, financial maturity may be extended, to a limited degree, by maintaining rapid crop tree growth.

2. If wildlife habitat management is an objective, diversify crop tree selection by species to improve future mast production and to increase the probability of having den trees in the stand. Red oak and beech are valuable hard-mast producers. White ash, beech, and basswood have good potential to be den trees because they have a greater tendency to form cavities than many other species.

3. Birches are more prone than most species to grow over stumps and rocks. Depending on landowner preferences, these trees may be desirable as aesthetic crop trees because of their uniqueness. However, they are poor choices for timber crop trees because of their instability.

4. Paper birch frequently occurs as an associated species with this type. Many landowners with aesthetic objectives prefer paper birch because of the attractiveness of its bark and the beauty of its foliage.

5. Northern hardwoods produce very attractive fall colors. If the landowner has aesthetic objectives related to autumn foliage, there is great potential to produce benefits. Red and sugar maples may be especially desirable aesthetic crop trees.

Natural Regeneration

1. The species composition of the regeneration is influenced by the site characteristics of the stand and the existing overstory composition. On many sites, we can most effectively influence the composition of the next stand by manipulating the percentage of crown closure in the overstory.

2. To favor tolerant regeneration (sugar maple and beech), retain an overstory with 80 percent crown cover. To favor intermediates (primarily yellow birch), retain an overstory with 30 to 50 percent crown cover; perhaps somewhat higher on wet sites.

3. To be considered well-established, spruce should be at least a foot tall; birch at least two feet tall; and beech, sugar maple, and hemlock should be three to four feet tall.

Harvesting trees resulted in this crown canopy admitting enough light to favor the establishment of seedlings and sprouts.

OAK CROP TREE MANAGEMENT

Crop Tree Selection

1. Diversify crop tree selection by species to provide more stable mast crops and to reduce the likelihood of suffering total crop failure because of a destructive agent such as gypsy moths.

2. White oak is often one of the most valuable oak species, but it is also one of the slowest growing. It is very susceptible to epicormic branching and, in many areas, it has been quite vulnerable to mortality after gypsy moth defoliation. White oak is a desirable species for selection as a wildlife crop tree because its acorns are preferred by many wildlife species.

3. Northern red oak is one of the most valuable oak timber crop trees, and it is fast-growing. It is very desirable as a mast producer for wildlife because of its relatively abundant production.

4. Regardless of the species, favor crop trees with vigorous crowns in dominant and codominant positions. Favor trees showing bark characteristics that indicate rapid growth and straight grain. Avoid trees with epicormic branches.

5. Many oak trees originate from seedling sprouts or stump sprouts. Stump sprouts can produce good-quality timber if the stem originates from a low stump. Companion sprouts with a U-shaped connection may be cut at different times, but V-shaped sprout connections should usually be treated as a unit (cut both or neither). The rigidity with which this guideline should be applied varies by species and length of the cutting cycle to be used in the stand.

6. Where the species composition is less than 50 percent oak, the stand's susceptibility to defoliation by gypsy moth is reduced. Generally, oaks with vigorous crowns are more likely to survive defoliation. Oaks on mesic sites have a greater vulnerability to mortality if defoliated.

This oak stand received a pre-commercial Crop Tree Management treatment through the Forestry Incentives Program. Cost-share programs can be used to help private, non-industrial landowners accomplish needed management work.

7. Black and scarlet oak are more likely to develop cavities than white oak and hickory. However, cavities in longer-lived species (like white oak and hickory) provide available shelter for wildlife for a longer period.

Natural Regeneration

1. Oak natural regeneration is relatively easy to establish on areas that have an adequate seed source available and a red oak site index less than 70. Better sites are more challenging to regenerate because of competition from other species. Well developed, advanced regeneration is a key to successful establishment of oak stands. Most oak natural regeneration is established when there is a bumper crop of acorns that provides enough food for insects and wildlife with some left over to germinate.

2. Management activities that establish regeneration and encourage its development should be initiated 20 to 30 years prior to final harvest.

3. Maintaining a closed overstory canopy while herbiciding midstory and understory competitors is often necessary to provide a microclimate suitable for regeneration establishment and development. When seedlings are three to four feet tall, provide additional moisture, light, nutrients, and growing space by opening the main crown canopy with a partial cut.

4. Evaluate the adequacy of established oak regeneration using the procedures described in the SILVAH manual referenced on Page 50. When regeneration meets these guidelines, remove the overstory.

Having adequate advanced oak reproduction established is a key to successfully regenerating stands that will include an oak component.

Artificial Regeneration

1. Oak seedlings may be planted in old fields or on previously forested sites. However, they usually require post-planting release from competing vegetation for at least three years. Tree shelters can be used to provide protection from animal damage and to accelerate early seedling shoot growth.

2. Oaks may be regenerated by direct seeding of viable acorns. Use of tree shelters can greatly reduce the number of acorns needed to obtain an oak component in a new stand.

PAPER BIRCH CROP TREE MANAGEMENT

Crop Tree Selection

1. In seedling-sapling stands that are overtopped or nearly overtopped with pin cherry, aspen, or red maple sprouts, reduce the competition by cutting. Where appropriate, apply herbicide to cut stumps. In sapling stands, the dominance of the paper birch component in the stand can be evaluated using milacre plots (3.7-foot radius). At least 20 plots should be measured in stands of 10 acres or less and at least one plot per acre in larger areas. In sapling stands, if more than 20 percent of the milacre plots contain aspen or red maple stump sprouts, release will be required to maintain dominance of paper birch in the stand.

In New England, paper birch is not only an aesthetically attractive tree, but it has traditionally been valuable as a timber crop tree.

2. In sapling stands, select crop trees with diameters at least equal to the mean stand diameter. The larger the diameter in relation to the mean, the better the chances of continued superior growth. Any selected paper birch stump sprouts should be thinned to one or two of the best stems.

3. In pole stands and larger, select dominant or codominant full-crowned trees. Timber crop trees should be straight, free of forks, and free of excessive branches for a minimum of 17 feet. There should be no wounds or injuries that can cause degrade in the merchantable stem. Avoid unstable trees growing on stumps or rocks.

4. If the long-term objective for the stand is to regenerate it to paper birch, try to select a high proportion of paper birch crop trees (at least two out of three). If the objective is to eventually convert the stand to more tolerant species, reduce accordingly the ratio of paper birch to other species.

5. For many people, the bright, white bark and attractive foliage of paper birch make it a preferred choice as an aesthetic crop tree.

Natural Regeneration

1. If intensive management for paper birch is anticipated, give preference to areas with a site index of 60 or greater for this species.

2. The establishment and development of paper birch regeneration requires full sunlight. The landowner must be willing to accept openings of at least an acre in size and preferably larger.

3. Stands should normally be regenerated when they are 60 to 80 years old, depending on site, stand condition, market, and landowner property goals.

4. Wind can carry light-winged seeds great distances, but the greatest amounts fall within 200 feet of the parent trees. Sexual maturity and seed bearing begin at about 15 years of age. Paper birch produces some seed nearly every year, a good crop every other year, and a bumper crop one year in 10. Seeds normally germinate in the spring following dispersal, but some may be stored in the forest floor for at least a year.

5. If it is determined that seed trees are needed, leave three to five healthy, desirable, full-crowned trees per acre. The seed trees can be removed after two seasons with minimum damage to the regeneration.

6. Skidder logging during the snowfree season, when the soil is not frozen, provides adequate scarification for germination and establishment of paper birch seedlings.

Clearcuts and/or seed tree cuts are needed to regenerate attractive, valuable stands of paper birch in New England. Public and landowner opposition to these treatments may be the greatest obstacle inhibiting the perpetuation of this valuable forest type.

WHITE PINE CROP TREE MANAGEMENT

(for growing high-value sawtimber)

Crop Tree Selection

1. Choose trees with straight boles and well-developed crowns that are capable of quickly occupying additional growing space. Usually, trees less than 50 years old with one-third or more of their total height in live crown will respond favorably to release.

2. Minimize the portion of the tree containing persistent dead branches. Manage the surrounding stocking to control the size of live branches on the crop tree. Try to keep just enough light on the lower portion of the live crown to keep the branches alive, but not enough light to stimulate rapid branch growth.

3. If growing clear lumber is an objective, try to prune crop trees that are 4 to 10 inches dbh and have small branches (less than 1.5 inches in diameter). However, don't make the mistake of selecting trees that have small branches, but also have small crowns. You must select crop trees that have vigorous crowns that will respond to release.

4. Natural pruning of white pine is often better in mixed stands of conifers and hardwoods than it is in solid white pine stands. White pines grown in association with hardwoods are often of good form.

Managing the size of live branches and minimizing the number of persistent dead branches on the bole is an important part of Crop Tree Management in white pine.

Natural Regeneration

1. Choose the right site. Stands with a hardwood site index of 60 or higher can be difficult to regenerate to pine.

2. After age 50, begin discriminating against overstory hardwoods when selecting crop trees. However, when choosing between hardwood crop trees, remember:

   a.) retaining mast-producing hardwoods, such as red oak, may encourage establishment of white pine seedlings because of the associated digging activities of small mammals;

   b.) established white pine seedlings do not compete as well beneath red maple and oak as they do under light-foliaged species such as birch, aspen, and pitch pine;

   c.) because of the later "leafing out" of oaks in the spring, white pine seedlings compete more effectively under oak than under maple; and

   d.) if white pine weevil is a problem, keeping some overhead cover reduces the likelihood of severe damage by that pest.

3. Start hardwood control measures early. Optimum white pine seed-bearing age begins when trees are 50 years old; therefore, hardwood understory control can begin at that time.

4. In thinnings after age 50, strive for some site disturbance to encourage the establishment of white pine in the understory.

5. Coordinating site disturbances with good seed crops, which occur every three to five years, improves the chances of successfully establishing regeneration.

Site disturbance and a good seed crop resulted in the establishment of these white pine seedlings.

Artificial Reforestation

1. In areas where white pine weevil is a problem, spacing should not be wider than 6-feet-by-6-feet to help prevent the development of broad crowns and crooked boles. If this pest is not a problem, wider spacings (such as 10-feet-by-10-feet, or even 12-feet-by-12-feet) are appropriate.

2. If there is significant hardwood competition, it must be treated to give slow-growing, young seedlings an opportunity to develop.

3. If the planting is in a cutover area, there is potential for damage from the pales weevil. The best way to avoid this possibility is to delay planting for two or three years to allow the weevil population time to subside.

4. In areas where the deer population is high in relation to the amount of available food, browsing of nutrient-rich white pine seedlings from the nursery may be a serious problem. Placing netting on the seedlings can protect the terminal buds. It may be necessary to raise the netting once each year to maintain protection of the terminal bud.

Netting on this recently planted white pine nursery stock will help protect it from damage caused by deer browsing.

HEMLOCK CROP TREE MANAGEMENT

Crop Tree Selection

1. Suppressed, understory hemlock trees are viable crop tree candidates. The older they are when released, the greater they seem to respond. Suppressed trees have fewer problems with butt rot and shake, and their smaller limbs prune earlier.

2. Maintain dense stands by releasing relatively few crop trees. This minimizes root damage caused by logging. It also limits exposure to full sunlight and the associated high evaporation of soil moisture.

3. For timber crop trees, avoid selecting trees with many large, broken, or dead limbs; seams; or injuries in the butt section. Rot, decay, and shake are often associated with these indicators.

4. Timber crop trees should usually be considered mature when they are 16 to 18 inches dbh.

5. Hemlock is a valuable source of cover for many wildlife species.

Patches of hemlock in a hardwood stand can provide variety that is aesthetically attractive and valuable as habitat for wildlife.

Natural Regeneration

1. A two- or three-cut shelterwood is the best method of regenerating hemlock. It compensates for slow seedling development for the first two years by reducing moisture stress and preventing hardwood establishment.

2. Remove trees mostly from the codominant and lower crown classes.

3. Avoid creating openings larger than one-half the height of the main canopy trees.

4. For the preparatory cut, use the stocking chart's B level (NA-FR-30, ***Managing Eastern Hemlock, A Preliminary Guide***) as the residual stocking. For the seed cut, leave 110 square feet of basal area in a high-density overstory that has 70 to 80 percent crown cover.

5. Use summer logging to accomplish site scarification. This process will mix the organic layer with mineral soil. Until the seedlings become rooted into the mineral soil, they are highly vulnerable to moisture stress.

6. Kill or remove advanced hardwood regeneration.

7. When reproduction is well-established (three to five feet tall), remove the overstory trees. Winter logging is preferred to provide protection for the advanced regeneration.

Overstory shade helps protect hemlock seedlings from moisture stress.

APPENDIX C

Creating Snags for Wildlife

by

Arlyn W. Perkey

This stand received a Crop Tree Management prescription that included wildlife considerations. Snags were created to provide suitable habitat for such species as woodpeckers.

Creating Snags for Wildlife

by

Arlyn W. Perkey

When doing Crop Tree Management for landowners with a wildlife objective, give some thought to developing some standing, dead, woody habitat. Because standing, dead trees (commonly referred to as "snags") provide excellent habitat for insects, they serve as an important food source for those wildlife species that feed on insects. They may also be a source of shelter, although it is important to remember that cavities in snags are usually not an adequate substitute for cavities in live trees. Some wildlife species use cavities in dead trees; others use cavities in live trees.

This tree was girdled several years ago to release adjoining trees. The life within it now is a family of pileated woodpeckers.

Girdling is perhaps the best way to create good snags for wildlife. However, this can be a tricky process. For years, foresters have been frustrated trying to kill trees by girdling. Tree death by girdling often takes longer than we like to wait, and if done improperly, it may not happen at all. I've found double-chainsaw girdling (two complete bands cut well through the bark and one inch into the wood) to be fairly effective. ***Caution: Cutting more than one inch deep may result in the tree blowing down during wind storms.***

When applying a crown-touching release to selected crop trees, there are four primary considerations in deciding which competing trees to girdle and which ones to fell:

1. Size of Tree - Generally, large trees are more desirable than small ones for use as standing, dead, woody habitat. They usually stand longer and can support larger cavities necessary for some species. Depending on the wildlife species being managed, tall snags may or may not be desirable.

2. Resistance to Death by Girdling - Some trees die fairly quickly after girdling, while others may literally live for years. This resistance to death by girdling varies by species, by individual tree, and, at least for some species, by season when the girdling is done. The ring-porous and semi-ring-porous species transport water from the roots to the crown in the outer ring(s), just inside the cambium. It makes sense that these trees could be killed easily by girdling with a chainsaw. My application of this theory has given me mixed results regarding how quickly the ring-porous and semi-ring-porous species have died.

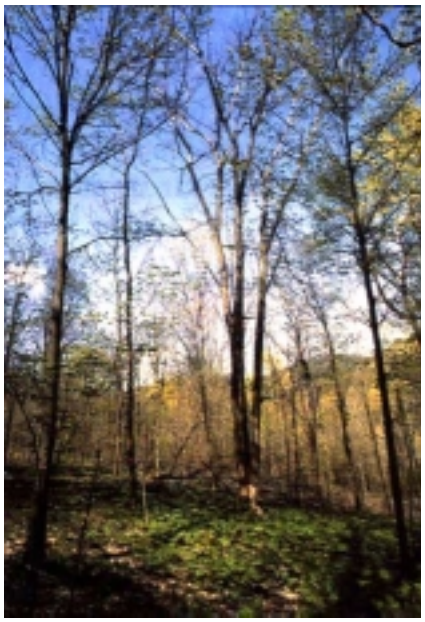
The following description of my experience with girdling is not based on any scientific experiment; it is based on my observations.

I have girdled elm, ash, and black cherry in southwestern Pennsylvania. Double-chainsaw girdling elm and white ash usually results in a quick kill (within two months) if the girdling is done during the growing season (especially from mid-July to mid-September). Generally, trees girdled during the dormant season not only leaf out in the spring, but continue to live for some time (often about two growing seasons). Results with black cherry are more varied. Some trees girdled during the growing season die quickly; others don't.

I have very limited experience girdling oak. The red oaks I've girdled during the growing season died quickly. This is consistent with published information which indicates that red oak transports water in the outer growth ring only. White oak and black oak did not die as quickly.

It may take several years for a diffuse-porous tree to succumb to the effects of girdling. Unlike ring-porous and semi-ring-porous trees, the diffuse-porous species transport water through a greater number of growth rings. Therefore, a quick kill would require such a deep cut into the tree that, in most cases, it is not feasible. Girdling deep enough to sever many growth rings usually results in an unstable tree that will not stand long. Therefore, diffuse-porous species should generally be considered as snag recruits only when it is acceptable to have trees that die over a period of years.

A girdled, diffuse-porous tree usually doesn't die until the roots expire from the interruption of the food supply, which is normally transported from the crown to the roots. This starvation of the roots may take a long time, especially if the tree is in good condition prior to girdling. Ring-porous and semi-ring-porous trees may die quickly if girdled during the growing season because the water supply to the crown is severed. Following is a list of Eastern trees categorized by porosity:



The elms in the center of this photograph were double-chainsaw girdled in August. They died within two weeks, and by the following spring, they were no longer competing with adjacent crop trees. Instead, they became a source of standing, dead, woody habitat.

Ring-Porous		Diffuse-Porous	
Black Cherry*	Elm	Maples	Holly
Black Walnut*	Ash	Beech	Hophornbeam
Butternut*	Oak	Yellow-Poplar	Hornbeam
Black Locust	Hickory	Birch	Sourwood
Honeylocust	Catalpa	Blackgum	Dogwood
Sassafras	Chestnut	Sycamore	Sweetgum
Hackberry	Coffeetree	Basswood	Cucumber
Red Mulberry	Persimmon*	Cottonwood	Aspen
Osage-Orange		Buckeye	Pines
		Spruces & Firs	Hemlock

* ***These species are semi-ring-porous. Bitternut Hickory is also semi-ring-porous, but the other hickories are ring-porous.***

A means of stretching out the availability of snags after a treatment is to girdle some trees in the ring-porous category between mid-July and mid-September, hoping for a quick kill. At the same time, girdle some trees in the diffuse-porous category, since they are likely to take quite some time to die. Similarly, another death-delaying tactic for the ring- and semi-ring-porous species is to girdle during the dormant season rather than the growing season.

3. Snag Durability - Some trees are more resistant to decay; consequently, they will provide standing, dead, woody habitat for a longer period of time. The following list categorizes trees according to their decay resistance:

RESISTANCE TO DECAY				
EXTREMELY RESISTANT	**RESISTANT**	**MODERATELY RESISTANT**	**NON-RESISTANT**	
Black Locust	E. Redcedar	Honeylocust	Willows	Ash
Red Mulberry	Junipers	E. White Pine	Aspen	Birch
	Chestnut		Cottonwood	Beech
	Osage-Orange		Basswood	Maple
	Catalpa		Buckeye	Hickory
	Sassafras		Butternut	N. Red Oak
	Black Cherry		Cucumbertree	Black Oak
	Black Walnut		Yellow-Poplar	Hemlock
	White Oak		Sweetgum	Spruce & Fir
	Chestnut Oak		Elm	Other Pines
			Hackberry	

If it is desirable to have snags in various stages of decay over a period of time, it may be advantageous to select potential snags from more than one category. Trees killed in the non-resistant category will provide punky wood relatively soon, and about the time they are falling down, trees in the resistant category will just be getting punky.

Another factor affecting snag durability is the degree of lean of the tree. Trees that lean significantly are less likely to stand for a long period of time.

4. Potential Forest Pest Influences - Creating snags to benefit wildlife may have some health implications for the crop trees remaining in the stand. For example, black cherry is resistant to decay, which makes it a desirable choice for a relatively long-term snag. However, girdling black cherry trees may provide conditions for a build-up of bark beetles. These pests cause gum spots, a serious degrade in black cherry.

There may be a necessary trade-off between providing standing, dead, woody habitat for wildlife and some loss of timber value in residual crop trees caused by gum spots. This value loss may be mitigated by killing the selected trees between July and January. This way, the dying trees do not create favorable habitat for bark beetles. However, it is particularly difficult to time the deadening of black cherry so that death will reliably occur between July and January.

This black cherry was girdled to release the sugar maple crop tree. Snag selection decisions may affect future insect populations, which can be detrimental to other trees.

Making Snag Selection Decisions

Following are steps that can help in making good choices for selection of trees to convert to snags:

1. Interview the landowner to be sure that your client's stand-specific wildlife management objectives can be accomplished by creating snags. For example, is the landowner interested in providing habitat for pileated woodpeckers?

2. Inventory the stand. Determine the species composition, size (dbh and height), and number of trees per acre that need to be cut or deadened to release the crop trees.

3. Analyze the size and species of potential snags, and evaluate how selection of a combination of species and/or season of treatment could be used to spread out the availability of standing, dead, woody habitat. Keep in mind, if there are many snags remaining in the stand at the time of the next management activity, they could pose a hazard to the people doing that work.

4. Consult with a wildlife biologist to determine the size class and number of snags needed to accomplish species-specific wildlife management objectives. Compare these needs with the inventory to see how they match up.

5. Evaluate the potential negative effects of creating snags in any particular species. For example, will creation of snags of any species cause forest health problems? Or, will delayed death of competing trees cause undue loss of growth or health risk for the crop trees? Consultation with an entomologist or a pathologist may be needed.

6. Select the species and size mix of snags that will best meet the wildlife management objective for the stand without jeopardizing the other stand-specific objectives. Select individual trees that lend themselves well to girdling. For instance, choose trees without seams or other indications of ingrown bark that could prevent a complete girdle of the tree.

Snags not only provide habitat for some species of wildlife, but when seen in the right light, they may also be aesthetically attractive.

Girdling trees can be a good way to create standing, dead, woody habitat needed to accomplish stand-specific wildlife management objectives. Using the preceding information, you can make informed choices regarding which trees to girdle and when to girdle them. This can enhance your ability to maximize benefits produced by minimizing the conflict between stand-specific objectives.

APPENDIX D

Flood Tolerance of Specific Tree Species

by
Karen J. Sykes

Natural resource managers who select crop trees in riparian zones need to be familiar with tree tolerances to flooding.

Flood Tolerance of Specific Tree Species

by

Karen J. Sykes

The following tables are **general** descriptions of the flooding adaptability of tree and shrub species commonly found in the riparian zones of the Central, Eastern, Northern, and Southern Deciduous Forest Regions. They have been divided into five categories: ***most water tolerant, highly water tolerant, moderately water tolerant, weakly water tolerant, and least water tolerant.***

Included with the tolerance lists are categories indicating the capability of individual tree species to produce timber, wildlife, aesthetic, and water-quality benefits. These categories are **subjective** and may change as more information becomes available. Where not enough information was found for some species, no benefit capability was assigned.

Most water tolerant trees are capable of living from seedling to maturity in soils that are waterlogged almost continuously year after year, except for short durations during droughts. These species exhibit good adventitious or secondary root growth during this period.

Highly water tolerant trees are capable of living from seedling to maturity in soils that are waterlogged for 50 to 75 percent of the year. Some new root development can be expected during this period. Waterlogging usually occurs during the winter, spring, and one to three months of summer.

Moderately water tolerant trees are capable of living from seedling to maturity in soils waterlogged about 50 percent of the time during the growing season. The root systems of these species produce few roots or are dormant during the waterlogged period. This period usually occurs in portions of the winter, spring, and summer.

Weakly water tolerant trees are capable of living from seedling to maturity in soils that are temporarily waterlogged for durations of one to four weeks.

Least water tolerant trees are capable of living from seedling to maturity in soils that are occasionally waterlogged for durations of a few days only.

TABLE 1

MOST WATER TOLERANT SPECIES

Species	Scientific Name	Benefit Capability			
		Timber	Wildlife	Aesthetics	Water Quality
ash, Carolina	Fraxinus caroliniana				
pumpkin	F. profunda				
aspen, bigtooth	Populus grandidentata	*	*		
baldcypress	Taxodium distichum	*		*	*
black spruce	Picea mariana	*	*		*
buttonbush	Cephalanthis occidentalis			*	
dogwood, red-osier	Cornus stolonifera		*		*
silky	C. amomum		*		*
planertree/water elm	Planera aquatica				
pondcypress	Taxodium distichum v. nutans				
swamp-privet	Forestiera acuminata			*	
tupelo, swamp	Nyssa sylvatica v. bilfora	*	*	*	
water	N. aquatica	*	*	*	
willow, bankers	Salix cottettii		*		
black	S. nigra	*	*	*	
Carolina	S. caroliniana		*		
purple-osier	S. purpurea		*		
sandbar	S. interior		*		
peachleaf	S. amygdaloides		*		

TABLE 2

HIGHLY WATER TOLERANT SPECIES

Species	Scientific Name	Benefit Capability			
		Timber	Wildlife	Aesthetics	Water Quality
ash, green	Fraxinus americana	*	*		*
American basswood	Tilia americana	*	*		*
balsam fir	Abies balsamea	*	*		*
hickory, water	Carya aquatica	*	*		
oak, bur	Quercus macrocarpa	*	*		*
Nuttall	Q. nuttallii	*			*
overcup	Q. lyrata	*	*		*
swamp white	Q. bicolor	*	*		*
water	Q. nigra	*	*		*
willow	Q. phellos	*	*		*
persimmon	Diospyros virginiana	*	*		
waterlocust	Gleditsia aquatica			*	

TABLE 3

MODERATELY WATER TOLERANT SPECIES

Species	Scientific Name	Benefit Capability			
		Timber	Wildlife	Aesthetics	Water Quality
alder	Alnus sp.	(West)	(East)		
ash, pumpkin	Fraxinus profunda	*			
white	F. americana	*			*
aspen, quaking	Populus tremuloides	*	*		*
Atlantic white-cedar	Chamaecyparis thyoides	*			
birch, river	Butula nigra	*		*	
yellow	B. alleghaniensis	*			
boxelder	Acer negundo			*	
catalpa	Catalpa bignonioides	*		*	
Eastern cottonwood	Populus deltoides	*	*	*	
elm, American [1]	Ulmus americana	*	*	*	
cedar	U. crassifolia			*	
hackberry	Celtis occidentalis	*	*	*	
hawthorn	Crataegus sp.		*		
hickory, bitternut	Carya cordiformis	*	*		
holly, deciduous	Ilex decidua		*	*	
honeylocust	Gleditsia triacanthos	*	*	*	
loblolly-bay	Gordonia lasianthus			*	
maple, red	Acer rubrum	*	*	*	*
sugar	A. saccharum	*	*	*	
silver [2]	A. saccharinum	*	*	*	
oak, Nuttall	Quercus nuttallii	*			*
pin	Q. palustris	*	*	*	*
southern red	Q. falcata var. falcata	*	*	*	*
willow	Q. phellos	*	*		*
Osage-orange	Maclura pomifera	*	*		
persimmon	Diospyros virginiana	*	*		
pine, pond	Pinus serotina	*			
loblolly	P. taeda	*			*
red	P. rubens	*			
shortleaf	P. echinata	*			
slash	P. elliottii	*			
white	P. strobus	*	*	*	
redbay	Persea borbonia	*		*	
spruce, red	Picea pungens	*	*		*
white	P. glauca	*	*		*
sweetbay	Magnolia virginiana			*	
sweetgum	Liquidambar styraciflua	*		*	
sycamore	Platanus occidentalis	*		*	

1/ Not recommended for planting due to susceptibility to Dutch Elm Disease.
2/ Much variation in response to waterlogging. More tolerant to waterlogging in North than in South.

TABLE 4

WEAKLY WATER TOLERANT SPECIES

Species	Scientific Name	Benefit Capability			
		Timber	Wildlife	Aesthetics	Water Quality
birch, gray	Betula populifolia			*	
paper	B. papyrifera	*		*	
black locust	Robinia pseudoacacia	*		*	
black walnut	Juglans nigra	*	*		
blackgum	Nyssa sylvatica	*	*	*	
buckeye, yellow	Aesculus octandra	*			
butternut	Juglans cinerea	*	*	*	
elm, winged	U. alata	*		*	
hazelnut	Corylus americana		*		
hickory, mockernut	Carya tomentosa	*	*		
pignut	C. glabra	*	*		
sand	C. pallida	*	*		
shagbark	C. ovata	*	*		
shellbark	C. laciniosa	*	*		
swamp	C. lieodermis	*	*		
holly, American	Ilex opaca		*	*	
American hornbeam	Carpinus caroliniana			*	
oak, black	Quercus velutina	*	*		*
blackjack	Q. marilandica	*	*		*
chinkapin	Q. muehlenbergii	*	*		*
cherrybark	Q. falcata var. pagodaefolia	*	*		*
chestnut	Q. prinus	*	*		*
laurel	Q. laurifolia		*	*	*
live	Q. virginiana	*	*		*
northern red	Q. rubra	*	*		*
post	Q. stellata	*	*		*
shingle	Q. imbricaria	*	*		*
Shumard	Q. shumardi	*	*	*	*
swamp chestnut	Q. michanxii	*	*		*
mulberry , red	Morus rubra		*	*	
pawpaw	Asimina triloba	*	*		*
pecan	Carya illinoensis	*	*	*	
pine, Virginia	P. virginiana	*		*	*
spruce	P. glabra	*			
redbud	Cercis canadensis			*	
sourwood	Oxydendrum arboreum			*	
Southern magnolia	Magnolia grandiflora			*	
sugarberry	Celtis laevigata	*		*	

TABLE 5

LEAST WATER TOLERANT SPECIES

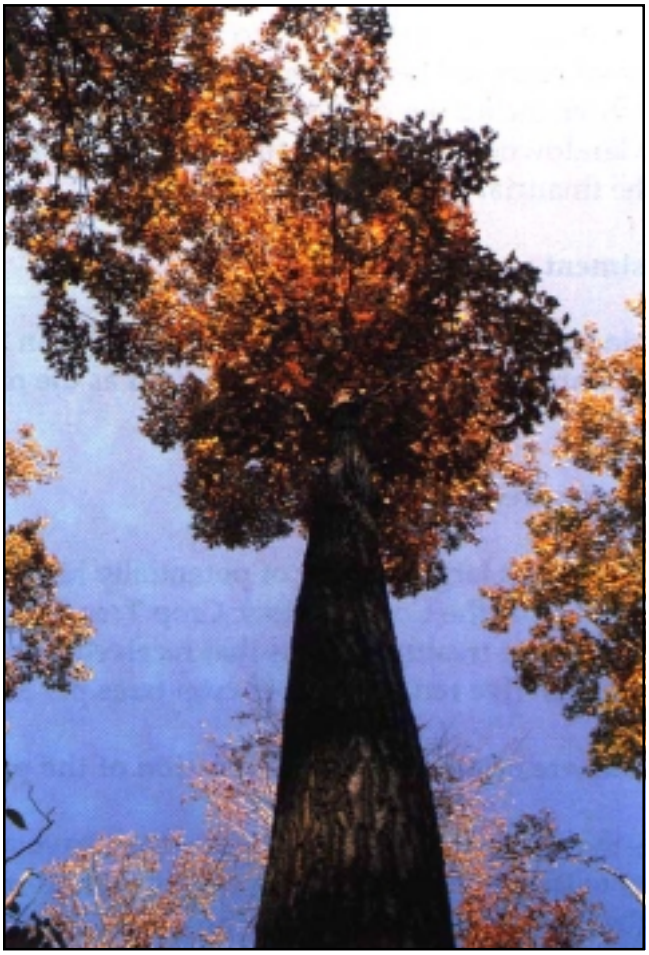
Species	Scientific Name	Benefit Capability			
		Timber	Wildlife	Aesthetics	Water Quality
American beech	Fagus grandifolia	*	*		*
black cherry	Prunus serotina	*	*		
flowering dogwood	Cornus florida		*	*	*
Eastern redcedar	Juniperus virginiana	*	*	*	*
elm, slippery	Ulmus rubra	*			
hophornbeam	Ostrya virginiana		*		
oak, white	Q. alba	*	*		*
pawpaw	Asimina triloba	*	*		*
sassafras	Sassafras albidum	*	*	*	
yellow-poplar	Liriodendron tulipifera	*	*	*	*

APPENDIX E

Timber Crop Tree Investment Analysis

by

Arlyn W. Perkey



During the past decade, this released red oak crop tree has grown 4.2" in diameter, earning a rate of return of 25 percent and an income of $44.

Timber Crop Tree Investment Analysis

by
Arlyn W. Perkey

Investing in timber crop trees can be financially rewarding if prospective investors understand the business. The following analysis of rates of return and crop tree income shows some favorable measures for timber crop tree investments. However, there are also some factors that hinder investment in timber crop trees on the private, non-industrial forest. An awareness of the following investment deterrents can help you provide sound investment advice to clients.

1. Age of landowners

The period of investment is long relative to human life span. Many people are often at least 40 years old before they become landowners. An 11" dbh tree that grows three inches per decade will require three decades to reach 20" dbh. Many landowners would be rather mature themselves before they could receive the financial benefit from such a tree.

2. Period of investment

Some of the periods of investment are too long (more than 30 years) to be attractive if the compound interest formula is used as the means of measurement.

3. Few high-value crop trees in stands

Most stands don't have a large number of potentially high-value crop trees per acre. For example, at the Coopers Rock Crop Tree Demonstration Area in Morgantown, WV, the treatment areas that received a crown-touching release had fewer than five red oak timber crop trees per acre.

4. High-value stands are often only a small portion of the property

Most properties that are available for purchase don't have a large portion of the land covered with a high-value timber component. It often isn't feasible to acquire just the desirable portions of the property. The seller usually wants to sell the whole parcel. If it is subdivided, the cost of subdivision increases the cost of the investment.

5. Market value of immature timber not reflected in current value of property

The current market value for land and timber often does not reflect the potential future value of high-quality crop trees. If the land is sold prior to maturity of the crop trees, it is difficult to have a fair price for the immature timber reflected in the market price of the land and timber. The non-liquidity of the investment is a disincentive for many people. However, this may be a good opportunity for investors who are in a position to wait until the trees mature.

6. Investments are risky

High-value timber crop tree investments are risky. Examples of risk include changes in the market and catastrophic loss caused by insects (gypsy moth) or weather events.

7. Awareness of investment opportunities and how to achieve them

Many landowners and potential landowners are unaware of the favorable investment opportunities that do exist for timber crop trees. People who own potentially valuable timber crop trees are often not aware of the management activities that can be used to help those crop trees reach their full financial potential.

This small sawtimber red oak with a 40 percent crown ratio is an example of a timber crop tree that is an excellent investment opportunity.

Crop tree income and rate of return can be used to improve landowners' awareness of timber crop tree investment opportunities. Below is a listing of the incomes and rates of return for 15 timber crop trees in West Virginia. The diameter growth information is based on 10 years of measured growth between 1982 and 1992.

Values are based on a stumpage rate of $75/MBF for trees 11.0 - 13.9" dbh, $150/MBF for trees 14.0 - 16.9" dbh, $225/MBF for trees 17.0 - 19.9" dbh, and $275/MBF for trees 20"+ dbh. The free-to-grow rating is determined by evaluating how free the crop tree crown is from competing neighboring trees. Possible ratings are 0, 1, 2, 3, or 4. A rating of "0" means there is no growing space available to the crop tree for crown expansion. Conversely, a rating of "4" means that the crown of the crop tree is free from competition on all four of its sides.

Income & Rates of Return for 15 WV Timber Crop Trees

Tree No.	DBH	Free To Grow	10-Year Growth	1982 Value	1992 Value	Crop Tree Income	Rate of Return
1	20.9"	3	4.4"	$88.37	$126.50	$38.13	3.7%
2	17.1	2	3.4	37.35	66.83	29.48	6.0
3	14.3	2	2.4	16.87	30.53	13.66	6.1
4	15.3	2	1.9	25.92	48.38	22.46	6.4
5	17.8	2	4.3	63.03	119.63	56.60	6.6
6	15.2	2	3.0	20.05	41.85	21.80	7.6
7	11.1	1	1.7	2.31	4.88	2.57	7.8
8	11.2	2	2.4	2.34	5.48	3.14	8.9
9	14.2	2	3.6	16.65	51.75	35.10	12.0
10	14.0	2	4.2	16.21	53.78	37.57	12.7
11	13.7	0	1.9	7.80	26.85	19.05	13.2
12	12.0	0	2.0	4.36	16.20	11.84	14.0
13	12.2	4	3.8	4.49	28.20	23.71	20.2
14	11.1	3	2.7	2.31	15.75	13.44	21.2
15	13.2	3	4.2	5.17	49.47	44.30	25.3
Avg.	**14.2"**	**2**	**3.1"**	**$20.88**	**$45.74**	**$24.86**	**11.4%**

The incomes and rates of return listed in the chart do not reflect any allowance for inflation or any real increase or decrease in stumpage value that may occur. Nor do they reflect any cost of owning the land, including purchase price, taxes, and administrative expenses.

Notice that Tree Number 1 is earning good income, but its rate of return is relatively low even though it has a high free-to-grow rating and a rapid rate of physical growth. This is because the tree is already large, and it has a high initial value.

Had a crown-touching release been applied to the highest value timber crop trees in this stand, more trees would have free-to-grow ratings of 3 or 4 with corresponding growth rates, crop tree incomes, and rates of return. Crop Tree Management can facilitate development of more trees with this high productive capacity.

The most difficult part of the investment analysis procedure (and the greatest potential for error) is estimating crop tree growth. Use the instructions described on the **Crop Tree Growth** sheet found in the back pocket of this publication to obtain reliable growth data.

Knowing the past growth rate of individual trees provides a good basis for estimating how they will grow in the future.

The diameter of this numbered crop tree will be measured annually at the dbh mark. This growth information will be used to calculate its rate of return and annual income so that the landowner can monitor how well it is meeting the financial management objective of the stand.

Following is an example of how the rate of return and crop tree income is calculated for an individual tree. Using Tree Number 11 (Pages E-4 and E-7) as an example, work through the steps listed to see for yourself how the process works.

Step 1 - Using a calculator with business analyst features, calculate the initial volume of the tree, using the following formulas:

Trees 11.0-14.9" dbh	Trees 15.0-19.9" dbh	Trees 20.0"+ dbh
$V = .16D^2H + D$	$V = .16D^2H + 1.5D$	$V = .16D^2H + 2D$

Where V = volume in board feet (Int. 1/4"), D = dbh in inches, and H = height in 8-foot bolts.

Tree Number 11 is presently 13.7 inches dbh, and its sawlog height is three 8-foot bolts. Consequently, its initial volume is:

$$V = (.16 \times 13.7 \times 13.7 \times 3) + 13.7 = 103.79 \text{ or } 104 \text{ BF}$$

Step 2 - Calculate the initial value of the tree by multiplying the volume by the stumpage value of $0.075/BF (initial value = .075 x 104 = $ 7.80). Enter this in the present value register of the calculator.

Step 3 - Calculate the subsequent volume of the tree, using its subsequent diameter and height. In this case, subsequent diameter is 15.6" (initial dbh + 10-Year Growth) and subsequent height is four 8-foot bolts (its merchantable height increased one bolt during the 10-year period). Its subsequent volume is:

$$V = (.16 \times 15.6 \times 15.6 \times 4) + (1.5 \times 15.6) = 179.15 \text{ or } 179 \text{ BF}$$

Step 4 - Calculate the subsequent value of the tree by multiplying its volume by its stumpage value of $0.15/BF (subsequent value = .15 x 179 = $26.85). The increase in unit stumpage value is because of the increased board foot value of larger trees. Enter this in the future value register of the calculator.

Step 5 - Enter 10 (for 10 years) into the time period register, and have the calculator compute the interest rate. For this example, it is 13.2%. To obtain the crop tree income, subtract the present value from the future value – in this case it is $19.05.

If you want to estimate the financial benefit of fully releasing crop trees, repeat the procedure with estimated accelerated growth rates. For the tree used in the example, it would not be unreasonable to increase its growth from 1.9 to 3.5 inches/decade. If there is no change in sawlog height, its rate of return would increase to 20.0%, and its crop tree income to $40.60.

Following is a **Timber Crop Tree Investment Analysis Sheet** with the trees in the table on Page E-4 used as the example.

TIMBER CROP TREE INVESTMENT ANALYSIS SHEET

LANDOWNER: ______________________________

STAND NUMBER: __________ **ACRES:** __________ **TYPE:** __________ **AGE:** __________

STAND HISTORY: ______________________________

____

Tree	Sp.		DBH	Ht.	Free* Grow	Vol.**	Price	Value	Time Prd.	Growth	Income	ROR
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
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		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
Average		Initial:										
		Subsequent:										

USDA Forest Service, NA-S&PF, Morgantown, WV
(August 1993)

Tree	Sp.		DBH	Ht.	Free* Grow	Vol.**	Price	Value	Time Prd.	Growth	Income	ROR
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
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		Subsequent:										
		Initial:										
		Subsequent:										
		Initial:										
		Subsequent:										
Average		Initial:										
		Subsequent:										

Average Income/tree: ____________________

Average ROR/tree: ______________________

Number of crop trees/acre: _______________

Income/acre: ______________________________ (no. of crop trees x average income/tree)

Income/acre/year: ______________________________ (Income/acre/time period)

* Free-to-Grow: A rating (from 0 to 4) indicating how many of the four sides are free from competition from neighboring crowns. A "0" classification means the crown has no room to grow. In contrast, a rating of "4" means the crop tree is free to grow on all of its four sides.

** Volume = .16 x D^2H + D for trees 11.0-14.9" dbh

** Volume = .16 x D^2H + 1.5D for trees 15.0-19.9" dbh

** Volume = .16 x D^2H + 2D for trees 20.0+" dbh where D=dbh in inches and H=height in 8-ft. bolts

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January 1994

Sources of Information

Beck, Donald E. 1977. **Twelve-year acorn yield in Southern Appalachian oaks.** Res. Note SE-244. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.

Beck, Donald E.; Olson, David F. Jr. 1968. **Seed production in Southern Appalachian oak stands.** Res. Note SE-91. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.

Beck, Donald E.; Della-Bianca, Lino. 1981. **Yellow-poplar: characteristics and management.** U.S. Department of Agriculture, Agriculture Handbook 583. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.

Christisen, Donald M.; Korschgen, Leroy J. 1955. **Acorn yields and wildlife usage in Missouri.** Twentieth North American Wildlife Conference. 20:337-357.

Christisen, Donald M. 1955. **Yield of seed by oaks in the Missouri Ozarks.** Society of American Foresters. 53:439-441.

DeGraaf, Richard M.; Scott, Virgil E.; Hamre, R. H.; Ernst, Liz; Anderson, Stanley H. 1991. **Forest and rangeland birds of the United States: natural history and habitat use.** U.S. Department of Agriculture, Forest Service, Agriculture Handbook 688.

Downs, Albert A.; McQuilkin, William E. 1944. **Seed production of Southern Appalachian oaks.** Journal of Forestry. 42:913-920.

Kidd, William E. Jr.; Smith, H. Clay. 1989. **Woodlot management: helping it grow.** West Virginia University Extension Service.

Lamson, Neil I.; Smith, H. Clay. 1989. **Crop-tree release increases growth of 12-year-old yellow-poplar and black cherry.** Res. Pap. NE-622. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Lamson, Neil I.; Smith, H. Clay; Perkey, Arlyn W.; Wilkins, Brenda L. 1988. **How to release crop trees in precommercial hardwood stands.** NE-INF-80-88. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Lancaster, Kenneth F.; Leak, William B. 1978. **A silvicultural guide for white pine in the Northeast.** USDA For. Serv. Gen. Tech. Rep. NE-41. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Lancaster, Kenneth F. 1985. **Managing Eastern hemlock: A preliminary guide.** NA-FR-30. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Lancaster, Kenneth F. 1984. **White pine management: A quick review.** NA-FR-27. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Leak, William B.; Solomon, Dale S.; DeBald, Paul S. 1987. **Silvicultural guide for northern hardwood types in the Northeast (revised).** Res. Pap. NE-603. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Liscinsky, Steve. 1984. **Tree seed production.** Game News. 55:23-25.

Marquis, David A.; Ernst, Richard L.; Stout, Susan L. 1984. **Prescribing silvicultural treatments in hardwood stands of the Alleghenies.** USDA For. Serv. Gen. Tech. Rep. NE-96. Broomall, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Miller, Gary W. 1986. **Cultural practices in Appalachian hardwood sapling stands-are they worthwhile?** Proceedings: Guidelines for managing immature Appalachian hardwood stands, May 28-30; Morgantown, WV.

Paugh, Joseph H. 1970. **Effects of thinning on acorn production on the West Virginia University Forest.** DA: West Virginia University.

Perkey, A. W. 1991. **A comparison: crop tree management to uneven-aged management.** Forest Management Update. 13:22-27.

Perkey, A. W. 1987. **Assessing wildlife habitat management objectives on the private, non-industrial forest.** Forest Management Update. 7:1-5.

Perkey, A. W. 1989. **Counseling clients considering harvesting immature timber crop trees.** Forest Management Update. 10:1-6.

Perkey, A. W. 1988. **Crop tree release - how well have we done?** Forest Management Update. 8:6-8.

Perkey, A. W. 1990. **Communicating with landowners: an observer's perspective.** Forest Management Update. 11:1-4.

Perkey, A. W.; Sykes, Karen; Palone, Roxane. 1990. **Crop tree management in riparian zones.** Forest Management Update. 11:8-15.

Perkey, A. W.; Sykes, Karen; Palone, Roxane. 1993. **Crop tree management in riparian zones,** 10 pages, Northeastern Area, State and Private Forestry.

Perkey, A. W. 1989. **If we all pull together, How happy we'll be.** Forest Management Update. 9:1-2.

Perkey, A. W. 1991. **So you want to be a private non-industrial landowner?** Forest Management Update. 12:1-9.

Rexrode, Charles O.; Smith, H. Clay. 1990. **Occurrence of gum spots in black cherry after partial harvest cutting.** Res. Pap. NE-634. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Roach, Benjamin A. 1977. **A stocking guide for Allegheny hardwoods and its use in controlling intermediate cuttings.** Res. Pap. NE-373. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Roach, Benjamin A.; Gingrich, Samuel F. 1968. **Even-aged silviculture for upland central hardwoods.** U.S. Department of Agriculture, Agriculture Handbook 355. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Safford, L. O. 1983. **Silvicultural guide for paper birch in the Northeast (revised).** Res. Pap. NE-535. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Sharik, T. L.; Ross, M. S.; Hopper, G. M. 1983. **Early fruiting in chestnut oak (Quercus prinus L.).** Forest Science. 2:221-224.

Sharp, Ward M.; Sprague, Vance G. 1967. **Flowering and fruiting in the white oaks.** Pistillate flowering, acorn development, weather and yields. Ecology. 2:243-251.

Smith, Clay H.; Lamson, Neil I. 1986. **Cultural practices in Appalachian hardwood sapling stands--if done, how to do them.** Proceedings: Guidelines for managing immature Appalachian hardwood stands, May 28-30; Morgantown WV.

Stringer, Jeffrey W.; Miller, Gary W.; Wittwer, Robert F. 1988. **Applying a crop-tree release in small-sawtimber white oak stands.** Res. Pap. NE-620. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Sykes, Karen J.; Perkey, Arlyn W.; Palone, Roxane S. 1993. [In press] **Crop tree management in riparian zones.** Proceedings: Riparian ecosystems in the humid U.S.- functions, values, and management, March 15-18; Atlanta GA.

Tryon, E. H.; Carvell, K. L. 1962. **Acorn production and damage.** Morgantown, WV: West Virginia University Agricultural Experiment Station. 5-18.

Tubbs, Carl H.; DeGraaf, Richard M.; Yamasaki, Mariko; Healy, William M. 1987. **Guide to wildlife tree management in New England northern hardwoods.** USDA For.Serv.

Gen. Tech. Rep. NE-118. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.