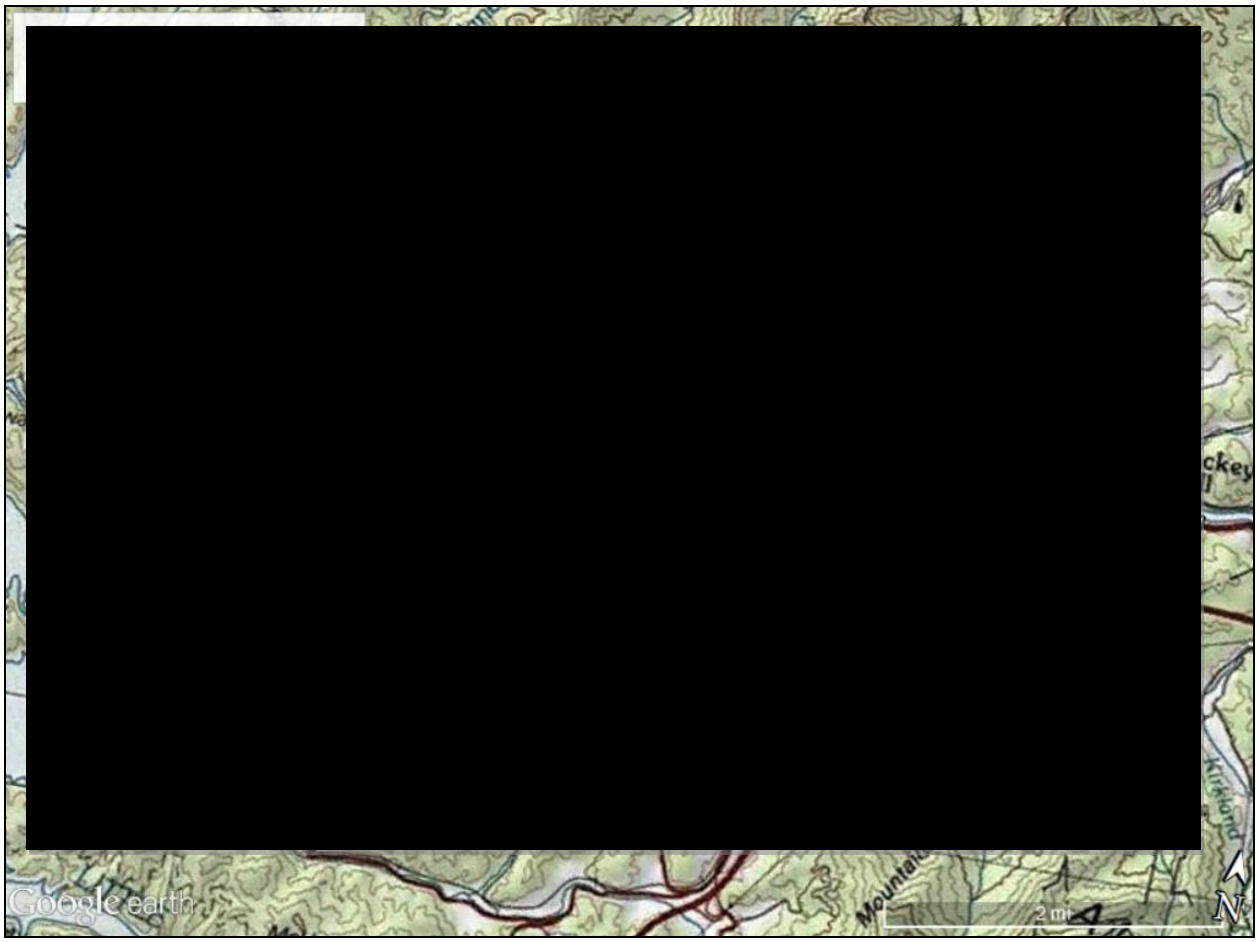
[redacted]

Forest Management Plan



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12/18/2016

FOREST MANAGEMENT PLAN

LANDOWNER: [redacted]

LOCATION: [redacted]

DATE: December 18, 2016

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PURPOSE OF A FOREST MANAGEMENT PLAN FOR PUV TAX DEFERMENT

A forest management plan is a short-range (10-year) planning guide for a private woodland owner that is interested in enhancing and enjoying multiple benefits from their forested property. The State of North Carolina recognizes the majority of forest land in NC is owned by "non-industrial private forest" owners (NIPF) like you. In fact, close to 61% of all NC timberland is owned by NIPF owners. Much of the timber fueling NC's timber industry is expected to come from this group. Forestry in NC is big and contributed much to our state's economy. In 2013, forest industry generated $18.7 billion in output and created over 70,000 jobs. For a summary of the impact of forestry in North Carolina – please refer to NCSU Extension Forestry's Economic Impact Data found at: https://forestry.ces.ncsu.edu/economic-impact-data. In 2015, NIPF timber sales in Swain County's 90,000 acres of NIPF timberlands amounted to $1.03 million in delivered forest products. This generates sales tax for the county and the state.

North Carolina has a vested interest in providing incentives for NIPF owners to keep their land in active "working forests" to provide a continued supply of timber for the state's economy and well-being. Therefore, the state has developed the "Present Use Value" (PUV) tax deferment program. This program is designed to allow NIPF owners who have 20+ contiguous acres in forest and who **follow** a written management plan accepted by their county's tax office receive a continual deferment on their land taxes. This has the ability to reduce land taxes 50% or more, and reduces the hardship of a high tax burden of landowners wishing to keep their lands in working forests.

The management plan written for the NIPF owner is a guide to help the landowner get the most out of their enjoyment of the land and fulfill the most important objectives landowner have in terms of recreation, forest health, wildlife , and water quality. The process of writing a plan for a landowner, I feel, is an

opportunity to help educate the landowner about "good" forestry and how harvesting timber not only contributes to the goals of the PUV program but also accomplishes other landowner objectives in terms of wildlife habitat, overall forest health, and future income generation. These plans are written for the landowner to get actively involved with their land. When bettering the land for future generations you are putting a part of you in it, making it your own. The purpose of the plan is therefore to give the landowner sound, practical advice, on timber health, harvesting, and regeneration strategies that minimizes negative impacts on our forests and forest ecosystems while maximizing the positive effects.

In order to remain in the PUV program, the landowner **must be active** in carrying out their plan. The county audits each property in PUV every 7-8 years. The landowner receiving PUV tax status with no intention of carrying out any forest management may lose PUV deferment and be required to pay the "highest-and-best-use" tax rate plus penalties of 3 years of back-taxes and interest.

Do not miss the opportunity to make a difference in your land – make it the best it can be for the land's sake, your betterment, and enjoyment, and for future generations.

PROPERTY OVERVIEW

The property owned [redacted], hereafter called "[redacted] Property", is a tract of approximately 38 acres. Approximately 2.5 acres are in home sites or outbuilding leaving 35.5 acres in forest or forest roads / trails, and is focus of this management plan. The property is located at address [redacted]

The majority of the property is a series of southwest facing ridges and hollows that drain south into [redacted]. The property ranges in elevation from approximately 1820' at the southwest corner to 2240' at the northeast corner. The eastern boundary of the tract borders the land managed by the Nantahala National Forest, USFS. Downstream from the [redacted] Property is also the [redacted]. The soils are derived primarily from metamorphosed shales and sandstones and tend to be acidic and relatively shallow with sharp flat (slate-like) rock within 20" of the soil surface. With the exception of the hollows, most of the site can be characterized as relatively dry and warm.

Like many properties in the southern Appalachians, the land was utilized for timber production and cattle grazing. Most (if not all) of the forested portion of the property was likely in forest grazing until half a century ago. Old fence lines exist across the ridgeline at the top of the property and there is strong evidence of old cattle driving roads in the hollow areas. Roughly, 110 years ago, the land reverted to forest, starting with yellow pines (shortleaf pine and Virginia pine). Hardwoods succeeded after pine establishment roughly 90 years ago. Due to the drier, relatively acidic conditions of the site, pine and oak were better able to compete than yellow-poplar, which vigorously competes on richer sites. The pines slowly died leaving a mixed pine/oak stand when the property was last inventoried by the NC Forest Service in 2008. Then, the overstory oaks were roughly 80-85 years but still capable of responding to openings in

the canopy. Also, there existed a large population of regenerating oak seedlings in the understory. The NCFS recommended removal of the remnant pines and some of the poorly formed oaks in the overstory to provide resources and sunlight for better formed canopy oaks. More importantly, the pine and poorly form oak removal would open sunlight and other resources for younger oak seedlings in order to develop into the next stand of timber. [redacted] has been successfully following this recommendation for the past 8 years, as time allows. This management plan is an update of the current conditions and provides recommendations for the next 10 years.

Management Areas

The [redacted] Property is broken into three areas with distinct vegetation types based on aspect, topography, soils, and land use. These can be seen below in Figure 1 (2013 aerial with leaf off) and Figure 2 (2015 aerial with leaf on). A brief summary of each area is given below:

Area 1 (~32.5 acres) ~90 year old oaks and 105 year old yellow pines. A distinct two-age stand is developing on most of the area. Sparsely spaced larger even-aged oaks with pockets of old yellow pine along the ridges with moderately shallow loam soils of moderate to severe soil hazard ratings. A thriving understory layer of young oak seedlings and saplings occur due to the nature of the site and as direct result of work [redacted] has performed removing overstory pines and oaks.

Area 2 (~2 acres) ~10 years natural regeneration of mixed pine / hardwoods. This unit is found near the bottom of the property where a large number of yellow pines were clearcut. The soils are less steep, slightly richer, and deeper than the majority of the property.

Area 3 (~1 acre) ~ 90 year old yellow-poplar cove. This small area is found in the southern-most hollow where spring seeps are located in deeper, richer, and moister soils.

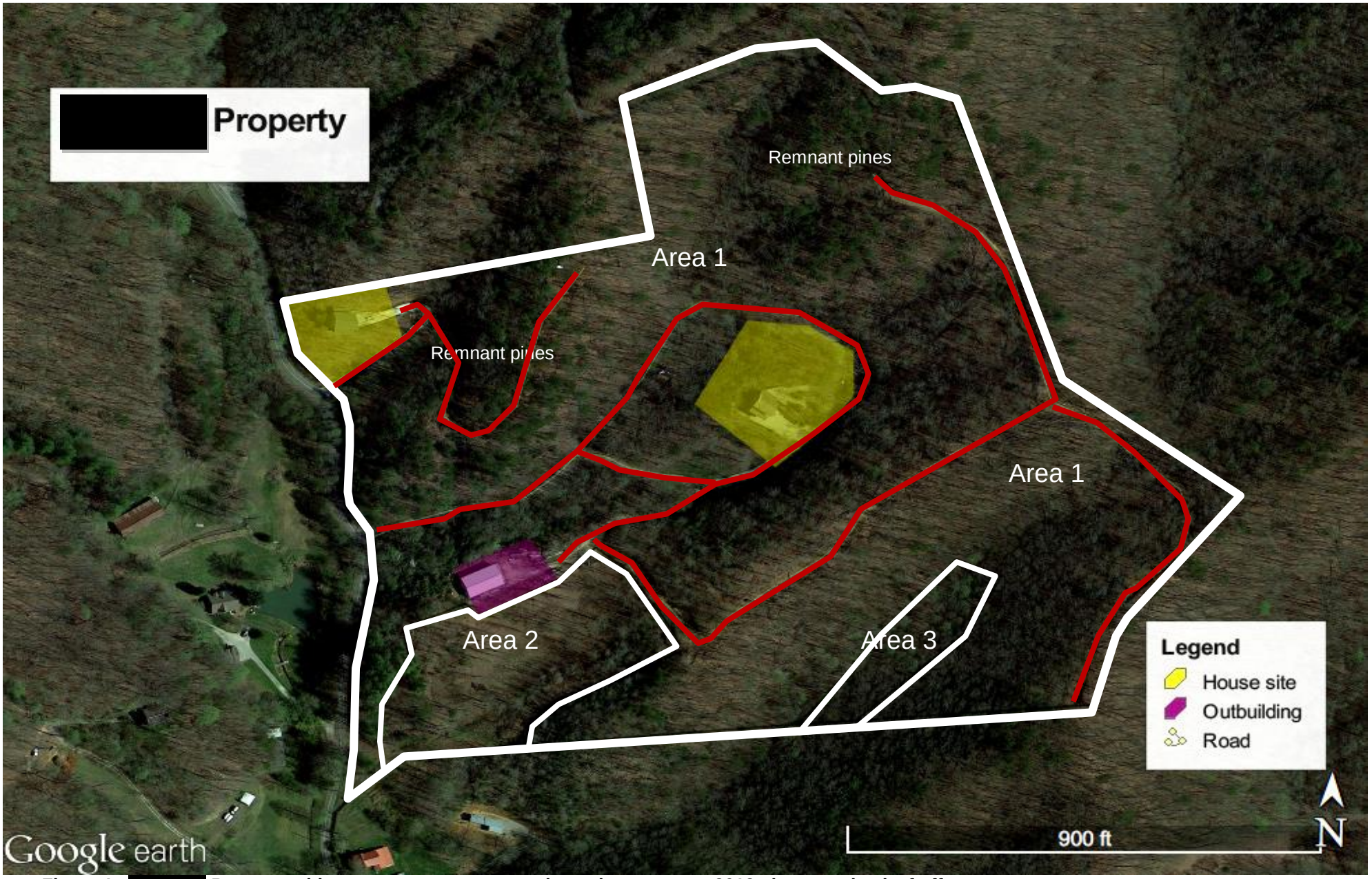


Figure 1. [redacted] Property with management areas, roads, and structures. 2013 photography, leaf off

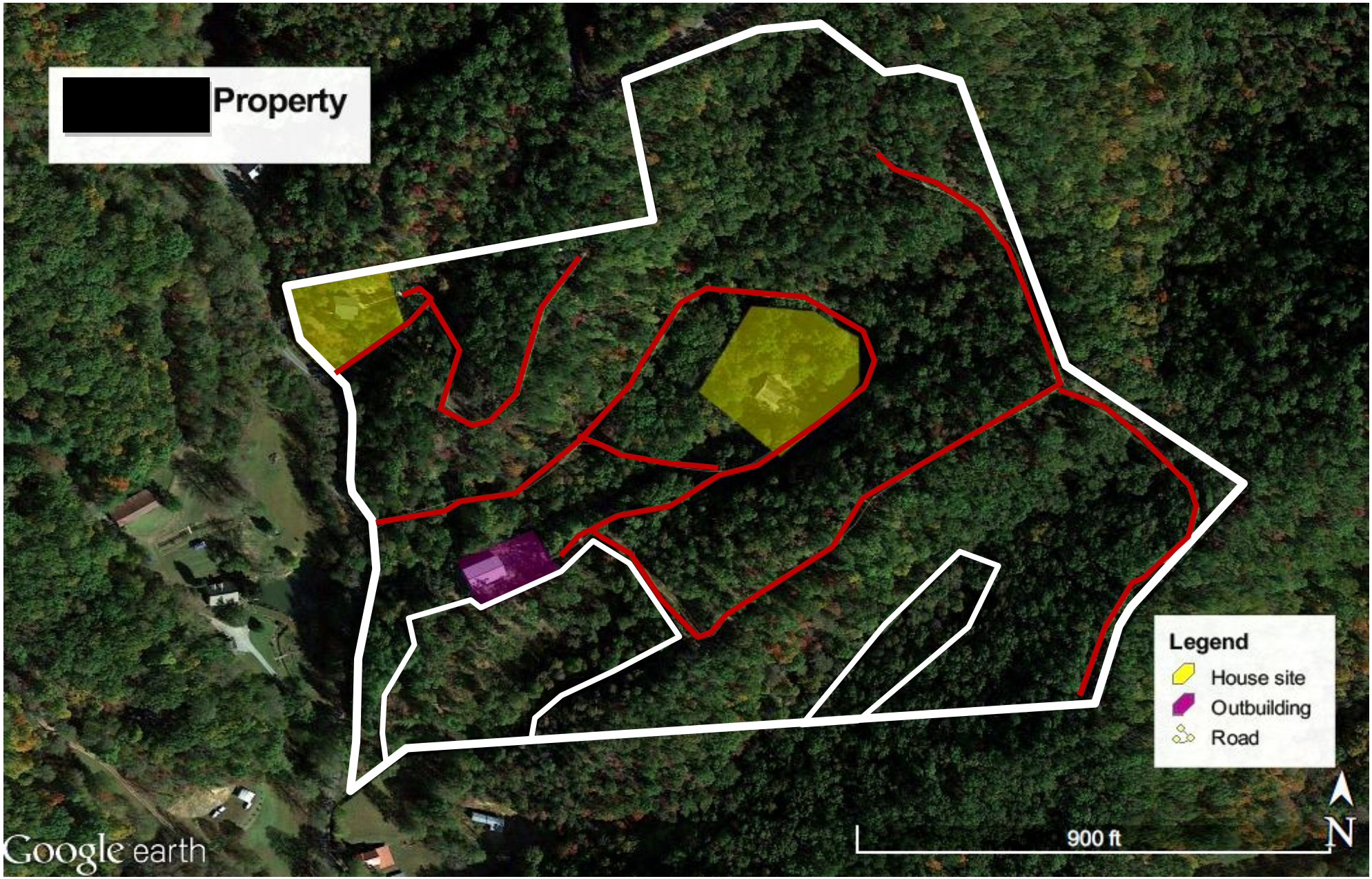


Figure 2. [redacted] Property with management areas, roads, and structures. 2015 photography, leaf on

Soils

The soils on the [redacted] property are derived from metamorphic shale and sandstone resulting in layered, sharp stone (called “channers”) not far from the soil surface. Steep slopes and relatively shallow soils result in relatively unstable conditions and wind through can be seen throughout the stand as seen in Figures 3 – 7.

Figures 3-4. Blow-down root ball - channery loam soil exposed

Figures 5-6. Blow-down root ball - channery loam soil exposed

Figure 7. Blow-down root ball - channery loam soil exposed

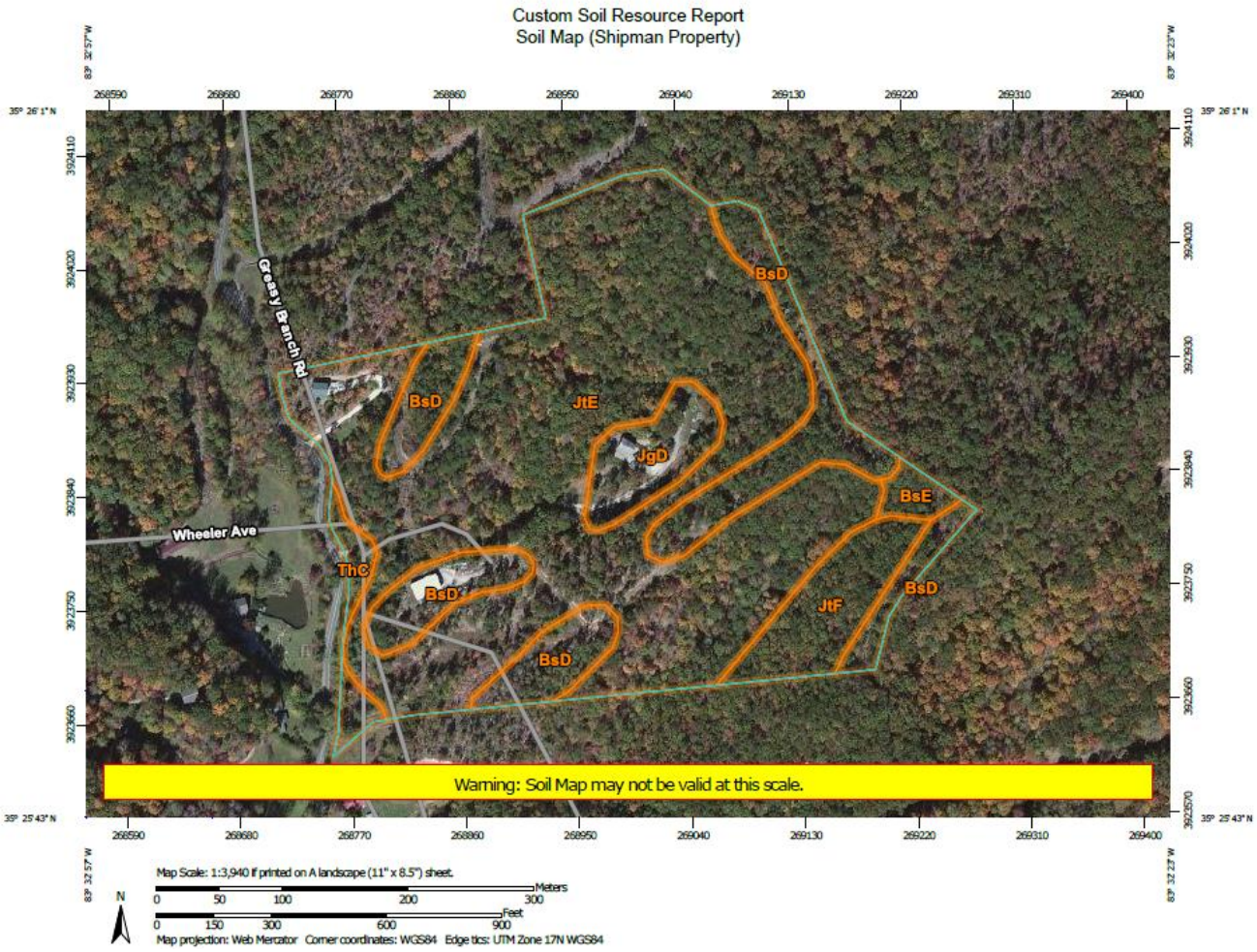
The resulting soils seen in the above pictures are termed channery loams. The three primary soil series in various combinations are:

Junaluska - Fine sandy loam 2 to 11 inches thick; 5 percent metasandstone channers by volume; common fine mica flakes; extremely acid. Sandy clay loam 10-25 inches; 5 percent by volume metasandstone channers; common fine mica flakes; strongly acid.

Brasstown – Channery fine sandy loam 2 to 10 inches thick;25 percent by volume metasandstone and phyllite channers; few fine flakes of mica; very strongly acid. Channery sandy clay loam 8-45 inches thick; 20 percent by volume metasandstone and phyllite channers; common fine flakes of mica; very strongly acid.

Tsali – Channery loam 1 to 10 inches thick; 20 percent metasandstone channers by volume; very strongly acid. Channery clay loam 10 to 16 inches thick; 16 percent metasandstone channers by volume; extremely acid.

These soils' approximate locations and acreages, derived from the NRCS Web Soil Survey, are provided in Figure 8. These are relatively shallow, well drained soils that dry out fairly quickly. They are also very acidic from the underlying rock material, making these soils relatively less productive than other soils found regionally. The dry, acidic conditions favor pines and oaks over yellow-poplar, which can out-compete oak on more productive sites.



Map Unit Legend ([redacted] Property)

Swain County Area, North Carolina (NC605)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BsD	Brasstown-Junaluska complex, 15 to 30 percent slopes	7.1	18.9%
BsE	Brasstown-Junaluska complex, 30 to 50 percent slopes	0.5	1.3%
JgD	Junaluska-Brasstown-Tsali-Urban land complex, 15 to 30 percent slopes	1.7	4.6%
JtE	Junaluska-Tsali complex, 30 to 50 percent slopes	25.0	67.1%
JtF	Junaluska-Tsali complex, 50 to 95 percent slopes	2.3	6.1%
ThC	Thurmont loam, 8 to 15 percent slopes	0.7	2.0%
Totals for Area of Interest		**37.2**	**100.0%**

Figure 8. [redacted] Property soils - from NRCS Web Soil Survey

Slope limitations

The topography of the [redacted] Property is seen in Figure 9. The underlying rock, under the right conditions, is prone to slide and due to the steepness of the soils found on the property, road construction, log landings, and machinery operations are considered moderately to severely limited. It should be noted that [redacted] has done an outstanding job developing, and adding to, the existing road system throughout the property. He used 3-5 inch crushed gravel based throughout and has an extremely well developed system of ditches, culverts, and water turn-outs that keeps these steep and well used roads in excellent condition (Figures 10 and 11).

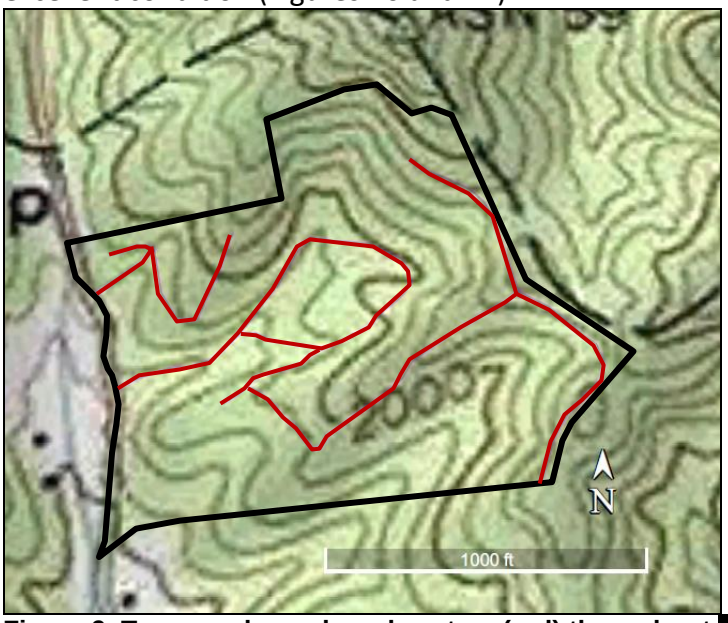


Figure 9. Topography and road system (red) throughout [redacted] Property.

Figures 10-11. Well-developed roads systems throughout [redacted] property. Left: 3-5 inch crushed stone base, grassed top along the top ridge of the property. Right: 3-5 crushed stone with gravel top and vegetated along the main access route. Inside ditching and water turnouts kepts in excellent repair.

LANDOWNERS OBJECTIVES

[redacted] first discovered this property's excellent wildlife habitat and hunting potential and was very happy to be able to purchase it sometime after he discovered it. He is a hard-working and skilled "do-it-your-selfer" and has developed over 1.1 miles of road access and fire breaks to every corner of the property. [redacted] built his home and his son's home on the property. He more recently built a large outbuilding housing his equipment. The [redacted] enjoy the property for its uniquely large amount of oaks and the beauty and habitat they provide. The property is excellent habitat for deer, turkey, grouse, rabbit, squirrel, songbirds, bear, and predatory species. They do not want to conduct an all-out timber sale at this point, but do realize the need to eventually remove the older overstory of oaks to make way for the younger regenerating oaks throughout the property. They have faithfully been following the advice of the 2008 NCFS management plan and would like to continue to do so for the next 10-20 years and then consider the next phase preparing for a final removal of the older timber. In the meanwhile, they will continue to manage the land to benefit oak establishment and health, maintain roads, and provide excellent wildlife habitat for friends and family to enjoy and hunt.

MANAGEMENT PLAN

Management areas 1 - 3 had timber inventory data information taken on them to describe timber species, stocking, and growth characteristics.

Definitions

Descriptive terms used in the management plan are defined below:

Basal area per acre (BA) – a tree stem density measurement. It is defined as the cross-sectional area (in ft^2) of all stems at 4.5 feet above the ground. Good stocking ranges from 90 – 150 ft^2 /acre depending on the timber species and the management objectives involved. I usually state the total BA for the unit and then break it down into percent BA by tree species – this helps to generate a picture of the diversity found on the unit.

Average diameter – most stem sizes range quite a bit in a stand of timber, so I give an estimate of the average diameter. Diameter is measured at 4.5 feet above the ground – also called dbh (diameter at breast height).

Average height – the average total tree height of the canopy trees is given.

Site index – is an estimate of the timber growth and productivity of the site. This varies by soil, tree species, and microclimate. It is estimated from the total age of a tree versus its total height. A 50 year-old oak that has grown 100 feet tall is on a much more productive site than a 50 year-old oak that has grown 65 feet tall. Site index values for oak typically range from 50 (very poor) to around 95 (very good).

Percent interest rate being grown by trees – this is a rough estimate of the diameter growth rate per year as a comparison against other rates of interest. A rule of thumb is when the interest rate grown by trees drops below about 5%, the stand is not growing as well as it could and may require that some silvicultural activities take place in order to improve stand productivity.

Timber Estimates

Eight sample points were taken on the [redacted] property, five were taken in area 1 – the oak/pine unit, one in area 2 – the regenerating mixed pine/hardwood, and 1 in area 3 a small rich cove dominated by yellow-poplar. All tree species for pulpwood (5 - 11 inch dbh) and saw timber (12 + inches) were sampled using a 10 BAF prism.

For basic estimates of current (marketable) timber, that is from 5 inches dbh and up, standard timber volume estimates were calculated. It should be noted that these are NOT accurate estimates but just provide a "ballpark" estimate of the volumes of sawtimber and pulpwood across the property. All hardwoods (mostly oak species) were calculated separately from pines and the totals added together. The results generated gave per acre and total volume for the management unit as well as the basal area / acre estimates by tree species.

Management Area 1 – Oak / Pine

Size: Approximately 32.5 acres
Aspect: Southwest ridges / coves, 1820'-2240' elevation
Age: ~95 years
Site Index: upland oaks - 65
Diameter Growth Rate of Overstory Oaks: <3% upland oaks

Basal Area (square feet / acre) of growing stock:

Species Group	BA sawtimber (ft^2/acre)	BA pulpwood (ft^2/acre)	BA total (ft^2/acre)	% sawtimber	% pulpwood
Oak	48	22	70	68%	32%
Pine	14	3	17	84%	16%
All	62	25	87	71%	29%

Non-timber vegetation: briar, blueberry, blackberry, mountain laurel, holly.

Timber: Predominantly drier, mixed oak (black oak, white oak, post oak, southern red oak, scarlet oak) with remnant yellow pine (shortleaf pine, Virginia pine) along some ridge tops. The site is steep but with medium depth soils that are moderately productive for oaks. Most of the area had been woodland grazed that succeeded into pine and then mixed pine / hardwoods roughly 110 years ago. The pine has started to

degrade over the past 20 years and in 2008 it was recommended that the pine and poorly formed oaks in the overstory be removed to make resources available to young oak seedlings. [redacted] has fulfilled this recommendation to a large extent, primarily on the pine removal and to a lesser extent on oak removal. The current stand is the result of natural regeneration of mostly oak seedlings or stump sprouts where overstory oaks had been cut. In those regions where remnant pines remain, southern pine been has been noted and throughout the stand there are pockets of wind-throw of older stems.

Figures 12-15. Left three: pine and oak stumps where overstory removal of pines and poorly formed oaks occurred. Note the regenerating oaks from stumps and seedlings. Right: remnant pines succumbing to southern pine beetle attack (roughly 8-10 trees affected). These remnant pines will continue to be removed.

The basal area measured was roughly 87 ft^2/acre with oaks capturing roughly 77% of the saw timber basal area and 80% of all timber basal area. The average height of the dominant's crown class was around 87+ feet tall and the average diameter at breast height (dbh) of sawtimber trees was around 14" for oaks and 15" for pines. The growth of the trees expressed as the "interest rates being grown by trees" (pg 1-45 of the Forester's Field Handbook) shows moderately slow growth (<3.0%).

The current stand density of 87 ft^2/acre and 105 trees/acre is considered within the range of "full stocking" (70%) for upland hardwoods but dense. This is a result of much of the pine and oak removal that had occurred since the last inventory. [redacted] has been diligent about following the recommendations and has been steadily removing pines and oaks. Much of the removed pine and oak was sold to a local contractor; however, [redacted] also has a Wood-Miser portable sawmill to directly mill wood himself.

Those removals provided sunlight to the oak saplings allowing them to grow successfully into the under story. This area is successfully developing into a two-age stand, a silvicultural technique employed by the USFS in much of the Southern Appalachians. The slower growth rates noted in the overstory oaks means a longer time until the canopy closes after openings are made. This provides partial sunlight for a longer time which benefits oak establishment while providing enough shade to reduce pine regeneration. This also provides ample sunlight for understory herbs and grasses benefiting wildlife.

Timber volume estimate (32.5 acres):

Species group	sawtimber (thousand board feet - MBF)	pulpwood (cords)
Oak	82	24
Pine	45	4
All	127	28

The current timber volume measured was relatively low due to overall slow growth and [redacted] removals of much of the overstory. Per-acre sawtimber was 4 MBF and per-acre pulpwood was 7 cords. These low volumes are not attractive for a timber sale. The 45 MBF of pine was exaggerated due to the few inventory samples. Two of the five inventory plots intentionally entered the remnant pines distorting the importance of the pine sawtimber. The remnant pines did not cover the entire area seen in (Figures 1 and 2) and contribute much less to the overall timber volume.

Health Issues: Remove remnant pines before more southern pine beetle attacks occur.

Regeneration Issues: Current regeneration of oak is excellent. Black oak, white oak, post oak, and scarlet oak were observed most in the understory.

Recommendations:
[redacted] should continue the steady removal of pines and poorly growing oaks in the overstory as he has done over the past few years. This method has been extremely successful in promoting new oaks in the understory that are growing into advanced regeneration. In 10 years, the area should be reassessed to determine if the oak in the understory is ready to respond to a partial or complete overstory removal. It may be at that time the [redacted] may decide to defer harvest until the understory stems reach maturity in 50-60 years. This is a technique routinely used by the USFS as a way to maintain wildlife habitat and successful oak production in less productive sites such as found on the [redacted] property.

As the understory oaks start to reach the height of roughly 15-20 feet, crop tree release may be applied to them to ensure the best oak stems will reach maturity. This is performed by killing any tree that is touching the crown of the crop tree, either by cutting or girdling larger stems, or through thin-line herbicide application on smaller stems. Larger stems may be killed and later harvested for firewood or milled. Details on crop tree release are provided in Appendix 1.

There are many snags (dead stems) of pines. If not a hazard to roads or property, it is recommended these be kept as much as possible for wildlife. We observed pileated woodpeckers while there taking advantage of insects found in those stems.

Management Area 2 – Regenerating mixed pine / hardwoods

Size: Approximately 2 acres
Age: ~10 years
Site Index: Brasstown soil series, 80 for white oak; Junaluska soil series, 61 for white oak
Aspect: Southwest facing side slope (approximately 1830 - 1960 feet elevation)

Regeneration vegetation: Area 2 had pines clearcut some 10 years ago and was left to natural regeneration. Two sample points (1/300 acre) revealed the following:

Species	Trees per acre
southern red oak	1050
scarlet oak	300
red maple	600
yellow-poplar	300
Total	**2250**

Observations and recommendations:
There is excellent regeneration of southern red oak and scarlet oak (60% of all timber seedlings). Other species not included in the sample plots but observed were sumac, grape, white pine, and short leaf pine. This stand currently provides excellent wildlife cover and food habitat and will for years to come. Eventually, over the next 2-5 years it is recommended that undesirable species be removed either by cutting or thin-line herbicide application. This should provide ample growing space for oak establishment as the main crop. In 10 years, a crop tree release could benefit the choice southern red oaks. This is performed by killing any tree that is touching the crown of the crop tree, either by cutting or through thin-line herbicide application. It is best to wait until the stems are 15-20 feet tall so you can pick those likely to have the best form upon maturity. Details on crop tree release are provided in Appendix 1.

Figures 16-17. Both images show ample southern red oak seedling in the sample plot. Note that even though the sample plots did not pick pine up, there are numerous pines (both yellow and white) regenerating as well.

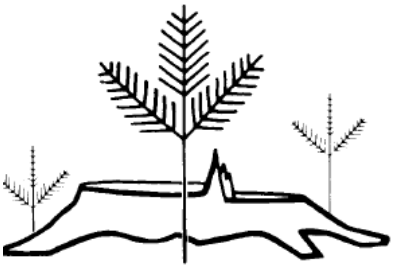
Management Area 3 – Yellow Poplar Hollow

Size: Approximately 1 acre
Age: ~90 years
Site Index: 107 yellow poplar (very productive)
Aspect: Southeast moist drainage (approximately 1910 - 2010 feet elevation)
Timber: This cool, moist ("mesic") was abandoned from woodland grazing in the past 90 years allowing natural regeneration of yellow-poplar and yellow birch.

Observations and recommendations:

Yellow-poplar dominates this stand with 83% of the 140 sq ft / acre basal area. Yellow-poplar sawtimber was 81% of all yellow-poplar stems, i.e. very few pulpwood sized stems. The diameter of the average yellow-poplar sawtimber diameter was 16 inches and the average yellow-poplar pulpwood was 10 inches. Yellow birch and white oak were also found in pulpwood sized stems. The volume of yellow-poplar in the one acre area was roughly 9.5 MBF for sawtimber and roughly 2.5 cords for pulpwood. The upper end of the stand marks the beginning of a series of springs that drain off the property. Even after the considerable drought in 2016, the springs still appeared to have some flow (Figures 18-19). [redacted] neighbors have benefitted from use of the springs and capture the water in a couple reservoirs. This is an informal agreement and can be changed at any time. However, at present, it is recommended that no timber harvesting should occur in this area, for two reasons: 1) the growth rate from an 88-year old dominant tree was estimated at 4.8%, a very good growth rate for a stem that age; and 2) it would best to not disturb the spring sites at the current time. When the [redacted] do decide to conduct a harvest operation, stems in this area should be included but maintaining adequate protection of the springs.

Figures 18-19. Left: springhead in Area 3 of [redacted] property. Right: below area 3 where neighbors utilizing spring water from [redacted] Property.



Woodland Owner Notes

Crop Tree Management in North Carolina

Landowners today are interested in forest management that promotes environmental stewardship and produces multiple benefits. Crop tree management can do just that. This system is designed for use in timber stands of adequate quality, but which are either not ready for final harvest and regeneration or belong to landowners who place high value on continuing stand management.

Crop tree management is a seven-step system that focuses on releasing trees that yield multiple benefits (including wildlife, water quality, and aesthetics, as well as timber) through intermediate cutting treatments around crop trees with the highest potential increase in value. Crop tree management requires making decisions about individual trees rather than an entire stand or forest.

Crop tree management was developed for use on nonindustrial private forests of the Eastern United States. Small, natural, mixed hardwood stands (generally 100 acres or less) are well suited to this method of management, and it works particularly well in areas such as riparian zones, urban and community woodlots, and forest buffers. Crop tree management can be used in precommercial as well as commercially operable stands.

This publication introduces readers to the seven steps involved in implementing crop tree management. The publication is tailored to Southeast species, objectives, and forest conditions and explains how the approach might be applied to trees for wildlife, water quality, timber, and aesthetics.

Crop tree management is an intermediate stand management strategy, like thinning. So what makes crop tree management different from typical thinning? Area-wide thinning, especially mechanized thinning, at its best takes out most of the poor trees, retaining most of the good trees for future harvest. The trees retained in an area-wide thinning are evenly spaced (for example, a target of 12- x 12-foot spacing, or the removal of periodic rows). Generally most of the emphasis in area-wide thinning is on the trees to be removed and the reasons for their removal. This is just the reverse of crop tree management, which focuses on retaining and managing the "best" trees with the greatest potential to produce specific benefits consistent with the landowner's goals for the property. Crop tree management singles out and "releases" only the "best" trees, regardless of their spacing or location. This release requires the removal of just those noncrop trees that are in direct crown competition with the selected crop trees. Crop tree management applies a "crown touching release"—removing or killing all trees with crowns that interfere with the crop tree. This is likely to result in an unequal distribution of

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free-to-grow, desirable crop trees throughout the stand.

The process of crop tree management can be labor intensive and expensive. Some timber tradeoffs to enhance amenities such as beauty, wildlife habitat, and recreation may be highly desirable. Prudent investors and managers will weigh these alternative opportunities and choose the combination that yields the greatest return in satisfaction as well as economics. Research has shown that crop tree management can produce multiple benefits including timber, wildlife, and aesthetics, and still generate attractive economic returns.

Responses to management inputs and returns on forestry investments vary with site quality, tree growth, timber quality, markets, and many other factors. In North Carolina, crop tree management opportunities are most attractive on sites with high potential productivity (and responsiveness). In general these are likely to include natural mixed hardwood and pine-hardwood stands on red river bottoms, branch bottoms, coves, lower slopes, and other deep, well-drained alluvial soils.

Crop Tree Management—The Process

Step 1. Identifying the Landowner's Property Goals

The first step in crop tree management is to identify the landowner's goals for a given property. This can be accomplished by answering the question "What uses are intended for this forestland?" Goals should address both long-term and immediate desires and can take the form of statements about future conditions. In all cases, goals should be consistent with the ultimate reason for owning the land. They must be realistic and achievable, and they must be compatible with the resources available. Examples of goals include:

- Enhance recreational suitability of the property
- Enhance the beauty of the property around the house and road
- Improve deer and turkey habitat for hunting

Step 2. Establish Stand-Specific Objectives

By developing stand-specific objectives, attention is focused on the stands with the greatest potential to help the landowner achieve overall property goals. Not every stand has the same (or even any) potential to accomplish property goals. For example, improving squirrel habitat by increasing hard mast production may not be possible or practical in a pure yellow-poplar cove, but could be addressed on a nearby oak-hickory ridge. Objectives are specific actions or steps that lead toward the accomplishment of goals. Keep in mind that objectives *must be specific* to be effective. Examples of specific objectives are:

- Improve deer habitat by increasing hard-mast production in oak and hickory
- Improve recreational access by turning an old logging road into a hiking trail
- Increase the variety of fall colors that can be seen from the road or house

Step 3. Develop Crop Tree Selection Criteria

Crop tree selection criteria are developed to match specific objectives. Examples of some timber-, wildlife-, aesthetic-, and water quality-crop tree selection criteria are included in Figure 1. Like the objectives, the selection criteria may differ from stand to stand, and selection criteria are almost certain to vary among landowners. Crop tree selection criteria should be designed to guide the selection of potential crop trees. Any tree meeting multiple selection criteria would be especially desirable because it is achieving multiple objectives.

Crop trees are those trees that best meet the tree selection criteria and thereby accomplish one or more stand objectives, leading toward the satisfaction of landowner goals. Conflicts may occur among criteria, and judgment must be exercised. Give priority to one particular crop tree in each case, or weigh external factors such as site or tree characteristics or the degree to which a criterion is satisfied by crop trees elsewhere in a stand. A tree that might not qualify as a crop tree in one spot could be the best tree available in another. When selecting crop trees, pick the best tree available in each case. Table 1 provides a general list of common tree species and some of the benefits they frequently provide.

Step 4. Inventory the Property

Inventory the selected stand or property to determine whether enough crop trees meet the selection criteria (see Appendix A). By using a systematic cruise and tally sheet(s) similar to the one in this publication (see sample in Figure 2, and Appendix B), the landowner can determine how many crop trees there are per acre or per stand and how many trees should be cut to release the crop trees. Most landowners should expect to find one- to several-hundred crop trees per acre. Higher numbers imply more work, higher cost, and heavier harvest levels

Table 1. List of common tree species and their frequently attributed benefits.

Species	Benefit Capability			
	Timber	Wildlife	Aesthetics	Water Quality
ash	+	+	+	
baldcypress	+		+	+
basswood	+	+		+
beech		+	+	
black cherry		+		
blackgum	+	+	+	+
cucumber	+	+	+	
dogwood		+	+	
elm	+		+	
hemlock			+	+
hickory		+		
holly		+	+	
hophornbeam		+	+	
maple	+		+	
oak (red)				
black	+	+		+
cherrybark	+	+		+
laurel		+	+	+
live	+	+	+	+
northern red	+	+		
southern red	+	+		
scarlet	+	+	+	
water	+	+		+
willow	+	+		+
oak (white)				
white	+	+		
chestnut		+		
swamp chestnut	+	+		+
persimmon		+	+	
pine, loblolly	+			+
longleaf	+	+	+	
shortleaf	+		+	
virginia				+
white	+		+	
redcedar	+	+	+	
river birch			+	+
sassafras			+	
sourwood		+	+	
southern magnolia		+	+	
sweetgum	+		+	
sycamore	+		+	+
yellow poplar	+		+	+

TIMBER

Dominant/codominant trees

- Healthy, vigorous live crown
- No forks or major branches low on main stem
- No dead upper crown branches
- No major stem defects
- High value commercial species
- Expected longevity of 20 or more years

AESTHETIC

Attractive flowers or colorful foliage

- Large, healthy crowns
- Expected longevity of 20 or more years
- Unusual species or tree form
- Visible from house, road, or pathways

WILDLIFE

Mast-producing trees

- Adequate sunlight to crown
- Large, healthy crown
- Reliable hard mast production
- Expected longevity of 20 or more years

Cavity trees

- Expected longevity of 10 or more years

WATER QUALITY

Dominant/codominant trees

- Healthy crown and root system
- Tolerant of flooding/suited to site
- Growth/nutrient accumulation potential
- Age/longevity potential

Figure 1. Examples of crop tree selection criteria for timber, wildlife, aesthetics, and water quality.

than may be justified. Lower numbers may not represent good use of the land and indicate stands that should be managed by some other strategy or should be regenerated completely.

A typical crop tree inventory would include information about species, category of crop tree (selection criterion), free-to-grow (FTG) rating (see Step 6), and information on leave and cut trees. Figure 2 shows a sample tally sheet.

Step 5. Decide How Many Crop Trees to Release per Acre

The number of crop trees to be released per acre depends on the number of trees meeting the criteria and how heavily the stand is to be cut. Whatever the number of crop trees to be released per acre, each crop tree should receive a complete crown touching release. Note that some areas or stands simply may not have enough crop trees to justify management by this method. In such cases, alternative management strategies including complete regeneration may be more appropriate.

Step 6. Decide Which Trees to Cut to Release the Crop Trees

To determine which trees are to be cut, look up into the crown of the crop tree and divide the crown into four equal quadrants (Figure 3). Examine each quadrant to determine whether the crop tree has adequate space to grow (freedom from competing trees). This is known as determining the free-to-grow rating (FTG). The FTG can range from 0 to 4. A rating of "0" means the crop tree crown has competition from neighboring crowns on all four sides (is *not* free to grow), and a FTG rating of "4" means the crop tree has adequate space to grow on all

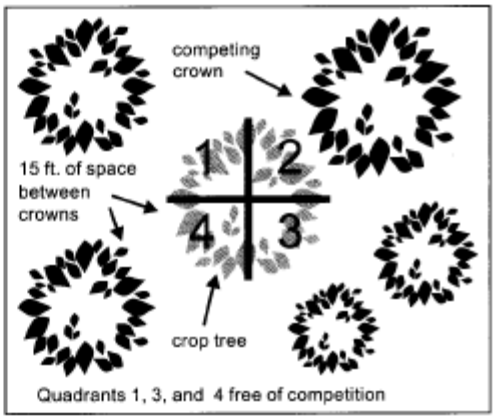


Figure 3. The crop tree in the center of this illustration has been divided into four equal quadrants. A free-to-grow rating is determined by evaluating each quadrant for competition from neighboring crowns. This tree has a free-to-grow rating of 3.

Figure 2: Sample Crop Tree Release Tally Sheet

Landowners: Jane and John Doe Date: December 15, XX

Stand ID and History: ① Abandoned ag field reverted to forest stand

Acres: 20 Number of sample plots: 20 Plot size (acres): 1/10 acres

Landowner Goals: ① To improve habitat for deer and turkey
② To improve timber quality

Stand Objectives: ① Improve habitat for deer and turkey by increasing hard mast production.
② Improve timber quality by releasing select oak to increase diameter growth.

Species	FTG*	Crop Tree Category				Competing trees to be removed
		Timber	Wildlife	Water quality	Aesthetics	
① red oak	4	X	⊗			
white oak	1	⊗	X			
hickory						X
red maple						X
red oak	1	⊗	X			
red maple						X
sweet gum						X
dogwood	0		X		⊗	
red cedar	0				⊗	
sweetgum	2	⊗				
⑳ red maple						X
sweetgum						X
river birch	2			⊗	X	
red oak	0	⊗	X			
red maple						X
sweetgum						X
yellow poplar	1	⊗		X		
sweetgum						X
elm						X
Total number sampled[⊗]:	Conversion Factor**	150	50	10	30	440
Number per acre	A × 1/a ÷ N = B	75	25	5	15	220
Stand total	B × C = D	1500	500	100	300	4400

*FTG - Free-to-Grow Rating
0 - competition on all four sides
1 - free to grow on one side
2 - free to grow on two sides
3 - free to grow on three sides
4 - free to grow on all four sides

**Conversion Factor
$A \times \frac{1/a}{N} = B$ $B \times C = D$
A = total number sampled
a = size of sample plot (acres)
N = number of sample plots
B = number per acre
C = stand size (acres)
D = stand total

⊗If a tree qualifies in more than one category (for example, timber and water), count the tree only once (the circled X) in the category where it makes the greatest contribution to accomplishing the primary objective.

For example: 150 timber crop trees on 20 tenth-acre plots equals $150 \times \frac{1/0.1}{20} = 150 \times \frac{10}{20} = 75$ timber crop trees per acre
75 timber crop trees per acre on 20 acres equals 75 × 20 acres = 1500 timber crop trees in the 20-acre stand

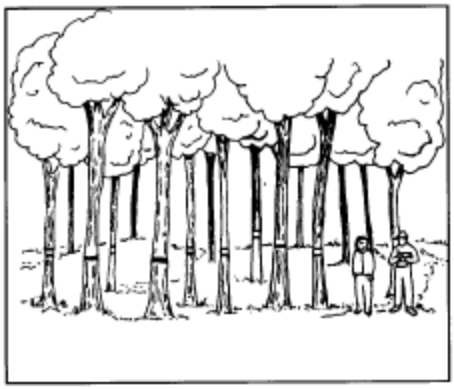


Figure 4. Visualize the proposed treatment on a small scale. In this illustration, crop trees are identified with one band of ribbon, and the trees to be cut have two.

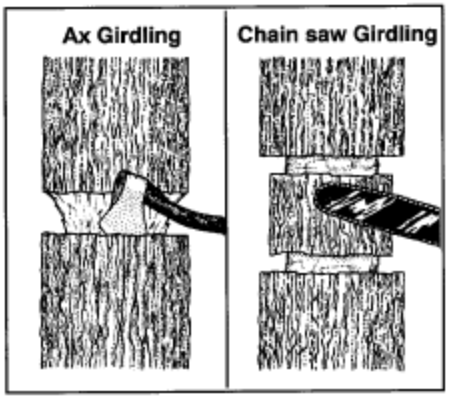


Figure 5. Example of ax and chain saw girdling.

four sides and needs no release. A crop tree is *not* free to grow in a quadrant if there is only 1 to 2 feet between the crop tree's crown and the neighboring crown. Assuming that a healthy tree crown might expand in radius 1 foot annually, the space between two competing crowns would decrease by 2 feet each year. At this rate, 15 feet between crowns would allow room for seven to eight years' growth. The ideal target of crown-touching release would be to give each crop tree an FTG of 3 or higher. Multiple entries into the stand over several years may be preferable to a single complete release of crop trees because of the risk of damage or degradation (such as that caused by storms or epicormic branching).

Step 7. Review the Proposed Treatment

Thoroughly review the stand-specific objectives for each stand, the crop tree selection criteria, and the number of crop trees to be released. Demonstrate the treatment (Figure 4) by setting up a few trial plots (1/5-acre, for example, would be a circular plot with a 52.7-foot radius). Flag the crop tree(s) with bright flagging. Mark competing trees to be cut with a different color flagging (those to be left can be marked with a third type of flagging if desired). Judge the heaviness of cutting either from flagged trees or after actual cutting on the trial plot(s). In crop tree management, only those trees directly competing with the crop trees need to be cut.

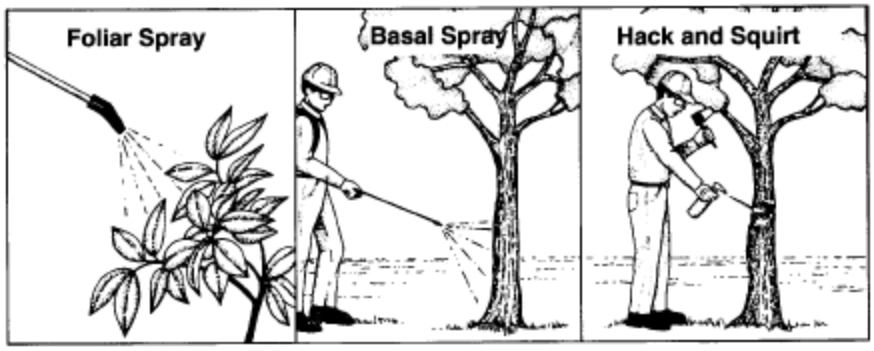


Figure 6. Three methods of applying herbicides: foliar spray, basal spray, and hack and squirt.

Those trees whose crowns do not directly compete with the identified crop trees remain in the stand. If a proposed cutting appears too heavy, reduce the number of crop trees selected for release rather than reducing the amount of release for each crop tree.

Crop Tree Release Techniques

If the competing trees to be removed have a marketable volume and value, seek help from a professional forester in marking, marketing, and harvesting the timber. If the trees to be cut are small or unsuitable for sale, they may be cut, felled, and left in place; girdled; or killed by an appropriate, labeled herbicide treatment. Mechanical girdling is the process of removing the cambium and bark from a ring around the trunk (Figure 5). This can be done with an ax or chain saw. Using an ax, cut a band of bark and living tissue 3 to 5 inches wide in a circular pattern around the tree. Using a chain saw, make two cuts, approximately 1 inch deep and 3 to 5 inches apart, in a circular pattern completely around the tree. This girdling treatment should interfere with the tree's ability to transport food. Herbicides, properly applied, can be safe, effective, and economical for controlling competing vegetation (Figure 6). Herbicides are designed for specific target species and conditions, so follow the directions on the label with respect to those conditions, timing, rate, and method of application to ensure effectiveness, personal safety, and environmental protection. Several common methods of application include foliar spray, basal spray, or squirted application to cuts through the bark (hacks or notches).

Summary

Crop tree management focuses on managing individual trees, expanding their potential to meet multiple landowner objectives. Crop tree management allows landowners to practice stewardship principles, retaining maximum control over stand conditions while accelerating progress toward multiple landowner benefits. Implementing crop tree management requires a clear understanding of property goals, establishment of appropriate stand-specific objectives, and development of suitable crop tree selection criteria. Selection of individual crop trees is guided both by the selection criteria and by desired stand conditions. A crown-touching release is applied around crop trees to free them from competition, thereby promoting accelerated growth and progress toward objectives. Crop tree management was developed primarily for small, natural, predominately hardwood stands, but could also be applied to riparian areas, urban woodlots, and other areas. However, not all stands (nor their owners) are good candidates for this labor-intensive strategy.

Appendix A
Systematic Sampling

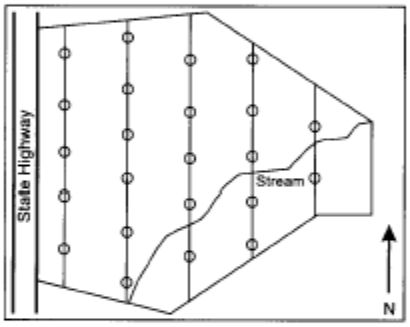
The following illustration demonstrates one way to conduct a plot sample inventory. The following calculations are used to determine the approximate number of plots to sample.

$$\frac{\text{Total area of stand (acres)}}{\text{Size of sample plot (acres)}} \times \left[\begin{array}{l}\text{Percent of total area to be sampled} \\ \text{(expressed as a decimal)}\end{array}\right] = \text{approximate number of sample plots}$$

For example: A 20-acre stand sampled at a rate of 10% using tenth-acre plots would require 20 plots.

$$\frac{20 \text{ acres}}{0.1 \text{ acres}} \times 0.10 = 20 \text{ plots (target number of plots)}$$

On a map of the area to be inventoried, draw parallel lines that reasonably cover the tract. Draw the lines perpendicular to drainage patterns to pick up changes in vegetation caused by changes in soil moisture and elevation. The lines represent the approximate path to be followed in sampling. Locate plots at regular intervals that will produce approximately the target number of sample plots. For example two-chain* intervals between plots along lines five chains apart will result in one plot per acre. In the case of tenth-acre plots this comes out to a 10 percent sample. The accompanying illustration depicts a typical layout.



A 1/10 (0.1) acre plot has a radius of 37.24 feet. Using a tape measure, mark the radius in several directions from plot center, like spokes on a wheel. Mark the outer boundary of the plot by marking boundary trees with flagging or chalk. Record information on crop trees within the boundaries and on competing trees to be removed. Collect data on appropriate tally sheets for the information needed in guiding future decisions. The information gathered frequently includes species, crop tree category, free-to-grow rating (FTG), and competing trees to be removed.

To summarize the data for the stand, total the trees on all plots. Calculate the per-acre totals by

$$\text{Total number} \times \frac{1/a}{N} = \text{number per acre}$$

a = size of sample plot (acres)
N = number of sample plots

For example: 300 crop trees tallied on 20 tenth-acre plots taken in a 20-acre stand would represent 150 crop trees per acre

$$300 \text{ crop trees} \times \frac{1/0.1}{20} = 300 \times \frac{10}{20} = 150 \text{ crop trees per acre}$$

Multiply the per-acre totals by the number of acres in the stand to get a reasonable estimate of the total number of crop trees in the stand.

For example: 150 crop trees per acre × 20 acres = 3,000 crop trees in the stand

*One chain equals 66 feet. Two chains (132 feet) by five chains (330 feet) is one acre (43,560 square feet).

Appendix B

Crop Tree Release Tally Sheet

Landowners: Date:

Stand ID and History:

Acres: Number of sample plots: Plot size (acres):

Landowner Goals:

Stand Objectives:

Species	FTG*	Crop Tree Category				Competing trees to be removed
		Timber	Wildlife	Water quality	Aesthetics	
Total number sampled†: ⊗	Conversion Factor**					
Number per acre	A × 1/a = N = B					
Stand total	B × C = D					

*FTG - Free-to-Grow Rating
- 0 - competition on all four sides
- 1 - free to grow on one side
- 2 - free to grow on two sides
- 3 - free to grow on three sides
- 4 - free to grow on all four sides

**Conversion Factor

$A \times \frac{1/a}{N} = B$

$B \times C = D$

A = total number sampled
a = size of sample plot (acres)
N = number of sample plots
B = number per acre
C = stand size (acres)
D = stand total

⊗†If a tree qualifies in more than one category (for example, timber and water), count the tree only once (the circled X) in the category where it makes the greatest contribution to accomplishing the primary objective.

Additional Resource Materials

The most complete reference on crop tree management is *Crop Tree Management in Eastern Hardwoods,* a 58-page book by Arlyn W. Perkey, Brenda L. Wilkins, and H. Clay Smith, published by the USDA Forest Service Northeastern Area, State & Private Forestry, as NA-TP-19-93, January 1994.

For more information on crop tree management, contact your county Extension center or visit the Internet at http://www.ces.ncsu.edu/nreos/forest/.

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