NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

FOREST STAND IMPROVEMENT

(Acre)

CODE 666

DEFINITION

The manipulation of species composition, stand structure, and stocking by cutting or killing selected trees and understory vegetation.

PURPOSES

- Increase the quantity and quality of forest products, e.g., saw timber, veneer, wood fiber, poles, pilings, maple syrup, naval stores, nuts and fruits.
- Harvest forest products.
- Initiate forest stand regeneration.
- Reduce the potential of damage from wildfire, pests, and moisture stress.
- Restore natural plant communities.
- Achieve a desired understory plant community.
- Improve aesthetic, recreation, and open space values.
- Improve wildlife habitat.
- Improve water conservation and yield.
- Achieve a desired level of crop tree stocking and density.
- Increase carbon storage in selected crop trees.

CONDITIONS WHERE PRACTICE APPLIES

All forest land where improvement of forest resources is needed.

This practice is not reportable if the area is not re-established to a desirable stand of trees. Removing trees to change land use is not Forest Stand Improvement.

CRITERIA

General Criteria Applicable to all Purposes

The harvest-regeneration strategy will be identified for all planned forest improvement harvesting:

- Uneven-aged management systems (single-tree selection, group selection, coppice selection)
- Even-aged management (clear-cut, seedtree, shelterwood, coppice)

Preferred tree and understory species are identified and retained to achieve all planned purposes.

Spacing, density, size class, and numbers of trees and understory species to be retained will follow established guidelines for the intended purposes.

Stocking guidelines shall contain stocking in terms of basal area, spacing, or trees per acre by species and size class distribution.

The method, felling direction and timing of tree cutting for harvesting shall facilitate efficient and safe tree removal and protect sensitive areas such as vernal pools, riparian zones, cultural resources and structures. Harvest within riparian zones will be directed away from the water so that equipment traffic is eliminated or minimized.

Soil erosion, displacement and compaction, rutting, hydrologic impact and damage to remaining vegetation will not exceed acceptable levels as determined by North Carolina Forest Practices Guidelines and NRCS quality criteria.

Slash and debris left on the site after treatment will not present an unacceptable fire, safety, environmental, or pest hazard. Remaining material will not interfere with the intended purpose or other management activities.

The extent or size of treatment area or intensity of the practice shall achieve all planned purposes.

Practice must comply with applicable federal, state, and local laws and regulations during the installation, operation, and maintenance of this practice including North Carolina's Forest Practices Guidelines and Forestry Best Management Practices (BMPs).

Conventional logging skidders and tractors can be used on most sites in the Piedmont and Coastal Plain. Special equipment (e.g., logging mats) will be used if needed on extremely wet sites (e.g., wooded swamp) to prevent soil compaction and rutting. Wetland sites shall not be logged when the soil is saturated. In the mountains, high-lead cable logging systems should be used where slopes exceed 40-45%, where logging road construction could cause landslides, or where stabilization of road cuts and fills is difficult or impractical. Logging roads shall not be constructed across slopes where the soil limitation is severe due to landslide hazard.

Additional Criteria for Increasing the Quantity and Quality of Forest Products – Woody Plant Control

Spacing and Number of Release Trees

The released trees should average no farther than 12 feet apart (304 trees per acre) if they are smaller than 4 inches in diameter. Trees 4 to 8 inches in diameter should be released at intervals of 12 to 15 feet (304 to 194 trees per acre). Where the minimum number of desirable trees is not present and openings are large enough, the area should be interplanted according to specifications set forth in the practice, "Tree/Shrub Establishment," Section IV of the Technical Guide (Code 612). Seedlings should be released during the same year that they are planted.

Methods of Removal or Control

Unwanted hardwood trees, shrubs, vines, or weeds may be removed or controlled by a number of techniques. These include chemical and mechanical treatments, or a combination of two methods. The methods may be classified as:

(a) Individual-stem treatments (with or without silvicides);

(b) Foliar spraying; and

(c) Soil application of silvicides or herbicides.

See Table 1 for methods of woody plant control.

Note: Criteria for use of fire for woody plant control are found in the standard for Prescribed Burning (Code 338).

TABLE 1 - Methods for Woody Plant Control

Hand Crew Methods	Effective Size of Target Stems	Equipment
directed foliar sprays	up to 6 feet tall	backpack sprayer
streamline basal sprays	up to 2 inches DBH	backpack sprayer with handgun
soil spots by grid	up to 10 inches DBH	spotgun or gunjet with straight stream spray tip
basal soil spots	all sizes	spotgun or gunjet with straight stream spray tip
injection	all sizes greater than 1 inch DBH	tubular tree injector, hypo-hatchet, axe or hatchet with spray bottle
stump sprays[1/]	all sizes	backpack sprayer
girdling[2/]	all	axe or mechanical girdler
Ground Machine Methods	**Equipment**	
foliar spray	crawler, skidder, farm tractor, all-terrain vehicle equipped with spray system	
pelleted or granular	crawler, skidder, farm tractor, all-terrain vehicle equipped with spreader with spinning disc or forced-air blower	
Aerial Method	**Equipment**	
foliar spray[3/]	helicopter	
granular or pelleted	helicopter	

1/ Stump spraying is used to reduce sprouting. Except for species such as red maple, ash, and chestnut oak, stumps large than 12" diameter are not likely to sprout.

2/ Girdling without a herbicide is only effective for easy-to-kill species or trees larger than 12" diameter.

3/ Aerial spraying is used for all sizes of major hardwood species. It is an appropriate method for larger tracts where brush is dense and terrain is difficult.

Refer to label for selected herbicide for optimum season for treatment, dosage, and application instructions.

Spray may drift and harm desirable plants downwind of the treated area and is to be avoided. Foliar spraying using aircraft, mist blowers, or ground equipment to apply chemicals is best adapted to large contiguous areas, remote from farms. This method is fast and effective, but there is danger to crops from the drift of the silvicide vapors unless strict precautions are taken. Foliar spraying may also be used to kill kudzu, poison ivy and other undesired noxious vegetation.

Special procedures are required for control of honeysuckle and kudzu. See North Carolina Agricultural Chemicals Manual.

Soil applications are especially effective on sandy soils.

Additional Criteria for Increasing the Quantity and Quality of Forest Products Pre-Commercial Thinning

Pre-commercial thinning is needed in forests where the stand of desirable trees of unmerchantable size is overstocked. Pre-commercial thinnings are applied to young stands, 2 to 4 inches in diameter. Such stands are classed as being in the sapling stage (trees 3 feet or more in height, and under 4 inches in diameter breast high). The practice is particularly needed in young, even-aged stands which have seeded in thickly in old fields, burns, and cut-over areas where diameter growth is negligible and a stagnated condition has resulted.

Species to be Favored

Trees to remain should be selected on the basis of the most desirable species, form, vigor, and crown development. Usually, only dominant and co-dominant trees should be released. Diseased, deformed, short, weak-crowned and otherwise defective trees should be cut. "Take the worst first."

Spacing After Thinning

Spacing of trees selected for leaving should be wide enough to permit fast growth until they are of sufficient size in diameter and height to yield useable or sellable products and the stand is ready for an intermediate cutting (commercial thinning). Some room should be left for crown spread; however, the trees should be left close enough to fully utilize the growing space until the first commercial thinning is made.

1. Southern Yellow Pines and Mixed Pine-Desirable Hardwoods: The number of released trees in stands averaging 2 inches to 4 inches in diameter should range from 304 (4" DBH) (average spacing 12 feet) to 436 (2" DBH) (average spacing 10 feet) per acre. The trees left after thinning should be far enough apart so that 3 to 8 years, depending upon site quality, will be required for their crowns to grow together. However, they should be able to close crown canopy and fully occupy the site in 5 to 10 years.
2. White Pine Types: The number of released trees should range from 304 (4" DBH) to 436 (2" DBH) per acre.
3. Southern Appalachian Hardwood Trees: Generally, thinning is not recommended until trees are over 4 inches DBH, unless most of the trees are growing at about the same rate and show evidence of stagnation. This rarely happens in yellow poplar stands since individuals assert dominance at an early age. However, if pre-commercial thinning is indicated by the condition of the stand, the number of released trees should range from 304 (4" DBH) to 436 (2" DBH) per acre. If thinning sprouts, removal of one of two V-shaped sprouts may kill the other. Therefore, U-shaped sprouts should be selected where only one of two is to be removed.

   When an objective is to regenerate northern red oak and only small oak seedlings are present, a special "oak shelterwood" system that eliminates understory/midstory trees with herbicides, can be applied. Sufficient light is provided to the forest floor for small oak seedlings to develop into large seedlings in about 10 years.
4. Spruce-Fir Type: The number of released trees should range from 436 (4" DBH) (average spacing 10 feet) to 680 (2" DBH) (average spacing 8 feet) per acre. Competing hardwoods should be removed. Red spruce and Fraser fir should be favored.

Methods of Removal

1. Cutting: Cutting is the usual method of removal of the undesirable elements of a stand in precommercial thinning. Competing trees, shrubs and vines may be removed by cutting with the following tools according to the diameter of the stems.

For trees, shrubs and vines 11/2 inches, or less in diameter:

- Rotary mower
- Pruning shears (two-hand types)
- Machetes
- Safety Bush (Swedish Bush) Axes
- Woodman's Pal
- Brush hooks

For trees 1 1/2 inches to 4 1/2 inches in diameter:

- Single and double-bladed axes
- Brush hooks
- Power-driven brush saws

For trees over 5 inches in diameter:

- One-man cross cut saws (46-48 inches)
- Frame or bow saws (26-42 inch blade)
- One-man power chain saw (18-24 inches)
- Portable, circular power saws (30-inch blade) (on level, unbroken ground)

For larger tracts: Drum chopper pulled behind a crawler tractor with a KG (shearing) blade. Leave rows of trees approximately 3 ft. wide in a "checkerboard" pattern. This results in a grid of trees on approximately 12 ft. X 12 ft. spacing.

2. Chemical Control of Hardwoods: When hardwoods are cut in pre-commercial thinning operations, sprouting may be reduced or eliminated by treating the stumps with an approved herbicide. However, where single trees of a sprout clump are left in thinning a hardwood stand, a poison or growth regulator (herbicide) cannot be applied to any part of the stump. To do so will result in killing or seriously damaging the single tree left for future harvest.

Optimum Seasons for Thinning:

1. Pine Types: In pine stands, pre-commercial thinnings should be made during the late fall and winter months - from October through March (unless wet conditions limit equipment operation) - to reduce the possibility of insect infestation, particularly the pine bark beetles.

   Summer thinning (May-August) is preferable where Fomes annosus is the primary threat.

2. Hardwood Trees: Generally, it is best to make pre-commercial thinnings in hardwood types during mid-summer because less sprouting results than when cutting is done in other seasons.

3. Pine - Hardwood Types: In stands where hardwoods are mixed with pines, and are cut in thinning, cutting should be done in the late fall and winter months.

Slash Disposal

Generally, disposal of the boles, limbs and tops of trees cut in pre-commercial thinnings is not a problem. The severed trees may be left in the stand where felled. However, in pine stands where they fall against the bases of trees selected to leave, severed trees should be pulled away where practical to reduce the possibility of fire losses and, in case of mid-summer droughts, to help avoid insect damage.

Additional Criteria for Harvesting Forest Products

Intermediate Cutting (Removal of trees from a stand between the time of its formation and the final harvest cutting)

1. When to Start: Start intermediate cuttings in a stand at the earliest age that the cutting will provide sufficient wood products to make a profitable operation. Site index curves are a useful reference to show growth characteristics and height potentials by age. Regulation and maintaining of proper spacing and stocking is most important for trees to grow quickly to economic and/or biological maturity.

2. Species to Favor: Favor the species best suited to the soil and site and which will yield the greatest return and benefit in the shortest time.

3. Trees to Leave: The selection of trees to leave should be based on management objectives, the form, condition, and vigor of individual trees.

4. Spacing: Intermediate harvests must provide space for growth of the better trees. Standard U. S. Forest Service thinning guides may be used. Recommended spacing guides follow:

   Pine Stands - Use D + X as thinning guide.

   D + X is an expression of linear distance in feet between leave trees. D + X is a way to express $(D + X)^2$, the growing space required by a tree for normal growth for a given number of years. "D" equals the diameter of the leave tree in inches at DBH (4-1/2 feet above ground). "X" is an added constant to give normal growth space for the leave trees. In most cases "X" will be 6 in southern pine. Therefore, the D + X spacing of 10" trees will be 10 + 6 or 16 feet. This means that (D + X) 2 would be 16 x 16, or 256 square

feet, the growing space made available for the crown of a 10" tree to grow for a given number of years.

In practice, the spacing must necessarily be in terms of diameter and linear distance, rather than square feet. To determine the desired square foot spacing, trees should be considered in groups of three or more, arranged in compact geometric figures with the several outside trees spaced approximately D + X feet apart. Mark trees in excess of D + X spacing for cutting. Always select trees of the poorest quality and the least desirable species for cutting.

Table 2 shows the relationship of tree spacing to basal area per acre. Basal area is the cross section of a tree stem at DBH (diameter breast height - 4 1/2' from ground) expressed in square feet. Optimum stocking is usually about equal to the Site Index when trees are 8 to 10 inches in diameter. Example: SI. 90-optimum stocking is 90 square feet per acre.

Table 2 - Tree Spacing to Basal Area Per Acre

DBH	D+2	D+3	D+4	D+5	D+6	D+8	D+10
4"	105	78	59	47	38	26	19
6"	134	105	86	71	59	44	33
8"	152	126	105	90	78	59	47
10"	165	141	121	105	93	73	59
12"	175	152	134	118	105	86	71
14"	182	161	143	129	116	96	81
16"	188	169	152	138	126	105	90

Hardwood Stands - Several factors affect the management of hardwood stands. These factors include (1) variety of species within a stand, (2) varying growth rates of each species, (3) relative vigor, and (4) tolerance of each species to shade.

Northern red oak, can only be successfully regenerated when large advance reproduction is present on the forest floor at the time of final harvest. Then any method of harvest is acceptable except single tree removal. A "shelterwood" thinning, including removal of mid-story and understory species allows for advanced oak reproduction requisite to establishing a stand after final harvest.

Cutting Cycle

The cutting cycle may be defined as the length of time between cuts on the same area or the planned interval between major felling operations in the same stand. This time varies with species, stocking, and site index. For well-stocked healthy stands, Table 3 will serve as a guide for setting cutting cycles.

Table 3 - Cutting Cycle * (Years) by Site Index

Forest Type	Site Index							
	50	60	70	80	90	100	110	120
Southern Pine	9	8	7	6	5	5	5	-
Upland Oaks - Hickory	9	8	7	6	-	-	-	-
Mixed-Cove Hardwoods	-	-	14	12	10	9	8	-
Bottomland Hardwoods	-	-	-	-	7	6	5	4

*The above cutting cycles are based on the length of time required for 2 inches of diameter growth for pine and upland hardwoods and 4 inches of diameter growth for mixed-cove hardwoods and bottomland hardwoods.

Harvest Cutting

Harvest cutting is the final major harvest cutting(s) made in a stand at or near the end of a selected rotation age to insure regeneration of a new stand of trees.

Apply harvest cut after the majority of the trees in the stand have reached harvest tree size. A harvest tree is one which has reached economic and biological maturity. Refer to site index curves. For example, a loblolly pine harvest tree will probably be approximately 16" to 18" DBH and 45 to 55 years of age, depending on site.

1. Types of Harvest Cutting — Even-aged Systems:

   Clearcutting - Removal of the entire stand in one cutting.

   Clearcutting is acceptable where adequate advance reproduction is established or tree planting, sprouting (coppice), or direct seeding is planned to establish a new stand.

   Clearcutting can be accomplished in patches, blocks, or strips. Clearcutting is a regeneration cutting and is applicable to both pine and hardwood stands. It is applied when a stand of timber reaches financial or biological maturity, or when an immature stand is composed predominantly of low quality, undesirable, and/or cull trees of little economic value now or in the foreseeable future. Size of clearcuts should consider economics, aesthetics, and needs of wildlife. At the time of harvest, all hardwood trees larger than 2 inches DBH (or 25 feet tall) should be cut, girdled, or chemically killed. If these trees are left standing, they develop into "wolf" trees of low quality and shade the surrounding reproduction.

   For adequate reproduction of hardwoods, the harvested area should be at least 2 acres in size. Larger areas are preferred to reduce the side shade effect in relation to the size of the clear-cut area, to reduce logging costs, and to create economical management units.

   Seed Tree - Removal of the old stand in one cut except for a small number of trees left singly, in small groups, or narrow strips, as a source of seed for natural regeneration. Number of seed trees per acre by species are listed in the standard for Forest Site Preparation (Code 490). After seedlings are established, seed trees should be removed within 3 years while the young seedlings are still flexible and logging damage will be negligible.

   Shelterwood - Removal of the mature timber in a series of cuttings, which extend over a period of years usually equal to not more than one-quarter and often not more than one-tenth of the time required to grow the crop. The establishment of natural reproduction under the partial shelter of seed trees is enhanced. Harvest the seed trees within 3 years after adequate seedlings are established to prevent excess damage from logging.

2. Types of Harvest Cutting — Uneven-aged Systems:

   Group Selection - Removal of mature timber in groups or strips, to create openings large enough for natural reproduction (seedlings and/or sprouts) to become established and develop normally. Openings created by cutting are usually 1/10 acre or less in size for species tolerant to shade. For species that are moderately tolerant or intolerant to shade, a good opening size is 1.5 to 2 times the height of surrounding trees.

   Openings should not exceed five times the height of surrounding trees (becomes a patch clearcut).

   Single Tree Selection - Removal of large individuals within the stand. Success usually depends on progressively enlarging the openings through subsequent cuttings. Note: This method is rarely used because it only favors shade tolerant species, and may only be successful for a few species such as sugar maple.

Additional Criteria for Improving Aesthetics

Judicious selection of trees should be done to improve both short-term and long-term appearance of an area while having a minimal effect on timber production or regeneration. This should be done during advance planning before harvesting.

Table 4 (on the following page) is a partial listing of species that can be specified for retention for beautification in North Carolina.

Table 4 — Species for Beautification

Species	Flowering	Foliage
Blackgum		X
Dogwood	X	
Holly		X
Live Oak		X
Magnolia	X	X
Red Maple		X
Redbud	X	
Redcedar		X
Sassafras		X
Sourwood	X	X
Sweetgum		X
Wild Plum	X	
Yellow Poplar		X

Additional Criteria for Improving Wildlife Habitat

Where practical, fire shall be used in southern pine stands to reduce understory competition. See standard for Prescribed Burning (Code 338). Where fire is not a practical alternative, mechanical methods listed under precommercial thinning or chemical control will be used.

Where grass-like conditions in the understory are desired, annual burning will be employed. Where a mixture of shrubs and grasses is desired, less frequent fires will be utilized.

During the first thinning, reduce stocking to no more than 300 trees per acre to allow for wildlife openings. Wider spacing (for hardwoods) is permissible where mast or fruit production is desired.

Mowing, other mechanical disturbance, or treatment with chemicals that may have a detrimental effect on nesting wildlife will not be conducted during the nesting season (April 15 - September 15).

CONSIDERATIONS

This practice may have cumulative ecosystem effects.

Actions taken during the development of a forest will affect its composition and economic value for years or decades.

Actions taken under this standard may adversely or favorably impact fish and wildlife species and their habitats.

Restoration of unique or rare forests such as Atlantic white cedar, longleaf pine, bottomland hardwoods, and pocosin forests is a desirable goal.

Silvicultural objectives and havest-regeneration strategies may change over time and may be limited by prior management.

Successful regeneration of desirable species is usually dependent upon timely application of forest stand improvement and other practices, e.g., prescribed burning, site preparation, tree and shrub establishment, prescribed grazing and use exclusion.

The extent, timing, size of treatment area, or the intensity of the practice should be adjusted to minimize cumulative negative effects (onsite and offsite), e.g., hydrologic and stream alteration, habitat fragmentation, nutrient cycling, biodiversity and visual resources.

Potential landowner and operator liability should be assessed before forest stand improvement activities begin.

The practice should be timed to minimize disturbance of seasonal wildlife activities.

Consider wildlife food and cover needs when making modifications to forest composition and tree spacing.

Consider retention of selected dead and dying trees, including down material, to enhance wildlife habitat values.

Pine slash has a high flammability for about two years, but by the end of three or four years, decomposition has advanced to the extent that the needles and most of the small limbs have fallen and the sapwood is completed decayed. By the end of five years, decay has reduced the fire hazard to virtually nothing.

Hardwood slash has a much lower flammability than pine during the first two years after cutting, as the leaves fall quickly. Thereafter, it decays at about the same rate as pine so that by the end of five years the fire risk is negligible.

Landowners should secure a written contract with any service provider that specifically describes the extent of activity, duration of activity, responsibilities of each party and amount and timing of payments for services provided.

Consider environmental concerns such as threatened and endangered species and natural areas.

Wildlife food and cover can be retained by minimal modifications to composition and spacing regardless of the purpose for treatment. Forested wildlife corridors can minimize fragmentation effects.

To choose a method of woody plant control, consider species and size of trees and other vegetation to be killed, presence of desirable tree species, density of unwanted hardwood trees or other plants, size and location of the area to be treated and cost of labor, equipment and materials.

Individual-stem treatments are usually best where desirable trees are intermingled with weed or cull trees and shrubs and need to be released from competition for sunlight, soil moisture and plant nutrients.

The selection of trees to release should be based on the owner's objectives, species adaptation, and the form and vigor of individual trees. Preferred species best adapted to the site are listed on individual soil interpretation records.

Natural regeneration after clearcutting hardwoods comes from both seed and existing reproduction, provided the area has been protected from fire and grazing. Seedlings generate one or more new stems usually from the root collar, especially if the old stem was broken during logging. New seedling sprouts, along with stump sprouts, will provide the oak and hickory component of the stand. Yellow poplar in the new stand comes primarily from seed and stump sprouts.

The group selection method of hardwood cutting keeps a continuous tree cover on the land and has maximum aesthetic value. This cutting favors the more shade tolerant species such as maple, oak, and hickory and retards the growth of intolerant species such as yellow poplar, white ash, and black walnut. It increases the time needed to grow trees to specific sawtimber size. See growth rates for various species of hardwoods shown in Appendix 1. Logging damage to residual trees is usually high. Removal of poorly formed, undesirable, or cull trees having some market value is desirable as a means of improving the residual stand.

Species such as dogwood, redbud, black cherry, wild plum, red maple, mulberry, holly, and black locust, may be retained because of their wildlife, aesthetic and soil-improving values. In addition, pure groups and mixtures of 10 to 15 trees of mast-producing species, such as oaks, hickories, elms, maples, beech, and blackgum, should be retained for their wildlife values, particularly on the more fertile sites. Trees in the latter category should preferably be of sawlog size and in the dominant crown class. Healthy trees in the codominant crown class are acceptable.

Direct sunlight is requisite for maximum production of fruits, nuts, and acorns. Limited numbers of den trees may also be retained, particularly if the landowner is interested in managing the forest for both wood and wildlife resources.

Where a landowner's objectives include wildlife, refer to the standard for Upland Wildlife Habitat Management (645).

Where wildlife habitat management is a goal of the landowner, the following should be considered:

- Creek bottoms and wet areas contain valuable species of wildlife food and shelter plants.
- Most species of wildlife prefer specific plant species or groups of species for habitat and food.
- Harvest tree openings make excellent browse areas until the crowns of desirable trees close. About 20 percent of the area should be in this condition for optimal management for several wildlife species.

Consider effects on the components of the water budget, especially on volumes and rates of runoff and infiltration.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider effects on erosion and the movement of sediment, oxygen demanding materials, and soluble and sediment-attached substances carried by runoff.

Consider effects on the quality of downstream water that could cause undesired effects on aquatic and wildlife communities.

Because silvicides are so effective and economical, their use has largely outmoded cutting or girdling alone, as a means of hardwood control.

PLANS AND SPECIFICATIONS

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, references to enclosed plans from other agencies or other acceptable documentation. The use of approved job sheets is encouraged where available.

Specifications may be developed for the practice as defined or separately for intermediate

harvests and harvest cutting segments of the reportable item.

If the use of pesticides is referenced in materials provided to the landowner, the following statement will be included:

Specific pesticide recommendations will be obtained from personnel who are licensed by the NC Department of Agriculture and Consumer Services in specialty area Forest Pest Control - Category G, in accordance with North Carolina Pesticide Laws and Regulations.

Note: All pesticides must be registered for use in North Carolina and approved for use by the U. S. Environmental Protection Agency (EPA). Refer to the current issue of "North Carolina Agricultural Chemicals Manual" prepared by the College of Agriculture and Life Sciences, North Carolina State University, for guidelines, rules and regulations regarding use of pesticides. Pesticide law requires that applicators follow instructions and safety precautions on the container label when handling, applying, or storing pesticides.

Specifications shall be based on the soils and their suitability for growing a wood crop or other compatible crops. Minimum documentation for this practice includes as appropriate:

- Species to favor
- Spacing
- Length of time (cutting cycle) between intermediate harvests;
- Number of crop trees
- Size of the area to be harvested to regenerate the stand
- Method of regenerating the stand
- Protective measures for seedling development
- Related measures such as releasing established seedlings
- Statement requiring compliance with all federal, state, and local laws

OPERATION AND MAINTENANCE

Operation and maintenance requirements are not applicable for this practice.

REFERENCES

1) Loftis, David L. 1983. Regenerating Southern Appalachian Mixed Hardwood Stands with the Shelterwood Method. Southern Journal of Applied Forestry, Vol. 7 No. 4.

2) Miller, James H. and Robert L. Mitchell. 1994 Ground Applications of Forestry Herbicides. USDA Forest Service Management Bulletin R8-MB21.

3) Mitchell, H. C. 1962. A Guide to Stocking Southern Pine Stands. USDA Soil Conservation Service.

4) Wenger, Karl F. editor. 1984, Forestry Handbook. Society of American Foresters.

5) Smith, David M. 1962. The Practice of Silviculture. John Wiley and Sons, Inc. New York. 7th Ed. 578pp.

Appendix 1 - Actual and Potential Diameter Growth of Selected Upland Hardwood Species

Species	Potential growth rate in managed stand	Age of 16" tree		Age of 22" tree	
		Unmanaged stands	Managed stands	Unmanaged stands	Managed stands
	(rings per inch)	(years)	(years)	(years)	(years)
Yellow-poplar	5	67	40	90	55
Black walnut	5	76	40	104	55
Scarlet oak	6	82	48	108	66
Red oak	6	87	48	113	66
White ash	7	90	56	119	77
Black oak	7	90	56	121	77
Sugar maple	8	104	64	137	88
White oak	8	114	64	146	88
Beech	8	114	64	151	88
Hickory	10	126	80	168	110
Chestnut oak	10	129	80	164	110