



Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD
FOREST STAND IMPROVEMENT

CODE 666

(ac)

DEFINITION

The manipulation of species composition, stand structure, or density by cutting or killing selected trees and understory vegetation to achieve desired forest conditions or obtain ecosystem services.

PURPOSE

This practice is used to accomplish one or more of the following purposes—

- Improve and sustain forest health and productivity
- Initiate forest stand regeneration
- Reduce fire risk and hazard and facilitate prescribed burning
- Reduce damage from pests and moisture stress
- Restore or maintain natural plant communities
- Achieve or maintain a desired native understory plant community for special forest products, grazing, and browsing
- Improve aesthetic and recreation values
- Improve wildlife and pollinator habitat
- Alter quantity, quality, and timing of water yield
- Increase or maintain carbon storage

CONDITIONS WHERE PRACTICE APPLIES

All forest land where the quantity and quality of trees can be enhanced.

CRITERIA

General Criteria Applicable to All Purposes

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

****Uneven-aged management systems (e.g., single-tree selection, group selection, coppice selection)**

****Even-aged management (e.g., clear-cut, seed-tree, shelterwood, coppice)**

****The extent or size and orientation of treatment area(s) shall be identified as part of practice design.**

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

****Spacing, density, size class, number and amounts 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 protect site resources, e.g., residual trees, wetlands, cultural resources, improvements and utilities. Time tree cutting to avoid buildup of insect or disease populations. Felling direction must be compatible with trail layout as specified by Alabama NRCS conservation practice standard (AL NRCS CPS), [Forest Trails and Landings \(Code 355\)](#). Forest stand improvement activities shall be performed to minimize soil erosion, compaction, rutting, and damage to remaining vegetation and maintain hydrologic conditions.

Refer to WINPST criteria in NRCS Conservation Practice Standard (CPS) [Integrated Pest Management \(Code 595\)](#), and Comply with applicable State and local laws if an herbicide will be used.

Refer to the AL NRCS CPS, [Access Road \(Code 560\)](#), standard for roads associated with forest stand improvement activities.

Slash and debris will be treated such that they do not present an unacceptable fire, safety, environmental or pest hazard. Such remaining material will not interfere with the intended purpose or other management activities. Refer to AL NRCS CPS, [Woody Residue Treatment \(Code 384\)](#). Burning of slash and other debris on-site shall follow the AL NRCS CPS, [Prescribed Burning \(Code 338\)](#).

Additional Criteria to Reduce Fire Risk and Hazard and Facilitate Prescribed Burning

Reduce stocking rates of trees to minimize crown-to-crown spread of fire. Remove “ladder” fuels to minimize the occurrence of crown fires.

Further treat or eliminate slash accumulations next to roads and trails.

Reduce or eliminate species with high volatility but not to a level that would compromise other intended purposes.

For additional wildfire risk and damage reduction, refer to the AL NRCS CPS, [Fuel Break \(Code 383\)](#), [Firebreak \(Code 394\)](#), and Alabama Job Sheet, [Forest Stand Improvement to Reduce Wildlife Hazard – AL666B](#).

Additional Criteria to Improve Wildlife and Pollinator Habitat

Manage for specific or a variety of cover types, species, size-classes, and stocking rates at the appropriate scale that meet desired wildlife habitat requirements.

Create, recruit, and maintain sufficient snags, nest, cavity, and den trees, and down woody material to meet requirements of desired species.

Use habitat creation and maintenance criteria in NRCS CPSs: [Early Successional Habitat Development/Management \(Code 647\)](#); [Restoration and Management of Rare and Declining Habitats \(Code 643\)](#); [Upland Wildlife Habitat Management \(Code 645\)](#); or, [Wetland Wildlife Habitat Management \(Code 644\)](#), as appropriate, to manage wildlife-related activities.

Additional Criteria to Increase Carbon Storage

Manage for tree species and stocking rates that have higher rates of growth and potential for carbon sequestration.

Additional Criteria for Thinning

- **Trees to Leave:** The selection of trees to leave in intermediate cuttings should be based on management objectives, adaptability of species to certain soils, the condition of individual trees as related to insects and diseases, and the form and vigor of individual trees. Species to favor on various soils are listed in the Woodland Reference #13-2, entitled “[Considerations for Forest](#)

[Management on Alabama Soils](#)“, in Section I of the Field Office Technical Guide. Merchantable dead trees and trees which are likely to die should be harvested during periodic thinnings.

- **Stocking:** Stand density is a measure of the stocking of a stand of trees. Basal area is the common method used by foresters to measure stand density.

Stands should be thinned to the desired basal area or spacing according to the species and DBH.

DESIRED STOCKING**			
HARDWOOD			
Avg. DBH Main Stand	Spacing		# Trees per ac.
	ft.	BA	
4	7-9	50-80	575-920
6	10-12	60-90	307-460
8	12-16	60-110	172-315
10	14-18	70-120	129-221
12	17-22	70-120	90-153
14	19-25	75-125	71-117
16	21-27	80-135	58-97
PINE			
4	8-10	40-60	460-690
6	10-12	60-80	307-409
8	12-14	80-105	230-301
10	14-17	85-115	156-212
12	17-20	90-120	115-153
14	19-22	95-130	89-122
16	22-25	95-130	69-94
** The smallest number is the “thin to” criteria under basal area (BA) and # of trees per ac. The largest number indicates when the stand needs to be thinned.			

- **Cutting Cycles:** The time between commercial thinnings will vary according to site quality, the degree of thinning based on a diameter increase of 2 in. at breast height for pine and upland hardwoods and a diameter increase of 4 in. at breast height for the other hardwood species.

Site Index	CUTTING CYCLES (years)		
	Pine & Upland Oak	Bottomland Hardwood	Sweetgum & Yellow-Poplar
60	8	—	—
70	7	—	—
80	6	11	12
90	5	10	10
100	5	9	9
110	5	—	8

- **Multiple Use:**

- a. Grazing - Where grazing is a management objective the residual basal area should be approximately 60 sq. feet.
- b. Wildlife - Mast bearing hardwoods should be retained where possible when wildlife is a management objective.
- c. Aesthetics - Flowering trees and shrubs should be favored when aesthetics is a management objective.
- d. Recreation - Intermediate thinnings should be timed in order not to conflict with recreational activities.

Criteria for Harvest Cutting

1. Definition: Harvesting merchantable trees that are either financially or biologically mature.
2. Purpose: To harvest forest products and to ensure that the forest is regenerated for both soil protection and the production of wood products and other multiple uses. To create openings for regeneration, harvest trees should be removed in groups, strips, or blocks. Openings should be at least 100 ft. wide to permit sufficient sunlight. Sawtimber rotations are generally from 35 to 60 years, and pulpwood/chip-n-saw rotations are usually 25 to 30 years. To maintain a sustained yield of forest products, a percentage of the total forest acreage can be harvest cut and regenerated each cutting cycle. This percentage is calculated by dividing the cutting cycle by the number of years in the rotation. To maintain a sustained yield of forest products on large acreages (1000 acres or more), a percentage of the total forest acreage can be clearcut and regenerated each year. This percentage is calculated by dividing the total acreage by the number of years in the rotation.
3. Pine:
 - Seed Tree Cut - Seed trees should be dominant trees of good quality that are at least 9 to 10 inches in diameter. Seed trees should be removed within 3 to 5 years to reduce damage to seedlings.

MINIMUM RECOMMENDED NUMBER OF SEED TREES (Per Acre)					
DBH =	9	10	12	14	16+
Shortleaf	—	20	14	12	12
Loblolly	—	12	9	6	4
Slash	—	12	9	6	4
Longleaf	—	55	38	28	21
Virginia	6	5	4	4	4
** Shelterwood cut of 30 sq. ft. of basal area.					

- Shelterwood Cut - A shelterwood cut involves leaving a large number of seed trees per acre. The trees are thinned to approximately 30 to 60 sq. ft. of basal area depending on species. The residual stand of trees should be removed within 3 to 5 years to reduce damage to seedlings.
- Clearcutting - All merchantable trees are removed. Site preparation is usually needed to enhance regeneration. See Alabama NRCS Conservation Practice Standard, Code 490, Forest Site Preparation. Natural regeneration methods such as seed-in-place, seedlings in place and seeding from the side may be used with clearcuts.
Tree planting and direct seeding are artificial regeneration options. Improved seedlings and improved seed should be used when possible. See Alabama NRCS Conservation Practice Standard, Code 612, Tree/Shrub Planting.
- Individual Tree Selection - The removal of trees individually or in small clumps. This type of harvesting creates an uneven-aged stand of timber. The stand is regulated by periodic volume removal. Regeneration occurs either continuously or periodically.

1. Hardwood:

- a. Clearcutting - Clearcutting is one method of regenerating bottomland hardwoods. All merchantable trees should be harvested, and small trees should be removed either mechanically or by the use of herbicides.
Yellow-poplar is a species which is easily managed by clearcutting if a seed source has been present for 3 to 5 years. Yellow-poplar seeds remain viable in the forest litter for up to 8 years. Normal harvesting operations will expose mineral soil and allow adequate germination of yellow-poplar seeds.
 - b. Shelterwood Cut - The shelterwood system can be used to obtain oak regeneration. The shelterwood system is preferable from a wildlife perspective. Stand density is reduced to 60% stocking to allow seedling establishment. When a stand of 500 or more seedlings per acre is 4.5 ft. or higher, the overstory stand should be removed. It may take as long as 15 to 20 years to obtain the desired reproduction once stand density is reduced.
2. Multiple Uses:
- a. Grazing - Areas to be regenerated should have a tree spacing of 8'x10' or 8'x12' where forest grazing is a management objective.
 - b. Wildlife - Mast bearing hardwoods should be retained where possible when wildlife is a management objective. Openings should be retained or developed as needed. See AL NRCS CPS, Upland Habitat Wildlife Management Code 645.
 - c. Aesthetics - Clearcuts and harvested areas should be irregular in shape where practical and flowering trees and shrubs should be favored after regeneration.
 - d. Recreation - Harvesting should be timed in areas used for recreation in order to avoid conflicts with recreational activities.
1. Release of Established Seedlings: Competing vegetation may be controlled by one or more of the methods listed in **Criteria for Timber Stand Improvement**, C. Methods of Removal or Control. If necessary, seedlings should be released from overtopping trees and shrubs no later than the end of the second growing season.
 2. Protection of Young Trees: Livestock should be excluded from stands of desirable hardwoods and overgrazing should be prevented on areas planted to pine. Control of wildfire is necessary throughout the life of all stands of trees.

Criteria for Timber Stand Improvement

1. Trees to Release: Trees to release are determined by the owner's objectives, by species adaptation and desirability, and by the form and vigor of individual trees. Favor the most vigorous and best formed trees of desired species. See Woodland Reference #13-2 entitled "[Considerations for Forest Management on Alabama Soils](#)" in Section I of the Field Office Technical Guide, for species to favor on various soils.
2. Spacing and Number of Release Trees: For pine trees less than 4 inches in diameter, released trees should average no farther apart than 12 ft. or about 300 trees per acre. Release pine trees 4 to 8 inches in diameter at intervals of 12 to 16 ft. or about 200 to 300 trees per acre. Release hardwood trees 4 to 8 in. in diameter at intervals of 14 to 19 ft. or about 120 to 220 trees per acre. If the minimum number of desired trees is not present, either replant or interplant according to specifications in Alabama NRCS Conservation Practice Standard, [Tree/Shrub Establishment \(Code 612\)](#).
3. Methods of Removal or Control: Either remove or control unwanted hardwood trees, shrubs, vines, and weeds by either chemical treatment, mechanical treatment, or prescribed burning. Factors to consider when choosing a method are: 1) species and size of trees and other vegetation to be killed, 2) presence of desired trees, 3) density of unwanted trees and other plants, 4) site quality, 5) size and location of the area to be treated, and 6) costs of equipment and materials.
 - a. Mechanical treatment - Trees can be girdled with either an axe or a mechanical tree girdler. Trees smaller than 12 inches in diameter may sprout, and such trees should be treated with a

herbicide.

- b. Cut and fell - Larger trees may be removed by the cut and fell method. Trees should be utilized for firewood where feasible. Tree stumps 14 inches in diameter or less should be treated with herbicides to prevent sprouting.
- c. Tree injection - Herbicides are applied to individual stems at the rate of 1 to 2 ml per in. of stem diameter.
- d. Spraying - Both high volume and low volume sprays may be used to kill undesirable woody plants. Low volume sprays are usually applied by aircraft.
- e. Soil treatment - Certain herbicides may be applied to the soil to control undesirable plants. Application rates will vary according to soil types and plant species.
- f. Prescribed burning - Prescribed burning can be used to control undesirable hardwoods usually 2 in. or less in diameter. For specifications, see AL NRCS CPS, [Prescribed Burning \(Code 338\)](#).

Caution: If not properly handled and applied, herbicides can be injurious to people, domestic animals, beneficial insects, desirable plants, and to fish and other wildlife. Use herbicides selectively and carefully. Follow recommendations when disposing of surplus herbicides and herbicide containers.

Criteria for Precommercial Thinning

Precommercial thinning is needed: 1) where stands of desirable trees are of unmerchantable size and are overstocked, thereby preventing satisfactory growth; and 2) where thinning will either increase the growth of remaining trees or enhance the beauty of the stand. Precommercial thinnings are usually applied to seedling and sapling-sized stands (stands with trees less than 5 in. in diameter).

1. Species to Favor: Favor trees according to desirable species, form, vigor, and crown development. See Woodland Reference #13-2, entitled "[Consideration for Forest Management on Alabama Soils](#)", in Section I of the Field Office Technical Guide for species to favor on various soils.
 - a. Selecting Trees to Leave –
 - i. Seedling-Sized Stands - In seedling-sized stands where all trees are about the same size, it is usually best to leave clumps of seedlings 6 to 10 ft. apart.
 - ii. Sapling-Sized Stands - In sapling-sized stands, release the best trees at 10 to 12 ft. intervals.
 - b. Removing Trees - Remove trees by one or more of the following methods:
 - i. Mowing Machine: Where trees are generally less than 2 in. dbh, mow strips 6 to 10 ft. wide and either cross-check or cross-mow strips of the same width. Remaining clumps should be 2 ft. wide.
 - ii. Bush and Bog Harrow, Chopper, or Bulldozer Strips - Disk trees in the seedling to small sapling size with a bush and bog harrow or knock them down with either a bulldozer or chopper. Remove in strips of the same width and cross-check in the same manner as for mowing. To prevent root damage, strips that remain should be 2 ft. wide.
 - iii. Hand Tools - Seedlings and saplings may be thinned with machetes, axes, bush hooks, hoes, or with power equipment such as chain saws. Seedlings up to 20 in. tall should be cut near the ground level. Seedlings and saplings taller than 20 in. may be cut at waist height if they are cut below living branches and stem needles.
 - c. Optimum Seasons for Thinning
 - i. Pine Types - In pine stands, precommercial thinnings should be done from October through March. Thinnings at that time reduce the possibility of insect infestation.
 - ii. Hardwood Types - Precommercial thinnings should be done in hardwood stands during midsummer because there is less sprouting then than during other seasons.
 - iii. Pine-Hardwood Types - Precommercial thinnings should be done in pine-hardwood stands in late fall and winter. Sprouting of hardwoods may be controlled by herbicides.
 - d. Slash Disposal - To reduce the possibility of loss from insects and fire, leave no trees cut in

precommercial thinnings either leaning against remaining trees or touching them. In high fire-risk areas, cut trees should be removed.

CONSIDERATIONS

Considerations for Wildlife and Pollinator Habitat

State Wildlife Habitat Guidelines, Wildlife Habitat Evaluation Procedure, and Forestland Assessment Scorecard are useful tools in planning forest stand Improvement.

Consider removing vines from crop trees but retaining vines with wildlife value (e.g., grape and poison ivy) on noncrop trees.

Increase quantity and quality of important mast (seeds, catkins, fruits, and nuts) sources for wildlife through crop tree management and other techniques.

Improve horizontal diversity or patchiness (of different age class units) across the forest for a variety of wildlife. Improve or maintain vertical structure or vegetative layering in treated stands.

Favor declining wildlife species by providing appropriately sized treatment areas or blocks of habitat.

Time forest stand improvement activities to minimize disturbance of seasonal pollinator and wildlife activities, such as nesting, movement, etc.

Timing of treatment and retaining dead or dying trees will minimize impacts on wildlife.

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

Considerations for Improving and Sustaining Forest Health and Productivity

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

Consider enlisting the assistance of a professional forester when seeking to rehabilitate degraded stands that have been repeatedly subjected to exploitative harvesting (high-grading). Often a complex site-specific treatment plan must be developed to overcome repeated exploitative timber harvest.

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 access control.

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

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

Slash, debris and other vegetation (biomass) removed during stand improvement may be used to produce energy. Management alternatives should consider the amount of energy required to produce and convert the biomass into energy with the amount produced by the biomass. Wildlife and sustainability requirements should also be considered.

Invasive or noxious woody vegetation should be controlled.

Clients should be advised of responsibilities of wildfire control and consider the development of a wildfire control plan including “defensible” space, access routes, fire-season water source, and location of wildfire control facilities.

Timing of treatment and retaining dead or dying trees will minimize impacts on wildlife.

Select appropriate tree removal techniques that would reduce the potential for erosion and sedimentation. Erosion rates and sediment yields may increase as a result of harvesting activities.

Proper selection and application of pesticides should be considered to minimize surface water transport and potential leaching to ground water.

Considerations for Increasing Carbon Storage

To increase carbon storage, consider shifting from even-aged to uneven-aged management to increase the retention of carbon onsite. Use regeneration methods that encourage advanced regeneration and retention of mature trees, such as shelterwood, to retain carbon onsite for longer periods. Consider retaining snags and downed woody debris for additional onsite carbon storage, and adopt techniques for maintaining soil quality, including organic carbon retention.

To grow trees that can store carbon in durable manufactured products, consider lengthening rotations to retain mature trees longer and grow to larger sizes; also consider using crop tree management techniques (Perkey et al. 1994) to concentrate growth on suitable long-lived species.

Considerations for Visual Quality

When forest stand improvement is being used to improve visual quality consider leaving trees that are attractive in shape and structure or flower and are appropriate to the site, especially around structures, roads, and home sites.

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, or other acceptable documentation. Clearly state the goals and objectives of the forest stand improvement. Specific stand-stocking guidelines will clearly document both the pre- and post-treatment stand condition.

OPERATION AND MAINTENANCE

Periodic inspections during and after treatment activities are necessary to ensure that purposes are achieved, and resource damage is minimized, e.g., assessment of insects, disease and other pests, storm damage, and damage by trespass. The results of inspections shall determine the need for additional treatment under this practice.

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