

**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 by manipulating stand density and structure.
- Harvest forest products.
- Initiate forest stand regeneration.
- Reduce wildfire hazard.
- Improve forest health reducing the potential of damage from pests and moisture stress.
- Restore 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 habitat.
- Alter water yield.
- Increase carbon storage in selected trees.

CONDITIONS WHERE THE PRACTICE APPLIES

All forest land where improvement of forest resources is needed.

This standard is not applicable for Alley Cropping (311); Multi-story Cropping (379); Windbreak/Shelterbelt Establishment (380); and Windbreak/Shelterbelt Renovation (650).

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, selection due to sprouting ability)
- Even-aged management (clear-cut, seed-tree, shelterwood, sprouting ability)

The extent or size and orientation of the treatment area shall achieve the intended purpose. These design characteristics will be noted in the plan.

The selection of trees to cut or leave should be based on the management objectives and the adaptability of species to the soil.

Trees should be cut that are diseased, insect infested, suppressed, severely damaged in harvesting operations, or have poor genetic qualities.

Kill unwanted trees, shrubs, and vines by any of the following means:

- Cutting
- Girdling
- Frilling
- Stem injection
- Basal bark spray

Spacing, density, size class, number of trees, and understory species to be retained, will follow established guidelines for the intended purposes. When woodland grazing is important, the trees will be spaced two feet wider than normal.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resource Conservation Service or get it by accessing the electronic Field Office Technical Guide.

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Stocking guidelines shall contain recommendations in terms of basal area, spacing, trees per acre by species, and size class distribution. Generally intermediate cuts will be made when the stand has grown two inches average stem diameter since the last cut.

The method, felling direction, and timing of tree cutting for harvesting shall protect site resources like residual trees, wetlands, cultural resources, improvements and utilities. Felling direction must be compatible with trail layout as specified by the Oklahoma NRCS Forest Trails and Landings (655) standard. Forest stand improvement activities shall be performed in a manner that minimizes soil erosion, compaction, rutting, and damage to remaining vegetation and maintain hydrologic conditions.

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 the Oklahoma NRCS Slash Treatment (384) standard for guidance. The burning of slash and other debris on the site shall follow the recommendations in the Oklahoma NRCS Prescribed Burning (338) standard.

Comply with applicable laws and regulations, including the Oklahoma Forestry Best Management Practices.

Additional Criteria Applicable to Final Harvest Purposes

Stumps will be left less than one foot high.

Trees will be utilized to the smallest top diameter acceptable to the buyer.

Harvesting will be done to remove over-mature trees, trees economically mature, or trees with poor form or condition. The harvest method used will determine the regeneration options available to the landowner to establish a new stand. Refer to the Oklahoma NRCS Tree/Shrub Establishment (612) standard. It is more feasible for the landowner to determine the preferred regeneration method and use an appropriate harvest system to facilitate that method. Provision will be made for replanting or regeneration. Care should be taken not to damage seed trees during the harvesting operation. Grazing will be controlled if necessary to protect the regeneration.

Additional Criteria to Reduce Wildfire Hazard

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 Oklahoma NRCS Fuel Break (383) and Firebreak (394) standards.

Additional Criteria to Improve Aesthetics and Recreation

To enhance the aesthetic and recreational values incorporate the following into the forest stand improvement:

- Creating openings for vistas
- Increase vegetation diversity (shape, texture, color, and size)
- Create visual screens where needed
- Remove safety hazards near pedestrian use areas
- Install trails

Additional Criteria to Improve Wildlife Habitat

Manage for tree species and stocking rates that meet desired wildlife species food and cover requirements.

Maintain sufficient snags and downed woody material to meet requirements of desired species in balance with conditions needed to achieve other intended purposes.

Minimize improvement actions that disturb seasonal wildlife activities.

Refer to the Oklahoma NRCS Upland Wildlife Habitat Management (645) and Wetland Wildlife Habitat Management (644) standards to further develop and manage wildlife-related activities.

Additional Criteria to Increase Carbon Storage in Selected Trees

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

Refer to the following list for recommended species:

American Elm	Cottonwood
Bald cypress	Green Ash
Basswood	Hackberry
Black Cherry	Kentucky Coffee tree
Black Locust	Loblolly Pine
Black Oak	Northern Red Oak
Black Walnut	Red Mulberry
Boxelder	Shortleaf Pine
Catalpa	Sycamore

NON-COMMERCIAL PRACTICE COMPONENTS

Practices are often performed on young stands to manipulate the stocking rate or control undesirable vegetation before the trees reach merchantability. This can be done by precommercial thinning, chemical release, or prescribed burning.

Precommercial Thinning

Precommercial thinning may be needed in dense, natural stands and in plantations where the number of planted trees has been supplemented with natural regeneration from surrounding stands. Precommercial thinning is justified if the stand contains 1,500 or more seedlings per acre.

This type of thinning will be performed when the natural seedlings are well established but before they reach three inches in diameter at breast height. The most effective results are achieved between ages two and five years. Delaying precommercial thinning can sharply reduce growth and increase thinning costs.

Pine trees may be removed mechanically by use of a rotary mower, bulldozer, bobcat with cutter, disk, drum chopper or by use of hand tools such as machete, axe, or brush hook. Equipment used will depend upon the size of the trees, the size of the area to be treated, site conditions, and the economic limitations of the landowner.

Strips of trees 8 to 10 feet wide will be removed from the stand to leave strips of young trees 1 to 3 feet wide as growing stock. These strips may then be cross-thinned in a checkerboard pattern to further reduce the number of trees per acre when the original stocking is extremely high. The residual clumps of trees will be 1 to 3 feet square in area. The clumps can be thinned with hand

tools so that one dominant tree per clump remains. The residual stocking will be 500 to 700 trees per acre for pine and 302 to 436 trees per acre for hardwoods.

Precommercial thinning will be done from mid-October through March when soil moisture conditions permit use of the selected equipment. This timing will reduce the danger of insects and disease.

Cut trees are generally left on the ground. Repeat treatments may be necessary in shortleaf pine stands due to the sprouting potential.

The construction and maintenance of firebreaks is strongly recommended due to high fuel levels and wildfire potential following the thinning. Refer to the Oklahoma NRCS Firebreak (394) standard for guidance.

Timber Stand Improvement (TSI)/Release

An inventory that identifies both the species to be controlled and retained will be needed in order to plan appropriate methods of control.

Chemical Release

Chemical herbicides may be applied to a forest stand to remove undesirable trees. The advantages of using chemical methods of release are that chemicals control vegetation with little soil disturbance; they can be used on steeply sloping land where equipment limitations are severe; they may be applied over large acreage quickly; landowners with small tracts can treat their property themselves; selectivity of the chemicals allows targeting specific types of problem vegetation; and chemical treatments may be used when mechanical methods are impractical or are not cost-effective. Chemical herbicides can be applied by tree injection, foliar spraying, basal application, and soil application. Refer to the Oklahoma NRCS Brush Management (314) standard for guidance.

Precommercial thinning in hardwood stands will be accompanied with herbicide use. Mechanical removal of the unwanted trees alone will cause sprouting instead of death of the trees and will result in a thicker stand after treatment. Guidance for selection of the proper herbicide, rates, and timing of the application will be obtained from recommendations by the local Oklahoma State University Extension Service. Landowners will be advised to follow label directions carefully to

avoid unsafe use of the chemical.

Timing of the chemical application is often critical. There are differences in the susceptibility of the various target species to different herbicides which influence the proper timing of application. Most hardwood species are more susceptible to chemical action in the spring or early summer, but they can be treated at other times.

Herbicide application following cutting, girdling, and frilling will increase mortality and reduce stump sprouting. When choosing herbicides use the safest available. Be aware of leaching, runoff potential, setback requirements, persistence, and toxicity ratings.

Species such as redbud, plum, dogwood and holly should be left in selected areas for aesthetics. A minimum of four (4) wildlife food trees per acre, such as oak, hickory, mulberry, and beech should be left in selected areas for wildlife. Direct sunlight is one of the key requisites for maximum production of fruits, nuts, and acorns. Limited numbers of den trees may also be preserved, particularly if the landowner is interested in managing his woods for dual use of woodland and wildlife resources.

Tree Injection. Use a Tree Injector or Hypo-Hatchet to inject the appropriate dosage of herbicide for the intended species. Calibrate injection device according to herbicide label dosage instructions. Make injections at 2 to 3 inch intervals completely around the tree. Refer to herbicide label for spacing recommendations.

Difficult to control species like hickory and dogwood may need a continuous cut rather than spaced cuts. This method may be used year round except during period of heavy sap flow for species such as maple.

Frill. Frill unwanted individual trees of all species of 3" DBH and larger. Make a single hack girdle or "frill" of overlapping axe cuts through the bark completely around the tree as close to the ground as feasible. Spray or paint the injured surface with herbicide using enough volume to wet treated areas. This method can be used year round, except during period of heavy sap flow for species such as maple.

Basal Spray. Treat only trees less than 6" DBH. Spray the lower 12" to 15" of the tree trunk, wetting to the ground line. If the trees are 1-2 inches in diameter and have smooth bark, a 2 inch wide band will be sprayed halfway around the stem to completely encircle it. Basal spraying will be done in late spring or early summer. Spray until there is runoff noticeable at ground line. This method is useable during any season, except when water or snow prevents spraying to ground line.

Stump. Spray the sides and cut surface of freshly cut stumps with the herbicide within 30 minutes of cutting. The cambium area next to the bark is the most vital area to wet. This method can be done during any season.

Soil Applications. Herbicide treatment to individual stems can also be accomplished through soil application of chemical formulations. Calibrate rate depending on soil texture and herbicide recommendations. Respraying may be necessary. Consult and follow the herbicide label. This method is usually done from March to early May.

The chemicals percolate into the soil during rainfall events and are absorbed by the tree's root system. Surrounding trees may also be damaged by this treatment due to this washing action. The landowner will be informed of this potential damage when soil application of herbicides is planned.

Soil applied herbicides will not be used near streams and other water bodies where there is the potential for runoff of the chemicals into the water during rain storms.

Foliar Spraying. Use appropriate equipment for spraying undesirable hardwood species. Avoid offsite drift. Keep herbicide mixture agitated. Respraying may be necessary. This method is applicable in spring and early summer after foliage has fully developed. Stocking guidelines shall contain stocking in terms of basal area, spacing or trees per acre by species and size class distribution.

The area will have a minimum of 300 well distributed trees per acre of desirable species and quality that need releasing from competition of undesirable trees. Where the minimum number of desirable species is not present, the area should be planted as set forth in the Oklahoma NRCS Tree/Shrub Establishment (612) standard.

Intermediate Thinnings

Cuts which manipulate conditions in a stand during the time period between regeneration establishment and final harvest of the trees are called intermediate thinnings. This type of thinning is generally done to control the spacing, quality, and species composition of the stand to attain the intended purpose of the practice. Intermediate treatments should be an integral part of the management plan to ensure the health and productivity of the forest.

Trees to be targeted for removal during improvement thinnings include:

- Suppressed trees that will not live until the next thinning
- Trees with injuries resulting from fire, ice, insects, lightning, etc.
- Poorly formed trees (forked, crooked, etc.) that have a low value
- Trees which are not well adapted to the site and have a resultant low growth rate
- Mature trees which have begun to decline in vigor
- Tree species which do not supplement the objectives of the landowner.

Residual stocking rates are based on diameter spacing guides or basal area spacing guides. These guides indicate the space required by a tree to maintain growth and vigor between cuttings.

Tree Spacing

Intermediate cuttings should provide the better trees left in the stand with sufficient growing space for a given number of years.

$D + X$ is one way to express the growing space required by a tree for normal growth over a given number of years. "D" represents the DBH (diameter breast height) of a tree and "X" is an added constant to give normal growing space to leave trees. In most cases "X" will be "6" for pine. "X" varies with the average stand diameter for hardwoods.

Ave. DBH	Pine (D+6)	Hardwoods
6"	12'	
8"	14'	16'
10"	16'	19'
12"	18'	22'
14"	20'	25'
16"	22'	28'
18"	24'	31'
20"	26'	34'

Other methods of achieving proper spacing are crown closure and basal area guides.

Cutting Cycle

A cutting cycle is the interval between cuts on the same area. This interval varies with species, site index and stocking. For fully stocked healthy stands, the following table will serve as a guide for the cutting cycle:

Site Index	Pine	Upland Oaks
50	9 yrs	9 yrs
60	8 yrs	8 yrs
70	7 yrs	7 yrs
80	6 yrs	6 yrs
90	5 yrs	
100	5 yrs	

Cutting cycles are based on 2 inches of diameter growth for pine and upland hardwoods and 4 inches of diameter growth between harvest on oak-gum and cottonwood.

Commercial Harvest Cutting

Commercial harvesting in merchantable forest stands is done periodically to increase growth on crop trees. The term "harvest cutting" as used in this practice refers to harvesting merchantable trees in addition to intermediate cuttings. They are trees considered to be financially mature because of condition, site, species, age, or management objectives.

Management to achieve all aged stands (uneven-aged management) is desirable for woodland owners with combined stands of pine and hardwoods. This allows for sustained harvests over time and is beneficial when managing for wildlife.

Forest stand improvement choices will be based on relative tree position in the stand, crown position, crown condition, tree health, stem quality, and species.

Crop trees can be selected in groups to create openings from 100 feet to 200 feet in diameter to benefit wildlife (except as noted below.) When natural reproduction is absent, at least 8 well distributed seed trees per acre should be left for stand regeneration.

Even-aged pine plantations will be clearcut upon maturity and replanted to the desired species adapted for the soil. The harvest is generally followed by site preparation practices. Refer to the Oklahoma NRCS Tree/Shrub Site Preparation (490) standard. The type of clearcut harvest made is determined by site conditions and the landowner's economic situation. Choices available include clearcutting an entire stand at a time or clearcutting a stand in strips or blocks in several cuts.

Clearcutting the entire stand at once may be done when sufficient seed or seedlings are in place to regenerate the stand or when tree planting is planned.

Strip, block, or patch cutting is used when seed from adjacent stands will be utilized to restock the area or on steep slopes where soil erosion is a concern.

Adjacent seed sources may be utilized when strips or blocks are cut perpendicular to prevailing winds so that the harvested areas are regenerated from blown seed. The cut areas should not be wider than 3 to 4 times the height of the trees to be used as a seed source. The area should be site prepared prior to seed fall. This method may be used for pine and light-seeded hardwoods.

Successful clearcutting and regeneration in hardwood stands may be attained through seedlings in place plus naturally occurring root and stump sprouts. The seedlings in place (advance regeneration) must be at least 4-1/2 feet tall and 1 inch in root collar diameter prior to the cut.

A clearcut site is aesthetically less pleasing for a short period following the harvest. The initial negative impact will be lessened by planning the size, shape, and location of the clearcut to blend more naturally with the landscape.

A patchwork of clearcuts resulting from harvests conducted at different times will provide a more diverse habitat for wildlife than one single large clearcut. Landowners with a wildlife management objective in addition to

their timber management goals may wish to consider this alternative.

Seed Tree Cuts. Seed tree cuts are the most frequently used method of natural regeneration for southern pines. This method consists of leaving enough seed-producing trees scattered over the area to ensure adequate stocking. The seed trees are later removed to eliminate shading effects when the seedlings are 2 to 3 years old.

The area should be prescribed burned prior to the seed tree cut to prepare a seedbed and control competing vegetation. Refer to the Oklahoma NRCS Prescribed Burning (338) standard. The regeneration cut will be timed so that seeds will be dispersed on a site freshly scarified by logging.

The minimum number of recommended seed trees per acre necessary for satisfactory regeneration of pines is as follows:

DBH (In)	Loblolly Pine	Shortleaf Pine
10	12	20
12	10	14
14	8	12
16+	4	12

Residual basal area will be 15 square feet per acre or less. Seed trees will be dominant trees of good form and quality with seed-producing capabilities. They will be well-distributed over the area to be regenerated.

The seed trees will be susceptible to lightning strikes and wind throw when the cut is complete. They should not be left in place longer than 2 to 3 years.

Areas lacking suitable seed trees and stands not naturally regenerated within two years should be planted to the most suitable species. Newly established seedlings, natural or planted, should be released from undesirable competition within two years after establishment, preferably the first year following establishment.

Wild fire prevention is necessary at all times for all forest types.

Shelterwood Cuts. Shelterwood cuts are similar to seed tree cuts, but more trees are left to regenerate the stand and to serve as a canopy shelter for the germinating seedlings. This method is well suited for naturally

regenerated southern pines. Leaving more trees after the harvest helps suppress the development of competing vegetation, and it also reduces the risks associated with poor seed crops during regeneration efforts. Removing the residual trees does cause damage to the seedlings, however.

Approximately 20 to 30 square feet of basal area per acre will remain when the initial cut is complete. This basal area equates to 37 to 55 10" DBH trees, 25 to 38 12" DBH trees, 19 to 28 14" DBH trees, or 14 to 17 16" DBH trees left per acre. The residual trees will be removed when the seedlings are 2 to 3 years old.

Selection Harvests. Selection harvesting involves periodic cutting of selected trees from all merchantable diameter classes. This method maintains an uneven-aged stand. The timing of the first cutting will depend upon merchantability of the products, site productivity, and size of the trees. First thinnings should be made just prior to overcrowding and reduction of diameter growth, and before the live crown ration is reduced to below 35 percent of total height. This will generally be between 13 and 15 years of age on productive pine sites and 17 to 25 years on hardwood sites.

Harvested volumes in fully stocked stands should generally approximate growth for the cutting cycle. In stands that are not fully stocked, only a portion of the growth is cut. The cutting cycle will approximate that discussed for intermediate treatments.

Slow-growing, poor quality, or undesirable trees will be cut, and the best trees will be left to improve quality and growth.

Harvest tree selection will be done either by targeting single individual trees or by removing a group of trees to create openings or gaps in the forest canopy. The openings provide freedom from competition for the natural establishment of shade-intolerant tree species. In this manner, a diversity of age and size class is maintained.

A group selection cut provides better regeneration opportunities for both pines and oaks than single tree selection because larger openings are created for these shade intolerant species.

Timber stands with a basal area of over 110 square feet per acre are considered overstocked and need to be thinned with a harvest cut. The desired basal area per acre is between 70 and 110 square feet.

Table 1: Basal area residual spacing guide for mixed hardwoods:

DBH (Inches)	Average Spacing D+8	# Trees per acre	Basal Area per acre
8	16	170	59
10	18	135	73
12	20	109	86
14	22	90	96
16	24	76	105
18	26	65	115
20	28	55	120

Salvage/Sanitation Cuts. Salvage cutting is the removal of trees damaged by insects, disease, ice, tornadoes, fire, and other disasters to obtain economic gain before tree value is lost. Sanitation cutting is the removal of trees attacked by insect or disease. The cutting is done to stop the infestations and is usually not expected to bring high economic benefits to the owner due to the emergency considerations of the operation.

These cuts usually remove trees in the oldest and largest size category. This removal is important in maintaining the health and productivity of the stand. Dead and dying trees may be left in the stand for wildlife nesting/roosting habitat when their retention does not endanger the health of the remaining trees.

CONSIDERATIONS

Silvicultural objectives and harvest-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 like 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 effects (onsite and offsite) like hydrologic changes including stream alteration, habitat fragmentation,

nutrient cycling, biodiversity, and visual resources.

Slash 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.

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.

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.

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.

PLANS AND SPECIFICATIONS

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, technical notes and narrative statements in the

conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

Follow-up and ongoing management activities will be needed to obtain desired results. Periodic assessments will need to be made to check for insect damage, disease problems, storm damage, or damage from trespass.

REFERENCES

NRCS Field Office Technical Guide, Section II - "Forestland Interpretations".

NRCS National Forestry Manual.

NRCS National Forestry Handbook.

OSU Extension Facts No. 5028, "Even and Uneven Aged Forest Management".

OSU Extension Facts No. 5030, "Tree Improvement in Oklahoma Woodlands".

OSU Extension Facts No. 5034, "Riparian Forest Buffers".

OSU Extension Facts No. 5035, "Selling Your Timber".

OSU Extension Facts No. 5036, "Deciduous Trees for Oklahoma".

Miller, James H. 1990. Directed Foliar Sprays of Forestry Herbicides for Loblolly Pine Release. Southern Journal of Applied Forestry 14:199-206.

Adams, Paul W., Soil Compaction on Woodland Properties, Oregon State University Extension Circular 1109 Dated 09/1997.

U.S.D.A. Forest Service, Region 3 FSH2509.22 – Soil and Water Conservation Practices Handbook, Dated 12/03/1990.