

**NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

FOREST STAND IMPROVEMENT

(Ac.)

CODE 666

DEFINITION

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

Removing trees to change from forest land to another land use is not Forest Stand Improvement.

This practice is not applicable to Alley Cropping-311, Multi-story Cropping-379 or Windbreak/Shelterbelt Establishment (operation and maintenance)-380.

PURPOSE

This practice is used to achieve one or more of the following purpose(s):

- Increase the quantity and quality of forest products by manipulating stand density and structure.
- Timely harvest of forest products.
- Development of renewable energy systems.
- 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.

CRITERIA

Use the following criteria in planning and applying this practice. The general criteria apply to all forest stand improvement. Additional criteria apply based on the intended purpose(s) of the practice.

General Criteria Applicable to All Purposes

Always consider or identify a harvest-regeneration strategy when doing improvement activities (refer to 'Criteria to Initiate Forest Stand Regeneration' for more information).

The extent, size and orientation of treatment area(s) shall be identified.

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 be 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 site resources (including residual trees, wetlands, riparian zones, cultural resources, utilities, improvements, and structures). Felling direction

CONDITIONS WHERE PRACTICE APPLIES

This practice applies on all forest land

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard, contact your Natural Resources Conservation Service [State Office](#) or visit the [Field Office Technical Guide](#).

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must be compatible with trail layout specified by FOREST TRAILS AND LANDINGS – NC Practice Standard 655.

Tree improvement should be timed to avoid insect buildup and/or disease outbreak.

Forest stand improvement activities shall be performed to maintain hydrologic conditions and minimize soil erosion, compaction, rutting, and damage to remaining vegetation.

Slash and debris will 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 WOODY RESIDUE TREATMENT – NC Practice Standard 384. For burning of slash and other debris on-site refer to PRESCRIBED BURNING – NC Practice Standard 338.

Comply with applicable federal, state and local laws and regulations during the installation, operation and maintenance of this practice.

Note: Specific pesticide recommendations will be obtained from personnel who are licensed by the NC Department of Agriculture and Consumer Services in specialty area Agricultural Pest Plant Category O (agricultural, plant) or G (forest) - in accordance with North Carolina Pesticide Laws and Regulations. All pesticides must be registered for use by 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" for guidelines, rules and regulations regarding use of pesticides. Users must **always** follow instructions and safety precautions on the container label when handling, applying, or storing pesticides.

Additional Criteria to Increase the Quantity and Quality of Forest Products by Manipulating Stand Density and Structure

Increasing the merchantable volume and quality of a stand of trees requires management of tree spacing (stocking) and release from competition. The greatest gains occur when improvements are applied to young stands of trees. Where a stand is overstocked, or crowded by competing vegetation, tree spacing after treatment should be wide enough to grow the intended

intermediate and/or final forest product(s). Where production of fiber and timber products is the goal, tree spacing after improvement should permit fast growth (see table below for recommended stocking of young stands) until trees can reach sufficient merchantable size for an intermediate, commercial thinning (see 'Additional Criteria for Timely Harvest of Forest Products').

Recommended Tree Stocking (trees/acre)–young stands			
Species	DBH		
	Seedlings	2"	4"
² SYP and Mixed SYP Hardwood	³ 300	436	304
White Pine	³ 300	436	304
Hardwoods	³ 300	⁴ --	304
Spruce-Fir	³ 435	680	304

¹ Diameter at breast height (4½ ft. above ground) in inches
² Southern Yellow Pine/Desirable Hardwoods
³ A forester may determine that a lower number may be appropriate for a particular site. Where minimum number of seedlings are not present, interplant according to TREE/SHRUB ESTABLISHMENT (612)
⁴ Thinning not recommended until 4" DBH

For releasing established trees from woody competition - Unwanted woody competition (generally hardwood trees, shrubs, vines and weeds) can be controlled using fire, chemicals and/or mechanical treatment. See PRESCRIBED BURNING – NC Practice Standard 338 for criteria for using fire for woody plant control. Chemical and mechanical methods are outlined in the table 'Methods of Woody Plant Control' below.

Methods of Woody Plant Control

Control Method	Size of Target Woody Stems	Equipment
<i>Mechanical</i>		
M mowing	up to 1 inch	Tractor and brush cutter
H Girdling ¹	All	Axe, girdler
<i>Chemical</i> – see herbicide label for specific instructions		
H directed foliar spray	Up to 6 feet tall	Backpack sprayer
H Streamline basal spray	Up to 10" DBH	Backpack sprayer with handgun
H Soil spot grid ²	Up to 10" DBH	Spotgun or gunjet w/ straight stream
H Basal soil spot spray	All	Spotgun or gunjet w/ straight stream
H Injection	Greater than 1" DBH	Tree injector, axe & spray bottle
H Stump sprays ³	All	Backpack sprayer
M Foliar spray ⁴	All	Ground sprayer, helicopter

M	Granules or pellets	All	Ground equipment, helicopter
H - Hand crew method		M - Machine method	
¹ Girdling without herbicide is only effective for easy to kill species or trees < 12" DBH ² Soil applications are especially effective in sandy soils ³ Stump spraying is used to reduce sprouting. Generally stumps > 12" diameter are not likely to sprout, exceptions include red maple, ash, chestnut and oak. ⁴ Aerial spraying is appropriate for larger tracts where brush is dense and terrain is difficult			

Chemical spray can drift and harm desirable plants outside the treated area. **THIS MUST BE AVOIDED!** Foliar herbicide spraying using aircraft, mist blowers, or ground equipment should be used on large, remote, contiguous areas that are not close to farmland. Special procedures are required to control honeysuckle and kudzu. Consult a professional for recommendations. Refer to BRUSH MANAGEMENT – NC Practice Standard 314 for controlling woody invasive species.

For pre-commercial thinning of overstocked stands – Pre-commercial thinning is used to thin overstocked stands of desirable, un-merchantable trees (sapling to 4-5 inch DBH). This situation often occurs on thickly seeded old fields, burns, and cut-overs; it can even occur where natural seeding invades planted areas. Pre-commercial thinning should release dominant and co-dominant desirable trees (species, form, vigor and crown development); and remove diseased, deformed, short, weak-crown or otherwise defective trees. Pre-commercial thinning methods are outlined below.

Methods of Pre-commercial Thinning

Method	Diameter of Target Stems	Equipment
<u>Mechanical</u>		
M	Mowing ¹	up to 1½ inch Tractor and rotary brush cutter
H	Cutting	up to 1½ inch Pruning shears, machetes, axes, brush hooks, power circular brush saws
H	Cutting	1½ to 4½ inch Various axes, brush hooks, power circular brush saws
H	Cutting	> 4½ inch Chain saws, large power circular brush saws, hand cross cut or bow saws

M	Chopping ²	< 4½ inch	Rolling drum chopper pulled by a crawler tractor
<u>Chemical</u> – see herbicide label for specific instructions			
H	When hardwoods are cut during pre-commercial thinning, sprouting can be reduced by treating the cut stump with an approved herbicide. Apply with a backpack sprayer or spray bottle to all size hardwood stumps. <i>Exercise care where natural regeneration of hardwoods from coppice is planned to restock a site.</i>		
H - Hand crew method		M - Machine method	
¹ Suitable for open land planted to trees where debris and stumps will not impede mowing equipment. ² For larger tracts. Leave rows ~3 ft. wide in a checkerboard pattern, resulting in a grid of trees spaced ~12ft. X 12ft.			

Optimal timing for pre-commercial thinning:

- PINE: Thin during late fall and winter (Oct – March) to help reduce potential insect problems. Where root rot (*Fomes annosus*) is a threat, thin during the summer (May-August).
- HARDWOOD: Thin during the mid-summer to reduce sprouting.
- PINE/HARDWOOD: Thin during late fall and winter.

Disposal of the boles, limbs and tops of trees cut in pre-commercial thinning is generally not a problem. Severed trees may be left in the stand where felled. In pine stands where trees 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 to help avoid insect damage.

Additional Criteria for Timely Harvest of Forest Products

(See 'Additional Criteria to Initiate Forest Stand Regeneration' for final harvest of forest products)

Merchantable trees can be removed at intermediate times from a stand to create space for remaining trees to grow before final harvest. In monoculture plantations, intermediate tree harvest operations should regulate/maintain spacing and stocking that allows trees to reach economic and/or biological maturity sooner. In mixed stands (hardwood and hardwood/pine) intermediate cuttings should select for quality and composition of desired harvest trees.

Commercial intermediate cuttings can begin at the earliest age that will provide sufficient wood products to make a profitable thinning operation. Based on management objectives, select and

leave desirable trees (form, condition, vigor) that are best suited to the site, and will yield the greatest return/benefit in the shortest time; poorer quality trees should be removed. There are a number of tables/guides that can be used for planning intermediate tree thinning. Simple spacing guidelines for intermediate cuts are outlined below. US Forest Service and NC Division of Forest Resources (*Foresters Field Handbook*) thinning guides *may* also be used to determine optimal spacing.

Spacing Guidelines for Intermediate Cuts

Pine			
Optimal stocking is generally when basal area ¹ is equal to the site index for trees 8-10 inches DBH (for a site index of 90, the optimal stocking is 90 ft ² basal area). In lieu of basal area determination, the D+6 method can be used in the field. D+6 is an expression of linear distance between leave trees and can be related back to basal area. D = DBH (diameter of leave tree at breast height - 4 ½ ft. above ground). For 10" DBH leave trees, the average distance between trees should be D+6 or 10+6=16 feet.			
Size (DBH)	Avg. Distance between leave trees (D+6)	Leave trees/Acre	
6	12	300	
8	14	222	
10	16	170	
12	18	134	
14	20	109	
16	22	90	
¹ Basal area is the cross section of a tree stem at DBH expressed in square feet (ft ²).			
Hardwood			
For a stand with adequate trees of favorable species, age and potential quality, the following table can be used to determine optimal stocking of 'leave' trees.			
Size (DBH)	Trees/Acre	Size (DBH)	Trees/Acre
6	200-340	14	50-90
8	140-240	16	40-100
10	90-150	18	35-60
12	70-115	20	30-50

A number of intermediate improvement cuttings may be needed depending on species, stocking, and site productivity. For well-stocked healthy stands, the table below is a guide for planning intermediate improvement cuts.

Cutting Cycle in Years by Site Index

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

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Bottomland Hardwoods	-	-	-	-	7	6	4
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Additional Criteria to Develop Renewable Energy Systems

Bioenergy intensity and frequency of energy biomass removals will be managed to prevent long-term negative impacts on the stand.

The harvesting of energy biomass shall be accomplished in a manner that will not compromise other intended purpose(s) and functions. If applicable refer to State woody biomass Best Management Practices (BMPs).

Additional Criteria to Initiate Forest Stand Regeneration

A regeneration strategy will be identified that is specific for a site prior to a harvest cutting. This strategy can include natural regeneration or planting (refer to TREE/SHRUB ESTABLISHMENT – NC Practice Standard 612).

For Even-aged management systems – Acceptable harvest methods for regeneration of even-aged stands include:

Clear cut – Clear cutting is the removal of an entire stand in one cutting. It is acceptable where advance reproduction is adequate; or, where tree planting, sprouting (coppice) or direct seeding is planned to restock the site. Clear cutting is applicable to both pine and hardwood stands; and, can be done in patches, blocks or strips. Clear cuts are applicable to biologically or economically mature stands; or, to immature stands of low quality, undesirable, or cull trees with little potential value. Generally, all tree cover is removed or knocked down during a clear cut. Size of clear cuts should consider economics, aesthetics and wildlife needs.

Seed Tree – A seed tree harvest removes all of a stand in one cutting except for a small number of trees left singly, in small groups or in strips as a seed source for natural regeneration. Seed trees left should be the genetically dominant, high quality stock on the site. See the table below for recommended minimum seed trees per acre. Successful natural regeneration from seed requires seed contact with bare soil (see FOREST SITE PREPARATION – NC Practice Standard 490). After seedlings are established, seed trees should be removed within 3 years,

while young seedlings are flexible and least susceptible to logging damage.

Minimum Pine Seed Trees/Acre

DBH	Tree Type			
	Shortleaf	Loblolly	Longleaf	White
10	20	12	55	12
12	14	9	38	9
14	12	6	28	6
16+	12	4	21	4

¹Diameter at breast height in inches

Shelterwood – A shelterwood harvest involves removal of mature trees over a period of years usually 1/4 to 1/10 of the time required to grow a tree crop. Over time natural reproduction under the existing 'shelter' of seed trees will occur. Harvest the seed trees within 3 years after adequate seedlings are established.

When regenerating 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.

For Uneven-aged management systems – Regeneration of uneven-aged stands is usually accomplished by natural regeneration; heavy seeded hardwoods are usually regenerated by coppice. Acceptable harvest methods for regeneration of uneven-aged stands include: **Single Tree Selection** – Large mature trees within the stand are removed. Success usually depends on progressively enlarging openings during subsequent cuttings. NOTE: This method is rarely used because it favors regeneration of only shade tolerant species such as sugar maple.

Group Selection – Mature trees are removed in groups or strips, to create openings large enough for natural reproduction (seedlings and/or sprouts) to occur. Openings are usually 1/10 acre or less for shade tolerant tree species; otherwise openings should be 1.5 to 2 times the height of surrounding trees. NOTE: Openings should not exceed five times the height of surrounding trees (this approaches a patch clearcut).

Additional Criteria to Reduce Wildfire Hazard

A well managed, actively growing stand of trees is the best defense against potential wildfire hazards. Refer to improvements under 'Criteria to Increase the Quantity and Quality of Forest Products' for improvement schemes that keep tree stand healthy and actively growing.

Additionally:

- Reduce stocking rates of trees to minimize crown-to-crown spread of fire
- Remove under-story and mid-story 'ladder' fuels to minimize the occurrence of crown fires
- Treat or eliminate slash accumulations next to roads and trails
- Reduce or eliminate species that are highly volatile while not compromising other intended forest management purposes.

Use WOODY RESIDUE TREATMENT – NC Practice Standard 385, FUEL BREAK – NC Practice Standard 383, FIREBREAK – NC Practice Standard 394 and PRESCRIBED BURNING – NC Practice Standard 338 to reduce fuel loading and vulnerability to wildfire.

Additional Criteria to Improve Forest Health – Reducing the Potential of Damage from Pests and Moisture Stress

A well managed, actively growing stand of trees is the best defense against pest and/or moisture stress. Refer to 'Criteria to Increase the Quantity and Quality of Forest Products' and 'Timely Harvest of Forest Products' for improvement schemes that keep tree stands healthy and actively growing.

Inspect trees periodically for insect and moisture stress problems. Remove or treat 'hot spots' of insect infestation or dead/diseased trees.

Additional Criteria to Restore Natural Plant Communities

Select trees to leave that are indigenous or native to the site and will reflect species composition of the desired stand. Consult a professional biologist or forester for trees to select during forest stand improvement activities.

Make final harvest decisions in established stands that facilitate planting and restoration of a desired natural tree community.

Additional Criteria to Achieve and Maintain a Desired Native Understory Plant Community for Special Forest Products, Grazing or Browsing

The understory community within a stand is largely controlled by manipulating tree spacing or density to vary the amount of sunlight that reaches the forest floor. Additional understory manipulations can be made with fire, and mechanical or chemical treatment.

Planned spacing and required understory manipulation will be determined based on intended use, and the expected native understory plant community for the site.

Additional Criteria to Improve Aesthetic and Recreation Values

Cut selected trees to improve short-term and long-term appearance of the stand and surrounding area. Select and keep trees with features such as showy flowers, brilliant fall foliage, persistent colorful fruits or noteworthy growth forms and shapes (see table below for a partial listing of North Carolina trees). Improvement harvest to improve aesthetics should have minimal affect on timber production or regeneration.

NC Species with Aesthetic Features (partial list)

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 to Improve Wildlife Habitat

Manage for a variety of native tree species and stocking rates that meet desired wildlife and pollinator species food and cover requirements.

Create, recruit and maintain sufficient snags and downed woody material for desired wildlife species; and, secondary cavity nesting species in balance with conditions needed to achieve other intended purposes.

Be aware of wildlife needs during tree improvement operations. Minimize improvement actions that disturb seasonal wildlife activities, especially during the nesting season.

Refer to EARLY SUCCESSIONAL HABITAT DEVELOPMENT/MANAGEMENT – NC Practice Standard 647, RESTORATION OF RARE AND DECLINING HABITATS – NC Practice Standard 643, UPLAND WILDLIFE HABITAT MANAGEMENT – NC Practice Standard 645 and WETLAND WILDLIFE HABITAT MANAGEMENT – NC Practice Standard 644 where wildlife management is a primary forest management goal.

Select to keep important wildlife trees (cavity or mast producers) and areas (bottomland, wet areas, etc.) during improvement harvests. Species such as dogwood, redbud, black cherry, wild plum, mulberry, holly, and black locust, may be retained because of their wildlife value. Additionally, pure groups and mixtures of mast-producing species, such as oaks, hickories, beech, and blackgum should be retained for their wildlife value, particularly on the more fertile sites. Trees in the latter category should preferably be and in the dominant crown class. Healthy trees in the codominant crown class are acceptable. Direct sunlight is requisite for good mast and fruit production.

Manipulating the understory for wildlife - Where practical, use fire in southern yellow pine stands to reduce understory competition and enhance the stand for wildlife. See PRESCRIBED BURNING – NC Practice Standard 338. Where fire is not practical, mechanical or chemical manipulation is the only alternative. Where grass-like understory conditions are desired for wildlife, annual burns are required. Where a mixture of shrubs and grasses is desired, less frequent (every 3-5 years) burns should be utilized.

Manipulating stand spacing or stocking for wildlife – In pine stands, reduce stocking to no more than 300 trees per acre at the first thinning to enhance early successional understory vegetation for wildlife (use fire along with thinning for best results). In older stands thin to a basal area that is 70-80% of Site Index(50) or less depending on tree species and site productivity. For hardwoods, wider spacing (less than 300 trees per acre) is recommended

around mast or fruit producing trees (to improve mast/fruit production for wildlife).

Creating openings for wildlife – Harvest tree openings and strips make excellent early successional browse areas until the crowns of desirable trees close. Minimum opening dimensions should be 1.5 to 2 times the height of surrounding trees. About 20 percent of the area should be in this condition for optimal management for several wildlife species. Areas adjacent to existing roads/trails, log decks, insect damage and under stocked areas are good candidates for wildlife openings.

Additional Criteria to Increase Carbon Storage in Selected Trees

For optimal carbon sequestration, improvement operations should select dominant or co-dominant trees that have higher rates of sequestration in biomass and soils; and, are best adapted to the site to assure strong health and vigor. Consult a professional, or research literature for plants that sequester carbon more efficiently.

Carbon sequestration benefits increase when trees are managed for durable products over a longer rotation. Calculate predicted carbon sequestration rates using current, approved carbon sequestration modeling technology.

CONSIDERATIONS

Silvicultural objectives and harvest-regeneration strategies may change over time and may be limited by prior management. Actions taken during the development of a forest affect its composition and economic value for years or decades to come.

Active management of woodland is required to maintain use-value property taxation in North Carolina.

Thinning creates a window of opportunity for increasing biodiversity within a stand of trees.

Plant community restoration requires extensive planning and management to approximate native conditions. Have realistic expectations, and be prepared to apply management/improvement activities over an extended period of time.

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.

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

For purposes other than improving wildlife, consider wildlife food and cover needs when making modifications to forest composition and tree spacing. Time improvement practice(s) to minimize disturbance of seasonal pollinator and wildlife activities. Selected dead and dying trees, including down material, can be left to enhance wildlife habitat values.

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

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.

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.

Pine slash is highly flammable for about two years. By the end of five years, decay has reduced the fire hazard to virtually nothing. Hardwood slash has much lower flammability than pine during the first two years after cutting. Thereafter, it decays at about the same rate as

pine so that by the end of five years the fire risk is negligible.

Forest herbicides are effective and economical; their use has largely outmoded cutting or girdling alone, as a means of hardwood control.

Invasive or noxious woody vegetation should be controlled. Consider other environmental concerns such as threatened and endangered species, natural areas and wetlands in planning improvement activities.

Clients should be advised to responsibilities of wildfire control and consider the development of a wildfire control plan that includes 'defensible' space, access routes, fire-season water sources, and location of wildfire control facilities.

This practice has the potential to affect National Register listed, or eligible, significant cultural resources (CULTURAL RESOURCES INFORMATION - NC, FOTG Section II). Follow NRCS state policy for considering cultural resources during planning.

PLANS AND SPECIFICATIONS

Specifications for applying this practice and protection of the site shall be prepared and recorded using approved specification sheets, job sheets, technical notes, narrative statements in the conservation plan (including references to plans prepared by other agencies or consultants), or other acceptable documentation.

Minimum documentation will include where applicable:

- map showing fields and extent of areas where tree improvement will be done
- species to favor or manage
- planned spacing after improvement
- length of time (cutting cycle) between intermediate harvests
- method of regenerating the stand; specific guides where natural regeneration is used
- method for releasing established seedlings or pre-commercial thinning
- tree improvement or forest management plan prepared by a registered forester when available.

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- statement requiring compliance with all federal, state, and local laws
- review of complexity and controlling factors involved to assign proper plan/design and construction job approval authority
- required operation and maintenance instructions

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance). Generally O & M operations for this practice involve operation activity only; no maintenance is required.

- Periodically inspect during and after improvement/treatment activities to insure that objectives are achieved and resource damage is minimized. Especially look for insect/disease and other pests, storm damage, and damage by trespass. The result of inspections shall determine the need for additional treatments under this practice.

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