

NATURAL RESOURCES CONSERVATION SERVICE
FOREST STAND IMPROVEMENT DESIGN PROCEDURES

(666DP)

INTRODUCTION

Forest stand improvement refers to the manipulation of species composition, stand structure, and stocking by cutting or killing undesirable trees and understory vegetation. Its purposes are listed in the standard Forest Stand Improvement (666).

The safest, least damaging, and most efficient way to eliminate undesirable vegetation is to kill the undesired trees, shrubs, etc., and leave them standing (MO FOTG, IS-MO666-cut). Three commonly applied forest stand improvement techniques that do not involving felling the vegetation include frilling, or girdling spaced cuts, herbicide injection, and basal bark spraying.

Cut stump herbicide applications may be used on felled trees/shrubs/etc.

Pre-commercial thinning involves cutting undesirable trees from commercial stands to achieve desired tree densities that promote optimal growth of desired species.

Timber harvesting consists of intermediate cuttings and regeneration cuttings. Intermediate cuttings remove merchantable trees in order to improve the growth of the residual stand or protect the stand from insect and disease outbreaks. Regeneration cuttings involve systematic harvesting of merchantable trees to start a new forest of desirable seedlings.



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A. Species to Favor

1. To select desirable species for the forest land site refer to Field Office Tech Guide, Section II-Forestland Interpretations, Section II-Windbreak Interpretations, or <http://soildatamart.nrcs.usda.gov/County.aspx?State=NE>.
2. Additional information related to appropriate species composition for native woodland and forest sites can be found in Terrestrial Natural Communities of Nebraska – Version IV (Nebraska Biology Technical Note #65). Projects intended to improve wildlife habitat should be designed to emphasize native species noted within that natural community.
3. Priority shall be given to improving sites having site indices of 55 or greater for the species selected (Section II-Forestland Interpretations). Site index is defined as a relative measure of forest site quality based on the height (in feet) of the dominant trees at a specified age (USFS, 1989; NE FOTG, II, Forest Land Interpretations, Guides to Suitable Soils for Wood Crops).
4. Trees to favor in Nebraska include: ponderosa pine, black walnut, eastern cottonwood, green ash, hackberry, bur oak, northern red oak, bitternut hickory, shagbark hickory, silver maple, and basswood.

B. Improvement Methods (Timber Stand Improvement – TSI)

1. Purpose for Weeding
 - a. Weeding is the partial or complete removal of overtopping and strongly competing trees, brush, or other undesirable growth from stands of desirable species (small to mid-sized trees). Included with weeding is liberation cutting (removal of wolf trees) and vine removal.
 - b. Weeding will be specified only if there are a sufficient number of desirable species present to result in an adequately stocked stand, approximately 150-200 desirable seedling/sapling sized trees per acre or 50-150 mid-sized trees.
 - c. To protect the soil and train the trees, remove only the growth immediately surrounding the crop trees and leave desired vegetation (i.e., desired species of seedling/sapling sized trees) not directly interfering with crop tree growth. In a space of 2 feet surrounding the crop tree, cut all growth that is one-third or more the height of the crop tree and, in a space of 4 feet, all vegetation taller than the crop tree.
 - d. Liberation cutting is recommended when there are large, excessively limby, “wolf” trees in the stand that are overtopping desirable seedling or sapling tree species. There should be a sufficient number of desirable trees underneath to benefit from this type of release.
2. Methods for Weeding
 - a. Cutting and treating with a herbicide:
 - 1) Cut and treat the stump with a chemical herbicide best suited to kill the species (Fig. 1).
 - 2) Apply chemical immediately after cutting in accordance with directions given on label
 - 3) In some stands stumps may be allowed to sprout back where low habitat is lacking or desired.



Figure 1

b. Girdling: Girdling involves cutting a groove or notch into the trunk of a tree to interrupt the flow of sap between the roots and crown of the tree.

1) Girdle the tree about breast height, being careful to cut clear through the cambium layer all the way around the tree (Fig. 2).

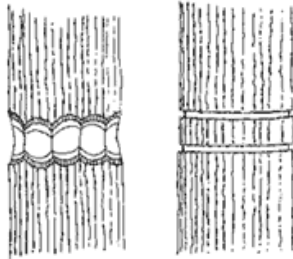


Figure 2

Figure 3

2) Girdling is an alternative for killing a few large weed or wolf trees larger than 12 inches in diameter (usually done with chain saws).

3) Another girdling 4-6 inches below the first cut can be done to be sure of an effective kill (Fig. 3).

c. Frilling and herbicide treatment: Frilling is a variation of girdling in which a series of downward angled cuts are made completely around the tree, leaving the partially cut bark and wood anchored at the bottom (Fig. 4).

- 1) All trees frilled should be treated with a herbicide. December 15 to March 15 is the best period for frilling and herbicide treatment.
- 2) Frill with an ax at a convenient height above ground.
- 3) Make cuts all the way around tree then immediately apply chemical herbicide in accordance with label directions.
- 4) Large trees (greater than or equal to 12 inches diameter) may be girdled 2 inches deep with a chain saw and treated.

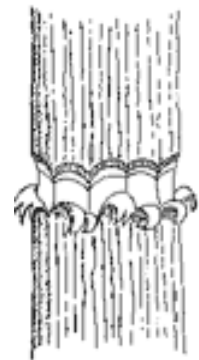


Figure 4

d. Spaced Cuts – Tree Injection: Tree injection involves introducing a herbicide into an undesirable tree through spaced cuts made around the tree trunk with an ax, hatchet, chain saw, or tree injector.

- 1) Cuts should be made 2 inches long and spaced with their edges 1 to 3 inches apart (Fig. 5).
- 2) Place a small amount of herbicide in each cut, according to directions on the herbicide label, generally 1 to 2 milliliters.
- 3) There are several models of tree injectors that may also be used to apply the herbicide.

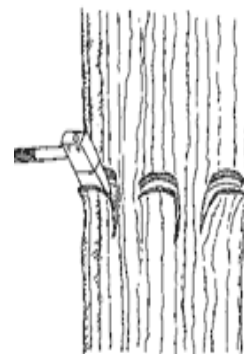


Figure 5

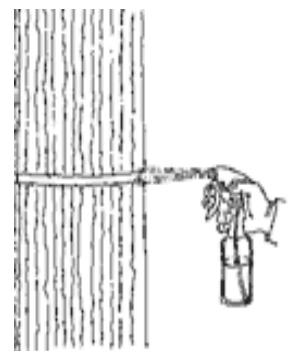


Figure 6

- 4) On difficult-to-control species, such as red maple, hickories and dogwoods, a continuous frill or girdle with herbicide may be necessary to achieve acceptable control. Many forest stand improvement contractors achieve maximum effectiveness by use of a single chain saw girdle and application of herbicide into the cut (Fig. 6). This method is also effective with large trees.

- e. **Basal Bark Spray:** Basal spraying, sometimes referred to as basal bark application, is a technique to deaden small trees, shrubs, or vines by spraying the lower 12 to 18 inches of the trunk with a herbicide (Fig. 7). The intent of the herbicide is to penetrate the bark and kill the tree and any basal buds that might sprout.

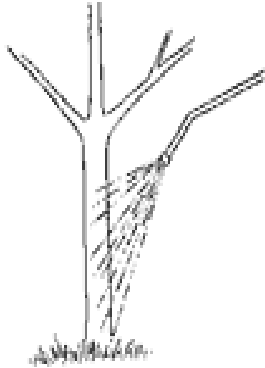


Figure 7

- 1) Herbicides used for basal spraying are generally applied in oil carriers.
- 2) Target trees or shrubs should be no greater than 6 inches in diameter.
- 3) Basal bark spraying works best on thin barked trees, such as maple or honey locust.
- 4) Minimize the amount of herbicide that runs into the soil to avoid damaging non-target trees.

C. Thinning (Pre-commercial)

Thinning is cutting trees from an overstocked stand composed of desirable species not of commercial size to increase the growth rate of the remaining trees. Proper space varies, depending on species, purpose of management, and quality of the site.

1. Types of trees usually removed in improvement thinning are:
 - a. Dead/dying, insect or disease infested trees.
 - b. Deformed (crooked), fork topped, or damaged trees (fire, lightning, porcupine).
 - c. Suppressed and co-dominant desirable trees to attain proper spacing.
2. Ponderosa Pine Stands - Western NE
 - a. For pine stands less than 6 inches diameter, thin to 10-12 feet spacing. For pine stands over 6 inches diameter the D+9 spacing rule is used as shown below, D being the average stand diameter.

Ave. Diameter (D in inches)	D + 9 Feet Spacing
6	15
8	17
10	19
12	21

- b. If forest land grazing is considered, add 1-3 feet to the spacing for site indices below 55 (NE FOTG, II, Forest Land Interpretations, Guides to Suitable Soils for Wood Crops).
- c. Time of year - thinning of ponderosa pine should be done in the fall and early winter months to avoid buildup of Ips (pine engraver) beetles in the slash and subsequent damage to the residual stand by beetles killing "leave" trees. If

thinned at other times of the year, the slash should be lopped and scattered to a maximum of 18 inches off the ground and left to decompose on the forest floor.

3. Hardwood Stands

- a. For stands under a 6-inch diameter, thin to 12 feet. One general rule-of-thumb for hardwood stands is to leave 5 feet to 8 feet of open space in at least two sides of the crown of the remaining trees. For black walnut stands, allow 10 feet growing space between crowns.
- b. Another method if the stand is uniform in diameter is the “diameter-times-two” rule. With this method, the average diameter in inches is multiplied by two; this is the number of feet to leave between the stems of the remaining trees.
- c. Pruning is also considered to be a timber stand improvement practice on selected high value crop trees to increase the quality of wood produced for sawlogs, veneer, etc. Black walnut, for example, will need pruning to get a desirable veneer log. Flush pruning is no longer an accepted practice. Refer to Tree/Shrub Pruning (660 and 660DP) and NE Forestry Technical Note 71 for guidelines on pruning.
- d. Heavy accumulation of thinning slash should be lopped and scattered close to the ground, piled for wildlife, or burned away from crop trees that are left. Check local and state laws when slash is burned or is near a public road.

D. Timber Harvesting

Timber harvesting consists of intermediate cuttings and regeneration cuttings.

1. Intermediate Cuttings - removing merchantable trees to improve the growth of the residual stand or protect the stand from insect and disease outbreaks. Types of intermediate cuttings are discussed below.
 - a. Commercial thinning - merchantable trees are removed from an immature stand (pole size) to achieve optimum stocking levels.
 - 1) The best-formed and most vigorous dominant and co-dominant trees will be left as crop trees for a future harvest.
 - 2) Crooked, forked, damaged, or wolf trees should be removed first. Then space out the better crop trees by removing adjacent co-dominant trees.
 - 3) Crop trees should be free from visual defect, have at least 40 percent live crown and have good form class (diameter/height ratio).
 - 4) Crop trees will be spaced at about average diameter, D+8 to D+12, depending on species and site index. Use management guide on woodland information sticks (available from local forester).
 - 5) A professional forester should be consulted in crop tree selection.
 - b. Salvage Cutting - removing trees damaged by wind, hail, ice, or snow to prevent insect and disease infestation.
 - 1) After severe weather it is recommended that the forest land owner walk through the forest and look for merchantable trees that were badly damaged.
 - 2) Harvesting these trees quickly will prevent disease and insects from deteriorating the value of the tree and protect the remaining stand.

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- c. Sanitation Cutting - removing diseased or insect infested trees within the stand to reduce the potential for spreading into healthy trees.
 - 1) Trees infested with bark beetles, woodborers, leaf defoliators, parasitic mistletoes, needle blights, canker diseases, or pine wilt typically proliferate in overmature and stressed immature trees.
 - 2) Timely identification of the signs or symptoms of these attacks is necessary and prompt removal is important to protect valuable crop trees.
 - 3) Contact your professional forester for on-site insect and disease identification.
2. Regeneration Cuttings – systematic harvesting of merchantable trees to start a new forest of desirable seedlings. Planning considerations on this harvesting category should consider the objectives of the landowner in accordance with the following:
 - a. Inventory of stand, including tree species, age, size, density, natural regeneration in understory, and condition (crown vigor of dominant and co-dominant trees).
 - b. Competing understory vegetation and undesirable tree species in stand.
 - c. Site factors, such as soil, slope, streams or other wetlands. These factors affect equipment operability, erosion hazard, and wildlife.
 - d. Wildlife survey of den trees, snags, and nut-producing trees.
 - e. Selection of appropriate regeneration cutting methods for pine and hardwood stands. Natural regeneration will be used whenever possible and practical.
 - f. Harvesting methods for the ponderosa pine type include: selection, seed tree, shelterwood, and group selection.
 - 1) Selection - Individual mature trees are selected throughout the stand for cutting in relation to the product desired.
 - a) Care should be taken not to cut all of the best dominant and co-dominant trees while leaving only suppressed or inferior trees.
 - b) The selection system should contain many size/age classes of trees to ensure a good selection of immature trees for future harvests.
 - c) Thinning (pre-commercial or commercial) may be done.
 - 2) Seed Tree - Three to four mature, good quality seed trees per acre are left for seeding in the future stand.
 - a) This produces an even aged stand.
 - b) Soil should be lightly disturbed to expose mineral soil (duff layer disturbed) for better seed germination.
 - c) This system would be used on the better pine sites with deep soils (bottoms, north slopes).
 - 3) Shelterwood - Mature stand is harvested in two to three stages to seed in new stand and protect seedlings from hot, dry conditions.
 - a) This method is used on droughty soils and on south aspects.

- b) Overstory seed trees should be removed when understory pine seedlings are established to prevent suppression during sapling stage.
- 4) Group Selection - Similar to the selection method except groups of mature trees are harvested creating small patch cuts.
 - a) Size of patch cut is usually less than one acre.
 - b) Natural regeneration from the surrounding trees is expected.
 - c) This method would produce an uneven aged stand.
- g. The harvest methods used for hardwoods are selection, group selection, and clear cutting.
 - 1) Clear cutting would be used in situations where the desired tree species are not in adequate supply for natural regeneration or when only undesirable species are present.
 - 2) Clear cutting on large forest tracts should be limited to areas/blocks that are less than 10 acres each.
 - 3) All the trees in a designated part of the forest stand are removed and the desired tree species are planted (e.g., black walnut, bur oak, red oak, white oak, hickories, basswood, etc.).
 - 4) Clear cutting is also appropriate for other hardwood species and situations, e.g., cottonwood, or where coppicing can be relied upon to regenerate the stand.
 - 5) The species planted must be able to produce the product desired in the sites that are clear cut. Selection and group selection have been described above.

3. General Requirements For Timber Harvest

- a. The natural beauty of the site will be considered during logging.
- b. If needed, natural screens may be left to cover unsightly areas. For example, slash will be lopped and scattered, piled and burned or broadcast burned to reduce fire and insect hazard.
- c. The logging and slash disposal job will be of sufficiently high standard to leave the cutover areas in a condition that will maintain acceptable aesthetics and will be compatible with other acceptable uses of the area.
- d. Trees shall be cut so that stumps are no higher than 12 inches on the high-ground side.
- e. Trees will be utilized to the smallest top diameter acceptable to the buyer whenever market conditions permit, and it is economically feasible.
- f. In selective cutting operations, care will be taken not to damage the residual stand during felling and skidding operations or to cause excessive soil damage.

- g. Riparian buffers of 35 -100 feet should be left on both sides of streams and other water bodies when clear cutting bottomland forest stands. A few trees may be removed in buffer strips as long as shade is maintained over the stream and there is no threat of erosion. For additional guidelines refer to Riparian Forest Buffers (391) and Herbaceous Riparian Buffers (390).
- h. Steep skid trails should be water barred every 100-300 feet. Minimize the number of random skid trails in a logging operation.
- i. Stay on designated skid trails and yard logs to trail, rather than driving skidding equipment next to felled trees. This prevents soil compaction and root damage to the residual stand.
- j. In selective cutting, leave some den trees, tall snags, and keep a variety of tree species in the residual stand, particularly along forest edges and streams. This will help maintain the diversity needed for many wildlife species.
- k. A management plan shall be developed and the cooperators will be encouraged to contact a professional forester for technical assistance on planning and marketing. The forest stand improvement plan should be incorporated into the landowner's conservation plan.
- l. Grazing – If the landowner's objective is to produce and maintain quality hardwood timber, livestock shall be excluded. For hardwood stands grazing should be excluded or strictly monitored.
 - 1) Livestock grazing in valuable hardwood stands can cause extensive damage.
 - 2) Productive capacity of the site for wood production is reduced by soil compaction from sharp hooves, browsing, physical damage of desirable young hardwoods, and grazing of understory plants that allows grass to invade.
- m. "Diameter limit" timber sales are discouraged, as they tend to leave the timber in a "high graded" condition. The definition of "diameter limit" timber sales involves setting a minimum DBH (diameter at breast height) for cutting timber (i.e., 10 inches), and all trees 10 inches and larger are harvested. If "diameter limit" timber sales are used, designate a higher diameter limit (i.e., 12-14 inches) to be cut. This applies to ponderosa pine in the Black Hills, Pine Ridge, and inter-mountain areas.

E. Wildlife Considerations

1. Leave beneficial trees, shrubs, and vines throughout the stand when they are not interfering with the growth of trees with commercial value. Understory structure is important to many wildlife species to serve as escape/hiding cover, nesting/fawning cover, and other uses. Refer to NE FOTG, Section II-Windbreak Interpretations, Conservation Tree/Shrub Groups, for information on wildlife value associated with each species.
2. Remove trees, shrubs, and vines considered invasive, or that provide low wildlife value, in favor of beneficial woody species. This removal may facilitate establishing snags, brush piles, edge feathering, or forest openings as described below.
3. Allow a select number (approximately 1-2 per acre) of older cull trees to remain as wildlife den trees or roost trees. These trees often provide either hollow trunks and/or an open limb structure.

4. Maintain snags (standing dead trees) that are \geq 6 feet tall and 6 inches DBH to provide habitat for cavity-nesting species. At least 3 snags per acre are desired with at least one snag \geq 10 inches DBH.
5. Provide one brush pile or more per acre to serve as habitat for small mammals and associated predators. Each brush pile should be a minimum of 15 feet in diameter and 5 feet tall.
6. Scatter additional slash material in loose patches throughout the stand to benefit species such as bobwhite quail and wild turkey. These loose patches can also be positioned to protect desired seedlings and saplings from damage caused by deer browsing and livestock trampling.
7. Create an edge or border between the forest and open field that is irregular, rather than straight. A 50 foot strip could be left untreated on the edge of the stand or edge feathering could be accomplished within this zone. Edge feathering involves cutting and leaving a portion of the larger trees along the forest edge to increase sunlight penetration and stimulate growth of understory woody and herbaceous cover.
8. Develop small forest openings within the forest stand varying in size from 0.5 acre to 5 acres and comprising 10% to 25% of the total area. Consider the needs of any area-sensitive forest wildlife species in relation to the total size of the stand prior to implementing this type of management.
9. Utilize management strategies that result in multiple age classes comprised of multiple species of woody vegetation to provide a diversity of structure and species composition to benefit a wider array of wildlife species.
10. Plant native vegetation within the stand to increase diversity of species composition and/or structure. A priority should be placed on mast-producing trees, shrubs, and vines as well as forbs within the herbaceous understory community. Refer to FOTG, Section II, Windbreak Interpretations, Conservation Tree/Shrub Groups for woody species. Information on herbaceous species and establishment is located in Herbaceous Vegetation Design Procedures (550DP).
11. For additional guidance refer to Upland Wildlife Habitat Management (645) and Wetland Wildlife Habitat Management (644). Supplemental information may also be provided in Restoration and Management of Rare or Declining Habitats – Woodland/Forest Design Procedures (643DPb) for native communities.
12. Address wildlife habitat quality criteria using the Woodland Habitat Evaluation Worksheet (NE-CPA-36) to meet a planned score of 0.5 or greater. Species-specific habitat models may also be used where appropriate.

F. SUPPORTING REFERENCES

[A Complete Natural Resource Inventory Glossary with Emphasis on Forestry, based on USDA Forest Service, Interim Resource Inventory Glossary, 6/89](#)

[Conservation Tree/Shrub Groups, NE FOTG, Section II-Windbreak Interpretations](#)

Forest Land Interpretations, Guides to Suitable Soils for Wood Crops, NE Field Office Technical Guide, Section II (not available electronically)

[Forest Stand Improvement \(666\), NE FOTG, Section IV](#)

[Herbaceous Vegetation Design Procedures \(550DP\), NE FOTG, Section IV](#)

[How to Prune Trees](#), NE Forestry Technical Note 71

[Missouri Field Office Technical Guide, Controlling Undesirable Trees and Shrubs, Conservation Practice Information Sheet \(IS-MO666cut\), 1/06](#)

[Ohio State University, Extension Fact Sheet F-45-97, Controlling Undesirable Trees, Shrubs, and Vines in Your Woodland, by Randall B. Heiligmann, 1997](#)

[Restoration and Management of Rare or Declining Habitats - Woodland Forest Design Procedures \(643 DPb\), NE FOTG, Section IV](#)

Terrestrial Natural Communities of Nebraska – Version IV, NE Biology Technical Note 65

[Tree/Shrub Pruning \(660\), NE FOTG, Section IV](#)

[Tree/Shrub Pruning Design Procedures \(660DP\), NE FOTG, Section IV](#)

[Upland Wildlife Habitat Management \(645\), NE FOTG, Section IV](#)

[Wetland Wildlife Habitat Management \(644\), NE FOTG, Section IV](#)

[Woodland Habitat Evaluation Worksheet \(NE-CPA-36\)](#)