# TECHNICAL NOTE

**WOODLAND TECHNICAL NOTE NO. 43** **OCTOBER 1, 2008**

## FOREST STAND IMPROVEMENT

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Forest stand improvement (FSI) is the manipulation of species composition, stand structure, and stocking by cutting or killing selected trees and understory vegetation. This practice is also sometimes called timber stand improvement or TSI.

This practice applies to forest land where competing vegetation hinders development and stocking of preferred tree and understory species. Treatments are aimed at improving the growth rate, species composition, and form quality of the forest by removing less desirable trees to concentrate subsequent growth on the most desirable trees.

Purposes for applying FSI include: increase the quantity and quality of forest products; harvest forest products; initiate forest regeneration; restore natural plant communities; and improve wildlife habitat, visual quality, recreation and open spaced values. Forest stand improvement may be accomplished through a timber sale or it may be noncommercial depending on the size, quality, and/or quality of trees that need to be removed and the market for forest products.

Material in this document provides guidance to meet a variety of purposes on forested lands. It is important to determine the purpose of the activity. Only through an onsite inspection of the area, understanding the objectives of the landowner, and identifying natural resource concerns, can a successful forest management plan be developed that will accomplish the intended purpose.

Mark unit boundaries and sensitive areas beforehand so they can be easily identified during improvement activities. Protect riparian zones, unique areas, and structures. To protect riparian zones or other water quality sensitive areas, refer to “Forestry Best Management Practices for South Dakota” published in 2003 or the most recent version. Leave a strip of existing woody vegetation at least 50 feet wide, along any nonwoodland border.

### FOREST STAND IMPROVEMENT - HARVESTING

The primary objective of harvesting is to remove wood products with a minimum disturbance to the site and to provide for regeneration of a new stand or perpetuation of the existing forest.

The harvest-regeneration strategy needs to be identified for all planned forest improvement harvesting.

Even-aged management refers to stands having only one age class (trees within a 20-year age span). Harvest-regeneration strategies include: shelter wood, seed tree, and clear-cut.

Ponderosa pine stands managed for timber production in the Black Hills are best suited to a two-stage shelter wood system. For group shelter wood cutting, clearings should be less than or equal to two acres. Limit openings to 260 feet for seed-tree cutting if seed trees are on both sides.

Uneven-aged management refers to stands having several age classes. Harvest-regeneration strategies include: single-tree selection and group selection. Uneven-aged silvicultural systems are not a desirable option for timber production in the Black Hills. For special situations, individual and group selection cutting methods can be used.

All cut trees shall be limbed full length on the trunk and slash scattered so it will lie within 18 inches of the ground. Logging slash shall be treated by lopping and scattering the vegetation, by removal from the site, or by piling and burning according to the Conservation Practice Standard (CPS) Forest Slash Treatment (384).

Limit damage to the site by using directional felling, limiting trails to less than 15 percent of the site, logging when the soil is dry or frozen, using the smallest size equipment possible, and using well organized access trails.

Use the logging system and equipment appropriate for the site. Take care to minimize damage in the residual stand when using mechanical methods.

Avoid wet soil conditions to minimize compaction and rutting.

The choice of commercial harvest method is highly specific and depends upon landowner objectives, stand and site conditions, species, markets, contractors, and other considerations. Landowners should seek advice from a professional forester before pursuing a commercial timber harvest. Know the amount of timber to be sold through inventory, receive sealed bids, obtain a signed contract, receive full payment before cutting begins, and supervise harvest operations.

**FOREST STAND IMPROVEMENT – THINNING**

The primary objective of thinning is to improve growth and quality of the remaining trees with minimum disturbance to the site. Wood products may or may not result. Woodland stands should be thinned before diameter growth on the larger, better quality trees is reduced. Stands should be thinned as soon as the overstocking is recognized. In well stocked, even aged stands, this usually occurs between 10 and 20 years of age.

**Pre-Commercial Thinning** – reducing forest stocking in immature stands by removing a portion of the non-merchantable trees in a stand. Ponderosa pine stands with average stand diameter up to 4 inches should be thinned to 10-foot spacing; stands with an average diameter of 5 to 6 inches should be thinned to 12-foot spacing. This guide is subject to professional interpretation. Variations will be necessary for stand conditions and site quality.

If selling timber is undesirable or not feasible, unwanted trees, shrubs, and vines may be killed by any of the following means: cutting, frilling, stem injection, or basal bark spray.

**Commercial Thinning** – reducing forest stocking by harvesting a portion of the merchantable trees in a stand. This may include some non-merchantable trees in the thinning operation. Determine the desired level of stocking that meets the landowner's objectives and the stands management needs.

Determine whether trees to be cut constitute a marketable volume of timber. Landowners planning to sell timber should obtain the services of a professional forester.

Remove suppressed and malformed trees, or trees of undesirable species, leaving sufficient well-formed, dominant, and co-dominant trees. Priority shall be given to thinning sites having site indices of 55 or greater.

Favor the species best adapted to the site (see Conservation Tree/Shrub Group descriptions, Section II of the South Dakota Technical Guide (SDTG)). Invasive species will be controlled in favor of native vegetation. The preferred species are identified and retained to achieve the intended purpose of improving the stand. Generally, ponderosa pine should be the species to favor in the Black Hills.

Spacing, density, and amounts of preferred plants are carefully planed. It is important to maintain adequate tree stocking or density per acre to fully utilize the site and create optimum growing conditions for the preferred tree species.

Kill unwanted trees, shrubs, and vines by any of the following means: cutting, girdling, frilling, stem injection, basal bark spray.

Cutting - Cut down unwanted trees in a stand by the use of a chainsaw, brush saw, feller-buncher, axes, or any other mechanical device. Stumps should be no higher than six inches above the ground. Twelve-inch stumps are allowable for commercial harvests. Cutting of deciduous trees should be followed by a suitable herbicide application to reduce stump sprouting. Treat the stump with a herbicide best suited to kill the species. Apply chemical immediately after cutting in accordance with directions given on the label.

Girdling: Girdle the tree about breast height being careful to cut clear through the cambium layer all the way around the tree. Girdling is an alternative for killing a few large weed or wolf trees larger than 12 inches in diameter.

Frilling and treating with a herbicide: Frill with an axe at a convenient height above ground. Make cuts all the way around the tree then immediately apply herbicide in accordance with directions given on the label. December 15 to March 15 is the best period for frilling and herbicide treatment.

When choosing herbicides, review leaching, runoff potential, setback requirements, persistence, and toxicity ratings of chemical formulations. Use the safest available herbicide. Follow all label directions and label precautions.

Take care to minimize damage in the residual stand when using mechanical methods.

To avoid damage from mountain pine beetles, do not thin ponderosa pine stands between April 1 and September 30 unless slash is to be removed from the site, chipped, or burned before spring.

Use the D + X spacing guidelines in even-aged stands; where D is the average stand diameter measured four and a half feet above the ground (DBH). Use Basal Area (BA) in uneven-aged stands.

| | Even-aged stands | Uneven-aged stands |
|---|---|---|
| Ponderosa pine: | D + 6 to D + 7 | 60 to 80 $ft^2$ BA/acre |

- Use the upper stocking levels (D+6) or 80 $ft.^2$ BA/ac. in healthy stands on the more productive sites where understory production (grass, shrub, and tree seedlings) is not a concern.
- Use the lower stocking levels (D+7) or 60 $ft.^2$ BA/ac. on less productive sites, to encourage growth of established tree seedlings, to improve forage production on grazable forests, to reduce fire hazards, or where lower levels are necessary when removing undesirable species or infected trees.

All stands: thin at 10 to 20 year intervals, up until ¾ of the rotation age is reached.

As the stand develops, the canopy begins to close as tree crowns expand and competition and subsequent reduced growth rates begin to affect the productivity of the stand.

**Suggested Spacing Guide for Ponderosa Pine in the Black Hills**

| DBH (inches) | Spacing (feet) | Trees per Acre | Basal Area ($ft^2$/ac) |
|---|---|---|---|
| < = 4 | 10 x 10 | 436 | 38 (for 4") |
| 5 | 12 x 12 | 302 | 42 |
| 6 | 12 x 12 | 302 | 60 |
| 7 | 13 x 13 | 258 | 69 |
| 8 | 14 x 14 | 222 | 78 |

Thinning should be discouraged from April 15 to July 15 to minimize the buildup of the pine engraver beetle (Ips). When possible, thinning of pine stands should be done in the fall and early winter months to avoid buildup of Ips beetles in the slash and subsequent damage to the residual stand by beetles attacking and killing leave trees. If thinned at other times of the year, the slash should be lopped and scattered to a minimum of 18 inches off the ground and left to decompose on the forest floor.

With all thinning, provide 3 to 5 feet of crown growing space on 2 or 3 sides of residual trees (5 to 10 feet for black walnut).

The purpose of intermediate cuttings or thinning is to improve the stands overall vigor and quality. The maximum response to thinning usually is found among the remaining co-dominant trees once they are released from competition with equals. The following general guidelines will be followed no matter which method of thinning is used.

Remove all merchantable trees that are suppressed.

Salvage high risk, damaged, or diseased trees.

Space the "keep" trees to allow room for growth and development.

Favor high quality dominant and co-dominant trees for retention.

Leave only good quality trees of the species desired that have full crowns, good form, are vigorous and have a good chance of developing into a merchantable product or meeting other resource objectives. Remove all crooked, dying, diseased, injured, and suppressed trees, when selecting which trees should be cut.

The method, felling direction, and timing of tree cutting for harvesting shall facilitate efficient and safe tree removal and protect sensitive areas such as vernal pools, riparian zones, cultural resources, and structures.

Consider pruning while thinning. The primary objective of pruning is to produce logs with clear wood. Other objectives include reducing fire hazards, improving access through a stand, and increasing the amount of sunlight to the understory. Please refer to CPS Tree/Shrub Pruning (660) for more detailed information and guidance regarding this practice.

Low intensity prescribed fires may be used to reduce fuel build-up, expose mineral soil for improved germination, or improve/increase green browse for wildlife. Please refer to CPS Prescribed Burning (338) for guidance. A prescribed burn plan shall be prepared.

Weeding can be used for the removal or reduction of overtopping and strongly competing brush or other undesirable growth from established seedlings of desirable species.

Each acre to be released should support a minimum of 150 to 200 live seedlings, evenly distributed over the area after treatment.

Release can be obtained by chemical or mechanical means.

Cooperators using chemicals shall be cautioned to read the label on the container before using the chemical, handle and apply the chemical according to the label instructions, dispose of unused material or empty containers in a safe manner and follow local, state, or federal laws and regulations concerning the use of agricultural chemicals.

Timing of the treatment shall coincide with intended purposes and minimize impact on other resources.

**IMPROVE UNDERSTORY PRODUCTION FOR GRAZING OR WILDLIFE HABITAT**

On sites with site indices below 55 or where the development of a grazing resource is a primary consideration, add 1 to 3 feet to the average spacing guidelines (D+8 to D+10).

Rotate forest stand improvement through a stand so that various stages of plant succession will be established.

Timing of treatment and retaining dead or dying trees will help minimize impacts on nesting birds and other wildlife. Food and cover for wildlife are further retained by minimal modifications of composition and spacing necessary to improve the vegetative cover considering the total resource base.

Perform heavier thinning to encourage fuller crown development, earlier seed production, and heavier herbaceous plant development.

**OPERATION AND MAINTENANCE**

Monitor populations and the potential of damage to site resources by harmful pests and take controlling actions as necessary. Comply with CPS Pest Management (595).

# Number of Trees per acre

**Spacing (feet)**

| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 1210 | | | | | | | | | | | | | | | | |
| 7 | 1037 | 889 | | | | | | | | | | | | | | | |
| 8 | 908 | 778 | 681 | | | | | | | | | | | | | | |
| 9 | 807 | 691 | 605 | 538 | | | | | | | | | | | | | |
| 10 | 726 | 622 | 545 | 484 | 436 | | | | | | | | | | | | |
| 11 | 660 | 566 | 495 | 440 | 396 | 360 | | | | | | | | | | | |
| 12 | 605 | 519 | 454 | 403 | 363 | 330 | 303 | | | | | | | | | | |
| 13 | 558 | 479 | 419 | 372 | 335 | 305 | 279 | 258 | | | | | | | | | |
| 14 | 519 | 444 | 389 | 346 | 311 | 283 | 259 | 239 | 222 | | | | | | | | |
| 15 | 484 | 415 | 363 | 323 | 290 | 264 | 242 | 223 | 207 | 194 | | | | | | | |
| 16 | 454 | 389 | 340 | 303 | 272 | 248 | 227 | 209 | 194 | 182 | 170 | | | | | | |
| 17 | 427 | 366 | 320 | 285 | 256 | 233 | 214 | 197 | 183 | 171 | 160 | 151 | | | | | |
| 18 | 403 | 346 | 303 | 269 | 242 | 220 | 202 | 186 | 173 | 161 | 151 | 142 | 134 | | | | |
| 19 | 382 | 328 | 287 | 255 | 229 | 208 | 191 | 176 | 164 | 153 | 143 | 135 | 127 | 121 | | | |
| 20 | 363 | 311 | 272 | 242 | 218 | 198 | 182 | 168 | 156 | 145 | 136 | 128 | 121 | 115 | 109 | | |
| 21 | 346 | 296 | 259 | 230 | 207 | 189 | 173 | 160 | 148 | 138 | 130 | 122 | 115 | 109 | 104 | 99 | |
| 22 | 330 | 283 | 248 | 220 | 198 | 180 | 165 | 152 | 141 | 132 | 124 | 116 | 110 | 104 | 99 | 94 | 90 |

# Basal Area

| | **20 feet$^2$** | | **40 feet$^2$** | | **50 feet$^2$** | | **60 feet$^2$** | | **80 feet$^2$** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **DBH** (inches) | Trees/ac | Spacing (feet) | Trees/ac | Spacing (feet) | Trees/ac | Spacing (feet) | Trees/ac | Spacing (feet) | Trees/ac | Spacing (feet) |
| 4 | 229 | 13.8 | 458 | 9.7 | 573 | 8.7 | 688 | 8.0 | 917 | 6.9 |
| 5 | 147 | 17.2 | 293 | 12.2 | 367 | 10.9 | 440 | 9.9 | 587 | 8.6 |
| 6 | 102 | 20.7 | 204 | 14.6 | 255 | 13.1 | 306 | 11.9 | 407 | 10.3 |
| 7 | 75 | 24.1 | 150 | 17.1 | 187 | 15.3 | 225 | 13.9 | 299 | 12.1 |
| 8 | 57 | 27.6 | 115 | 19.5 | 143 | 17.4 | 172 | 15.9 | 229 | 13.8 |
| 9 | 45 | 31.0 | 91 | 21.9 | 113 | 19.6 | 136 | 17.9 | 181 | 15.5 |
| 10 | 37 | 34.5 | 73 | 24.4 | 92 | 21.8 | 110 | 19.9 | 147 | 17.2 |
| 11 | 30 | 37.9 | 61 | 26.8 | 76 | 24.0 | 91 | 21.9 | 121 | 19.0 |
| 12 | 25 | 41.4 | 51 | 29.2 | 64 | 26.2 | 76 | 23.9 | 102 | 20.7 |
| 13 | 22 | 44.8 | 43 | 31.7 | 54 | 28.3 | 65 | 25.9 | 87 | 22.4 |
| 14 | 19 | 48.3 | 37 | 34.1 | 47 | 30.5 | 56 | 27.9 | 75 | 24.1 |
| 15 | 16 | 51.7 | 33 | 36.6 | 41 | 32.7 | 49 | 29.8 | 65 | 25.8 |
| 16 | 14 | 55.1 | 29 | 39.0 | 36 | 34.9 | 43 | 31.8 | 57 | 27.6 |
| 17 | 13 | 58.6 | 25 | 41.4 | 32 | 37.1 | 38 | 33.8 | 51 | 29.3 |
| 18 | 11 | 62.0 | 23 | 43.9 | 28 | 39.2 | 34 | 35.8 | 45 | 31.0 |