United States Department of Agriculture

Forestry Technical Note #5

Natural Resources Conservation Service - Indiana - January 2018

666 Forest Stand Improvement Methods

Photo Credit: John W. Taylor, Jr, U.S. Forest Service

Forest Stand Improvement (FSI is the cutting or killing of undesirable vines, shrubs, and trees in a forest stand. When resources such as space, light, water, and nutrients are freed up through an FSI operation, the desirable trees are allowed to increase growth and health, produce more fruit/nuts, and potentially increase in value. Often FSI is done in conjunction with other forestry and wildlife management practices as part of an overall resource management system designed to help woodland owners achieve their management objectives.

Treatment Methods

FSI work is most commonly accomplished by hand (using a number of different tools/implements) or occasionally with small machines such as a rotary mower, or skid steer with cutting or grinding attachments. Equipment used will depend on the size of the trees, size of the area, site conditions, and the economic constraints set by the landowner. Cut trees are generally not removed and are left on the ground.

There are several ways to implement FSI. These methods may be used in conjunction with each other over time to achieve desired results. Cut Stump (with or without herbicide), Girdling (with or without herbicide) Basal Bark Spray, Frilling, Stem Injection, Foliar Spray, and Prescribed Burning are all acceptable means of implementing FSI through the Natural Resources Conservation Service (NRCS) in Indiana. Each method has advantages and disadvantages in particular situations and are explained in more detail in the sections below.

Some of these treatment methods involve cutting down trees. This act comes with more guidelines in Indiana when the activity is a Federal Action, due to threatened and endangered species such as the Indiana and Northern Long-Eared bats. Not cutting down trees by leaving them standing is often the safest, least damaging, and most efficient way to eliminate undesirable vegetation. (See the US Fish & Wildlife Service Forest Management Guidelines for Avoiding Incidental Take of Indiana Bats on the Indiana NRCS FOTG site.)

Invasive species are becoming more of a problem in the forest landscape. If present, invasive species populations can significantly increase once trees are thinned and more sunlight and nutrients are available to these plants. For this and many other reasons, invasive species should be controlled either before or in conjunction with FSI work. See Indiana (IN) Field Office Technical Guide (FOTG) Standard (314) Brush Management for more information on removing invasive species.

When conducting FSI, minimize disturbances to the site such as rutting, soil compaction, excessive disturbance to the litter layer, and the addition of fill material. Facilitate efficient and safe tree removal by controlling the method, felling direction, and timing of tree cutting, Slash, debris, and vegetative material left on the site should not present a fire or pest hazard or interfere with the intended purpose. Protect sensitive areas such as vernal pools, riparian zones, and cultural resources.

Herbicides

Some FSI treatment methods involve applying a herbicide. Some particularly hard to kill tree species such as maple, hickory, dogwood, locust, and ailanthus are best killed with herbicides. In general, methods of killing standing trees that do incorporate herbicides require less time to be effective than those techniques that do not use herbicides.

Other advantages are that herbicides: are easy to use by landowners, allow for treatment of target species, cause minimal soil disturbance, can be used on steep slopes where other equipment use is limited, can be quickly applied over large areas, and can be used when mechanical methods are impractical or not cost-effective.

Timing of herbicide application is critical. Several factors influence the proper timing of application, such as differences in the susceptibility of various target species to different herbicides and at different stages of growth.

The sprouting of cut trees or bridging the gap of a girdling cut can be eliminated by treating the cut with herbicide. Most herbicides need to be applied immediately to freshly cut tree surfaces, optimally within 15 minutes, unless otherwise specifically directed by the herbicide label. If an oil-soluble mix is used, spray the sides of the stump to the root collar and to the cambial area until thoroughly wetted.

During the spring “sap-flow,” water-carried herbicides might not be absorbed adequately enough to be effective. Treatment with an oil-carried herbicide is therefore recommended in the spring when treating species that exhibit a strong spring “sap flow.” Examples of these species include maples (Acer spp.), grape (Vitis spp.), and ironwood (Ostrya virginiana.).

NRCS does not give specific herbicide recommendations. Contact a professional forester, the Purdue University Extension Service, or a licensed pesticide applicator for specific herbicide recommendations. Always apply herbicides according to labeled directions.

FSI Methods

FSI in Indiana can be implemented using the following methods and appropriate herbicides as necessary to obtain satisfactory control.

Cut Stump

Cut Stump involves cutting and dropping the tree with or without herbicide to the cut surface. Where felling of the undesirable tree is the chosen technique, there is often a high probability that the stump will sprout. Only the cambial area (outer wood next to bark) needs to be treated with herbicide to prevent sprouting.

Some herbicides labeled for cut stump application are formulated to be mixed with oil. These materials do not move readily within the plant, but penetrate the bark. To be effective in suppressing stump sprouting, the entire stump (Figure 1), particularly the bark and exposed roots, must be thoroughly sprayed. Timing is less critical with these materials because they are not so dependent on movement downward from the cut surface to distribute the herbicide. In situations where immediate treatment of stumps is not possible, an herbicide in an oil carrier should be used rather than one in a water carrier.

Figure 1

When herbicide is not applied, the goal is often to induce sprouting on the stump or just below the soil surface, often called coppicing. For this method, choose desirable species that will readily re-sprout such as oaks, black walnut and black cherry. Cut stems that do not have good form or that have indications of low vigor. The smaller the tree the better. As trees increase in size, above 12 inches DBH (Diameter at Breast Height) the chances of sprouting greatly diminishes. Most desirable tree specie’s optimal size to coppice are 1 to 6 inches DBH, with 6 to 12 inch DBH trees having roughly a 50% chance of sprouting. Optimally, sprouts are best if origination is from the soil near the stump and not along the side of a large stump. For higher likelihood of soil originating sprouts, keep stump heights below 6 inches with optimal height at 2 inches or a low as possible. Within 5-8 years, cut multiple sprouts to only one sprout.

Girdling

Girdling involves “ringing” the tree using a chainsaw or an ax. This method is generally used to control trees larger than 5 inches in diameter. Make horizontal cut(s) 1 inch to 1.5 inches deep into the wood portion of the tree (past the bark) all the way around the tree at waist height. If using an ax, make the ring at least 4 inches wide and 1 inch deep into live wood. When using a chainsaw the width will be as wide as the chain. If using herbicide, make one ring (Figure 2), and apply herbicide immediately into the freshly cut rings. If not using herbicide, make rings approximately 4 to 6 inches apart. Young fast growing trees can callus over the girdles and recover, so timing is important - girdling without herbicide is more effective after full leaf out but can take longer to see results. Caution should be used to

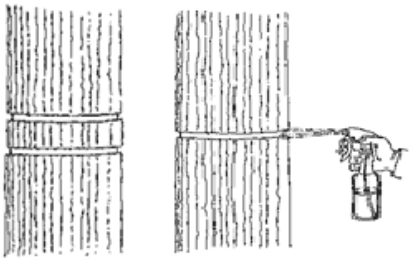


Figure 2

avoid girdling hollow trees. When girdling trees on steep slopes it is a good practice to start at the bottom of the slope and work up, in order to avoid working below freshly girdled trees.

Frilling

Frilling, sometimes referred to as Hack-and-Squirt, is a variation of girdling in which a series of downward angled cuts are made completely around the tree using an ax or a hatchet, leaving the partially severed bark and wood anchored at the bottom (Figure 3). The cuts should be ¾ of an inch deep into live wood . The effectiveness of both girdling and frilling can be increased by using herbicides, in which case, the herbicide should fill or saturate the frill.

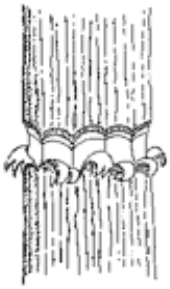


Figure 3

Stem Injection

Tree injection (also sometimes referred to as Hack-and-Squirt or Spaced Cut Injection) involves introducing an herbicide into the undesirable tree through spaced cuts made around the trunk of the tree with an ax, hatchet, or tree injector (Figure 4). Visualize this as a discontinuous frill with a small amount of herbicide placed in each cut. Use an ax or a hatchet to make non-overlapping horizontal cuts penetrating into the sapwood (the outer area of lighter-colored wood in the stem cross section) completely around tree. Cuts are approximately 2 inches long and are spaced with their edges 1 to 3 inches apart, depending on the tree species and the specific herbicide being used. Insert a small amount of herbicide in each cut. This method is not recommended for use during heavy sap flow in spring.

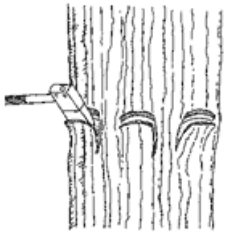


Figure 4

Foliar Spray

A foliar application directs the herbicide/water mixture directly onto the leaves of a tree or shrub. This treatment is highly effective on smaller understory plants or trees/shrubs that have been previously cut and allowed to re-sprout. Depending on the herbicide and tree species, spraying is done to the upper 1/3 of the foliage or over the entire canopy, saturating the leaves. Use a foliar spray to remove all undesirable understory plants or as a single species control in patches of undesirable trees and shrubs. Depending on the type of herbicide used and the specific objective, most situations call for an application of herbicide during the growing season in late summer and early fall, prior to dormancy. If spraying re-sprouts, be sure that adequate foliage has developed to absorb enough herbicide to kill the root system. The potential for spray to drift onto non-target and/or sensitive areas should be taken into consideration.

Basal Bark Spray

Basal spraying, sometimes referred to as basal bark application, is a technique used to kill small trees, shrubs less than 6 inches in diameter, and occasionally vines, by spraying the entire circumference on the lower 12 to 18 inches of the stem with an herbicide. Treating larger stems (greater than 6 inches DBH) may be necessary for some invasive species, such as Tree-of-Heaven, that readily re-sprout.

Using a low pressure backpack sprayer, thoroughly wet the lower 12 to 18 inches of the stem, completely encircling the root collar area (Figure 5). Be cautious not to overspray to the point of runoff into surrounding soil. Herbicides for basal bark spraying are diluted in an oil-based carrier such as mineral-, paraffin-, aliphatic-, and vegetable oil-based products. Follow manufacturer's label directions specifically for basal bark application. Ready-to-use herbicide oil mixtures are also available. Basal bark spraying can be used anytime except when bark is wet, frozen, or during temperatures above 85° F (because it can potentially volatilizes and kills off target plants).

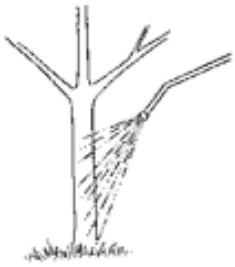


Figure 5

Prescribed Burning:

Prescribed burning, often combined with another FSI treatment method, can be a useful tool in aiding in the reduction of undesirable tree/shrub species. Fortunately, many undesirable species are not fire tolerant while several desirable species are more tolerant of fire. Use prescribed fire very carefully in order to enhance the effects of FSI or to help restore native communities. Prescribed fire is typically not used when high valued timber trees are to be retained in the stand.

Prescribed fires are conducted by having a prescribed burn plan written, following all laws and regulations, then establishing firebreaks around a pre-determined burn unit, conducting the burn, and lastly following up with any "mop up" to prevent re-ignition. (See IN FOTG standard (338) Prescribed Burning).

FSI Treatment Types
Management decisions should be based on a thorough and current forest inventory, and the type of FSI will depend on the specific purposes and objectives for the site. Overall management systems can be separated in two main strategies: uneven-aged systems (i.e. single-tree selection, group selection, coppice selection) or even-aged systems (i.e. clear-cut, seed-tree, shelterwood, coppice). Uneven-aged management is a planned sequence of treatments designed to maintain and regenerate a stand with three or more age classes. Even-aged management will result in stands of trees that are all nearly the same age.

FSI treatments may be done in conjunction with the regeneration harvest, as in the uneven-aged system, or at various times between regeneration events, as in the even-aged system. The term “intermediate treatment” is often used to describe thinning of even-aged stands, since these treatments are applied between planned regeneration events or at an intermediate time during the rotation. “Harvest and regeneration” treatments are made when the forest stand has reached economic and/or physiological maturity. The harvest method will be dictated by the species, site, and landowner’s type of desired management system. Often FSI is used before or after a timber harvest to manipulate forest conditions or light levels, to kill undesirable species, or to remove damaged trees and trees with poor form and growth.

FSI treatment levels are described in terms of **crop trees per acre, basal area per acre, trees per acre, between tree spacing**, or by any other appropriate and professionally accepted density.

Basal Area and Trees per Acre
Basal Area is a common term used in forest management. It can be used for determining stocking volumes, growth, when to thin or harvest, and how much to thin or harvest. Basal Area is a square feet measurement across one acre. Basal area and trees per acre thinning choices are based on: relative tree position, crown position, tree health, stem quality, species, land use objectives, and other criteria as applicable.

For even-aged stands with an average DBH of 6 inches or more, Table 1 can be used as a guide for residual stocking after thinning.

Table 1

Ave. Stand Diameter (inches)	Spacing (feet)	Basal Area (sq. ft.)	Trees Per Acre (no.)
Hardwood Species			
6	13	55	258
8	16	60	170
10	19	65	121
Pine Species			
6	12	60	304
8	14	75	222
10	16	90	170

For uneven-aged stands create or maintain age/size classes which occupy an equal amount of ground space per acre. (i.e. 25% seedling/sapling, 25% pole, 25% small sawtimber, 25% large sawtimber) Each improvement activity should: regenerate a new age/size class (if needed), harvest mature trees and reduce numbers in each age/size class, and maintain or develop appropriate age/diameter class distributions

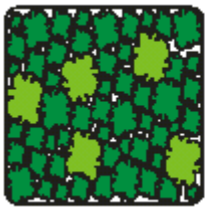
Crop Tree Release Thinning
Crop Tree Release (CTR) is a forest stand improvement practice based on a “crown-touching” release technique. CTR focuses on releasing, or providing more room for individual trees that produce the desired benefits, according to landowner goals and site objectives. CTR differs from traditional thinning in that it assures that most site resources are focused on a small number of selected trees rather than being widely distributed to all residual trees.

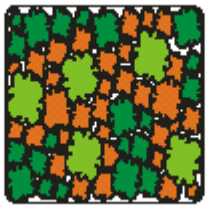
Select and mark/flag 20 to 75 crop trees per acre. Final harvest crop trees may result in as few as 10-20 crop trees per acre. Select crop trees based on the following criteria: dominant or codominant canopy tree, stump sprout at <6 inches (if applicable), healthy crown, minimal epicormic branching, good form, free of defects and disease, desired species, and adapted species.

If possible, apply CTR early in stand development, at or near the time of canopy closure, to maximize the number and distribution of available crop trees per acre. This condition will continue for about 10-15 years after canopy closure. However, beyond 25-30 years, the number of crop trees will continue to decline without CTR. A young stand can hold a maximum of 60-70 crop trees per acre. An older stand will hold far fewer crop trees per acre.

A general guideline is to focus on finding the best available crop trees, regardless of spacing, and provide them with an adequate release on all sides of the their canopy. Following an arbitrary spacing rule can lead to inefficient investments in substandard trees.

In high-risk locations, CTR in commercial stands can be limited to two sides around each crop tree. In these cases, such as young stands of high value release, or yellow poplar stands, release on at least two sides when crop trees are 2-5 inches in DBH with 3-4 feet of growing space.


Select Crop Trees


Mark Competing trees


Remove Competing Trees

Most stands will adjust the stand treatment by altering the number of crop trees per acre, not the degree of release around each crop tree. For most efficient application of CTR, make sure each crop tree receives a 3- or 4-sided release. Any competitor whose crown touches that of the crop tree should be eliminated. Three sides can be used for small sawtimber crop trees to limit the risk of epicormic branching where timber quality is a concern. Sub-canopy trees should be retained around crop trees to protect them and add other benefits to the stand, unless they conflict with management objectives.

Crop trees must be able to compete success fully after release in the forest community and live long enough to provide benefits that meet management objectives; thus crop trees are usually found in dominant or codominant crown classes. Trees in intermediate or suppressed crown classes, particularly shade-intolerant species, generally do not respond well to CTR.

Wild Grapevine Control

Although grapevines are native plants and good for wildlife, they can grow into the crown of trees, thus killing the tree or, more often, reducing the tree's growth rate and adding weight that can lead to branch breakage. Since grapevines do provide soft mast for wildlife (small grapes), not all grapevines need to be eliminated. Consider leaving grapevines on poor quality trees to serve as wildlife food.

Control grapevines by using a Basal Bark treatment or Cut Stump treatment (or a Foliar spray on Japanese Honeysuckle). No cutting is necessary on Basal Bark treatment as described in previous sections. In mature deeply shaded woods, grapevines can sometimes be cut without the use of herbicide. Cut vines may sprout but, with limited sunlight, these sprouts will eventually die.

Most situations will involve a combination of thinning and/or harvesting, along with vine control. In such areas with plentiful sunlight herbicide application may be required. Height of cut is not critical when not using herbicide, however when applying a herbicide, make the cut approximately 12 inches above ground and saturate the entire cut surface with herbicide. Cut and treat cut surface wherever vines can take root, as this can occur in multiple locations. Consider making two cuts: one at the ground and the other at waist height for clear identification of the "swinging" cut vine. Cut vines do not need to be removed from the tree, nor is there any need to cut vines like poison-ivy or Virginia creeper on large trees, as these do not tend to grow into tall upper canopies. However, do consider cutting invasive Japanese Honeysuckle or other tangling vines.

Temporary Forest Opening

Often called group openings, these temporary openings are essentially small clear-cuts created in a forest in order to provide early successional forest habitat for wildlife or to regenerate the stand. Temporary openings provide sunlight to the forest floor which will result in a tremendous amount of sprouts, shrubs, grass, and herbaceous vegetation. The resulting thicket provides high quality food and cover for a large number of wildlife species, especially neotropical songbirds, wild turkey, ruffed grouse and whitetail deer. In addition, foresters often use group openings to help regenerate shade-intolerant trees such as oaks.

A new temporary forest opening

Desired tree response one year later

Openings should be somewhat irregularly shaped to provide increased edge habitat. Avoid placing openings in ravines, on north facing slopes, and within 150 yards of existing water sources for the protection of bat and amphibian populations. South facing slopes are preferred since they tend to have more direct sunlight and remain free of snow for a longer time in the spring and fall.

Temporary forest openings are created with a chainsaw or small machines by cutting and dropping all trees and brush in an area ¼ of an acre to 10 acres in size, in large blocks of forest, and do not comprise more than 60% of the total forest acres. If regeneration of shade intolerant species is a goal, then openings should be at least 1.5 times the height of surrounding trees to allow adequate sunlight to reach the forest floor. An example of this if the surrounding trees are 80 feet tall then the opening needs to be at least 120 feet in diameter. All woody stems over 1 inch in diameter should be cut, and stumps should be left no higher than 6 inches for desirable species and no higher than 18 inches for undesirable species. Desirable species, such as oaks, should be cut low to the ground and left untreated to encourage quality stump sprouts. Stumps of undesirable tree species may be treated with herbicide to prevent re-sprouting. Openings should be placed in recently harvested areas where few or no quality trees remain or where adequate advanced oak regeneration is occurring.

Thinning to Initiate Regeneration

To initiate adequate natural regeneration of shade intolerant species, thinning may be needed before a harvest or regeneration cut. First, evaluate the site for advanced regeneration of desirable species and mature desirable tree species in the overstory. If advanced regeneration is not sufficient and there are adequate numbers of desirable tree species in the overstory, then proceed with thinning.

Establishing adequate advanced regeneration is about managing sunlight in the canopy layers. Adjusting light levels by thinning can also favor seed germination and seedling survival of desirable species, such as oak, while suppressing competition from undesirable trees and shrubs. The majority of the thinning work will take place in the forest understory, midstory, and intermediate crown positions, while leaving the overstory mainly intact. Some removal of undesirable forest floor saplings and overstory may also be needed if either is very dense.

Uncut ll Understory Thinning. Note the Diffuse Light Levels

This thinning technique can be considered the first cut in a two-stage shelterwood operation The main objective is to create a diffuse light level allowing enough sunlight to establish young saplings. There should be no major gaps in the upper canopy, as too much sunlight can increase the establishment of undesirable competition. Ideally, thinning should be done after a large seed crop. Concentrate on cutting out undesirable trees species first. Some

understory desirable species may need to be cut in order to increase diffuse light levels. Stumps of desirable species should be less than 4-6 inches in height to facilitate sprouting from the soil. Low-origin sprouts are less susceptible to rot entering from the parent stump.

Initiating or improving regeneration may also need to take place as a follow up to a timber harvest.

Invasive Species Control

Following a disturbance in the forest, such as a FSI or a timber harvest, invasive plant species' populations can quickly spread into these sunlight-rich open areas. If invasive species are present or on nearby properties, their populations should first be controlled. For invasive woody species, this control may take up to three or more years. See IN FOTG standards (314) Brush Management and (315) Herbaceous Weed Control to control undesirable invasive species.

OPERATION AND MAINTENANCE

Forest Stand Improvement carries a maintenance life of 10 years. The level of FSI should be intense enough to not need FSI for 10 years.

Prepare an Operation and Maintenance plan for the site and review it with the operator. The plan will describe actions that must be taken to ensure that the practice is applied correctly during its design life. As a minimum, include periodic inspections for assessment of insects, disease, and other pests, storm damage, and damage by trespass to ensure intended objectives are achieved and resource damage is minimized. Periodically take out dead or diseased trees to allow more sunlight to reach the ground. Maintain property boundaries for future forest management activities.

Slash and debris left on the site after treatment 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.

Protect woodlands from grazing livestock except as part of a grazing plan to facilitate removal of undesirable understory vegetation to allow the restoration of native plants.

References:

Technical Guide to Crop Tree Release in Hardwood Forests; Published as University of Kentucky's Cooperative Extension publication FOR-106; Published as Southern Regional Extension Forestry publication SREF-FM-011; Partial funding by Tennessee Department of Agriculture, Division of Forestry 08-0070 R12-4910-079-005-08 PB1774-4M-12/07

The Ohio State University Fact Sheet F-45 – Controlling Undesirable Trees, Shrubs, and Vines in Your Woodland.

Adopted from Missouri NRCS (IS-MO666cut) Controlling Undesirable Tree and Shrubs Informational Sheet; and Missouri NRCS (IS-MO666ctm) Crop Tree Management Conservation Practice Information Sheet; and Missouri NRCS/MDC/UMC (JS-BIOL-27) Temporary Forest Openings for Wildlife Job Sheet

Forest Stand Improvement; Control of Wild Grape Vines—Code 666; Conservation Practice Job Sheet; Ohio—Natural Resources Conservation Service March 2009

Forest Improvement Handbook; Rathfon, Ron; Saunder, Mike R.; Stump, Don; FNR-IDNR-414; Purdue University

Photo credits: John W. Taylor, Jr, U.S. Forest Service; James H. Miller U.S. Forest Service; and Chris Neggers, The Nature Conservancy; and Missouri NRCS/MDC/UMC (JS-BIOL-27) Temporary Forest Openings for Wildlife Job Sheet

Figures taken from: Missouri NRCS (IS-MO666cut) Controlling Undesirable Tree and Shrubs Informational Sheet; and Missouri NRCS (IS-MO666ctm) Crop Tree Management Conservation Practice Information Sheet.

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