SP 680

Professional Hardwood Notes
Technical Information on Hardwood Silviculture for Foresters

Treatments for Improving Degraded Hardwood Stands

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Popular sentiment is that the small trees in the lower canopy when released will become the large trees of tomorrow. This assumption has been perpetuated in the diameter-limit harvests that have led to what we call high-grading today. The largest and best trees are repeatedly harvested leaving the smaller, inferior trees to perpetuate the next stand. In reality, the trees being released are often of similar age as those being cut. The smaller, released trees did not have a chance to prosper in competition with the faster-growing, overstory trees. These released trees are incapable of continued growth with their small, spindly crowns. The consequence of removing only highly valued trees with each harvest is a hardwood resource with ever lower levels of economically valuable trees.

Degraded, low quality or problem hardwood stands generally result from the historic absence of markets for low-value trees. After many years of only harvesting the most valuable trees, millions of acres of degraded stands in the eastern hardwood region have few trees worth managing. These stands need silvicultural treatment to increase their value and productivity. Recent improvement in the markets for pallets, ties, chips and pulpwood increases the management options available for treating degraded stands.

Forest practitioners and landowners should understand why and how these problem stands were created so that fewer of these stands occur in the future. The goal of this publication is to explain why hardwood stands become degraded and to describe corrective measures for improving degraded hardwood stands.

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Degraded stand with fire-scarred trees and trees with poor form.

Degraded Hardwood Stands

Definition

The term "degraded" in this manuscript includes all low-quality and problem hardwood stands. As a

result of past practices, degraded hardwood stands usually contain trees that are crooked, rotten or diseased; are of undesirable species; are physically damaged from previous logging operations and are not growing at a satisfactory rate. Degraded stands also contain patches of too many or too few trees and regeneration of desirable species is lacking. Most importantly, degraded stands usually do not contain large volumes or numbers of desirable growing stock trees (Haymond and Zahner 1985). These degraded stands present great opportunities, but tough challenges for forest management (McGee 1982). The opportunity for improving these stands is considerable, as many acres now produce just a fraction of their potential.

It is assumed that usually, but not always, these stands have been repeatedly cutover and only the best trees removed. But degraded stands also occur on low-quality sites or as a result of fire, insects or disease. It is always important to determine "why" a stand is degraded. If the degraded stand occurs on a poor site, careful planning of treatment is recommended because there is little management that can improve tree growth on poor sites.

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Damaged trees usually do not improve with growth as shown by this fire-scarred yellow-poplar on a good site.

How Did These Stands Become Degraded?

A cause of degraded hardwood stands is repeated cuttings through practices (commonly called high grading, diameter-limit cutting or select cutting), where the best trees are harvested and previously described non-marketable and defective trees are left. Cutting only the largest and best trees removes those trees that are best suited for the site and leaves trees for growing stock that are less adapted to the site. Yet, repeated high grading with no stand improvement has progressively removed the best timber and left the stand in a degraded condition.

Most of these harvests are conducted for short-term economic gain, without consideration for the growth and composition of the growing stock that is left and regeneration of the future forest. Historically, the only markets available were for the best trees, which promotes high-grading. This type of cutting does not make provisions for the regeneration of many desirable species, especially oaks and hickories. The mostly undesirable, shade-tolerant species (blackgum, red maple, sugarberry, boxelder, hornbeam, sourwood and beech) in the midstory and understory prior to the harvest remain, suppressing the growth and development of desirable, regenerating species. However, with the expansion of markets for low-quality products, landowners will have more options for addressing degraded stands.

Many of these harvests were done in the name of good forest management (Ezell 1992). Landowners thought that the large trees were the older trees, so they removed them to give room for young trees to develop. We now know that small trees that are left are not necessarily young trees (Clatterbuck 2004) and that cutting the biggest and best trees out of a stand usually results in degraded stands.

Repeated harvesting entries into a stand usually result in damage to some residual trees from logging wounds. In addition to poor harvesting practices, fire, insects and disease, wind, ice, grazing and grapevines have degraded many trees in hardwood stands. What we find in many degraded stands today is a mosaic of degraded remnants left over from previous harvests, some regrowth of desirable species and a large proportion of shade-tolerant species that are undesirable for timber production (Ezell 1992). Often, stands have a patchy distribution of trees, including crowded conditions in some areas (overstocked) and sizable openings or widely spaced trees (understocked) in others (Nyland 2006).

Site quality is another cause of degraded stands. Some sites are so poor, they are not capable of growing good hardwoods. These sites might include the thin soils and droughty conditions found on exposed ridges and steep, south slopes. Typical species composition is blackjack oak, post oak, chestnut oak, eastern redcedar, Virginia pine and vacciniums. However, many degraded stands occur on medium- to better-quality sites. Better-quality stands can be regenerated on these sites (McGee 1982). In most cases, rather than representing the true potential of stands on these sites, the trees present are often a result of a combination of harvesting practices and other factors such as burning or grazing, and not just because the site is poor (Smalley 1982, McGee 1982, Haymond and Zahner 1985). Because of the presence of degraded trees on these sites, many landowners and practitioners infer that these sites are poor. However, with careful planning and harvest of poorer trees, these better sites can produce better stands of hardwoods.

Causes of Stand Degradation

1. High Grading or Diameter Limit Logging
   - Reduces stem quality
   - Reduces merchantable volume
   - May change species composition
   - Promotes canopy discontinuity
   - Changes diameter distribution
2. Grazing or Fire --- Increases rot and can reduce regeneration
3. Repeated Logging Entries --- Logging damage to residual trees and regeneration
4. Insects and disease, wind, ice storms and other factors

Bruce Kauffman

A degraded hardwood stand with oak decline.

In summary, degraded stands usually have the following features (Nyland 2006):

- few trees of desirable species, good vigor or good form remain as growing stock, limiting the future potential for volume and value growth
- the stand often has a patchy distribution of residual trees, resulting in incomplete site utilization and little control over understory development
- limited usable volume remains, making further cutting commercially marginal or infeasible
- few large seed trees remain, complicating attempts to establish a new cohort
- understory plants may dominate the understory, particularly in the more open areas, further challenging chances to regenerate new seedlings across the stand

Why Does the Problem of Degraded Stands Persist?

While some causes of degraded trees are controllable, the majority of degraded stands are not managed. The simple answer is that the landowners have little economic incentive to improve the stand (McGee 1982). Markets for degraded hardwoods are not generally available, and where they do exist, the income is marginal at best. More options are available to rectify a degraded situation when markets exist for small and low-value material.

Improvement of some severely degraded stands may require a cash outlay and the cost of removing poor trees may exceed the value of the stumpage. Many owners are reluctant or unwilling to invest in these stands. Often they feel that other investments may yield more certain results. Moreover, timber may be viewed as a one-time windfall rather than a long-term investment. Some owners, aware of the length of time and associated risk of forest investments, choose not to spend funds on these stands. Often, because they cannot properly evaluate the site potential and lack knowledge of stand management and markets, owners cannot properly evaluate the possible return on their investment (McGee 1982).

With degraded stands, three options for management are generally available: (1) rehabilitate the stand, (2) regenerate the stand, or (3) postpone action or leave the stand alone.

Assessing Degraded Stands (Adapted from: Ezell 1992)

1. Perform a forest inventory
2. Determine site quality
3. Determine stocking and distribution of desirable trees (AGS)
4. Consider species composition (desired vs. unwanted trees)
5. Estimate tree quality by considering tree form, potential tree grade and tree crowns of residuals
6. Evaluate regeneration potential through a regeneration survey, both desirable species and control of interfering vegetation
7. Estimate age of the stand
8. Determine objectives of management and markets

Unfortunately, leaving the stand alone is the option used too often, even on sites capable of growing quality timber. Rehabilitation of a degraded stand requires the measure of acceptable growing stock. If there is not enough growing stock to produce a new stand, then regeneration of the stand is necessary. Regenerating the stand often has the potential to create a better quality stand than what is currently on the site.

Corrective Measures for Degraded Hardwood Stands

Stand degradation can occur quickly, but usually develops over a long period following successive harvests and wildfire. Acceptable growing stock (AGS) refers to trees of commercial and desirable species that are capable of increasing in value and volume, and are or can become viable crop trees. Stands are not considered seriously degraded if they contain 30 to 50 ft^2 of basal area of AGS per acre. Degraded stands usually lack trees in the sawtimber size class. Thinning is usually not economically feasible in degraded stands because of the lack of growing stock. Thus to address degradation, treatments should increase growing stock either by rehabilitation of

the existing degraded stand or by regeneration. **The major key to deciding to rehabilitate or to regenerate is the measure of adequate growing stock**. The recognition and classification of AGS will often require professional assistance.

Determining a Course of Action

Degraded stands must be evaluated to determine the cause and the level of the problem, as well as their potential for value increases with treatment. McGee (1982) provides a useful checklist for evaluating and prescribing treatments for degraded and problem hardwood stands. Ezell (1992) and McGee (1982) base stand evaluation on six criteria: site quality, manageability of trees, culling of trees, desirability of the species, advance regeneration and stand age. Highly productive sites bring a higher return on investment, since the *site quality* is greater. The *manageability of trees* is determined by species, stem form and the ability to respond to silvicultural treatment based on crown position (dominant, codominant, intermediate, overtopped) and condition. Crown condition is evaluated on the fullness or size relative to expected size of a tree of that height and diameter. The estimated basal area (measure of stand density) of desirable trees feasible for future management is 30 to 50 square feet per acre or about 40 to 50 small sawlog-size trees per acre.

Trees to be culled may or may not be an asset to the stand. Although they may have little timber value, they may be desirable to wildlife and to potential regeneration through sprouting or seeding if they are of a preferred species. *Undesirable species* such as red maple, beech, blackgum, dogwood and others are usually shade-tolerant, taking growing space from more valuable species, or inhibiting regeneration, so they should be controlled. The amount and distribution of *advanced reproduction* and the seeding and sprouting of desirable species must be assessed to determine regeneration potential. The ability of residual trees to respond to silvicultural treatments is related to *age*: young, vigorous trees with balanced crowns have a greater capacity to respond to release than older trees approaching maturity.

The Decision to Regenerate

If a sufficient number of AGS trees are not present in the degraded stand, then the stand should be regenerated, because a new young stand

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Degraded stand with a few acceptable growing stock (AGS) trees.

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A diameter-limit harvest leaving white oak trees with little potential to increase in value. The second photo is of the same tree 15 years after the harvest. Note that the tree still retains surface defects (knots and branches) that degrades the stem. The tree grew 1.5 inches in diameter in fifteen years after release.

generally has the potential to create a better-quality stand. Methods of regeneration include clearcutting, patch clearcut, shelterwood and group selection. Most hardwood species can be regenerated by one, two or all three of these methods. The species likely to be present following the regeneration harvest will vary for each stand and will depend upon many factors including advance reproduction, seed and sprout sources.

Obviously, desirable species should be favored through pre- and post-harvest site preparation. Equally important is the determination of the unwanted species that might need to be controlled; simply harvesting degraded stands and allowing nature to take its course may not improve the stand composition. Midstory species such as maple, blackgum, dogwood and beech sprout prolifically, can be a problem and will need to be controlled (probably by herbicides).

Most species have specific pathways that promote successful regeneration. Yellow-poplar, sweetgum, black cherry and ash reproduce from seed; oaks and walnut from advance reproduction; and almost all small hardwood stumps will sprout to some degree. Recognizing the regeneration sources, regeneration methods, site productivity and the growth habit of each species and how they all interact in their associated competitive environments will assist in your assessment of site preparation needs for successful regeneration of the favored species.

While most hardwoods regenerate quickly and readily following some form of clear felling, one of our most favored groups, the oaks, presents special regeneration problems (Loftis and McGee 1993). For the oaks, advance reproduction (pre-existing seedlings from 1 to 4 feet tall) must be present or developed prior to the final harvest. Established advance reproduction gives oaks an initial advan-

tage over faster-growing species. Without advance reproduction, oak will probably not be a component of the new stand. Serious mistakes are often made assuming that small (less than 1 foot) oak seedlings will compete with faster-growing yellow-poplar, birch, ash and locust when released. On higher-quality sites, oak advance reproduction of sufficient size (greater than 4 feet) and number (60 to 80 per acre) must be cultured at least three to five years or more to increase the probability of becoming an overstory species (Stringer 2005). On poorer sites, oaks are much more readily regenerated, often from small stumps.

Regeneration of most degraded stands requires removal of overstory and midstory trees, usually through clearcutting. Otherwise, these trees will influence the growth and development of the regeneration. Ideally, the clearcut is achieved by a commercial harvest and no cash outlay is required of the landowner. However, many degraded stands may not contain enough timber value for the harvest to be profitable. Regardless, clearcutting is an efficient regeneration method to quickly remedy degraded hardwood stands. Fortunately, most degraded stands regenerate readily following clearcutting.

The Decision to Rehabilitate

Stand rehabilitation involves improving the existing degraded stand by (1) harvesting less desirable trees and retaining desirable growing stock, and (2) securing and protecting desirable regeneration in the open spaces. Nyland (2006) lists four steps that occur during the recovery of degraded stands when adequate growing stock is present.

- protect desirable residual trees or groups of trees by removing the poor and undesirable trees
- growth is concentrated on residual trees of AGS
- regeneration fills the spaces between the widely-spaced trees
- enhance desirable seedling reproduction and development success by controlling, with herbicides, interfering understory and midstory vegetation

The removal of less desirable trees provides more growing space for the residual trees. McGee (1982) calls this "sparse tree retention" and it leads briefly to two-aged stand structure (Stringer 2002) with a sparse, older age class and a regenerating age class. From a stand productivity perspective, the growth of the sparse trees can produce a quick return in 10 to 20 years (Miller et al. 2004). However, when sparse trees are harvested, damage is likely to occur to the 10 to 20 year developing hardwoods.

An advantage of rehabilitated stands with two-age structure is that regeneration of the stand occurs without clearcutting. Additionally, some future short-term income is generated from retention trees that otherwise would not be available if these trees were harvested. Development of higher-grade butt logs is possible through additional growth when retention trees are selected with the potential to increase in grade. Also, by leaving some larger trees on the site, sexual reproduction can still take place, providing seed for regeneration as well as mast for wildlife.

Conversely, rehabilitating stands does have several potential problems (McGee 1982). Trees selected for retention must have the ability to grow quickly into higher size and value categories. Epicormic branching may reduce the grade of these retained trees. In addition, trees must be logged

Silvicultural Treatments for Rehabilitation of Degraded Stands

1. Two-age management or deferment cutting or sparse tree retention
2. Site preparation techniques (either pre- or post-harvest) of clearcuts and deferment cuts to favor regeneration of desired species
3. Enrichment plantings (if prescribed) and control of undesirable species in the midstory and understory
4. Crop tree release of acceptable growing stock (AGS)
5. Adjusting harvest opening size to target advantageous conditions based on reproduction present, site-quality conditions and AGS
6. Consider mixed pine-hardwood stands on lower-quality sites

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Forked and poor quality trees remaining after repeated high-grading.

and culls controlled without physically damaging the retention trees. Many smaller trees must be cut, lopped and injected, which is usually done as an expense. Once these smaller trees are controlled, then the reproduction will have an opportunity to grow unhindered. As retention trees reach harvestable size, there must be a means to harvest these trees with minimal damage to the developing reproduction.

Rehabilitating degraded stands is not a panacea. It is a stop-gap treatment that provides some benefit while shaping the stand to be more productive in the future. Many degraded stands do not have enough desirable trees to make rehabilitation worthwhile. The decision to rehabilitate rather than regenerate should be based on an objective evaluation of available growing stock. If the rehabilitated stand can provide some income and logs in the future, the stand can be rehabilitated; otherwise, the stand should be regenerated. Regardless, rehabilitated stands will probably need to be regenerated in 10 to 30 years.

Choosing Other Options

Sites on upper slopes, ridges and eroded soils have inherently poor productivity and tend to slowly grow short-bodied hardwood trees. Many of these trees have been subjected to fire and occasional cutting, which has further degraded stand quality. These sites may be better managed for other uses such as wildlife habitat. Another possibility is mixed hardwood-pine stands where pine is planted at a wide spacing (perhaps 100 or more pines per acre) and natural hardwoods are allowed to grow between the pines (Clabo and Clatterbuck 2015). Pines are well-adapted to and grow at a faster rate than hardwoods on these poorer and drier sites. The attractiveness of this two-stage method is that the pine can provide an earlier income from thinning, while hardwoods grow for a longer time.

Many degraded hardwood stands on low productivity sites can also be converted to pine. However, control of hardwood competition can be costly.

Markets for degraded hardwoods can substantially reduce site preparation needs.

Action may be postponed or many degraded hardwood stands are left alone with some hope that they may improve. Degraded stands are not likely to improve much without treatment. A few trees per acre may increase in value, but the culls, damaged, poorly formed and undesirable trees will also continue to grow. A degraded stand today will, without some type of treatment, remain a degraded stand. Owners should carefully assess their property and determine the priority of degraded stands within their management goals.

Enrichment planting is a low-cost compromise between doing nothing and spending the time and money to completely harvest and regenerate the stand (Haymond and Zahner 1985). Where a certain species is sparse or absent, enrichment planting would allow the introduction of one or more desirable species without completely regenerating the stand. Competing vegetation in the vicinity of the planted seedling must be controlled for the planted seedling to prosper. Another method is to plant seedlings after complete vegetation removal (clear-cutting) to enhance a species that may not be part of the natural regeneration pool. Enrichment planting has been discussed by practitioners and researchers, but few trials have been conducted, especially in planting hardwood seedlings in a residual hardwood stand. Although recommendations can not be made based on research data, introducing pines in hardwood stands to create a diversified, mixed stand has been successful on medium- to low-quality sites (Clabo and Clatterbuck 2015).

Another alternative is to adjust management so only portions of the stand are treated with a prescription rather than treating the entire stand. This alternative is appropriate in targeted areas where stocking (AGS) is favorable or on better-quality sites. In these circumstances, methods to enhance individual tree development may be more positive than stand level treatments. Managing the size of openings is a means of providing regeneration to targeted areas within stands (LeDoux 1999). Crop-tree release (Mercker 2004; Stringer et al. 1988) can be particularly useful when focusing on individual trees.

Summary

Degraded hardwood silviculture is complex, due to the range of species, sites and level of degradation.

Factors That May Affect Degraded Stands

1. Stands with more than 50 square feet of basal area per acre of acceptable growing stock (AGS) are generally not considered degraded.

2. Normal thinning is generally not practical in degraded stands, but timber stand improvement (TSI) to remove unwanted trees may be. There is not enough AGS to justify a thinning. Regeneration harvesting and thinning are separate operations with different purposes. Thinning is an intermediate operation to promote residual trees. Regeneration harvesting is to initiate and develop reproduction.

3. Capital is usually limited for improving degraded stands. The costs and benefits of practices should be carefully considered. Dividing stands may be necessary because degraded stands often have areas that should be regenerated and areas where residual trees can be managed. It might be acceptable to culture portions of the stand rather than implementing treatments across the entire stand.

4. Generally treat high-quality sites first.

5. Stand regeneration is the better alternative than stand rehabilitation when AGS is not adequate.

6. Two-age methods are suggested for treatment of degraded stands in establishing viable and desirable regeneration as well as some potential increase in value of trees. Favored residual trees or groups of trees should be widely spaced with regeneration being promoted in the open spaces between trees.

7. Treatment of a tolerant, undesirable midstory and understory is usually necessary. Pre-harvest site preparation costs may be lower in hardwood stands than post-harvest activities.

8. On lower-quality sites, consider mixed pine-hardwood stands.

Degraded stands often result from mistreatment and neglect, but some poor stands result from natural causes. Most treatments that can be prescribed for improving the stand will result in better conditions and increased productivity, but come at a cost that may be a serious deterrent. Judging whether enough acceptable growing stock is present is key in determining whether to rehabilitate or to regenerate degraded stands. There is no perfect, one-size-fits-all method for success. Individual stand conditions must be assessed and techniques applied that would bring the stand closer to conditions favorable for producing desirable trees, while keeping costs at a minimum. Most landowners desire to do something environmentally positive to return degraded stands to more favorable conditions. Stand rehabilitation, where appropriate, and regeneration, where necessary, will set the stage for a gradual stand recovery.

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Regeneration Potential Recommendations for Degraded Stands

Species	Acceptable				Unacceptable	
Stem Quality	**Good**		**Poor**		**Good/Poor**	
Vigor/Age	**Vigorous/Young**	**Poor/Old**	**Vigorous/Young**	**Poor/Old**	**Vigorous/Young**	**Poor/Old**
Regeneration Potential **Adequate** Present	Complete regeneration possible Concentrate site preparation for regeneration on unwanted overstory and midstory trees OR Culture sparse overstory trees	Complete regeneration required in near future Concentrate site preparation on overstory and midstory trees	Complete regeneration required Concentrate site preparation for regeneration on unwanted overstory and midstory trees		Complete regeneration required Concentrate site preparation for regeneration on unwanted overstory and midstory trees	
Regeneration Potential **Currently Inadequate** Present, but in need of culturing to become adequate	Postpone harvest Use midstory removal. If harvest is required, leave groups of overstory trees Concentrate site preparation for regeneration on competing understory vegetation		Postpone harvest Use midstory removal If harvest is required, leave groups of overstory trees Concentrate site preparation on competing overstory and midstory trees	Postpone harvest Use midstory removal If harvest is required, concentrate site preparation on overstory and midstory trees	Postpone harvest. Use midstory removal to culture regeneration If harvest is required, concentrate site preparation for regeneration on overstory and midstory	
Regeneration Potential **Inadequate** Not present	Postpone harvest Culture spare overstory until adequate regeneration is established If harvest is required, consider leaving groups of overstory trees	Complete regeneration required Consider complete or partial artificial regeneration (species enrichment, mixed pine/ hardwood, or complete pine conversion)	Postpone harvest Retain poor - formed overstory as a seed source for regeneration If harvest is required, consider leaving groups of overstory trees	Complete regeneration required Consider complete or partial artificial regeneration (species enrichment, mixed pine/ hardwood, or complete pine conversion)	Complete regeneration required Consider complete or partial artificial regeneration (species enrichment, mixed pine/ hardwood, or complete pine conversion)	

Source: Adapted from Dr. Jeff Stringer, Dept. of Forestry, University of Kentucky

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