United States
Department of
Agriculture

Forest Service

Southeastern Forest
Experiment Station

General Technical
Report SE-76

Guide to Regeneration of Bottomland Hardwoods

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Acknowledgments

The author thanks Dr. John D. Hodges of Mississippi State University, Dr. Jacqueline L. Haymon of Clemson University, and Dr. John Toliver of the U.S. Department of Agriculture, Forest Service for their comments and suggestions regarding the regeneration methods described in this manual.

September 1992

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Introduction

Efforts to regenerate or restore bottomland hardwood forests sometimes fail. Good planning greatly increases the likelihood that such projects will succeed. Effective silvicultural planning involves:

(1) Interpretation of site characteristics.
(2) Selection of appropriate species.
(3) Selection of appropriate regeneration methods.

This guide identifies the site factors that most strongly influence the success of bottomland hardwood regeneration and explains how the private landowner can evaluate a site's potential for producing bottomland hardwoods. It describes and explains methods that can be used to regenerate desirable hardwood species on bottomland sites.

Interpretation of Site Characteristics

Hydrology and soil characteristics largely determine whether sites are suited to produce bottomland hardwoods. Hydrology–when, how often, for how long, and to what depth water covers the site–strongly affects the site's suitability for bottomland hardwoods. It also determines which hardwood species will be most productive on the site and should influence the landowner's choice of regeneration methods. Soil characteristics affecting the growth of bottomland hardwoods include fertility, texture, and structure. Together with site topography and hydrology, these characteristics control soil moisture, soil aeration, and nutrient availability.

If the landowner is not familiar with the site's hydrology, then he or she should consider delaying regeneration for a year or two to observe it. One can assess site wetness by digging holes during the wet season (usually winter) and measuring the depth to the water table. If the water table is less than 18 inches below the surface of the soil the site is considered wet; if it is between 18 and 24 inches below the surface the site is considered moderately wet; and if it is more than 24 inches below the soil surface the site is considered dry for bottomland hardwoods. Some heavy clay soils appear not to have a water table but are extremely wet in winter and dry in summer. Soil color and mottling sometimes indicate depth to the wet-season water table. Dark soil colors (especially dark grays) as opposed to light bright soil colors (such as oranges and yellows) indicate wet sites. Depth to mottling (spots or patches of color different from the dominant soil color) often indicates the location of the seasonal high water table. If regeneration cannot be delayed so the landowner can assess site wetness by direct observation, then information about site elevation–a fair guide to site hydrology–can be obtained from topographic maps prepared by the U.S. Geological Survey. County Extension Agents can help landowners find information about local site elevation.

Soils suitable for bottomland hardwoods range from well-drained loams to poorly-drained clays. However, even well-drained sites are moist and may be flooded during the dormant season. Most hardwoods prefer moist but well-drained fertile soils such as alluvial soils in river bottoms. Winter flooding replenishes the nutrient supply, but many hardwoods cannot tolerate growing-season flooding that lasts longer than a few weeks. Information about soil fertility, drainage class, seasonal high water table, and general suitability for various forest types can be obtained from USDA Soil Conservation Service soil survey maps. There is a soil survey map of each county in the Southeast, and these maps are normally available from County

Extension Agents or County Foresters. County Agents can even arrange to have soil samples tested to help landowners assess site fertility and soil texture.

Present and past land use may indicate whether a site is suitable for production of bottomland hardwoods. If a site supports desirable hardwoods now, this usually indicates that the potential for regeneration or restoration is good. However, if the site's hydrology has changed since the present stand was established, it may be impossible to produce a new stand that will be similar to the existing one. Old fields and recently cut-over sites must be evaluated closely. Sites on flats and ridges in the floodplains of rivers or streams can usually support desirable bottomland hardwood species. In general, sites that are droughty throughout the growing season, sandy, and inherently infertile are not likely to support vigorous stands of bottomland hardwoods.

Selection of Appropriate Species

Once depth to the seasonal high water table, fertility, and drainage have been determined, individual hardwood species can be selected on the basis of site suitability and the landowner's objectives.

Soil type and hydrology ultimately determine which species will be successful on a given site because subtle differences in drainage and fertility will favor one species or species mix over others. For example, a site that is flooded for long periods during the growing season will support only cypress and hardwoods that are most flood tolerant. However, it should be understood that all sites are unique and that there can be much genetic variation within individual species. County Extension Agents and County Foresters can provide local expertise that cannot be provided in a general guide.

The following tabular guide (adapted from Kennedy 1990) provides information on species flood tolerance. Those who use this guide must take into account that tolerance to flooding depends not only on duration and season of flooding but also on depth of flooding and number of flooding events each year.

Continuous flooding		Periodic flooding		
January–June	January–May	January–May	January–April	January–March
Cypress	Green ash	Sweetgum	Sawtooth oak	Shumard oak
Overcup oak	Nuttall oak	Water oak	Sycamore	Cherrybark oak
Water hickory	Persimmon	Willow oak	Cottonwood	Swamp chestnut oak
Water tupelo	Water tupelo	Nuttall oak	Sweet pecan	Nuttall oak
Swamp tupelo	Swamp tupelo	Green ash	Nuttall oak	Green ash
	Red maple	Swamp tupelo	Green ash	Swamp tupelo
		Red maple	Swamp tupelo	Red maple
			Red maple	

–Adapted from Kennedy 1990

Site fertility and genetic differences within species can influence the ability of trees to tolerate flooding. High levels of fertility can occasionally compensate for poor drainage. We cannot know exactly how long individual trees or species will survive a given flooding event, but the more flood tolerant a species is, the longer individuals of that species can survive a flooding event and subsequent flooding events.

Baker and Broadfoot (1979) have developed a field method of evaluating sites for production of commercially important southern hardwoods. Their manual is easy to use, covers 14 southern hardwood species, and requires little knowledge of soil science. It was originally designed for use in the Southern Mississippi Valley, but is generally applicable to the Southeastern Coastal Plain. The manual is available from the Southern Forest Experiment Station, New Orleans, LA.

The desirability of tree species depends on the goals of the landowner. Oaks are quite valuable both as a commercial timber species and as producers of mast for wildlife. Hickories are also valuable to wildlife but are less valuable as sources of timber and pulp. Both swamp and water tupelo are utilized by many nongame wildlife species. Green ash is a very valuable timber species but has little value for wildlife. Sweetgum, which is often found growing with red oaks, is fairly important commercially.

The commercial value of many timber species varies with local market conditions. If commercial value of the timber is the most important factor in species selection, the landowner should study local market conditions before taking steps that favor some species and groups of species at the expense of others. However, current conditions may not be the best guide to conditions 60 years in the future. The County Agent or County Forester

should be able to provide some information about long-term market trends. Historically, there has been strong demand for red oaks from the bottomlands and baldcypress from the swamps.

Selection of Regeneration Methods

Once it has been determined that a site is suitable for production of bottomland hardwoods and a preferred species mix has been selected, some plan for regeneration must be made. Even if the site is currently dominated by the desired species, there is no guarantee that seedlings of that species will regenerate and grow into dominant positions in the future stand. However, steps can be taken to improve the chances that desirable seedlings will survive.

Options for regeneration may depend on the current status of the site. It may be necessary to plant or direct seed old agricultural fields if they are large and the distances to seed sources great. On the other hand, mature or overmature stands of desirable species can be harvested and naturally regenerated in ways that promote the growth and survival of desirable reproduction. Where stands have been high-graded or are made up mainly of undesirable species, enrichment plantings 1 to 3 years prior to harvest may be successful.

The following key and the flow chart (fig. 1) can help the user select an appropriate regeneration method. The key presents pairs of numbered statements. The user decides which statement in the first numbered pair best describes the site and is directed either to the number 2 statements or to the number 10 statements. The user then makes another choice and is directed to another pair of statements. Eventually, the user is directed to a numbered regeneration method on a specific page. The flow chart is a simplified version of the key. It too directs users to the numbered regeneration methods. A PC (personal computer) version of the key is available from David Gartner, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, 2730 Savannah Highway, Charleston, SC 29414.

Key to Site Regeneration Methods for Bottomland Hardwoods

1. Site is cleared and currently nonforested. Go to 2
1. Site currently supports a mature, overmature, or poor quality hardwood stand. Go to 10

2. Adequate advanced reproduction is present (200-500 desirable seedlings per acre). Go to 3
2. Adequate advanced reproduction is not present. Go to 4

3. Reproduction is small (< 4.5 ft), or being suppressed by competition. Go to 9
3. Reproduction is large (> 4.5 ft), or most stems are free to grow, or both. No treatment needed

4. The site is an abandoned agricultural field Go to 5
4. The site is a recent clear cut. Go to 6

5. Oaks are preferred. Method 1, Page 12
5. Oaks are not preferred. Method 2, Page 13

6. The site is not clogged with logging debris, cull trees, undesirable saplings, or vines. Go to 7
6. The site is clogged with logging debris, cull trees, or advanced reproduction of undesirable species. Go to 8

7. Oaks are preferred. — Method 3, Page 13
7. Oaks are not preferred. — Method 4, Page 13

8. Oaks are preferred. — Method 5, Page 14
8. Oaks are not preferred. — Method 6, Page 14

9. Competition consists of grasses and herbaceous plants, as in an old field. — Method 7, Page 14
9. Competition consists of vines and undesirable woody seedlings and saplings. — Method 8, Page 15

10. Adequate numbers of large desirable seedlings are present (200-500 seedlings > 4.5 ft per acre). — Go to 11
10. Adequate numbers of large desirable seedlings are not present. — Go to 13

11. Timber production is the landowner's most important goal. Esthetic values and maintenance of the current wildlife habitat are less important. — Method 9, Page 15
11. Esthetic values and maintenance of the current wildlife habitat are as important as timber production. — Go to 12

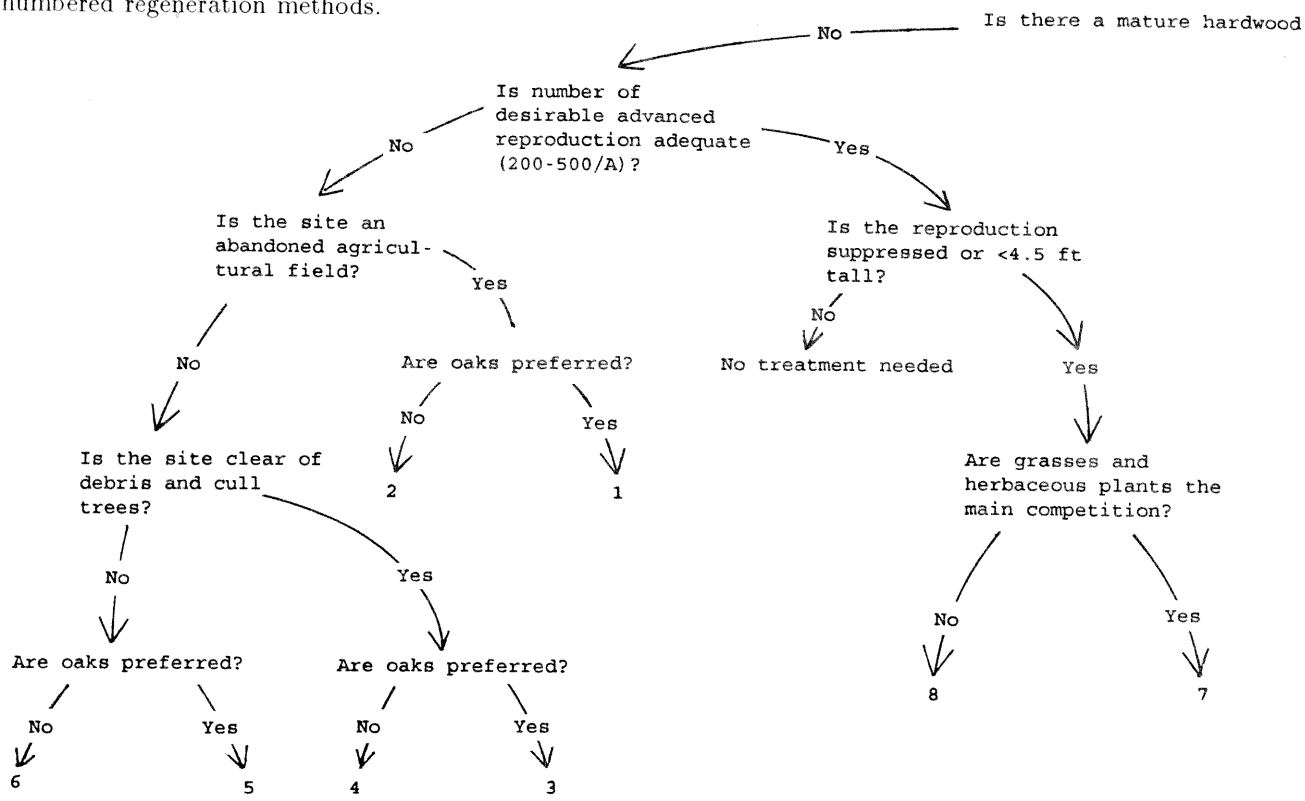
12. There are some trees of desired species in all diameter classes from 3 in to 12 in, as would be expected in an uneven-aged stand. — Method 10, Page 15
12. Diameter distribution of desirable species is irregular or most trees are in the same diameter class. — Method 11, Page 16

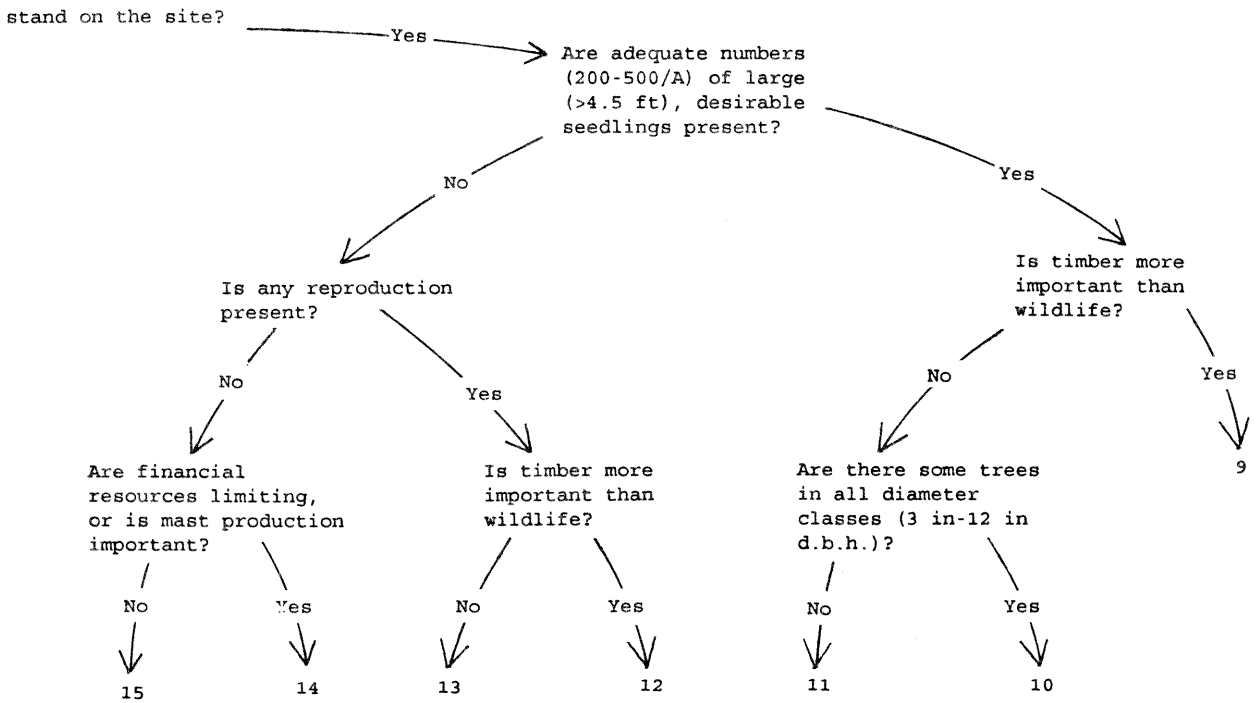
13. Advance reproduction of desirable species is plentiful but is small or overtopped by more vigorous vegetation. Go to 14
13. Adequate numbers of desirable seedlings or sprouts are not present. Go to 15

14. Timber production is the landowner's most important goal. Method 12, Page 17
14. Esthetic values and maintenance of wildlife habitat are as important as timber production. Method 13, Page 17

15. Financial resources are limited or wildlife habitat and mast production are important. Method 14, Page 18
15. Timber production, and particularly production of oak, is the landowner's priority goal. The landowner has sufficient funds to invest in artificial regeneration. Method 15, Page 19

Figure 1–Flow chart for key to numbered regeneration methods.




stand on the site?
Yes
Are adequate numbers (200-500/A) of large (>4.5 ft), desirable seedlings present?
No
Yes
Is any reproduction present?
No
Yes
Are financial resources limiting, or is mast production important?
No
Yes
15
14
Is timber more important than wildlife?
No
Yes
13
12
Is timber more important than wildlife?
No
Yes
9
Are there some trees in all diameter classes (3 in-12 in d.b.h.)?
No
Yes
11
10

Regeneration Method 1

–After disking or spraying with post-emergent herbicide to control weed competition, plant seedlings or direct seed with acorns.

Planting. Plant 200 to 500 seedlings per acre depending on the expected level of competition from other vegetation. The more competition you expect, the more seedlings you should plant. Seedling size and quality are very important; the seedlings should have root-collar diameters of at least 1/4 in, 12- to 18-in tops, and 8-in tap roots with at least five good-size lateral roots attached.

The landowner who wants trees to capture the site more rapidly and who wants accelerated cash flow can consider planting a nurse crop several years before planting seedlings of the desired hardwood species. Such a nurse crop consists of fast-growing shade-intolerant trees like loblolly pine, cottonwood, or sycamore; the nurse trees shade out competition and limit the growth of less desirable trees. Five years after the nurse trees are planted at a wide spacing, the hardwood seedlings that will form the main crop are interplanted under them. The landowner can harvest the nurse crop as pulpwood 10 to 15 years later, releasing the hardwood saplings. This technique has not been tested fully but is based on widely accepted principles of forest succession on old fields. However, results will depend very much on site conditions and may not always be satisfactory.

Direct seeding. Oak species that produce larger acorns are the best candidates for direct seeding. Direct seeding works best with acorns of Nuttall oak and is progressively less successful with those of water, willow, and cherrybark oaks. Acorns should be planted 2 in deep and at spacings of from 3 ft x 10 ft to 2 ft x 15 ft (about 1,500 acorns per acre). Sow only one seed per planting location. If weedy competition is heavy, it may be necessary to mow or disk again later in the growing season. Direct seeding is usually less expensive

than planting seedlings, but squirrels and other rodents will consume some of the planted acorns. Disking or mowing treatments may be expensive, but can be critical to the survival of the seedlings where severe competition (Johnson grass, heavy vines) is a problem. On such sites, the high cost of controlling competing vegetation may make direct seeding inappropriate. Direct seeding is unlikely to give good results in areas smaller than 2 acres. Animals frequently consume large percentages of seed sown in small clearings, and large proportions of small clearings can be shaded by surrounding trees.

Regeneration Method 2

–Plant 200 to 500 seedlings of the desired species per acre. Planting may be followed by one or two disking treatments depending on the level of competition during the first growing season, but disking may not be needed on all sites or for all species. Direct seeding with pecan and hickories will also work here.

Regeneration Method 3

–Direct seed acorns or plant seedlings as in Method 1. Plant in clear spots away from stumps and competing saplings. Deaden culls and undesirable saplings by injecting them with herbicide. After leafout in the spring, spray competition with herbicide or cut stems manually. Note that cut stems will resprout vigorously. Chemical and manual control of undesirable species is expensive and is not always necessary for successful establishment.

Regeneration Method 4

–Plant seedlings of the desired species as in Method 1. Deaden culls and undesirable saplings by injecting them with herbicide. After leafout in the spring, spray competition with herbicide or cut stems manually. Note that cut stems will resprout vigorously.

Regeneration Method 5

–First, unless the fuel load is insufficient to carry fire or the site is too wet to permit burning, burn during the summer to get rid of debris and to kill back some of the competition. Bushhogging, rotary drum chopping, or heavy disking can be as effective as controlled burning. Inject culls and undesirable saplings not killed by fire or other treatments and spray other competition that resprouts. Plant seedlings as in Method 1. If the root systems of oak seedlings are small in comparison to tops (< 1/3 the height of the shoot), clip the tops back to within about 1 in above the root collar. The seedlings will resprout and the sprouts will be more vigorous than the original tops. Direct seeding (see Method 1) is a practical possibility only if competition from undesirable species will not be heavy and only if the area to be treated is larger than 2 acres.

Caution–Prescribed burning requires knowledge, preparation, and great caution. Burning should be conducted only under the supervision of knowledgeable persons and with the approval and cooperation of appropriate fire suppression agencies.

Regeneration Method 6

–Fell or inject culls. Inject or spray undesirables to reduce competition. Seedlings can be planted as in Method 1. Green ash and most other hardwood seedlings can be clipped back in the same way oak seedlings are clipped (see Method 5). Direct seeding (see Method 1) is an option.

Regeneration Method 7

–Do nothing unless competition is quite severe (Johnson grass, heavy vines). If the seedlings are in rows, disk or mow between rows to control competition. Otherwise, spray around the seedlings with herbicide, protecting the seedlings with some kind of barrier. A light burn in late fall provides some control of herbaceous vegetation and is less expensive than disking or spraying. A burn kills some desirable seedlings, but other desirable seedlings resprout with increased vigor. Some perennial weeds resprout following controlled burning.

Caution–Prescribed burning requires knowledge, preparation, and great caution. Burning should be conducted only under the supervision of knowledgeable persons and with the approval and cooperation of appropriate fire suppression agencies.

Regeneration Method 8

–Apply herbicide to woody competition and vines, injecting larger stems and spraying smaller ones. Sever stems manually if herbicide use is unacceptable. A controlled burn in late fall can be used to topkill all seedlings if the site is dry enough to carry a fire. However, all surviving seedlings–including the undesirables–will resprout.

Caution–Prescribed burning requires knowledge, preparation, and great caution. Burning should be conducted only under the supervision of knowledgeable persons and with the approval and cooperation of appropriate fire suppression agencies.

Regeneration Method 9

–Clearcut the site, felling all overstory trees and poles of desirable species and felling or injecting all other overstory trees and poles. Birds of prey will benefit if occasional dead snags are left standing. If most desirable reproduction is at least as tall as the competing vegetation, no further treatments are necessary. Otherwise, fell undesirable saplings with a chainsaw or deaden them by herbicide injection, and spray or manually sever smaller woody competition and vines.

Regeneration Method 10

–An uneven-aged stand exists and can be maintained by the group selection method. Individual trees of undesirable species or poor quality should be cut or injected. Thinning may be appropriate for dense groups of desirable saplings or poles. Poles with the potential to become high-quality crop trees should not be cut. Where undesirable, rough, or overmature trees stand over desirable reproduction, 1/2-acre to 3-acre openings should be

created. All or virtually all trees in such areas should be felled so that existing reproduction can develop and new seedlings can become established. Den trees and other trees especially valuable to wildlife can be retained, however.

The key here is to treat groups of trees. Where regeneration is needed, openings should be made. Where trees need to be thinned or released, this should be accomplished. Economically mature trees can be cut for timber. The idea is to apply needed treatments while always favoring trees with the greatest potential value. This process should be repeated every 5 to 7 years.

Caution–Any opening up of the stand canopy may result in epicormic branching, which can reduce the commercial value of the residual trees. Wherever possible, cuts should be planned so that high-value trees are not left exposed on the edges of openings.

Regeneration Method 11

–A balanced uneven-aged stand can be created by means of patch clearcutting or group selection. Because the initial diameter distribution of desirable species is poor, it will take at least 25 years to restructure the stand.

Small patch clearcuts (3 to 5 acres) can be made throughout the stand every 5 to 7 years. At each cutting, from one-seventh to one-fifth of the total area of the stand is regenerated. When the entire area has been cut over once, an approximately balanced uneven-aged stand consisting of relatively uniform patches of trees in 5 to 7 age classes will have been created. The youngest trees will be new seedlings and the oldest 25 years of age. The landowner can now begin thinning work in the areas that were regenerated first to increase the growth of the best trees.

Group selection (see Method 10) can produce similar results over 25 to 35 years. The advantage of group selection is that existing trees with good potential can be retained and grown to financial maturity. The biggest advantage of patch clearcutting is its simplicity of application.

Caution–Group selection cutting and patch clearcutting expose the boles of trees around regenerated areas to more sunlight. Increased exposure to sunlight can cause previously clear portions of affected boles to produce new branches (epicormic branching). Epicormic branching can reduce the commercial value of trees significantly. Trees in younger and more open stands may not sprout as prolifically as those in older stands with fully closed canopies.

Regeneration Method 12

–Release the existing regeneration by removing undesirable midstory and understory vegetation by injection, by spraying, or by severing the stems manually. Use of herbicides will inhibit sprouting. Removal of undesirable midstory and understory vegetation will create a better light environment for desirable reproduction. If desirable seedlings are of poor form and vigor, they can be severed near the groundline and allowed to resprout. The new sprouts will have good form and vigor and will often grow taller than unsevered reproduction within 3 years. When the majority of desirable seedlings are large enough (usually in 3 to 5 years), clearcut the site.

Regeneration Method 13

–Release existing oak regeneration by removing undesirable midstory and understory vegetation. This can be accomplished by injection, by spraying, or by severing stems manually. Use of herbicides will inhibit sprouting. Then perform from one to three intermediate shelterwood cuts that remove overstory culls, undesirables, and suppressed trees. Each intermediate cut should reduce stocking density to about 40 percent of the original value. These cuts can be made at 2- to 10-year intervals depending on the growth

of the regeneration and the landowner's goals. The last intermediate cut is followed by a final cut that removes the mature or overmature overstory and releases the oak reproduction. Such a program keeps mature mast-producing trees on the site while providing for their eventual replacement by other oaks.

Group selection cutting or patch clearcutting can be substituted for shelterwood cutting but should not be initiated until advanced oak reproduction is large enough (4.5 ft in height) to compete successfully with other vegetation when released from overhead shade. If the site varies in quality and desirable reproduction is growing at different rates in different places, groups of trees can be harvested as the reproduction growing beneath them reaches 4.5 ft in height.

Caution–Any opening up of the stand canopy may result in epicormic branching, which can reduce the commercial value of the residual trees. Wherever possible, cuts should be planned so that high-value trees are not left exposed on the edges of openings.

Regeneration Method 14

–First, try to determine why there is a lack of advanced reproduction (seedlings and saplings) on the site, particularly if the desired species are a major component of the overstory.

The canopy may be too dense to permit enough light to reach the forest floor, particularly if midstory and understory vegetation is heavy. If this is the case, opening up the canopy and thinning out the midstory and understory (see Method 13) may be enough to get desirable regeneration established. Site hydrology may have changed since the trees composing the mature stand were established. Flooding may now be too deep or too frequent to allow adequate time for germination and seedling establishment. Frequent flooding may also remove acorns from the site. If a change in hydrology is the problem, it

may be more appropriate to plant seedlings of swamp tupelo, water tupelo, or baldcypress, the species best adapted to wet conditions. Large populations of feral hogs sometimes consume mast crops before the seeds can germinate. If feral hog numbers are reduced, then acorn crops may be sufficient to produce large numbers of seedlings. Once established, oak seedlings can be released by the methods already described. If undesirable trees also produce large seed crops, these trees should be removed in shelterwood cuttings.

Regeneration Method 15

–The landowner has three options in this situation.

1. *Enrichment underplanting with oak seedlings.* From 300 to 500 seedlings per acre are planted under the existing tree cover. Because these seedlings survive and grow only if they receive adequate light, the stand must be relatively open. It may be necessary to remove undesirable understory and midstory vegetation and to fell or deaden overstory cull trees and undesirables. When most of the planted seedlings have reached a height of 4.5 feet, the overstory can be removed. At that time, all nonmerchantable timber should be felled or deadened by injection. The oak reproduction must be kept free to grow for at least the first year following removal of the overstory. Competition can be sprayed or cut manually. The cost of purchasing and planting seedlings and keeping them free to grow may be less than the cost of site preparation, sowing, and competition control associated with direct seeding with acorns. Enrichment underplanting with seedlings can increase the oak component of a hardwood stand, but the landowner should understand that it will not produce a pure stand of oak.

2. *Direct seeding with acorns after clearcutting.* On many sites, it will be possible to employ planting machines only after extensive shearing or rotary drum chopping with heavy equipment. On other sites, use of planting machines will not be possible. Manual seeding

requires little site preparation. A prescribed burn, if there is enough dry fuel to carry the fire, will improve access and visibility for planting and provide early competition control. It may be necessary to disk, mow, or spray with herbicides for several years after planting to enable the oak seedlings to reach a free-to-grow state. Areas to be seeded should be larger than 2 acres; rodents consume high proportions of acorns sown in smaller openings. Because animals frequently destroy many of the acorns sown in forest areas–especially forest areas with large populations of rodents or feral hogs–direct seeding prior to clearcutting is not encouraged. If competition control treatments are required, direct seeding is costly. However, direct seeding alone is less expensive than planting seedlings.

Caution–Prescribed burning requires knowledge, preparation, and great caution. Burning should be conducted only under the supervision of knowledgeable persons and with the approval and cooperation of appropriate fire suppression agencies.

3. *Establishment of a hardwood plantation using seedlings.* The site is clearcut and all unmerchantable timber is removed. Shearing or drum chopping treatments and controlled burning are used to prepare the site, which is then planted with high-quality seedlings. Competition is controlled mechanically or with herbicides until the planted trees have reached a free-to-grow state or until the crown-interlock stage has been reached. Nitrogen and phosphorus fertilizers may be required depending on site fertility. Establishing a hardwood plantation by planting seedlings is costly; it may not be economical.

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McKevlin, Martha R. 1992. Guide to regeneration of bottomland hardwoods. Gen. Tech. Rep. SE-76. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 35 pp.

This guide will help landowners, consulting foresters, and public service foresters regenerate bottomland hardwoods. It discusses (1) interpretation of site characteristics, (2) selection of species, and (3) selection of regeneration methods. A dichotomous key for selection of appropriate regeneration methods under various conditions is presented.

KEYWORDS: Site characteristics, dichotomous keys, oaks, green ash.

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