Natural Reproduction Methods for Hardwood Regeneration

Figure 1. A white oak shelterwood in northern Arkansas. Excellent white oak regeneration has been established.

Introduction

Some common points of confusion in regenerating hardwood stands center on a lack of knowledge regarding silvicultural systems and methods. While sometimes considered unimportant, understanding what a silvicultural system is ensures that forest managers have a shared foundation when prescribing management techniques. Various silvicultural systems and reproduction methods should be defined to ensure that their implementation achieves the desired management goals without unexpected outcomes (Figure 1).

A silvicultural system is a planned program of treatments extending throughout the life of a stand, including regeneration, intermediate treatments, and appropriate protection measures. A reproduction method is the process used to establish a stand. Reproduction methods are categorized as even-aged, two-aged, or uneven-aged.

Even-aged methods regenerate a stand with reproduction of the same age class, where seedlings are established within 20 percent or less of the rotation length. Even-aged methods (clear-cut, seed-tree, and shelterwood) are considered the most successful for regenerating hardwood stands due to the greater knowledge and experience of stand development associated with these methods. Two-aged methods result in stands with two age classes. Uneven-aged methods regenerate stands with at least three age classes. Single-tree and group selection methods have a history of misuse and are often discouraged in hardwood management because managing shade-intolerant species like oak is complicated and difficult. However, increasing attention is being given to uneven-aged methods as knowledge of these practices grows. The following sections describe each reproduction method, including its application and variations for hardwood management.

Clear-Cut Method

Overview

The clear-cut reproduction method involves the removal of all trees in a stand during a single harvesting operation (Figure 2). Future natural regeneration will either come from seeds buried in or lying on the forest floor before harvest, or from seeds deposited onsite after harvesting. Regeneration from advance regeneration (1- to 4-foot-tall seedlings with well-established root systems existing before harvest) is considered a product of the shelterwood method, while root and stump sprouts are considered products of the coppice method (both described later). Regardless of the form of regeneration, the new stand will be even-aged and undergo canopy stratification over the first 10 to 20 years of the rotation. Ecologically, clear-cutting is a major disturbance and closely mimics major wind events such as hurricanes and large tornadoes. However, clear-cuts differ by lacking the pit/mound topography associated with windthrown trees, the tree boles removed during use, and the snags left by wind-snapped trees.

Clear-cutting favors the development of shade-intolerant, light-seeded species that require bare mineral soil for germination, such as eastern cottonwood, black willow, American sycamore, green ash, and yellow-poplar. Moderately shade-tolerant and shade-tolerant species can become established before harvest. These species include oaks, hickories, ashes, maples, elms, beech, and other shade-tolerant species. Clear-cutting favors these species if they are present as large advance regeneration before harvest.

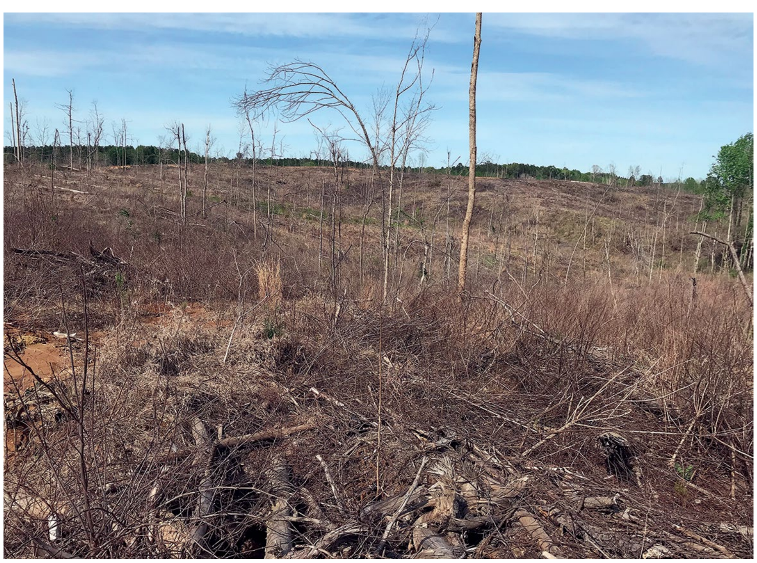

Figure 2. A clear-cut in northern Mississippi.

The clear-cut reproduction method is a straightforward operation. In general, two types of clear-cuts are recognized. Complete clear-cuts involve felling all trees greater than 1 inch in diameter at breast height (DBH) (diameter at 4.5 feet above ground level). Full sunlight, along with a complete lack of competition for water and nutrients, is available to the new, developing vegetation. Commercial clear-cuts involve the removal of only merchantable trees. Without instruction, logging contractors often leave trees of poor form, unmarketable species, or those outside the limits of merchantability standing on-site. While commercial clear-cuts have greater vertical and horizontal structure compared to complete clear-cuts, residual stems interfere with the development of desirable regeneration. Often, these residual trees are controlled during chemical site preparation or are felled by logging equipment during harvesting.

Advantages of the Clear-Cutting Method

- In some instances, clear-cutting has proven successful in regenerating hardwoods.
- Clear-cutting can maximize short-term economic returns for landowners.
- Clear-cutting provides the sunlight required for growth and development of moderately shade-intolerant to shade-intolerant species.
- Clear-cutting aids tree development through the effects of desirable competition.
- Clear-cutting favors early-successional plant and animal species.
- Clear-cutting may improve water quality by enhancing sediment deposition.

Disadvantages of the Clear-Cutting Method

- Clear-cutting reduces horizontal and vertical structure for wildlife.
- Clear-cutting creates a lack of aesthetically pleasing appearance.
- Clear-cutting produces inconsistent results in achieving adequate desirable natural post-harvest regeneration.
- Clear-cutting leaves no provision for natural regeneration in the event of seedling crop failure.
- Clear-cutting creates a lack of hard mast production for at least 20 years.
- Thirty to 40 years must pass before trees are large enough for economic returns.
- Clear-cutting displaces wildlife species that require mature stand conditions.

Application

Although often not appropriate, the clear-cut method is the most widely used method of regenerating hardwood stands. Typically, no provisions are made to ensure adequate sources of regeneration before harvesting. However, when implemented carefully, this method can successfully regenerate many hardwood species.

Using the clear-cut reproduction method to favor light-seeded species such as eastern cottonwood or black willow is risky because it relies on floodwaters or wind for seed distribution from nearby or distant sources. Success has been achieved using clear-cutting combined with intensive site preparation to remove all downed coarse woody debris during eastern cottonwood regeneration efforts. This approach is necessary to maximize bare mineral soil exposure for eastern cottonwood seed germination and seedling development. Floodwaters are essential but unpredictable for distributing eastern cottonwood seed and depositing silt, although seed viability diminishes during prolonged flooding.

Floodwater can also disseminate green ash and American sycamore seeds in some systems, but clear-cutting remains a more reliable method for regenerating these species. Both species can regenerate through advance regeneration, as well as from stump sprouting or wind dissemination. In all cases, pre-harvest regeneration evaluations should be conducted to ensure adequate stocking or sprouting potential is present before harvest.

If yellow poplar is the desired species, the clear-cut reproduction method has proven to be effective. Naturally, yellow poplar must be present in the overstory before harvesting. If present, an adequate supply of seed is often buried in the forest floor and remains viable for up to 7 years. Harvesting scarifies the forest floor, exposing mineral soil required for yellow poplar germination.

The clear-cut reproduction method can also regenerate heavy-seeded species, such as the oaks and hickories. However, conducting a regeneration evaluation before harvesting is essential to determine if adequate stocking of the desired species is present. If adequate stocking is present, then a clear-cut operation may be considered. Harvesting should take place during the dormant season (November through early March) when dry conditions prevail. This maximizes sprouting potential and provides the best opportunity to use the current year's seed crop. Ideally, mechanical shearing residual stems after clear-cutting yields the best results. This process cuts all residual stems at ground level, encouraging stump sprouting. Harvesting during the growing season reduces sprouting potential because stored food reserves in the root system are at a minimum.

If adequate advance reproduction is absent, steps must be taken to establish and develop regeneration before harvesting. Steps in this process may include:

- Wait until advance regeneration establishes and/or develops to an appropriate size before harvesting;
- Reduce competition, especially if midstory shade-tolerant species are present; or
- Plant desired species through a supplemental planting operation.

The clear-cut reproduction method may also be required for severely degraded stands previously subjected to diameter-limit or high-grading operations. High-grading is a practice in which the highest-value trees are removed, leaving only inferior trees without consideration for future development or species composition. In such stands, managers may find that starting over with clear-cutting and planting is the most efficient means of regeneration. For a detailed explanation of diameter-limit cutting or high-grading, please refer to MSU Extension Publication 3451 at extension.msstate.edu.

Variations

Patch Clear-Cut Method

Most clear-cutting operations could be classified as block clear-cutting, where the size and boundaries of the harvest area are based on ownership or management boundaries. Opening sizes typically range from small to cuts encompassing several hundred acres, although there is no biological limit to the maximum size of a clear-cut. Patch clear-cutting differs by placing limits on opening size. Typically, openings of 2 to 7 acres are created (Figure 3). Smaller clear-cut sizes maintain the conditions necessary for regenerating shade-intolerant species while preserving a forest for landowners who do not want to cut entire stands for aesthetic purposes. In addition, wildlife management efforts often use this method to create habitats for various wildlife species. Another advantage of patch clear-cutting is the ease of creating irregular boundaries. A disadvantage is the increased management and logging costs associated with creating and tracking multiple patches.

Strip Clear-Cut Method

Strip clear-cutting involves alternating strips or corridors of harvested, unharvested, or thinned trees within a stand (Figure 4). This method provides the same aesthetic and habitat-creating benefits as patch clear-cutting while simplifying logging operations and reducing costs. This method has not been widely used in Southern hardwood silviculture but has shown promise in research.

Figure 3. Patch clear-cut established for creation of wildlife habitat.

Figure 4. A strip clear-cut on the Yale-Myers School Forest, Windham County, Connecticut. The strip is oriented east to west to take advantage of full sunlight conditions.

Seeds-in-Place Method

The seeds-in-place method relies on seeds falling before harvest or dispersal from trees felled during harvesting (Figure 5). This method requires knowledge of the seed maturity of species targeted for regeneration and the ability to time harvesting operations accordingly. This is often difficult or uncertain, making the method rarely used in Southern hardwood silviculture.

Figure 5. Acorns on branches of felled oak. These acorns are mature and could provide seed for regeneration of a fresh clear-cut. (Photo courtesy of Pierce Young, private lands biologist, Mississippi Department of Wildlife, Fisheries, and Parks)

Seed-Tree Method

Overview

The seed-tree reproduction method involves leaving a few well-distributed trees of desirable species per acre (usually between 5 and 10) after harvesting operations. Seed-tree cutting can work with light-seeded species but has been less successful with heavier seeded species like oaks. The method involves three stages. Trees intended to serve as seed sources should be selected and monitored 5 to 10 years before any cutting operation. This allows managers to select the best specimens for future seed production. Selected trees should have characteristics of good potential seed production such as well-developed, vigorous crowns and evidence of past seed production. If the stand has been thinned before, then preparatory work may be unnecessary as potential seed trees may be obvious. After selections are made, all other trees are removed except for seed trees (Figure 6). After successful regeneration, seed trees are then removed to allow development of regeneration into an even-aged stand. It may be necessary to control competing, shade-tolerant stems through midstory injection before removal of non-seed trees. For more information on midstory injection in hardwood stands, please consult MSU Extension Publication 2942 at extension.msstate.edu.

Only slightly less intense than the clear-cut method, the seed-tree reproduction method creates a major disturbance that mimics stands devastated by fire or wind, where a few scattered residual trees are left. As with clear-cutting, differences between seed-tree cutting and natural disturbances include the removal of tree boles from the stand, the lack of pit/mound topography, and the absence of snags.

The seed-tree reproduction method is correctly employed when used for light-seeded species that use wind seed

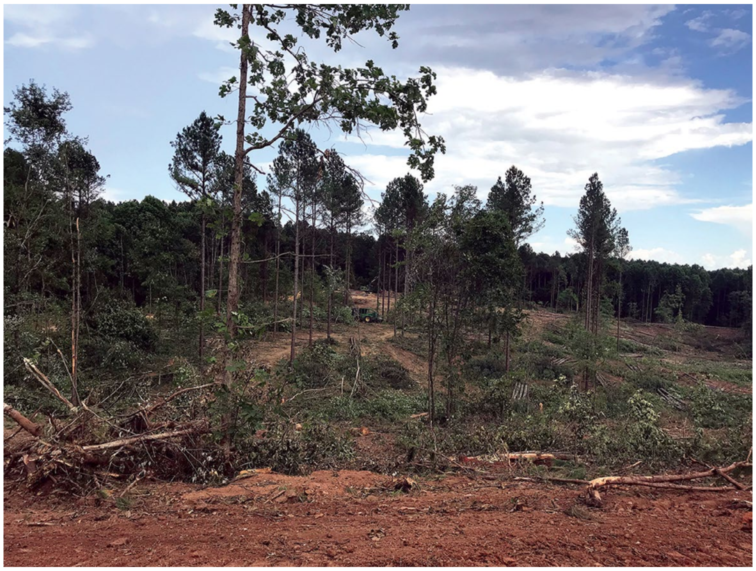

Figure 6. Seed-tree cutting establishment in a stand of loblolly pine. Even though residual pine density is low, approximately half of these trees would be cut to bring overall stem density down to a level appropriate for correct seed-tree stocking.

dissemination. Seed crop potential can be checked by periodically using binoculars to observe developing seed, or by obtaining branches containing flowers or seed. If a good seed crop is detected, then site preparation treatments can be conducted before seedfall to prepare the seedbed. If a poor seed crop is detected or if an insufficient number of seedlings are established, then seed trees can be left as a seed source for the next few years. Additional site preparation may be necessary to maintain acceptable seedbed conditions, but these treatments can be delayed until an adequate seed crop is detected.

Advantages of the Seed-Tree Method

- Trees left to regenerate the area are of superior appearance and assumed genetics.
- Seed-tree cutting is considered more aesthetically pleasing than clear-cutting by some.
- The seed-tree reproduction method promotes early successional plant and animal species, which benefits wildlife habitat creation for certain species.

Disadvantages of the Seed-Tree Method

- Seed trees may develop epicormic branches after the initial harvest, potentially resulting in a substantial loss of economic value.
- Seed trees are more susceptible to windthrow and lightning damage.
- The clear-cut reproduction method often produces similar regeneration results.
- Wildlife species that require dense, mature forest conditions may be displaced.

Application

Generally, the seed-tree method is not considered feasible for regenerating bottomland hardwood forests. With only a few trees left after initial harvest, forest floor conditions are essentially the same as a clear-cut. Seeds of light-seeded species (eastern cottonwood, black willow, and American sycamore) are distributed long distances by wind and water from adjacent stands. Some light-seeded species, such as sweetgum, readily regenerate from root and stump sprouts, and soil-banked seed of species like yellow poplar can remain viable for several years. Seed trees are generally considered ineffective in regenerating heavy-seeded species, such as oaks and hickories. These species are regenerated primarily through advance regeneration established before initial harvest. Seed dissemination of these species in seed-tree harvesting is very short and achieved through gravity, small mammals, birds, and sometimes water. Therefore, additional trees are necessary for adequate seed distribution to cover a stand after regeneration efforts begin.

Shelterwood Method

Overview

The shelterwood reproduction method involves removing trees in a series of partial harvesting operations to establish advance regeneration under the shade of existing overstory trees (Figure 7). A textbook installment of the shelterwood reproduction method involves a minimum of three harvesting operations. The first operation is called a preparatory cut, in which selected trees are retained for their potential seed production capabilities. Removing competing trees from lower crown classes helps provide the light necessary for establishing and developing regeneration after the second harvest. In addition, diseased, unhealthy, undesirable, or problematic trees may also be removed during this cut. Removing selected overstory trees encourages crown growth and promotes wind firmness of the stand. Midstory stems that block sunlight from reaching the forest floor are often chemically treated at this stage as well. In practice, preparatory cuts are often omitted due to economic considerations, and the operation is performed simultaneously with the next cut.

The second operation, conducted several years later, is called the seed cut. In the seed cut, trees are left to produce seed and provide shade for developing regeneration. For oak species, research has shown that a suitable range of basal area capable of producing advance regeneration after a seed cut is between 40 and 60 square feet of basal area per acre. Maximum regeneration typically occurs at 50 square feet. Consequently, most forest managers use this as their target basal area in seed cuts. The final operation is the removal cut, in which seed trees are removed and a new even-aged stand is regenerated. For more information on regenerating hardwood stands using the shelterwood reproduction method, please consult MSU Extension Publication 3461 at extension.msstate.edu.

Figure 7. An oak forest that has undergone the seed-cut stage of a shelterwood. Overstory trees have been removed leaving a targeted basal area of 50 square feet to establish advance regeneration.

The ecological counterpart to the shelterwood method is either a mild windstorm in which a few overstory trees are downed or a moderate wildfire that removes much of the understory and midstory but kills only a small portion of the overstory trees. Use of the shelterwood method may either set back or promote succession. A heavy seed cut (leaving only a few overstory trees) will promote shade-intolerant species, thereby setting succession back. A light seed cut, in which many overstory trees are left, will provide heavy shade on the forest floor and promote regeneration of shade-tolerant species thereby promoting succession.

Advantages of the Shelterwood Method

- A greater number of residual trees after the seeding cut increases the amount of seed reaching the forest floor compared to the seed-tree method.
- The method provides increased structure and diversity for wildlife habitat.
- It is considered the most aesthetically pleasing even-aged regeneration method.
- Unlike the clear-cut and seed-tree methods, shelterwoods can advance forest succession to a later stage.

Disadvantages of the Shelterwood Method

- The additional harvesting operations may cause site damage, particularly if conducted during wet conditions.
- Log grade may be decreased for seed trees that develop epicormic branches during the shelterwood process, thereby losing economic value.
- The risk of windthrow is higher.
- Attracting a logging contractor for the removal cut may be challenging if an economically viable quantity of trees is not maintained.

Application

The shelterwood method is widely regarded as the most flexible and successful even-aged reproduction method for hardwoods. The method can provide for establishment of shade-intolerant species if midstory trees are removed during preparatory or seed cuts and the overstory is removed soon after establishment of advance regeneration. With moderately shade-intolerant to moderately shade-tolerant species, the method can provide for both establishment and early development of seedlings provided that midstory species are removed no later than the seed cut. Finally, the method is highly effective for establishing and growing shade-tolerant species without requiring midstory stem removal.

For oaks, several other considerations are warranted. In general, the preparatory cut does not result in establishment of new oak seedlings. Advance oak regeneration is typically established over a period of several years, usually after several heavy mast years. In years of lower acorn production, wildlife often consumes a significant portion of the mast crop. Also, if periodic thinnings have been conducted, the preparatory cut may not be necessary. Adequate oak regeneration may already be present although early thinning often promotes development of shade-tolerant species.

Care is needed when conducting shelterwood operations. Harvesting too many trees may result in establishment of shade-intolerant species at the expense of more moderately shade-tolerant species like the oaks. Harvesting too few trees can result in establishment of shade-tolerant species which may outcompete species like oak and ash. When implementing the shelterwood method to develop advance oak regeneration, it is important to remove smaller trees first, ensuring that larger, more vigorous overstory stems are retained as seed sources. Removal of residual midstory stems may be warranted if the light levels necessary for continued seedling development are not present. Once advance regeneration has reached an acceptable size, then residual trees are removed.

Variations

The shelterwood method can provide a wide array of variations due to the dual objectives of providing seed and shelter for developing seedlings. As commonly practiced, the uniform shelterwood, as described previously, provides that residual trees are distributed evenly across the stand. Basic variations to this uniform pattern are listed below.

Strip Shelterwood Method

The strip shelterwood method involves alternating strips of areas harvested as a uniform shelterwood with unharvested strips or strips using a different reproduction method. The utility of this method for hardwoods is relatively unknown.

Irregular Shelterwood Method

The irregular shelterwood method involves lengthening the regeneration period so that essentially two age classes are managed for extended periods of time. The term "irregular" is taken from the variation in tree heights within the stand. The irregular shelterwood method is not an uneven-aged (by definition, three or more age classes) method, but it does have two age classes that may complicate silvicultural management of the stand.

Coppice Method

Overview

The coppice reproduction method involves regeneration of stands by vegetative processes, such as root and stump sprouting (Figure 8). In practice, the harvesting operation involved resembles a clear-cut, but regeneration is by sprouting instead of from seed. From an ecological perspective, coppicing is similar to a major disturbance like a windstorm, where many trees are downed in a stand. Intact root systems resprout, and in several species, limbs in contact with the ground can even take root. Unlike other even-aged reproduction methods, the coppice reproduction method usually involves removing the entire tree, including branches. Since most objectives involving coppicing are intended to produce fuelwood or biomass, less coarse woody debris is left onsite and can result in nutrient depletion.

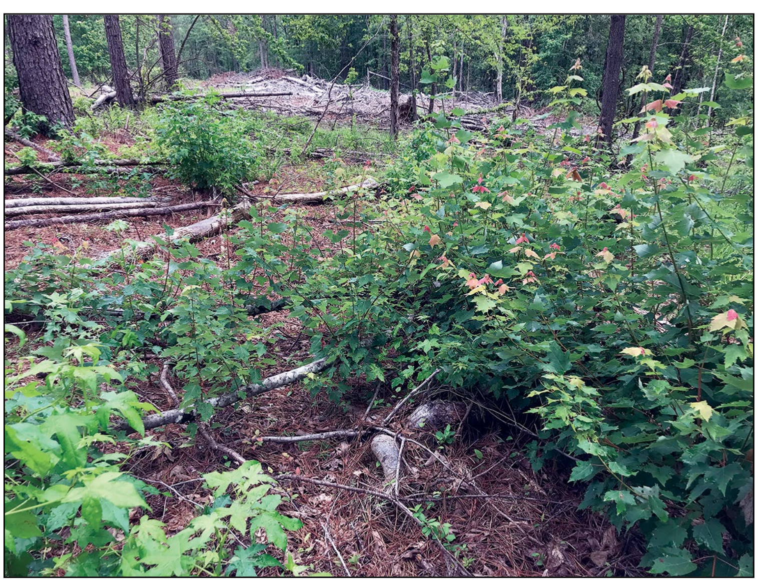

Figure 8. A 1-year-old stand of coppice red maple and sweetgum.

Advantages of the Coppice Method

- It can maintain parent tree genetics onsite.
- Established root systems result in rapid growth.
- Rapid early growth can result in earlier mast production.
- The method produces a lot of browse and low cover that some wildlife species require.

Disadvantages of the Coppice Method

- Resulting trees are from sprout origin and are inferior in quality to boles developed from seed or advance reproduction.
- Decay of stumps around stump sprouts often leads to decay in the sprouted tree, with a resulting decrease in quality and/or stem failure in some boles.

Application

The coppice reproduction method is typically applied in one of two scenarios. The first is in combination with the clear-cutting reproduction method, and the second involves the production of hardwood biomass in plantation settings. Coppicing is relatively common, although its usage is rarely recognized. When bottomland hardwood stands are harvested, subsequent regeneration is from seed, advance reproduction, and sprouts. As mentioned in the clear-cut reproduction method section, regeneration from sprouting results from the coppice reproduction method rather than a release of advance regeneration or germination of seed after clear-cut harvesting occurs.

The method is also used in short-rotation woody biomass plantations. Rapidly growing species (eastern cottonwood, American sycamore, black willow, and sweetgum) are planted and then grown for 5 to 10 years with little intermediate treatment. At the end of the rotation, the plantation is harvested for pulpwood or fuel. Instead of replanting the site, stumps from the previous stand are allowed to sprout, establishing a stand for the next rotation. Some thinning of stems within a sprout clump may be necessary to focus growth on one or two stems. This cycle may be repeated several times, but eventually, root systems become too large to be supported by the resulting small stems after harvesting. Once this point is reached, the site is prepared for planting with new seedlings and the cycle of harvesting/sprouting is restarted. For more information on short-rotation hardwood biomass plantations, please consult MSU Extension Publication 3019 at extension.msstate.edu.

Two-Aged Method

Overview

The two-aged reproduction method (also known as the deferment reproduction method and the leave-tree method) is uncommon in the United States but has been used for centuries in Europe and Asia. Essentially, the creation of a two-aged stand is similar to that of one created using the seed-tree or shelterwood methods. However, residual seed trees are not removed either until new regeneration has developed into mature trees, or they may be left indefinitely (Figure 9). Regeneration is from seedlings established after harvest, which develop in openings created by partial harvesting of the parent stand.

Figure 9. Two-aged stand initially created using the shelterwood reproduction method. The original plan included removal of residual seed trees, but secondary considerations dictated maintenance of remaining overstory trees for aesthetic purposes.

Advantages of the Two-Aged Method

- An overstory is present at all stages of stand development.
- It offers an alternative to the complete removal of all trees in aesthetically sensitive areas.
- The method provides some continuous overstory canopy for use by various wildlife species.
- Stands can provide mast throughout all stages of development.
- Residual trees, if of good vigor, will increase in diameter and volume.

Disadvantages of the Deferment Method

- Regeneration may not develop well under the overstory canopy (depends on the number of residuals).
- Residual trees are susceptible to damage from lightning strikes, windthrow, and ice.
- Seed dispersal for heavy-seeded species, such as oaks and hickories, is limited.
- The potential for log grade reduction in residual trees through the production of epicormic branches is high.
- Overall stand marketability and logging productivity are decreased if the best trees are usually left as seed trees.

Application

When using the two-aged reproduction method, overstory trees are harvested, leaving whatever residual basal area is deemed appropriate, similar to establishing a shelterwood. However, unlike in shelterwood cutting, residual trees will be left after the establishment of reproduction. These residual trees may be removed during thinning operations once reproduction has reached merchantable size. The cycle can be repeated with the next rotation, maintaining an overstory throughout all stages of stand development. This method offers extra potential benefits by not only retaining seed trees for the next rotation but also by selecting some trees for the benefit of wildlife habitat or aesthetic value. Selected trees can be expected to live at least 50 to 80 years after seed cutting (depending on species and stand type, less for bottomland hardwood species).

Here are several characteristics to consider when selecting trees to leave when implementing the two-aged reproduction method:

- Single, dominant stem with no major forks;
- Dominant or codominant crown position;
- No more than a 10-degree lean from vertical;
- No more than a 15 percent sweep, crook, or decay;
- No dead or dying major branches in the upper crown;
- No signs of developing epicormic branches on the butt log; and
- Not a species prone to dieback or decline after heavy cutting.

Single-Tree Selection Method

Overview

The single-tree selection reproduction method is intended to create or maintain an uneven-aged stand (three or more age classes) in perpetuity. Individual trees are periodically removed from a stand across several diameter classes to maintain a predetermined uneven-aged diameter distribution. Trees removed from the overstory create small canopy gaps, typically 0.1 to 0.12 acres each on average, which allow for the establishment and development of regeneration. Shade-tolerant species are most likely to be successfully regenerated using this method unless additional work is performed to open canopy gaps as adjacent tree crowns widen and fill the gaps. Consequently, it may be difficult to regenerate shade-intolerant and moderately shade-intolerant species using this method. The single-tree selection reproduction method promotes succession by simulating the gap-structured stands associated with old-growth forests. Differences include the absence of felled tree boles, pit/mound topography, and snags associated with the death of old trees.

As previously mentioned, single-tree selection favors development of shade-tolerant species (sugarberry, boxelder, hickories, elms, and maples). The small gap size does not allow sufficient sunlight to reach the forest floor for successful regeneration of shade-intolerant species (eastern cottonwood, black willow, American sycamore, sweetgum, and yellow-poplar). There are proponents of the method that support its use to regenerate moderately shade-intolerant species like oak. However, the method has not been proven in management with an emphasis on profitability. Unless a heavy removal regime of repeated stand reentries is established (5 to 10 years and 50 percent or more of the overstory and midstory), it is very unlikely that these species will be successfully regenerated using single-tree selection. Questions concerning subsequent development of these species as the stand develops remain unanswered. Gaps created by the single-tree selection method alone typically do not allow enough space for development and recruitment of these species into the overstory (Figure 10). Such gaps often close before developing regeneration can reach the overstory, hence the need for repeated reentries to further release growing reproduction.

Figure 10. A canopy gap created by removing a single overstory tree in a bottomland hardwood forest. Little additional sunlight reaches the forest floor through gaps created using single-tree selection. (Photo courtesy of Trent Danley, officer, Alabama Department of Conservation and Natural Resources, Division of Wildlife and Freshwater Fisheries)

Advantages of the Single-Tree Method

- It can regenerate shade-tolerant species.
- Maintaining a continuous forest canopy cover is aesthetically pleasing.
- Stands maximize both vertical and horizontal structure for wildlife habitat.

Disadvantages of the Single-Tree Selection Method

- It requires frequent stand entries to maintain proper diameter distributions.
- Frequent entries result in greater damage to residual trees.
- This method does not promote the regeneration and development of shade-intolerant or moderately shade-tolerant species.
- Considerable economic loss in timber revenue can occur when compared to even-aged methods.
- It can be difficult to implement due to lack of experience, research results, and practicality in many stands.

Application

Most bottomland hardwood researchers conclude that the single-tree selection reproduction method is not applicable to hardwood stands, especially for species such as oak. Many of the species valued in hardwood management are shade-intolerant and are not promoted by the single-tree selection method.

Group Selection Method

Overview

The group selection reproduction method involves the removal of trees in small groups (Figure 11). The size of the group opening is subject to debate but generally ranges from 0.5 to 2 acres. A circular opening with a diameter twice the height of the surrounding stand is considered the maximum size for a group selection opening, though larger openings are sometimes considered appropriate. Although regeneration of many bottomland hardwood species can occur in smaller openings, those of 1 acre or larger are generally considered necessary for recruitment of shade-intolerant species, including most bottomland oaks, into the overstory.

Figure 11. Small group selection cut in the Mississippi Delta testing viability of the method in regenerating oaks. (Photo courtesy of Trent Danley, officer, Alabama Department of Conservation and Natural Resources, Division of Wildlife and Freshwater Fisheries)

Advantages of the Group Selection Method

- Opening sizes are large enough to regenerate most shade-intolerant species.
- A forest canopy covers most of the stand, which is more aesthetically pleasing to many.
- It provides high structural diversity for wildlife habitat.
- The method has proven more successful with regeneration of shade-intolerant and moderately shade-intolerant species than the single-tree selection method.

Disadvantages of the Group Selection Method

- It involves repeated stand entry to maintain an uneven-aged stand structure.
- Group selection provides lower revenue compared to even-aged methods.
- The effect of adjacent canopy on the development of regeneration is unknown.

Application

As usually practiced, openings of 1 to 2 acres are created in the stand. Areas with adequate advance regeneration of desired species are selected for creating openings. Areas without sufficient regeneration, as well as areas between group openings, are thinned to promote the growth of residual trees and to start the regeneration process. Entries are typically performed on a 7- to 20-year cutting cycle. Each entry or reentry is used to create new openings, thin areas between openings, and release or thin trees in older openings as needed. Theoretically, this cycle can be perpetual, but several limitations exist when using this method:

- Initiating the method is complicated because trees established in uneven-aged stands are typically not well distributed across all areas of the stand.
- The edge-to-center ratio of openings is very high, and adjacent trees exert a disproportionate effect on the group of regeneration.
- Due to group shape and size, adjacent trees often quickly close the opening as their crowns spread.
- The size and arrangement of groups within a forest make them difficult to map, locate, and manage.
- Standard inventory techniques do not provide the information needed for management using group selections.
- Commercial harvesting is complicated.
- The scattered distribution of groups makes it difficult to construct and maintain an access system.

Finally, converting an even-aged stand to uneven-aged status using group selection as the reproduction method is challenging. Assuming an 80-year-old, 100-acre stand and making ten 2-acre group selection openings every 15 years, the last group openings will contain 140-year-old trees at harvest. These trees will likely experience higher incidences of mortality due to insects, diseases, and abiotic factors such as wind. In addition, the longevity of some short-lived species raises questions about viability with the group selection reproduction method and its longer process of implementation. This problem can be somewhat alleviated by establishing regeneration for these species when thinning between groups.

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