A Practical Alternative to Single-Tree Selection?

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ABSTRACT. *When landowners want to develop and maintain an uneven-aged tree structure in eastern hardwood stands, single-tree selection often is suggested as the only advisable, long-term partial regeneration harvest method. Single-tree selection is preferred because it provides a means for improving quality and controlling stocking of the residual stand necessary for sustained yield of desired products. Although studies have shown that single-tree selection is feasible where desirable shade-tolerant species can be regenerated, it is rarely applied because marking stands for harvest can be difficult and time consuming. Instead, diameter-limit cutting is the most common partial regeneration practice used in eastern hardwoods, primarily because it is much easier to apply. Unfortunately, strict diameter-limit cuts do not provide for control of residual stocking or improve the quality of residual trees. However, based on 20-yr results, most objectives of single-tree selection can be attained with flexible diameter-limit harvest guidelines based on potential value increase of individual trees combined with an improvement cut in small sawtimber trees at each periodic cut. North. J. Appl. For. 10(1):32–38.*

Landowners often want to use a partial (nonclearcutting) regeneration practice when managing hardwood stands because this approach provides both periodic income from timber sales and the benefits of a continuous cover of merchantable trees. Maintaining at least a partial cover of merchantable trees provides esthetic and sometimes wildlife benefits that are temporarily lost following more intense regeneration practices such as clearcutting. In general, at each cutting period, partial harvest practices are intended to reproduce new trees (shade-tolerant species) for the future, provide growing space for residual trees, and yield relatively frequent periodic income from timber sales. When regeneration is successful, an uneven-aged stand structure can be maintained for many years.

Single-tree selection is often regarded as the only prudent partial harvest practice because it provides strict control of residual stand stocking and quality for long-term management. However, marking selection stands can be difficult, and unfortunately, few practicing foresters in the eastern United States use single-tree selection to manage hardwood stands for sustained yield. In fact, diameter-limit cutting is the most common partial cutting practice in eastern hardwoods, primarily because it is the easiest to apply. But unlike single-tree selection methods, diameter-limit cutting does not provide controls on the residual stand that are important for sustained yield and development of high-quality trees. Forest managers who wish to develop and maintain uneven-aged stand structures need more practical methods for applying partial cutting practices.

In this paper, we describe an alternate marking technique for applying a partial regeneration cut in Appalachian hardwood stands. It is applied as a flexible diameter-limit practice coupled with some of the safeguards and controls of single-tree selection Guidelines are based on projected rate of return of individual trees combined with an improvement cut in merchantable sawtimber size classes. Most of the guidelines were described by Trimble et al. (1974). We believe that the flexible diameter-limit practice described is a sound method for making partial regeneration cuts in Appalachian hardwoods.

Preliminary 20-yr results indicate that this method is easy to apply in the woods and can achieve many of the residual stand goals of single-tree selection. We discuss the objectives of this practice, how it is applied, and our experiences on approximately 500 ac of central Appalachian hardwood stands that have been cut twice on a 10-yr cutting cycle. We also discuss the type of data that need to be collected, how to mark individual stands, and how to adjust the cut to make allowances for sustained yield

Background

Smith (1980) described four partial cutting practices as applied in Appalachian hardwoods. Single-tree selection is arguably the only genuine uneven-age silviculture practice (when openings are not desired) because it closely monitors residual stand structure at each periodic cut. Residual stand structure is defined using the combination of three factors.

residual basal area (RBA), largest residual tree, and diameter distribution for a particular site index (Smith and Lamson 1982). The optimal combination of these factors depends on landowner objectives such as esthetics, wildlife habitat, and timing of income. Once a stand structure has been defined that best meets these objectives, periodic harvests are made to achieve and maintain the desired stand. Stand structure goals are achieved by cutting individual trees of various sizes throughout the stand at regular intervals. Continued partial cuts applied in this way will eventually promote a stand where tree size indicates tree age.

In practice, several periodic cuts may be required to convert an existing stand to the desired stand structure. Following the transition cuts, periodic harvest cuts are planned so that the residual stand is about the same at the beginning of each growth period, thus ensuring continued regeneration and a sustained yield of desired products.

To plan a single-tree selection cut, a current stand inventory is compared to residual stand goals to determine which dbh classes have a surplus or deficit number of trees. Marking guidelines are developed in the office to reduce surplus trees, allow for increasing the number of trees in deficit dbh classes, and to remove low-quality and high-risk trees. Cut ratios used by the marking crew are defined for each dbh class so that the desired residual stand is attained. For example, if the goal is 6 residual trees/ac in a particular dbh class and the inventory indicates there are 12 trees/ac, 50% of the trees in that dbh class could be cut. For this dbh class the cut ratio is "1 to 2," or one of every two trees could be cut. Because there could be numerous cutting ratios, possibly a different ratio for each dbh class, markers must keep a running count of "cut" trees in each dbh class and choose which to cut using species, spacing, and potential quality as guides.

A simpler partial harvest method is available in which each merchantable tree is evaluated independent of all other trees in the stand—specific rules defined in the office allow marking crews in the woods to recognize which trees to cut. The need to keep a running count of cut trees is eliminated. This partial harvest method is a combination of flexible diameter limit based on potential rate of return in each species group plus an improvement cut to improve quality of immature merchantable growing stock. Guidelines on minimum RBA are used to adjust diameter limits prior to marking to prevent overcutting and provide for sustained yield.

Rate-of-return diameter-limit cutting is an easy to use alternative to single-tree selection yet offers similar benefits: periodic commercial harvests, reliable establishment of regeneration, cultural improvement of growing stock, and a sustained yield of desirable products. In most cases, experienced crews can confidently apply this cutting practice with a careful review of the guidelines described here and a little practice in the field.

Flexible Diameter Limits

In applying flexible diameter-limit cutting, trees are removed because they are either low quality, high risk, or no longer earn an acceptable rate of return. Studies have shown that rate of return declines for large sawtimber trees even though they continue to grow (Grisez and Mendel 1972, Guttenberg and Putnam 1951, Duerr et al. 1956, Mendel and Trimble 1969, Mendel et al. 1973, Trimble and Mendel 1969). At some diameters, the rate of return becomes unacceptable; that is, the tree should be cut because the value of future growth is less than the cost of retaining it for one more growth period.

Rate of return declines for large Appalachian hardwood trees because log quality and merchantable height, the major sources of value increase, change little once the dbh exceeds 16 in. Consequently, the value of annual volume growth is a continually smaller percentage of stumpage value as the tree grows beyond a certain diameter. Harvesting trees when they no longer earn an acceptable rate of return maximizes rate of return from the whole stand. Through periodic cuts, growing space is continually made available to new trees earning the highest rate of return possible.

Rates of return for individual trees were derived from research results (Trimble et al. 1969) on dbh and merchantable height growth, potential grade improvement, and changes in tree value for 10 Appalachian hardwood species on different sites. Cutting diameters were determined by projecting tree-value increase until the next cutting period (10–15 yr in this case) and calculating the rate of return for each size class. Initial and projected tree values were based on estimates of the value of 4/4 No. 1 common lumber net of conversion cost contained in a particular tree. The dbh at which a tree earns a particular rate of return differs by species, quality, and the growth rate of individual trees.

Rate-of-return guidelines help the forest manager recognize which trees will earn an acceptable rate of return if allowed to grow for one more cutting cycle. Marking is relatively simple because species and tree size (dbh) serve as the guide for cutting individual trees. Marking guidelines based on rate of return are summarized in Table 1. For a given species, site index, and desired rate of return, trees of the indicated dbh or larger are marked for cutting unless a potential tree-grade improvement is expected before the next harvest cut. If butt-log grade will improve in the next growth period, value increase and potential rate of return usually is acceptable.

For the improvement cut, undesirable or high-risk merchantable trees below the rate-of-return diameter limits are removed to help improve quality in the residual stand. Actually, all size classes are managed on the basis of potential rate of return. Trees removed to improve the residual stand also have low potential rates of return. Table 2 lists the characteristics of trees which should be removed to improve the residual stand. Note that each characteristic implies low potential for increase in value or a risk of dying before the next periodic cut. As a result, each periodic harvest cut can be used to remove some mature trees and culture immature trees for the future. However, with additional periodic cuts, volume removed for the improvement cut in immature trees should decrease and then become more stable.

Culls, in this instance, are trees that do not have at least one potential 16-ft log that is more than 50% sound, i.e., volume deduction due to rot or defect. Near culls are trees with significant rot (40%) in the butt log that will continue to increase to cull condition before the next periodic cut. Low-vigor trees, such as shade-intolerant species in an overtopped crown position, are unlikely to grow efficiently. Similarly, rough trees and trees

Table 1. Minimum-cutting 2-in. dbh limits by species, site index, and desired rate of return for the financial-maturity method.

	Low rate			Medium rate									High rate		
	2%			3%			4%			5%			6%		
Species	80[a]	70	60	80	70	60	80	70	60	80	70	60	80	70	60
Yellow-poplar	26	26	24	24	22	22	20	18	18	20	18	18	18	18	18
Am. beech	24	22	22	22	20	20	20	18	18	20	18	18	18	18	18
Black cherry	32	30	30	28	26	24	22	20	18	20	20	18	18	18	18
Red maple	32	30	30	28	26	24	22	22	18	20	20	18	18	18	18
White ash	30	28	28	26	24	24	22	20	18	20	20	18	18	18	18
Sugar maple	32	32	30	28	28	24	22	22	18	20	20	18	18	18	18
N. red oak	26	26	24	24	24	22	22	22	20	22	20	20	20	18	18
White oak	24	22	20	22	20	20	20	18	18	20	18	18	18	18	18
Chestnut oak	24	24	22	22	22	20	20	18	18	20	18	18	18	18	18
Other long-lived species	26	26	24	24	24	22	20	20	18	20	20	18	18	18	18

[a] Northern red oak.

more than 15 in. dbh with butt logs below construction grade 3 (Rast et al. 1973, Hanks 1976) are not likely to increase in quality. Short-lived species such as black locust, sassafras, and butternut probably will grow slowly or die before the next cut unless they are unusually vigorous.

Controlling Residual Stocking

As with any selection practice, adequate residual stocking must be maintained to assure sustained yield of desirable merchantable products in the future. In addition, each cutting period should establish new trees and stimulate diameter growth. Single-tree selection is designed to control residual stocking by retaining a predetermined number of trees in each merchantable dbh class. Thus, when the selection practice is used, the residual stand is about the same, and the cut volume is primarily from dbh classes with surplus trees.

With flexible diameter-limit cutting, no effort is made to control the number of residual trees per diameter class. Instead, RBA goals are used to maintain desired stocking, and stand structure is left primarily to chance that trees removed in each periodic cut will help stimulate recruitment of trees into larger diameter classes. Preliminary observations indicate that tree recruitment is sufficient in central Appalachian hardwoods managed with flexible diameter limits so long as residual stocking is maintained using basal area or a similar guide to control cutting.

Foresters are accustomed to controlling residual stocking using periodic growth, volume, basal area, number of trees, spacing, etc. For this practice, Trimble et al. (1974) suggested the following RBA/ac guidelines in sawtimber-size trees (11.0 in. dbh and larger) by northern red oak site classes:

Table 2. Marking guidelines for the silvicultural improvement cut (sawlog sizes–above 11 in. dbh).

For all rate-of-return classes, mark:

1. Culls and near culls.
2. Trees with significant rot (40% or more) in the butt log.
3. Very low-vigor trees (vigor 4).
4. Extremely rough trees with tree butt-log grade 5.
5. Any tree more than 15 in. with tree butt-log grade 4.
6. Any short-lived species, such as black locust, sassafras, and butternut, unless unusually vigorous.

Excellent (SI 80): 70–85 ft^2
Good (SI 70): 55–70 ft^2
Fair (SI 60): 40–55 ft^2

These guides were developed assuming that 10% of the unmarked basal area may be lost to logging and that the residual stand will contain 15–20 ft^2/ac in pole stems (6–10 in. dbh). In heavily stocked stands that have not been cut previously, markers should strive for a residual basal area at the upper level. In stands that have been cut, aim for an RBA near the bottom of the range. Maintaining these RBA or similar goals should allow periodic cuts on at least a 10-yr cutting cycle for the better growing sites.

Other measures besides basal area can be used to help control residual stocking. Harvest cuts can be planned so that volume removed roughly equals periodic merchantable-volume growth. Foresters are familiar with local periodic board-foot (bf) or cubic-foot (ft^3) volume growth based on site-quality class. To verify this information, permanent plots could be established and measured periodically. In central Appalachian hardwoods, estimated annual bf growth (International 1/4-in.) by site class for 75-yr-old sawtimber-size stands are:

Site class	bf/ac/yr	ft^3/ac/yr
Excellent oak SI 80	400	80
Good oak SI 70	300	60
Fair oak SI 60	200	40

Using the above estimates, a forest manager could plan to cut about 3 mbf/ac per 10-yr cutting cycle on good sites. However, more accurate estimates of growth in a particular stand would be needed for extended planning periods.

Marking the Stand

When marking a stand using flexible diameter limits, it is important to have an inventory to develop a stand table by species and 2-in. dbh classes (Table 3). The inventory is used to set the minimum dbh cutting limits so that harvest-volume and RBA goals are achieved. During the inventory, it is useful to estimate the improvement cut marking—trees that meet criteria specified in Table 2 that should be removed to improve the residual stand (Table 4). The improvement cut is subtracted

Table 3. Preharvest per acre stand inventory.

	Number of trees by dbh class											
Species	12	14	16	18	20	22	24	26	28	30	32+	Total
Yellow-poplar	0	0	0	0	0.2	0	0	0	0	0	0	0.2
Am. beech	0	0.2	0	0	0	0	0	0	0	0	0	0.2
Black cherry	0.8	0.8	2.8	1.3	0.5	0.5	0	0	0	0	0	6.5
Red maple	0.5	0	0.2	0	0	0	0	0	0	0	0	0.8
White ash	0	0.2	0	0	0	0	0	0	0	0	0	0.2
Sugar maple	3.0	1.7	1.5	0	0.5	0	0	0	0	0	0	6.8
N red oak	4.5	6.3	8.5	4.7	4.7	2.5	0.2	0	0	0	0	31.5
White oak	0.2	0	0	0	0	0	0	0	0	0	0	0.2
Chestnut oak	0	0	0	0	0	0	0	0	0	0	0	0
Other long-lived species	4.5	4.5	1.3	0.7	0.3	0.2	0	0	0	0	0	11.4
Short-lived species	0.5	0.2	0	0	0	0	0	0	0	0	0	0.8
Total	14.0	13.9	14.3	6.7	6.3	3.2	0.2	0	0	0	0	58.6

Note: total volume (Int. 1/4-in.) = 12.1 mbf; total basal area = 80.6 ft^2

from total inventory and then rate-of-return marking guidelines are set up to cut a portion of the remaining merchantable stand (Table 5). The flexible diameter-limit portion of the cut is adjusted so that the total harvest cut, improvement cut plus trees larger than the cutting limits, leaves the desired RBA.

Table 6 illustrates how the "in-office" harvest cut is used to adjust the flexible diameter-limit cut. The initial stand contained 12.1 mbf/ac of merchantable volume with 80.6 ft^2 of basal area/ac. On the basis of growth estimates for this northern red oak site index 70 stand, the periodic 10-yr cut should be about 3 mbf/ac, and RBA should be between 55 and 70 ft^2. Based on the preharvest inventory, trees to be removed in the silvicultural improvement cut total 1.2 mbf and 8.3 ft^2 of basal area. The improvement cut alone does not remove enough merchantable volume for a commercial sale and leaves too much RBA. Therefore, a rate of return must now be selected so that the flexible diameter-limit portion of the harvest, in addition to the improvement cut, removes enough volume and basal area to achieve the desired residual stand.

Harvest-cut volume usually increases as the guiding rate of return increases, so it is best to begin the in-office harvest using low rates of return and increase the guiding rate until harvest-volume and RBA requirements are met. In this example, no trees are large enough to be harvested using cut diameters corresponding to a 2% rate of return. Increasing the required rate of return to 3% lowers the minimum cut diameters, but the harvest cut increases by only 100 bf/ac in this stand. At 4%, minimum cut diameters are low enough to harvest an additional 1.7 mbf/ac, and the flexible diameter-limit cut is just about right. Total harvest volume now equals 3 mbf/ac and RBA is 61.8 ft^2/ac, within the recommended range. Note that for this particular stand, a harvest cut based on a 5% rate of return or higher leaves RBA too low—the cut is too heavy at these higher rates of return especially with periodic sustained yield as an objective.

Once the guidelines are set, the marking crew simply marks trees for removal according to species and minimum cutting dbh, plus additional trees for the improvement cut.

Experience with Flexible Diameter Limits

On the Fernow Experimental Forest near Parsons, WV, we have applied flexible diameter limits on about 500 ac using 3, 4, and 6% rate-of-return cutting guidelines. Each set of guidelines has been replicated twice on areas with a northern red oak site index 70. Rate-of-return guidelines remain constant in research stands, although, in practice, guidelines could be reset before each harvest to adjust the total cut.

When management began, harvest yields slightly exceeded estimated growth because the study areas were overstocked. Stands contained old residual trees and reproduction resulting from logging in 1905 plus reproduction following the death of the American chestnut in the 1930s. During the 1950s and

Table 4. Silvicultural improvement cut per acre inventory.

	Number of trees per/ac by dbh class											
Species	12	14	16	18	20	22	24	26	28	30	32+	Total
Yellow-poplar	0	0	0	0	0	0	0	0	0	0	0	0
Am. beech	0	0.2	0	0	0	0	0	0	0	0	0	0.2
Black cherry	0.2	0.3	0.2	0.2	0.1	0	0	0	0	0	0	1.0
Red Maple	0.2	0	0.1	0	0	0	0	0	0	0	0	0.3
White ash	0	0.2	0	0	0	0	0	0	0	0	0	0.2
Sugar maple	0.3	0.4	0.3	0	0.2	0	0	0	0	0	0	1.2
N red oak	0.2	0.3	0.3	0.2	0.2	0.1	0	0	0	0	0	1.3
White oak	0.1	0	0	0	0	0	0	0	0	0	0	0.1
Chestnut oak	0	0	0	0	0	0	0	0	0	0	0	0
Other long-lived species	0.5	0.5	0.5	0.3	0.1	0	0	0	0	0	0	1.9
Short-lived species	0.1	0.1	0	0	0	0	0	0	0	0	0	0.2
Total	1.6	2.0	1.4	0.7	0.6	0.1	0	0	0	0	0	6.4

Note: board foot volume cut (Int. 1/4-in.) = 1.2 mbf; basal area cut = 8.3 ft^2

Table 5. Preharvest per acre inventory minus silvicultural improvement cut.

	Number of trees by dbh class											
Species	12	14	16	18	20	22	24	26	28	30	30+	Total
Yellow-poplar	0	0	0	0	0.2	0	0	0	0	0	0	0.2
Am. beech	0	0.1	0	0	0	0	0	0	0	0	0	0.1
Black cherry	0.6	0.5	2.6	1.0	0.4	0.5	0	0	0	0	0	5.6
Red maple	0.4	0	0.1	0	0	0	0	0	0	0	0	0.5
White ash	0	0.1	0	0	0	0	0	0	0	0	0	0.1
Sugar maple	2.7	1.4	1.2	0	0.3	0	0	0	0	0	0	5.6
N. red oak	4.3	5.9	8.2	4.6	4.6	2.4	0.2	0	0	0	0	30.2
White oak	0.2	0	0	0	0	0	0	0	0	0	0	0.2
Chestnut oak	0	0	0	0	0	0	0	0	0	0	0	0
Other long-lived species	4.0	4.0	0.8	0.4	0.2	0.2	0	0	0	0	0	9.6
Short-lived species	0.4	0.1	0	0	0	0	0	0	0	0	0	0.5
Total	12.6	12.1	12.9	6.0	5.7	3.1	0.2	0	0	0	0	52.6

Note: total board-foot volume (Int. 1/4-in.) = 10.9 mbf; total basal area = 72.3 ft^2

1960s, some of the study areas were logged using light partial cuts aimed at removing old residuals and risk trees to condition the stand for the next cut. Since then, each of the six study areas has been cut twice using a selected rate of return and the associated diameter limits. Each stand will be cut a third time by 1994. The second diameter limit cuts removed an average of 3.7 mbf/ac, leaving an average residual volume of 7.6 mbf/ac. Over time we expect periodic yield to equal periodic growth at about 3 mbf/ac every 10 yr, becoming more predictable, and as species composition changes to mostly tolerant species, tree recruitment stabilizes.

Preliminary results from stands managed using flexible diameter limits indicate that single-tree selection goals for residual number of trees have been met following two periodic harvest cuts. Observed stand structures from diameter-limit areas were compared to single-tree selection residual-tree goals appropriate for the study areas (Figure 1). Results showed that diameter-limit cuts allowed for adequate recruitment of trees into larger diameter classes. There were surplus trees in the 6- to 18-in. diameter classes after two harvest cuts, indicating a favorable outlook for at least the next two or three periodic harvest cuts.

Generally, most of the volume removed for the silvicultural improvement cut is removed during the first and second cuts, especially when mature unmanaged commercial stands are cut for the first time. We found that volume removed for silvicultural purposes averaged 36% of total harvest cut during the first cutting period and 26% for the second cut for previously unmanaged stands. Logging damage to sawtimber-size trees accounted for between 1–2% of the residual volume. Silvicultural considerations are expected to have decreasing influence on the harvest as the number of periodic cuts increase.

Partial cutting tends to maintain or increase the number of small seedlings per ac compared to uncut stands where continual shade hinders germination and development. In flexible diameter-limit and selection stands, small reproduction increased as a result of partial harvest cuts (Figure 2). Although some intolerant species such as black cherry and yellow-poplar germinate and grow for a short time, surveys of large reproduction indicate that partial-cutting promotes future stands dominated by tolerant species such as sugar maple, red maple, and American beech (Figure 3). Tolerant species also make up a greater proportion of poletimber trees per ac (Figure 4). However, flexible diameter-limit cutting can create small openings where clumps of large trees are removed in the same periodic harvest Some intolerant species have the potential to regenerate and

Table 6. Per-acre stand appraisal for selecting an acceptable rate of return.

Item	Volume[a] (bf)	Basal area (ft^2)	Total harvest (bf)
Stand inventory	12,100	80.6	—
Silviculture mark	1,200	8.3	1,200
Residual	10,900	72.3	—
Mark rate of return 2%	0	0	1,200
Residual	10,900	72.3	—
Rate of return 3%	100	0.7	1,300
Residual	10,800	71.6	—
Rate of return 4%	1,700	9.8	3,000
Residual	9,100	61.8	—
Rate of return 5%	1,800	9.8	4,800
Residual	7,300	52.0	—
Rate of return 6%	1,800	10.5	6,600
Residual	5,500	41.5	—

[a] Board-foot volume = Int. 1/4-in. rule.

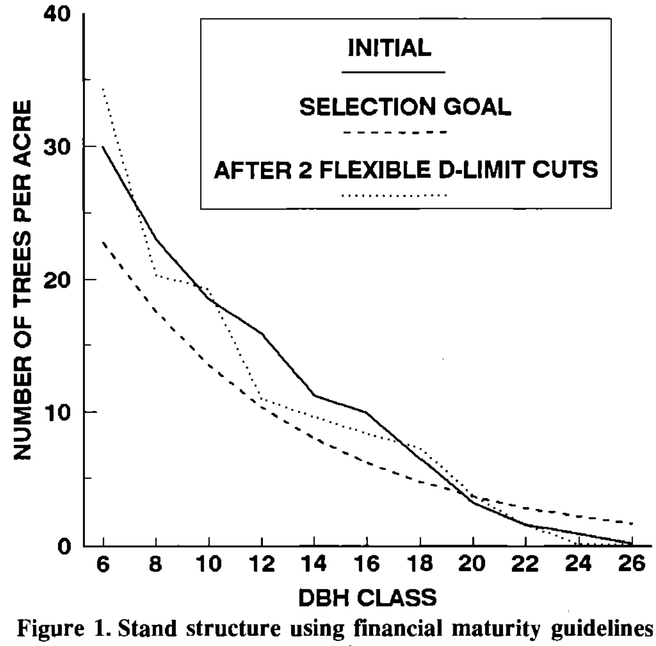

Figure 1. Stand structure using financial maturity guidelines (3%) compared to appropriate single-tree selection goals.

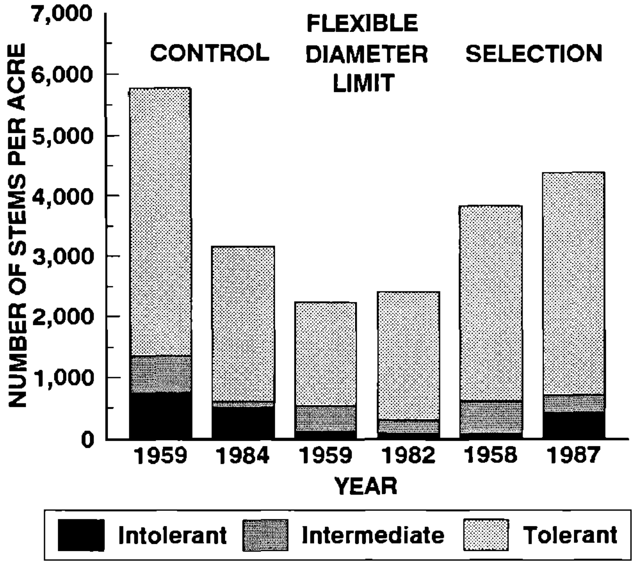

Figure 2. Small reproduction (1.0 ft tall to 0.99 in. dbh) of commercial hardwood species by tolerance class.

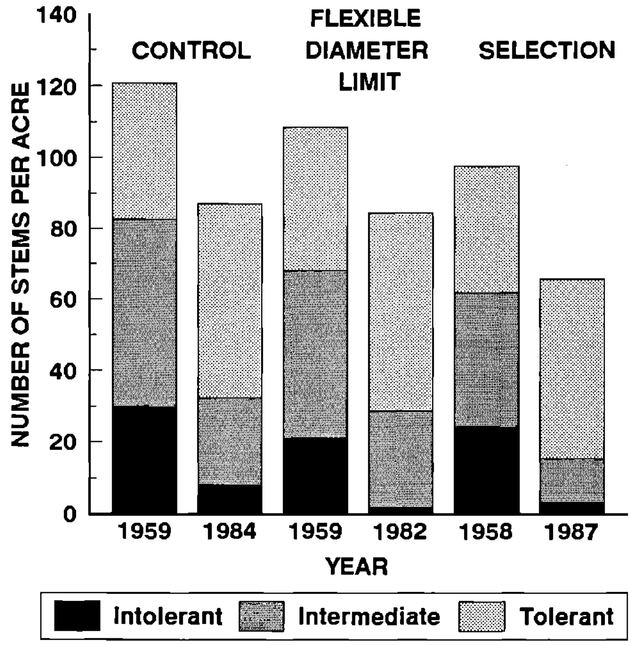

Figure 4. Poletimber (5.0–10.9 in. dbh) by tolerance class.

develop in such openings, but the repeated use of this practice should promote a stand containing mostly tolerant species (Figure 5).

Since stand management began in six stands managed using flexible diameter limits, the periodic market return on residual stand value ranged from 7–14% and averaged 10%. Inflation averaged 3.7% over the study period. Other partial-harvest study areas on the Fernow Experimental Forest have provided similar returns over 40 yr of management (Miller and Smith 1991). By comparison, single-tree selection and strict 17.0-in. dbh diameter-limit cutting (nonflexible) applied in Appalachian hardwoods on site index 70 earned returns on residual stand value of 10% and 9.8%, respectively.

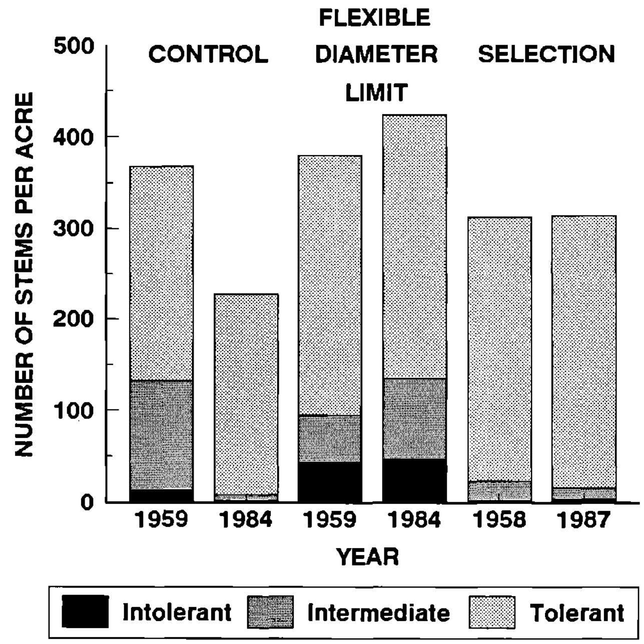

Figure 3. Large reproduction (1.0–4.9 in. dbh) of commercial hardwood species by tolerance class.

Discussion

Practicing foresters often have a negative attitude toward any type of diameter-limit cutting, viewing such practices as high-grading. High-grading is used to describe harvests of only selected species of a given product size. In flexible diameter-limit cutting, each species has its own cut limit based on potential growth and rate of return, while the accompanying silvicultural cut allows for continual improvement of the immature residual stand. In addition, RBA guidelines prevent overcutting and ensure an uninterrupted flow of wood products.

The minimum-cutting dbh limits presented in Table 1 and improvement cut rules in Table 2 are to be used only as guidelines to simplify marking. Modifications can be made to accommodate specific management objectives. For instance, a particular tree may be eligible for cutting, but the forest manager has the option to retain it for wildlife or esthetic purposes. The marking crew may also choose to relax the dbh cut limits if too many trees are being cut in a portion of the stand. Guidelines also can be adjusted to improve tree spacing.

When appropriate minimum rate-of-return dbh cut rules are determined during in-office planning, other cut or leave rules can be added to accommodate management goals. One way to modify the concept is to extend the silvicultural or improvement cut to include poletimber trees. Trees of poor potential quality or undesirable species could be sold where possible or otherwise felled and left in the woods. This part of the improvement cut may require cutting an additional 10 to 20 pole- and sawtimber-size trees per ac during an initial harvest. As culls and undesirable trees are eliminated, preferred trees have more room to develop and may be better distributed throughout the stand. In one 34-yr study on the Fernow, a selection stand on an excellent growing site managed commercially for both poles and sawtimber was worth 33% more than a similar stand managed for sawtimber only (Smith and Miller 1987). A significant portion of this value increase is due to managing the poles.

Figure 5. Application of financial-maturity practice after two cutting periods using 3% rate of return (northern red oak site index 70).

The rate of return used to define the minimum dbh cut rules for each species is not necessarily the rate of return on the entire stand. By definition, rate of return of immature trees is greater than the selected rate of return, so the residual stand as a whole earns more than the guiding rate. At first, the temptation is to harvest using dbh limits for a high 6% return. This approach may overcut some stands, reduce volume production, interrupt periodic harvests, and lead to long-term returns less than 6%. The best approach is to work from the preharvest inventory and choose a rate of return whose dbh cut rules achieve the RBA guidelines for the site. If necessary, the rate-of-return guideline can be adjusted to accommodate changes in the improvement cut at each harvest.

One way to become familiar with the flexible diameter-limit method is to apply it on a small area or establish a small plot(s) of a known acreage, say, 1 to 2 ac. Inventory the stand and at the same time inventory (separate tally) the trees that would be removed with an improvement cut (Table 2). Develop a stand table (number of trees by species and 2-in. dbh classes). Use dbh limits in Table 1 to begin marking the trial plot similar to the procedure presented in Table 6. Plastic flagging of different colors is helpful for temporary trial marking. Start with the lowest rate of return and the associated large dbh cut limits. Mark trees according to the cut limits for each species group plus high risk trees with characteristics listed in Table 2, keeping in mind minimum RBA guidelines for the site. Then increase the selected rate of return and note how additional trees are marked for cut as the dbh cut limits are reduced.

We believe that flexible diameter-limit cuts which include improvement of smaller merchantable growing stock are a practical alternative to single-tree selection when partial regeneration methods are best suited to landowner goals. It is easy to apply in the woods, achieves many of the residual stand goals of selection practices, and earns similar rates of return. In fact, it is difficult to distinguish between a stand managed using 3% rate of return guidelines and a selection stand where the largest residual trees are 22 to 26 in. dbh (Figure 5).

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