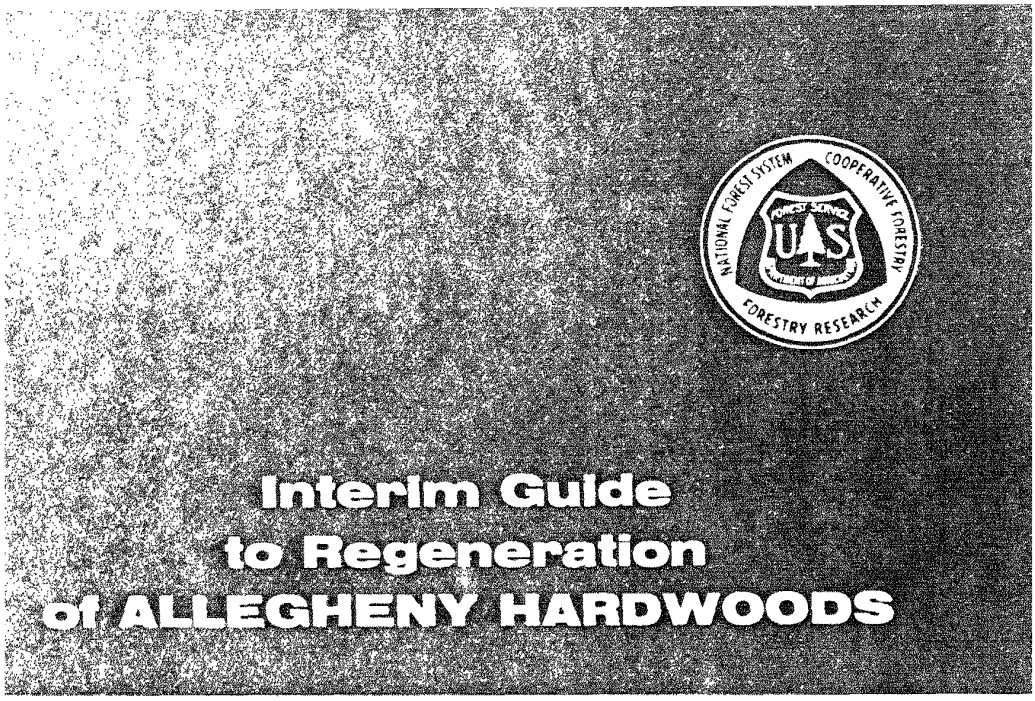

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Interim Guide to Regeneration of ALLEGHENY HARDWOODS

ABSTRACT

Regeneration of Allegheny hardwoods is difficult to obtain because of excessive deer browsing on tree seedlings. Satisfactory regeneration is obtained after clearcutting only in stands where advance seedlings are abundant before cutting. Where advance seedlings are sparse, shelterwood cutting will often increase their numbers, provided that competition from grasses, ferns, beech root suckers, and striped maple is not excessive. Soil drainage and the importance of esthetic and recreation uses also affect the choice of silvicultural system and cutting procedure. In this paper, we provide guides needed for evaluating the regeneration potential and prescribing the most appropriate treatment for cherry-maple stands on the Allegheny Plateau of Pennsylvania and New York.

Regeneration of Allegheny Hardwoods

REGENERATION is often difficult to obtain after harvest cutting in the cherry-maple forests of the Allegheny Plateau of Pennsylvania and New York. Surveys of clearcuttings made in the late 1960s show that only about half of these cutover areas are reproducing satisfactorily *(Grisez and Peace 1973)*. Excessive browsing of tree seedlings by an unusually large deer herd is the major cause of these failures *(Marquis 1975; Jordan 1967; Shafer et al. 1961; Grisez 1957; Bennett 1957; Frontz 1930)*.

Good reproduction sometimes develops after clearcutting in spite of deer browsing *(Husch 1954; Hough 1953; Ostrom 1938; Elliot 1927)*. More recent research has shown that the number of advance seedlings present before cutting is a major determinant of regeneration success. Those stands in which advance seedlings are abundant can generally be harvested by clearcutting, with assurance that a satisfactory new stand will develop on the area. Guides have been developed to help the forest manager evaluate advance reproduction and predict probable regeneration success *(Grisez and Peace 1973)*.

Research has also shown that shelterwood cutting techniques can be used to increase the amount of advance reproduction in stands where it is not adequate. Although there are certain stand and site conditions where shelterwood cutting should not be used, this cutting method provides a means of reproducing many Allegheny hardwood stands that would fail to regenerate satisfactorily if clearcut *(Marquis 1973; Husch 1954; Hough 1937)*.

Recent evaluations of regeneration cuttings made 30 to 40 years ago suggest that tolerant species such as sugar maple, beech, and hemlock find a place in the main crown canopy of new even-aged stands only if they have an appreciable head start on the faster growing and less tolerant species. To insure their representation in the new stand, specified numbers of saplings and small pole-size stems of these species may be retained as growing stock when the main portion of the existing stand is harvested.[1]

Although results to date are still tentative and there is additional research now under way that will probably result in further refinements, the information now available provides a far better basis for mangement than what has been available previously.

This publication is a summary of information now available about the regeneration of Allegheny hardwoods in the form of an interim guide suitable for field use. This guide covers only regeneration and applies only to stands that are ready to be harvested.

Silvicultural Systems

A major decision to be made on any forest tract is whether it will be handled on an even-aged or uneven-aged system. This decision must be based on the management objectives for that area and on the biological restraints inherent in the ecosystem in question.

Because Allegheny hardwood forests contain many species spanning a range of tolerance levels, the choice of the silvicultural system to be used would be wide were it not for deer pressures on regeneration. Heavy browsing makes regeneration difficult to obtain under any silvicultural system, but is most restrictive under cutting techniques that require seedlings to develop where dense shade prolongs their exposure to deer (which occurs under individual-tree selection cutting) or where the deer pressure tends to be concentrated on small numbers of seedlings (as with group-selection cutting).

For this reason, uneven-aged silvicultural systems are not as useful as they might be in Allegheny hardwoods and are not recommended in this guide except for those areas where even-aged silviculture is inappropriate because of management objectives or site con-

[1] Roach, Benjamin A. Effect of residual saplings of sugar maple and beech on the species composition of new stands following harvest cutting. Unpublished office report. USDA For. Serv. Northeast. For. Exp. Stn., Warren, Pa. 1975.

ditions. These include locations where recreation, esthetics, and similar land uses are of such high importance that they preclude any cutting technique that completely removes the overstory. For areas fitting this description, skip the sections "Stand Diagnosis" and "Guides To Regeneration" that follow and refer to the section on "Uneven-Aged Silviculture" at the end of this guide.

For all other situations, including stands where esthetics and recreation may be important but do not preclude even-aged silviculture, refer to the Stand Diagnosis and Regeneration Guides that follow.

Stand Diagnosis

Before using the reproduction key that follows, make a stand diagnosis to evaluate regeneration potential. The stand diagnosis includes the identification of stand units and evaluation of the existing overstory and understory vegetation.

Normally a stand diagnosis would be performed in the process of deciding that a particular stand is ready for harvesting. If so, collection of understory data is the only additional task required, and it can be done at the same time that overstory data are collected. The description that follows includes only those items of information needed to evaluate regeneration. Additional information may also have been required to determine what cutting, if any, was appropriate.

Identification and Sampling of Stand Units

Stand units are usually identified first from aerial photographs and later are checked on the ground and adjusted as needed. The stand area should be small enough so that it will have reasonably similar stand and site conditions throughout, but large enough to provide efficient operation. Stand size normally falls between 10 and 50 acres, but may be larger or smaller under some conditions.

Once the stand unit has been identified, sample plots are located by using some systematic sampling scheme to insure that the plots are well distributed throughout the stand. As a general rule, one sample plot per acre will provide an adequate sample, but in no case should the number of overstory plots be fewer than 10 nor the number of understory plots fewer than 20.

Overstory Evaluation

Information about basal area for each of two species groups, total number of trees, and mean stand diameter are needed for evaluation of overstory stocking. Basal area can be estimated by a prism count, and numbers of trees can be estimated by a tree count of a 1/20-acre (26-foot 4-inch radius) plot. All trees 0.5 inch dbh and larger should be included in both the prism count and the tree count. The same center point should be used for both counts. Mean stand diameter and stocking level can then be determined from stocking charts.

For stocking charts and how to use them, see appendix.

The two species groups on which basal area must be recorded are: (1) black cherry, white ash, and yellow-poplar; and (2) all others. A sample form showing the information needed is presented as figure 1. Additional data about the overstory are often needed for other purposes, so the actual form may differ from that shown in figure 1; but it must include the items provided here.

When all plots have been sampled, the sum and mean of the prism and tree counts are calculated. Next the proportion of basal area in black cherry, white ash, yellow-poplar and the average basal area of both species groups combined are computed; then stocking charts are used to look up mean stand diameter and stand stocking percentage. All the computations may be recorded on the tally form, as illustrated in figure 1.

Understory Evaluation

To evaluate the understory, you need information about the stocking of advance reproduction in several species-size groups and about the stocking of undesirable competitors. Observations of soil drainage are also best made when the understory is sampled.

Figure 1.—Sample stand diagnosis tally form for regeneration.

Forest Allegheny Compartment 261

Stand 17 Date 9/74

Plot No.	Overstory: Prism Count Basal Area in trees 1 inch dbh & larger — BC-WA-YP	Overstory: Prism Count Basal Area in trees 1 inch dbh & larger — Others	Overstory: Tree Count Trees 1 inch dbh & larger	Understory: Advance Reproduction — small	Understory: Advance Reproduction — large	Understory: Undesirable Competitors — fern	Understory: Undesirable Competitors — grass	Understory: Undesirable Competitors — beech st.maple	Site: poorly drained
1	30	100	35	✓	✓	✓			✓
2	80	80	22						
3	50	80	41	✓					
4	20	120	40	✓					
5	100	30	29		✓				
6	10	100	38			✓	✓		
7	40	80	31						
8	20	80	28	✓					
9	20	100	20	✓					
10	30	90	46	✓			✓	✓	
Σ	400	850	330	6	2	2	2	1	1
$\bar{x}$	40	85	33 x 20 = 660						
both groups	125		% of plots	60	20	20	20	10	10
%BC-WA-YP	32		% of plots	70					

Understory vegetation plots should be 6-foot-radius plots. The same plot centers should be used as for overstory evaluation. Some additional understory plots may also be needed to meet the minimum of 20 plots. Spaces for recording understory data are provided on the sample form (fig. 1).

Understory and soil-drainage information need be recorded only as a check mark or yes-no entry. However, actual numbers or coverage may be recorded if these data are desired for other purposes. At the minimum, indicate with a check mark each plot that contains:

- *Small advance reproduction.*—At least 15 black cherry stems or 80 stems of any desirable species under 0.5 inch dbh. In making this determination, do not count newly-germinated seedlings because survival is often poor during the first few months after germination.
- *Large advance reproduction.*—At least four acceptable stems of sugar maple, beech, or hemlock 1 to 2 inches dbh or at least two acceptable stems of these species 3 to 4 inches dbh, or at least one-half the above number of both size classes. Acceptable stems of these species must have reasonably straight boles and moderate crowns so that they can be expected to survive and grow into acceptable growing stock if released.
- *Grass-fern.*—At least 30 percent of the ground area is covered by a grass or sedge, or at least 30 percent is covered by hay-scented fern or New York fern. If the identity of the ferns is uncertain, count any fern that grows as individual fronds from the ground level, and ignore any ferns that grow in clumps. Because coverage of grass and ferns is usually spotty, it is best to estimate the coverage of these species on plots larger

than 6-foot-radius. The 1/20-acre plot used for the tree count is better. This estimate is an ocular one, based on the proportion of ground area covered by these plants.

- *Beech root suckers or striped maple stems.*—At least eight stems (total) of these two species.
- *Poorly drained soil.*—Plot has evidence of standing water during wet periods or soil mottling within 6 inches of the surface. As with grass and fern, evidence of soil drainage is better observed on the 1/20-acre plot than on the smaller 6-foot-radius plot.

When all plots have been sampled, compute proportions of plots with checkmarks in each category above, as shown in figure 1.

Guides to Regeneration of Allegheny Hardwoods

Figure 2 is a flow chart from which it is possible to evaluate the regeneration potential of a stand and arrive at a prescription for treating it. Data from the stand diagnosis (fig. 1) are needed for using this chart.

For simplicity of presentation, wording in the flow chart has been kept at a minimum. More complete descriptions of the criteria at each branching point (shown in rectangles on the chart) are contained in the section entitled "Prescription Criteria", with numbers and letters keying the descriptions to the chart. More complete discussions of the regeneration prescriptions (shown in ovals on the chart) are contained in the section entitled "Regeneration Cutting Guidelines", with letters keying the discussions to the chart.

To arrive at a prescription for a particular stand, start at the top of the chart and follow the lines through the appropriate branches until you reach a prescription, referring to the following sections for detailed information as needed.

These guides are intended for use only in stands that are mature or that are at least 60 years old and ready to be harvested for some other management consideration.

PRESCRIPTION CRITERIA

1. Soil Drainage:

   a. *Well drained.*—Less than 30 percent of the stand area has evidence of standing water during wet periods or soil mottling within 6 inches of the surface. Soil drainage is not such that it will limit silvicultural alternatives.

   b. *Poorly drained.*—More than 30 percent of the stand area has evidence of standing water during wet periods or soil mottling within 6 inches of the surface. High water tables following complete overstory removal on poorly drained soils will often interfere with regeneration and make even-aged management undesirable. The problem may be compounded if the poorly drained soil is in a valley or topographic depression where frost pockets may form *(Hough 1945)*. Water tables are kept at lower levels by evapotranspiration if overstory stocking is never reduced below the B level.[2]

2. Advance Reproduction:

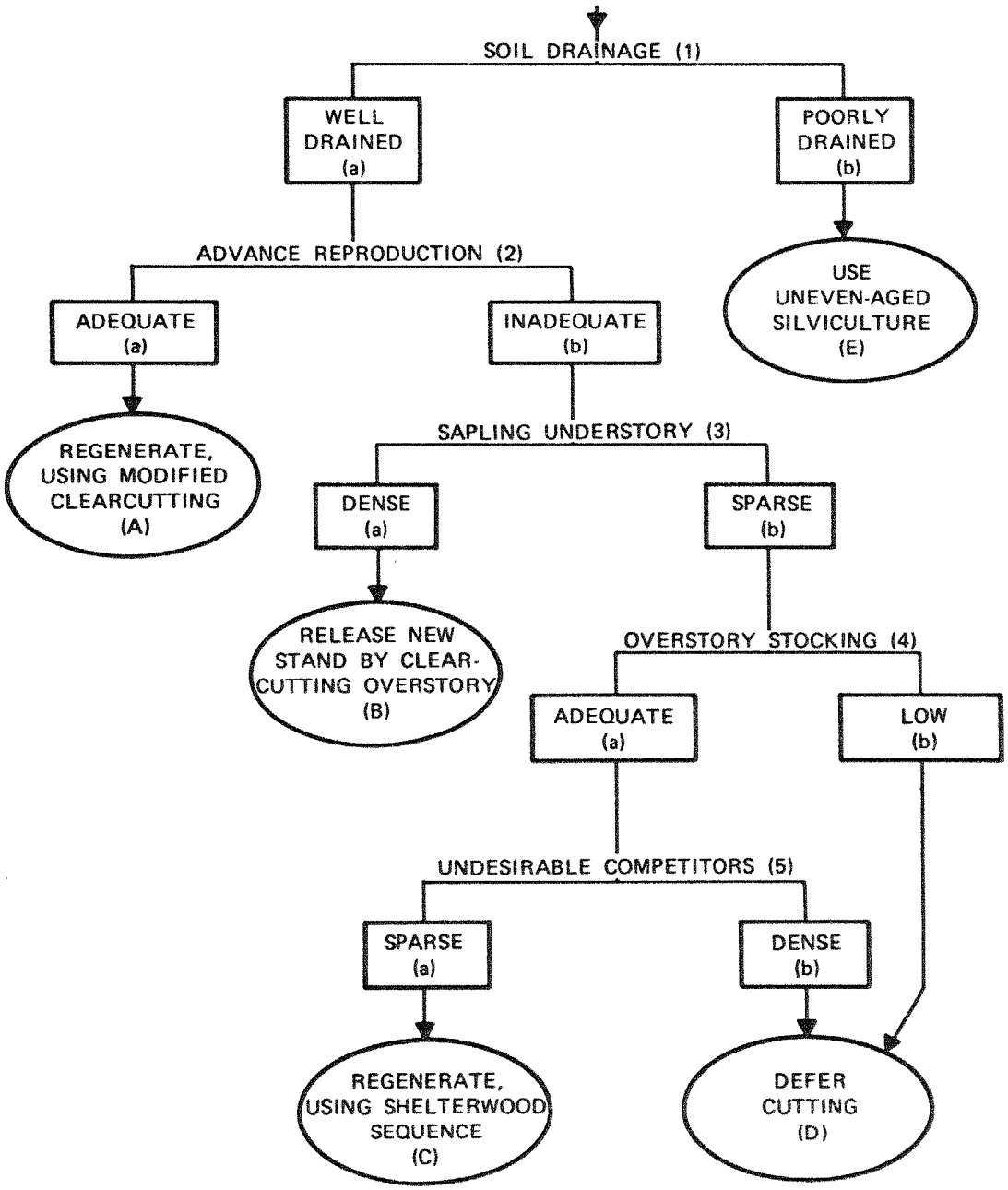
   a. *Adequate.*—At least two-thirds of the reproduction plots are stocked with small advance reproduction, or at least one-half of the plots are stocked with small reproduction, and enough additional plots are stocked with large reproduction to total at least two-thirds of the plots stocked.

   To be stocked with small advance reproduction, a 6-foot-radius plot must contain at least 15 black cherry stems or 80 stems of any desirable species less than 0.5 inch dbh. In making this determination, do not count newly germinated seedlings, because survival is often poor during the first few months after germination.

   To be stocked with large advance reproduction, a 6-foot-radius plot must

[2] Roach, Benjamin A. Interim guide to Allegheny hardwood stocking. Unpublished office report. USDA For. Serv. Northeast. For. Exp. Stn., Warren, Pa. 1975. See appendix for the stocking charts and a brief description of their use.

Figure 2.—Guides to Allegheny hardwood regeneration.



contain at least four acceptable stems of sugar maple, beech, or hemlock 1 to 2 inches dbh, or at least two acceptable stems of these species 3 to 4 inches dbh, or at least one-half of the above numbers of both sizes classes. To be acceptable, trees must have reasonably straight boles and moderate crowns so that they can be expected to survive and grow into acceptable growing stock if released.

b. *Inadequate.*—Fewer than two-thirds of the reproduction plots meet the stocking criteria listed in a. above.

3. Sapling understory:

a. *Dense.*—At least two-thirds of the reproduction plots are stocked with large advance reproduction; these stems plus small poles up to about 8 inches dbh are adequate in species composition, number, and quality to form a new stand composed of these stems alone. Stands that meet these criteria are two-aged stands resulting from heavy partial cuttings during the past 20 years or so. The overstory is usually sparse.

b. *Sparse.*—Fewer than two-thirds of the plots are stocked with large advance reproduction; or species composition, number, and quality of these saplings plus small poles up to 8 inches dbh are inadequate to form a new stand.

4. Overstory Stocking:

a. *Adequate.*—Stocking level of overstory trees 0.5 inch dbh and larger, as determined from stocking charts in the appendix, is 80 percent of A level or higher.[2]

Overstory stocking may also be considered adequate if it is between 70 and 80 percent of A level and the low density is due to some recent reduction such as insect or disease outbreak, ice damage, or windthrow.

b. *Low.*—Stocking level of overstory is less than prescribed above.

If the stand has been below normal in stocking for some time and still has poor advance reproduction, it is doubtful that further reduction in stocking will rectify the problem. Furthermore, the low stocking will make it difficult to get an operable cut without reducing the overstory density too much. In such cases, shelterwood cutting should not be attempted.

5. Undesirable Competitors

a. *Dense.*—Thirty percent or more of the reproduction plots are heavily stocked with grass, or 30 percent or more are stocked with ferns, or 30 percent or more are stocked with either beech root suckers or striped maple stems.

To be heavily stocked with grass or ferns, a plot of any size must have at least 30 percent of the ground area covered by any grass or sedge, hay-scented fern, or New York fern. If the identities of the ferns are uncertain, count any fern that grows as individual fronds from the ground level, and ignore any ferns that grow in clumps.

To be heavily stocked with beech root suckers or striped maple stems, a 6-foot-radius plot must contain at least eight stems (total) of the two species.

The stocking levels prescribed here for undesirable competitors is based on preliminary research findings and may be modified substantially as better information becomes available on the extent to which these species interfere with desirable regeneration. However, it is known that partial cutting will greatly stimulate these competitors where they are sufficiently dense before cutting.

b. *Sparse.*—Less than 30 percent of the reproduction plots are heavily stocked with grasses, ferns, beech root suckers, or striped maple stems as prescribed above.

Regeneration Cutting Guidelines

EVEN-AGED GUIDELINES

The type and number of cuttings required to regenerate new even-aged stands of Allegheny hardwoods will depend upon the amount of advance regeneration present before cutting and the relative importance of recreation and esthetic uses of the stand in question.

If advance regeneration is sparse in well-stocked stands, a shelterwood cutting sequence is appropriate. First, a seed cutting is made to open up enough growing space to encourage the establishment of new seedlings. This is followed in 5 to 10 years by a removal cutting to harvest the remaining overstory and release the newly established seedlings.

If advance regeneration is abundant, the seed cutting is not needed; and the overstory may be removed by clearcutting.

The unsightly initial appearance of a one-cut removal (either clearcutting or shelterwood removal cutting) may be improved by spreading the removal over two cuttings. In this way, reproduction has time to grow large enough to cover slash, stumps, and soil disturbance before all of the overstory is gone. This technique has not been thoroughly tested, but it warrants consideration in areas where esthetics and recreation are comparable in importance to timber production.

Clearcutting (A)

To insure successful reproduction, clearcutting or any other overstory removal cutting should be done only in stands where the advance regeneration is abundant (meets the stocking criteria previously described). The numbers of advance seedlings required may appear to be large, but this is because browsing by deer will destroy many of them before they can develop into sapling size. The impact of deer on regeneration is probably more severe in Allegheny hardwoods than in any other eastern forest type.

In areas where timber production is the primary goal of management, the overstory is generally removed in a single operation or clearcutting. All trees, including culls and nonmerchantable trees, should be removed or killed so that they do not interfere with the developing reproduction. However, up to 100 stems per acre of 2- to 6-inch diameter sugar maple, beech, and hemlock of acceptable quality may be retained to insure representation of these species in the next stand.

Two Removal Cuts for Esthetics

In areas where esthetics are important, but where timber production is still a primary goal of management, the removal may optionally be spread over two separate cuttings.

When two removal cuttings are used, the first one should reduce stocking to 30 percent of the A level,[2] with the residual made up of uniformly spaced individuals of the most vigorous, most desirable, and most windfirm stems. This cutting will provide a considerable increase in light and moisture for the already established seedlings, permitting them to begin rapid height growth.

The remaining overstory should then be completely removed about 5 years later, by which time some of the new seedlings should be 5 feet high or taller. In this way, stumps, slash, and logging disturbance will be at least partially hidden by the large reproduction before all overstory is removed; and the site will at no time be devoid of protective vegetation. Of course, the additional entry to the area will produce some increase in costs of management, and extra care may be required to insure that excessive amounts of reproduction are not destroyed by skidding during the second operation.

Distribution and Layout of Reproduction Cutting Areas

Forest yield regulation under even-aged management is achieved primarily by scheduling the cutting of the harvest-regeneration areas. To provide a sustained yield and an even flow of timber products, areas to be cut must be scheduled carefully to create and maintain the desired age-class distribution over the compartment, working circle, or forest area. Thus in scheduling regeneration areas, you must consider not only the condition of the stand in question but also the distribution of age classes, volumes, and stand

conditions in the surrounding stands. Furthermore, wildlife and esthetics are affected by the distribution of cutting areas. For a more complete discussion of this subject, the reader is referred to a paper by Roach *(1974)*.

Visual appearances of new harvest-cut areas can be improved if certain established procedures are followed such as: limitation of opening size to a maximum of about 50 acres; avoidance of new openings immediately adjacent to ones of the previous cutting cycle, avoidance of geometric shapes in the outline of the openings; care in the location of roads; and use of measures to reduce the height of slash piles and other logging debris. However, slash piles protect seedlings from deer browsing *(Grisez 1960)* and should not be removed from the site.

Detrimental effects sometimes attributed to clearcutting can also be avoided if certain established procedures are followed. Erosion and sedimentation of streams is avoided if temporary roads are carefully laid out and then water-barred or seeded with grasses after logging is complete. Avoidance of skidding during wet periods is also important. Further protection against sedimentation and increased stream temperatures can be achieved by leaving strips of vegetation 50 to 100 feet wide on each side of all permanent watercourses.

Release Cutting (B)

In stands that have developed a dense sapling and small pole understory, removal of the remaining overstory is all that may be needed to obtain a new stand. This will release the saplings and small poles so that they can develop fully.

Stands appropriate to release cuttings are usually two-aged stands that have resulted from heavy cutting (heavier than normal thinnings) during the past 10 to 20 years. Often the overstory is sparse and may be of poor quality, depending on the nature of the previous cutting. The understory, too, is often of less-than-ideal composition. Thus, the appropriate silviculture for such stands must be decided on an individual basis.

The merits of retaining and working with the existing overstory must be weighed against liquidation of the overstory and working with the understory. In either case, it should be recognized that new seedling regeneration will be extremely difficult to establish in such stands and that the choice is among the age classes already present on the site.

Shelterwood Cutting (C)

A shelterwood cutting sequence appropriate in Allegheny hardwoods involves a seed cutting followed by one or two removal cuttings.

Seed Cutting

The major goal of the seed cutting is to reduce canopy density uniformly to create optimum environmental conditions for seedling establishment. The seed cutting should reduce the overstory to 60 percent of A-level stocking, as determined from the stocking charts (appendix).[2]

In addition to providing shelter for the establishment of new seedlings, the residual overstory serves as a source of seed. Thus it is important to retain the larger and more desirable stems until the final harvest. Valuable species that are poorly represented in the stand should receive special consideration for retention.

Trees removed during the seed cutting should be distributed uniformly throughout the stands. Cutting of groups of trees that would create large canopy holes should be avoided. Insofar as possible, the trees removed should also be the least desirable in the stand and should generally come from the lower crown classes. Thus culls, poorly formed individuals, and less desirable species should be removed first—especially in the smaller size classes—along with a few better individuals and larger stems where removal is required to achieve relatively uniform canopy opening.

Additional purposes of this cut, like that of any thinning under even-aged management, is to provide the best stems and best species in the stand with adequate growing space to maximize value increase and seed production before the final harvest. It should also tend to concentrate trees in a narrower range of diameters.

If it is desired, small, unmerchantable trees that would normally be killed after the final removal cutting can also be removed during the seed cutting.

In laying out actual cutting boundaries, remember that shelterwood cutting will eventually result in complete overstory removal. Distribution of cutting areas for wildlife, control of their size and shape, and blending of the eventual opening with surroundings must be considered at the time of the seed cutting. (See section on "Distribution and Layout of Reproduction Cutting Areas", under "Clearcutting".)

Removal Cutting

In most shelterwood situations, a single removal cutting will normally be made 5 to 10 years after the seed cutting to harvest the remaining overstory and release the now-established reproduction. In areas where esthetics are more important, the removal may optionally be spread over two separate cuttings. (See section on "Two Removal Cuts for Esthetics", under "Clearcutting".)

In all cases, timing is dependent upon the establishment of new seedlings and should be made only if advance regeneration stocking levels meet the guides described previously. If reproduction does not meet these guides, removal cutting should be deferred.

All trees, including culls and nonmerchantable stems 2 inches dbh or larger, should be removed so that they do not interfere with the developing reproduction. However, up to 100 stems per acre of 2- to 6-inch diameter sugar maple, beech, and hemlock of acceptable quality may be retained to insure representation of these species in the next stand.

Deferred Cutting (D)

In this guide to regeneration of Allegheny hardwoods, we recognize two situations where satisfactory regeneration may not be obtainable with any of the cutting techniques available.

In stands lacking adequate advance reproduction, and where overstory stocking is below 70 to 80 percent, neither clearcutting nor shelterwood cutting are likely to be successful. There are not enough advance seedlings to expect good results from clearcutting, and shelterwood cutting will probably not stimulate new seedlings because the overstory density is already low enough for advance seedlings to have developed if some other factor were not limiting. In such situations, it is recommended that cutting be deferred until more information is available on the treatment of such stands, or that other special measures such as artificial regeneration and protection from deer be considered.

In stands lacking adequate advance reproduction and containing dense coverage of grasses or ferns or numerous beech root suckers or striped maple stems, shelterwood cutting may stimulate these competing plants to the point where they interfere with desired reproduction. The nature and extent of the competition offered by these plants have not been fully evaluated, but there are numerous examples of regeneration failure that can be attributed to them. Until more detailed information is available, we recommend that shelterwood cutting be deferred in stands containing these plants in amounts exceeding the limits previously specified.

Where beech or striped maple are the problem, a possible alternative is to kill these stems by mistblowing herbicides *(Smith and Trimble 1970)* before shelterwood cutting. However, such treatments are not effective on grasses or ferns and have not been tested in the Allegheny hardwood type. Such a treatment would kill any desirable advance reproduction present, and a whole new crop of advance seedlings would have to be developed before the removal cutting. Thus attempts to eliminate beech and striped maple in this way should be limited to stands where the need for cutting is urgent, where grasses and ferns are not a problem, and where no other alternative is available.

UNEVEN-AGED GUIDELINES (E)

Both individual-tree selection and group-selection cutting methods may be useful in Allegheny hardwoods, particularly on small ownerships or on portions of large ownerships where recreation and esthetics are especially

important. Although considerable information is available from other northern hardwood regions, guidelines are not available for the Allegheny Plateau where deer browsing limits reproduction.

Individual-tree selection cutting in any northern hardwood type will tend to favor the tolerant species such as beech, hemlock, and sugar maple, and discriminate against less tolerant species. In the Allegheny hardwood type, deer browsing further alters species composition. Hemlock and sugar maple are heavily browsed, and beech is sometimes used less *(Hough 1965)*. Thus individual-tree selection cutting where deer browsing is heavy will tend to produce stands primarily of beech or, in some instances, may interfere with development of any species of reproduction *(Richards and Farnsworth 1971)*.

Similar problems may occur in the small openings of group-selection cutting. Reproduction in early strip and patch cuttings on the Allegheny Plateau was often completely destroyed by deer.

Because of the lack of information and the potential damage to reproduction, use of uneven-aged silviculture should be considered experimental and should be limited to those stands or properties where even-aged silviculture is not appropriate.

Nevertheless, these cutting methods offer many potential advantages for small properties and areas where esthetics and recreation are especially important, and they deserve to be tried in such situations. Results of such trials should be observed carefully.

Individual Tree Selection Cutting

As a general guide, individual-tree selection cutting should reduce stand stocking to the B level.[2] In selecting trees to remove, deliberate attempts must be made to cut trees in all diameter classes to develop and maintain a balanced stand structure. Unless this is done, gaps and surpluses will occur in the diameter distribution, which will eventually lead to alternating periods of low and high yield rather than sustained even-flow yields. The approximate diameter distribution to be maintained should be:

Diameter group (inches dbh)	*Residual basal area (percent)*
1-5	14
6-10	32
11-16	32
17+	22

Cuttings may be made every 10 to 20 years, but the actual interval depends on the time required for the stand to return to within 80 to 90 percent of A-level stocking.

Group-selection cuttings may also be useful where small openings are desired to create diversity of appearance or habitat or to increase the proportions of the less-tolerant species in the reproduction. To maintain the desired visual effects, group-selection openings should usually not be larger than a few acres and may be as small as about 1/3 acre. Individual-tree selection cuttings should also be made in the area between openings.

If less-tolerant reproduction is obtained in group-selection openings, its growth and survival are enhanced if the openings are enlarged during subsequent cutting cycles to maintain adequate light exposure. Enlargement of the openings on all sides is not necessary; best results are obtained if the enlargement is made on the southern edge of the established reproduction. Considerable planning is required to fit the new cuttings into the mosaic of previous ones; this should be done at the time of the initial cuttings where possible.

The regulation of cut and yield can be difficult under group-selection cutting. Volume control is extremely difficult because there is no way to regulate size distribution of the residual stand. The small size (and therefore large number) of the openings required make area control extremely difficult on large properties, but it can be achieved on smaller ones.

Appendix

STOCKING CHARTS FOR ALLEGHENY HARDWOODS

Adapted from Roach[2]

The two charts that follow permit the evaluation of stocking level for stands of Allegheny hardwoods. To use these charts, you must have data on: numbers of trees per acre 0.5 inch dbh and larger, total basal area per acre in trees 0.5 inch dbh and larger, and proportion of the total basal area represented by black cherry, white ash, and yellow-poplar. See section on "Overstory Evaluation" for further details on data needed.

The two charts are similar. The first is for stands 3 to 10 inches in diameter; the second is for stands 6 to 15 inches in diameter. Average diameter is the diameter of the tree of average basal area.

Each chart contains two series of lines. The "A" lines represent 100 percent or full stocking for stands containing the proportions of black cherry, white ash, and yellow-poplar shown. These are the levels of stocking that all stands will tend to approach if they are left undisturbed for a sufficiently long period of time.

The "B" lines represent 60 percent of full stocking. At B level, the individual trees in the stand have considerable growing space, but there are still enough trees to fully occupy the site. Total stand growth is about the same as at A level stocking, but this growth is being put on fewer trees. At densities below B level, individual trees may grow a little faster because they have even more growing space, but there will be too few trees to fully occupy the site, so total stand growth will be sacrificed. In thinnings, stand density is normally reduced to the B level. We also recommend this level for the seed cut of a shelterwood sequence.

An example will illustrate proper use of the charts. Consider a stand that has 300 trees per acre and 145 square feet of basal area, of which 72.5 square feet (or 50 percent) is in black cherry, white ash, and yellow-poplar.

Find the point in the chart where the line for 300 trees intersects the line for 145 square feet, and note where this point falls in relation to the A-level percent composition curves. This stand would be 100-percent stocked if it contained 30 percent black cherry, white ash, and yellow-poplar instead of 50 percent. Also note where the point of intersection falls in relation to the diagonal lines representing average diameter. It falls between the 9-inch and 10-inch lines; we can interpolate here and estimate that this stand has an average diameter of 9.4 inches.

Now, imagine that there is a line representing 9.4 inches: follow that line upward on the chart to the point where it would intersect the A-level 50-percent cherry-ash-poplar line. Note that this point corresponds to a basal area of about 159 square feet. This is the basal area we would expect of a fully stocked stand of the same average diameter and containing the same proportion of cherry, ash, and poplar as our sample stand. Since our sample actually contains only 145 square feet of basal area, it is 91 percent (145/159) stocked.

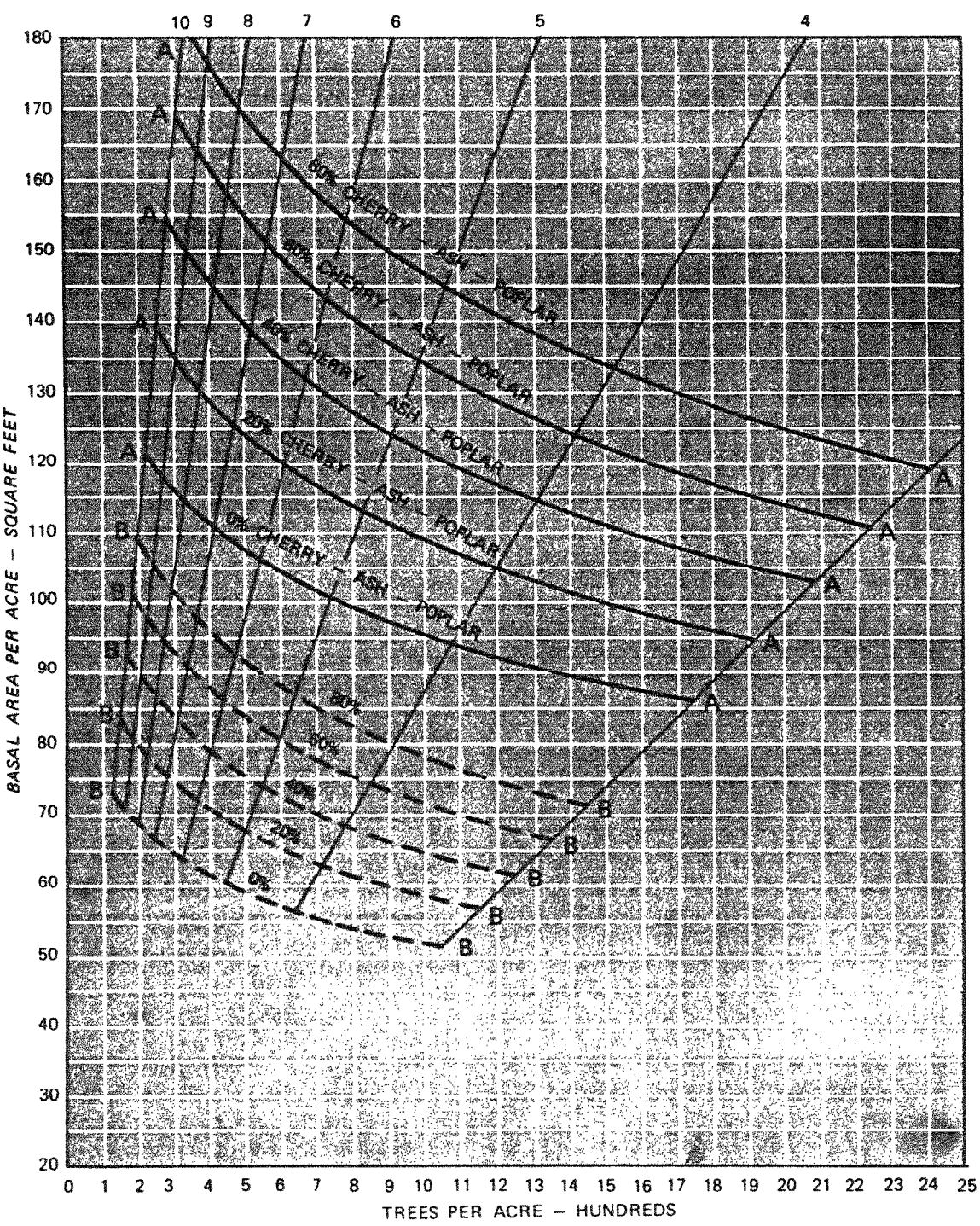
B-level stocking for the sample stand can be determined in the same manner. Follow the 9.4-inch diagonal line downward in the chart to the point where it would intersect the B-level 50-percent cherry-ash-poplar line. Note that this corresponds to a basal area of about 95 square feet. This is the minimum basal area that should be left after thinning or shelterwood cutting, *provided* that the species composition and average stand diameter are not altered by the cutting.

Caution must be exercised here, however, because species composition and average stand diameter are usually altered by cutting. If trees removed are from the smaller sizes, as recommended in the shelterwood cutting guidelines, mean stand diameter will be increased by the cutting. Experience has shown that this increase is often about ½ inch for each 10 percent of the stocking removed. Likewise, the valuable black cherry, white ash, and yellow-poplar are usually favored, so the proportion of these species may be increased by cutting. Both changes increase the amount of basal area required for minimum (B-level) stocking.

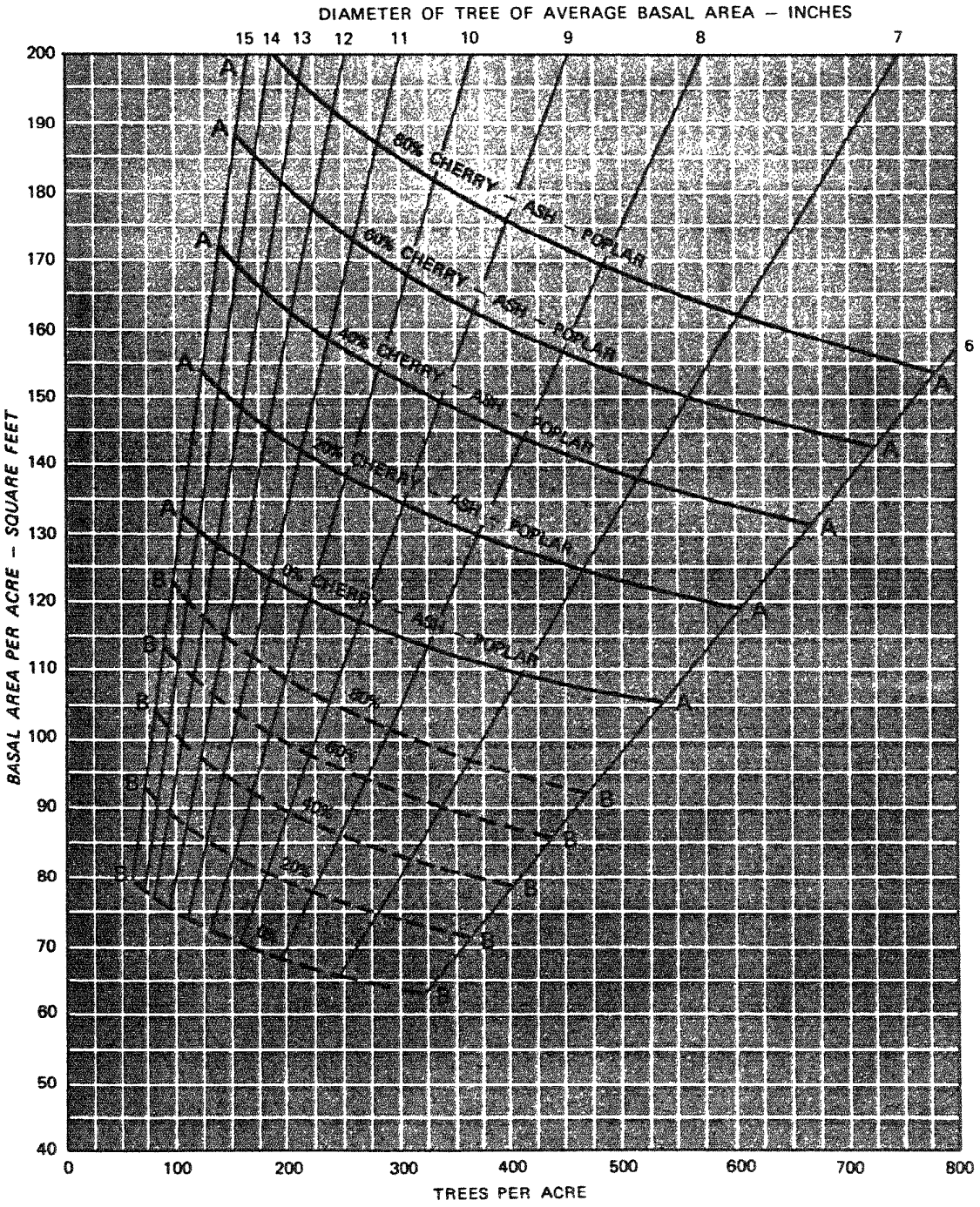
STOCKING GUIDE FOR ALLEGHENY HARDWOODS

1.

FOR STANDS 3 TO 10 INCHES IN DIAMETER



STOCKING GUIDE FOR ALLEGHENY HARDWOODS
2.
FOR STANDS 6 TO 15 INCHES IN DIAMETER



Using our example above, and assuming no change in species composition or mean stand diameter, we would normally prescribe that cutting remove 50 square feet of basal area to reduce density from the existing 145 square feet (91-percent stocking) down to the B level of 95 square feet (60-percent stocking). However, if cutting increases average diameter by ½ inch for each 10 percent of stocking removed, the residual stand would have a mean diameter of about 11 inches. B level for an 11-inch diameter stand with 50 percent cherry-ash-poplar is 100 square feet of basal area. So the cutting should actually remove 45 square feet of basal area—rather than the 50 square feet originally calculated. To avoid overcutting in actual situations, possible changes in both diameter and species composition must be considered.

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