New Approaches to Uneven-Age Management in New England

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ABSTRACT. Because of greater emphasis on nontimber values in New England, uneven-age management is drawing more interest among the larger ownerships. Uneven-age management approaches recommended in the past were both costly and biologically undesirable. However, recent findings are enabling the development of more feasible uneven-age guidelines for regenerating valuable species, conducting practical cutting operations, controlling marking, and keeping records.

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For years, uneven-age management has been the common practice on nonindustrial private ownerships in New England, sometimes conducted under the label of "partial cutting" or "selective cutting." On national forests and many industrial ownerships, even-age management with clearcutting or shelterwood cutting has been the rule for the last couple of decades. This choice was based on the biological and economic advantages of even-age management, as contrasted with certain prominent disadvantages of the uneven-age approach. But times are changing. Because of certain esthetic and wildlife concerns, there is a growing interest in uneven-age management on the large ownerships.

Certain advances in knowledge and concept have provided ways to overcome some of the traditional objections to uneven-age management. In this article we review some of the past problems with the system, and describe some of the new approaches that are available—especially those developed in cooperation with the White Mountain National Forest in New Hampshire. These approaches may be useful, in concept at least, in other regions that are pressured by nontimber interests toward alternatives to even-age management.

THE SYSTEM IN BRIEF

Uneven-age management rests on the assumption that each major stand can be maintained indefinitely as a reproducing, growing population of trees. Each harvesting entry into a stand does three things: (1) removes mature trees; (2) cultures the stand by removing poorer individuals and increasing growth on the best stems; and (3) provides space and seedbed conditions for the regeneration and development of new individuals. Two harvesting methods are available: individual-tree and group selection. Residual stand objectives are defined by three factors:

(1) *Stand Density.*—The basal area following cutting should be high enough to ensure adequate growth per acre and quality development, yet low enough to ensure good individual tree growth, regeneration, and development of understory trees.

(2) *Diameter Distribution.*—This refers to the numbers of trees by diameter class, or, more generally, to the basal area per acre in various size groups such as sapling, poles, and small and large sawtimber. The familiar inverse J-shaped curve, relating numbers of trees to dbh class, commonly is used to describe or derive diameter distributions, though there are other possible curve forms. The diameter distribution is specified so that there will be sufficient trees to continually grow into the next larger size class, with extra trees to allow for mortality, damage, and leeway to select for the best individuals. The diameter distribution also determines the proportion of growing stock and proportion of growth in sawtimber trees.

(3) *Maximum-Size Trees.*—This is approximately the largest tree to be left in the residual stand based on site potential and desired product. The maximum-size tree represents the upper limit of the diameter distribution, and usually is determined in conjunction with that factor.

These are the essential three factors, though other residual-stand objectives may be specified in terms of species mix and quality classes.

PROBLEMS AND SOLUTIONS

Species/Quality

Uneven-age management has been consistently linked with the regeneration of tolerant or moderately tolerant species. In New England, one of the main objections to the system is that it has regenerated large amounts of beech—commonly a low-value timber species.

In deriving new uneven-age guidelines, two deveopments have made it possible to overcome this problem First, we have found that the occurrence and regeneration of tolerant species are strongly influenced by site or habitat (Leak 1980). Certain soils, such as sandy tills, will regenerate abundantly to beech or red maple under single-tree selection; fine-textured soils will produce a significant proportion of sugar maple; while excessively wet, dry, or shallow soils will regenerate softwoods.

On those sites where single-tree selection will regenerate undesired species, we now recommend group selection. Years of experience on the Bartlett Experimental Forest in New Hampshire (Leak and Filip 1977) have shown that group selection is effective in regenerating about one-third or more intolerant or intermediately tolerant species, e.g., yellow birch (Table 1). Group selection cuttings that re-

Table 1. Approximate proportions of milacres dominated 10 to 15 years after cutting by tolerant or intermediate plus intolerant regeneration (commercial species) by selection-system harvesting method.

Selection method	Established regeneration: Tolerants[a]	Intermediate/ intolerants[a]
Individual-tree	9/10	1/10
Small groups ($^1/_2$–$^2/_3$ acre)	2/3	1/3
Large groups (1–2 acres)	1/2	1/2

[a] Tolerants: beech, sugar maple, red spruce, eastern hemlock; intermediates: yellow birch, red maple, white ash; intolerants: paper birch, aspen.

move everything 2 in and larger result in the most intermediate or intolerant regeneration; this approach is recommended when saplings and small poles are undesirable in species or quality or where noncommercial species are dominating the understory. Group selection also can be applied primarily to overstory trees, allowing the understory of tolerant to moderately tolerant species to develop.

Concern often is expressed over potential quality of the stems that develop in uneven-aged stands. Research in the Lake States indicates that stem quality of tolerant hardwood reproduction under partial cutting is as good as on clearcut areas (Zillgitt 1950). Suppressed trees of sugar maple (Trimble 1968), hemlock, and red spruce apparently respond well after cutting in terms of growth and quality. To encourage natural pruning on pole-size and larger stems, observation and data from the Lake States (Godman and Books 1971) indicate that residual basal area (4.6 in and larger) should be 70 to 80 ft^2 per acre.

Impractical Diameter Distributions

In keeping with experience in the Lake States (Crow et al. 1981) and Appalachians (Smith and Lamson 1982), recommended residual diameter distributions for New England (Leak et al. 1969) were based approximately on the inverse J-shaped form of diameter distribution using a quotient (Q) between numbers of trees in 2-in dbh classes of 1.3. This fairly low Q provides for a high proportion of sawtimber (approximately 75% of the basal area) and was thought to be optimum for the production of quality sawlogs. However, as an immediate goal in small sawtimber or cutover hardwood stands, the Q of 1.3 proved impractical and discouraging (Table 2). Obviously, in such stands, the recommended residual goal led to a heavy cut in poletimber and a very light cut in sawtimber. Not only was this impractical from the standpoint of logging economics, but new growth information (Solomon 1977a) began to indicate that low Q's (high proportions of sawtimber) did not necessarily produce good growth responses in second-growth stands (Table 3). Stands with only 30 and 45% sawtimber often provided about as much or more sawtimber net growth as those with 60% sawtimber. Even accretion minus mortality (which leaves out ingrowth into the sawtimber size classes) was often best with 30 or 45% sawtimber, unless the amount of residual sawtimber was below about 20 ft^2 of basal area, e.g., the 60 ft^2/30% sawtimber treatment.

Three other factors led us toward more flexible guidelines on diameter distribution and less emphasis on a high percentage of sawtimber in the residual stand. First, simulated stand dynamics (Adams and Ek 1974) and field studies (Goff and West 1975) began to indicate that alternatives to the J-shaped distribution, such as sigmoid forms, were natural and economical. Second, diameter growth was found to decline rapidly with increasing tree size on mediocre sites (Leak 1983), implying that it might be difficult to maintain large amounts of vigorous sawtimber on less productive soils. Third, the diameter distribution is specified primarily to maintain a continuous flow of timber products, but, in practice, timber yields generally are controlled over several to many stands that make up a sustained-yield unit.

As a result, we recommend a range in alternative residual diameter distributions for hardwood stands in terms of basal area per acre by three dbh groups (Table 4). A similar approach is used for mixedwood stands, except for higher residual basal areas per acre. The diameter distribution with a low proportion of sawtimber (Q = 1.7) is a useful immediate goal in small-sawtimber stands, cutover stands, and stands on poor sites. Over time, on medium or better sites, it should be possible and desirable to decrease the Q (increase the proportion of sawtimber) until a diameter distribution is reached that is optimum for the site, species composition, and product

Table 2. Basal areas per acre by dbh group for a typical small sawtimber stand, a residual stand based on Q = 1.3, and the calculated cut.

Dbh group (in)	Typical small-sawtimber stand	Residual goal (Q = 1.3)	Cut
6–10	52	20	32
12+	62	60	2
All	114	80	34

Table 3. Basal-area growth per acre in sawtimber-size trees (10.6 in dbh and larger) related to stand basal area per acre (4.6 in dbh and larger), and percent of stand basal area in sawtimber.

Stand basal area	Percent sawtimber	Sawtimber basal-area growth: Net growth	Sawtimber basal-area growth: Accretion minus mortality
60	30	1.31	0.27
	45	1.66	.76
	60	1.61	.76
80	30	1.95	.64
	45	1.62	.49
	60	.45	.37

Table 4. Recommended residual diameter distributions for northern hardwoods in basal area per acre[a] by dbh group, and Q (quotient between numbers of trees in 2-in dbh classes).

Dbh group (in)	Q 1.7	Q 1.5	Q 1.3
6–10	40	32	23
12–14	20	21	21
16+	15	22	31
All	75	75	75

[a] Recommended basal area varies depending on the chosen maximum-size tree. This table is based on a 20-in maximum tree size.

goals High amounts of residual sawtimber (Q = 1.3) are more feasible in older stands of large sawtimber on better sites, especially after several entries. In applying these guides, emphasis is placed on improving stand quality and vigor, and being flexible on the amount of basal area to leave within dbh classes. Experience to date indicates that stands under group selection may be handled under the same density and diameter-distribution guidelines as those under individual-tree selection (Leak and Filip 1977).

Although the relation of age to size may be poor in previously unmanaged stands, the dbh groups will begin to represent distinct age groups as management continues over time (Tubbs 1977).

Marking Control

Marking for uneven-age management is regarded as more difficult than for even-age management, primarily because the marker must account for diameter distribution as well as stand density, species quality, spacing, etc. The amount of training and experience required commonly is voiced as a serious objection to uneven-age management in New England. This objection is potentially important because stand diagnosis and prescription come to naught if marking objectives cannot be carried out accurately in the field.

Four marking aids can be used to ease the problem. First, as described in the previous section, our approach is to prescribe and control diameter distribution by three diameter groups only—poles, small sawtimber, and large sawtimber. A second aid to marking control is a preliminary prism-plot inventory, showing basal area per acre by diameter group, quality, species, etc., that allows the development of precise marking rules (Table 5). In this simple example, it is evident that by concentrating the marking on defective and high-risk sawtimber, a residual stand will result that is composed mostly of acceptable growing stock in amounts close to the residual density and diameter distribution recommended for Q = 1.5 (Table 4). More detailed marking instructions can be developed that are based on removing all (or portions of) the basal area in certain species-size-quality classes. However, because initial stand inventories are not always precise, a third marking aid is needed: the markers should check the leave stand with prisms fairly regularly—especially at the outset of a marking job. The fourth aid to marking control is training: the establishment of a few training plots with known initial inventories that can be used for practice in developing prescriptions, writing marking rules, and marking to given levels of density and diameter distribution. On a ½-acre hardwood training plot on the Bartlett Experimental Forest, four marking crews from the White Mountain National Forest produced consistently acceptable results (Table 6).

Table 5. Hypothetical prism-plot summary showing initial basal area per acre by tree classes and dbh group, and the proposed residual goal.

Dbh group (in)	Initial stand: Acceptable growing stock	Defective	High risk	All	Proposed residual goal (approx. Q = 1.5)
6–10	30	6	—	36	36
12–14	20	12	12	44	20
16+	20	12	8	40	20
	70	32	20	120	76

Marking control for group selection requires special precautions. As mentioned earlier, we generally recommend individual-tree marking between the groups, and are inclined to use the same residual density and diameter distribution guidelines for both individual-tree and group selection. These guidelines are applied to the entire acreage (including groups) on stands scheduled for group selection. With small groups of several trees, the marking procedures are the same as for individual-tree selection. With larger groups (more than 1/10 acre), some element of area control is useful: we recommend a simple dot tally of approximate group sizes to ensure that the total proportion of the area in groups does not exceed the cutting cycle divided by the rotation commonly used for that timber type under even-age management. Residual basal area between groups can be raised 10% as a buffer against heavy cutting In addition, marker training should be provided on how to locate groups in clusters of overmature, defective, or undesirable trees, especially on sites that are regenerating low-value tolerant species, and on what sorts of trees to leave as border trees along group edges.

Records

A common notion in New England is that the formal application of uneven-age management requires more record keeping than even-age management. This objection may be based on two factors: (1) experimental forests engaged in research on uneven-age management commonly use 100% inventories to monitor stand development, and (2) most allowable-cut formulas for uneven-age management are based partly on growth—and accurate growth estimates in the past have required a system of remeasured plots.

Actually, records for uneven-age management are similar to those required for even-age management Acreage estimates are needed for stands and compartments (or cutting units) to about the same accuracy as required for even-age management Stands require a cursory examination or low-accuracy prism-plot inventory to determine whether cutting should be scheduled. Then, a prism-plot inventory is made before cutting to de-

Table 6. Training plot summary for ½-acre plot showing basal area per acre by dbh group for the initial stand, desired residual stand, and actual residual stands left by four marking crews.

Dbh group (in)	Initial stand	Desired stand	Residual stands by crew: 1	2	3	4
6–10	24	18	19	18	16	18
12–14	29	27	21	21	27	27
16+	45	34	32	34	34	33
All	98	79	72	73	77	78

fine residual stand goals, develop marking guides, and estimate probable cut. Because of our flexible guidelines on residual diameter distribution, prism-plot samples should be entirely adequate for inventory, diagnosis, and prescription. A marking tally is required to determine the sale volume or the volume of products to be delivered to the plant; or, the volume can be scaled at the mill. The basal area by diameter group of the residual stand generally can be estimated with sufficient accuracy by subtracting the marking tally from the before-cutting estimate. Only if there is excessive logging damage or some question about logger's compliance would a postlogging cruise be needed. Growth estimates for the residual stand commonly are desirable to estimate future cut and the cutting cycle. In most forest types, growth data and/or simulators (Solomon 1977b) are available for this purpose without the need to have permanent growth plots. For general planning purposes, we commonly assume a basal area growth in hardwoods of 2 ft^2 per acre annually. Therefore, a cutting cycle of about 15 to 20 years would provide a cut of 30 to 40 ft^2 or about 7 to 10 cords per acre—commonly an operable cut. Cutting cycles of between 10 to 20 years are used depending on accessibility, stand value, and risk of mortality or degrade.

Damage

Logging damage is a concern in any partial cutting operation in New England (Nyland and Gabriel 1971, 1972). Commercial thinning in even-aged stands may cause appreciable damage, but the problem is compounded in uneven-aged stands where large trees are being harvested next to smaller growing stock. Steep slopes or rough topography result in more severe damage. A number of measures can be taken: marking trees to minimize felling damage, directional felling, limiting the size and type of equipment, skidding log-length instead of tree length, using winching devices, laying out main skid trails to avoid quality growing stock, removing bumper trees along skid trails at the close of the logging job (and leaving extra basal area during marking to offset this removal), and avoiding spring logging when the bark readily peels off. In addition, the use of group selection should help reduce damage by concentrating the logging activity. Despite the precautions, however, both the short- and long-term effects of logging damage remain a persistent, unsolved problem.

Another damage problem is windthrow in partially cut stands on wet or shallow soils. Where uneven-age management is the only alternative on such sites, the best approach appears to be light cutting, marking of trees that show signs of leaning or root upheaval, frequent returns (short cutting cycle), and a small, maximum tree size coupled with a relatively small amount of residual sawtimber. Windthrow is especially damaging in mixed or softwood stands, and could severely limit the application of uneven-age management in these types.

Access Costs

Limited cost information (Filip 1967) indicates that the direct felling-skidding costs per unit volume are not greatly different between even- and uneven-age management. The difficulty with uneven-age management sometimes is the initial financing of roads: building roads into inaccessible areas and then removing only about one-third of the volume within skidding distance of the road. It may be necessary to use slightly heavier cutting (minimum residual stocking) and longer cutting cycles on the first entry into inaccessible areas.

CONCLUSION

New approaches to uneven-age management in New England are making the system more feasible, biologically as well as economically. These approaches should prove useful in the northeastern states and, with local adaptations, to other regions in the eastern United States that have a range of species with varying tolerances and timber values, cutover or young sawtimber stands, and the need for uneven-age management due to esthetic or wildlife concerns. The use of individual-tree and group selection on appropriate sites will help ensure the regeneration of desirable species. Earlier guidelines on diameter distribution—emphasizing the need for high percentages of sawtimber—have been relaxed so that several alternatives are available to meet specific stand and site conditions Control of marking can be facilitated by flexible residual stand goals, diagnostic inventories, prism checks, and acreage checks on the area allotted to group cuttings. The need for excessive records is eliminated by a flexible approach to defining residual stand goals, and by the availability of growth information for most forest types. Carefully designed and supervised logging operations will be needed to overcome the two most important remaining obstacles: logging damage and initial access costs.

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