Best Density and Structure for Uneven-Aged Northern Hardwood Management in New England

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ABSTRACT: *Choice of the best residual density (basal area per acre) and structure (diameter distribution) for uneven-aged management of northern hardwoods is a complex decision that depends on the manager's decision rules, product objectives, site conditions, and—perhaps most important—current stand conditions. In contrast to other recommendations on residual density and structure, growth information from a study in New Hampshire shows that a residual basal area of 60–80 ft²/ac coupled with a sawtimber basal area as low as 25–35 ft²/ac (equivalent to a q-ratio of 1.5–2.0) may result in adequate 10 yr board-foot growth responses in previously unmanaged stands on mediocre northern hardwood sites. North. J. Appl. For. 20(1):43–44.*

Key Words: Northern hardwoods, stocking, structure, growth.

When marking a northern hardwood stand for uneven-aged management through individual-tree or small-group selection, the manager comes face-to-face with the question of how much basal area to leave in the residual stand and how much of this basal area should be in sawtimber-sized trees. In other words, what is the optimum stocking and structure? Recent concerns over heavy cutting have prompted a renewed interest in, and lots of questions about, the application of uneven-aged management (e.g., Thompson 2001). The purpose of this note, therefore, is to reexamine existing growth information from a study in New Hampshire to show why there may be a range of options on optimum residual stocking and structure.

Background

There are two basic approaches used in determining the best residual stocking and structure: (1) optimum economic response, and (2) optimum growth response. In general, the optimum economic approach in terms of acceptable rates-of-return or present net worth leads toward low residual stocking in volume and value as Duerr and Bond (1952) clearly point out. Most economic studies confirm this point (e.g., Adams and Ek 1974, Lu and Buongiorno 1993, Gove and Fairweather 1992, Hansen and Nyland 1987). The higher the acceptable rate-of-return, the lower the optimum volume and value of the residual stand.

On the other hand, for optimum responses in terms of board-foot growth in northern hardwood stands, residual stands with fairly high board-foot volumes or low q-ratios (in the larger trees at least) commonly are recommended. For example, available guidelines suggest about 50–70 ft^2 of sawtimber per acre (about 75–85 ft^2 in poles and sawtimber) or q-ratios of about 1.2 or 1.3 for cutting cycles of 10–15 yr (Arbogast 1957, Crow and Tubbs 1981, Hansen and Nyland 1987, Nyland 1998). (q is the ratio between numbers of trees in successively smaller 2 in. dbh classes and is used as a rough guide to appropriate diameter distributions; low q ratios reflect a gradually sloping curve with a high proportion of sawtimber trees.) For very long cutting cycles of 20–25 yr, lower sawtimber densities of 25 to 40 ft^2 have been suggested (Nyland 1998).

Two factors sometimes make it difficult to follow the standard recommendations for optimum growth: the influence of current stand conditions, and the effects of site. Available published data from an earlier comprehensive growth study on the Bartlett Experimental Forest in New Hampshire (Solomon 1977) were reexamined to illustrate the effects of these two factors. This study consisted of 10 yr growth responses from four levels of residual basal area and three levels of percent sawtimber on 1/3 ac plots, replicated four times. The stand was northern hardwoods, about 70 yr old with some older holdovers, growing on a sandy, washed till. Species composition was about 30% beech (*Fagus grandifolia*), 25% red maple (*Acer rubrum*), and 20% paper birch (*Betula papyrifera*), with smaller percentages of yellow birch (*Betula alleghaniensis*), sugar maple (*A. saccharum*), white ash (*Fraxinus americana*), and hemlock (*Tsuga canadensis*). Site index for sugar maple on these sites is about 50.

Results

Annual growth responses over a 10 yr period in basal area per acre are in Table 1. Net growth of the entire stand (trees >4.5 in. dbh) declined from about 2 ft^2/ac at residual densities of 40 and 60 ft^2 of basal area down to less than 1 ft^2 at a residual density of

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Table 1. Average annual growth in ft² of basal area per acre over a 10 yr period related to residual stand basal area, percent and basal area of sawtimber (Solomon1977).

Stand basal area (ft^2)	Sawtimber (%)	Sawtimber basal area	Stand net growth	Sawtimber net growth	Sawtimber accretion minus mortality	Sawtimber ingrowth
		(ft^2)				
40	30	12	2.22	1.43	0.26	1.17
	45	18	2.00	1.33	0.43	0.90
	60	24	1.84	0.51	0.10	0.40
60	30	18	1.71	1.31	0.27	1.04
	45	27	2.29	**1.66**	**0.76**	0.90
	60	36	2.01	**1.61**	**0.76**	0.86
80	30	24	1.69	**1.95**	**0.64**	1.31
	45	32	1.67	**1.62**	0.49	1.13
	60	45	1.15	0.95	0.37	0.59
100	30	30	1.74	1.85	0.45	1.40
	45	45	1.21	1.57	0.35	1.22
	60	60	0.91	1.10	0.60	0.50

100 ft^2 with 60% sawtimber. Net growth of sawtimber (trees >10.5 in. dbh) was 1.6 ft^2 or better at 60 ft^2 residual basal area with 45% or 60% sawtimber, or 80 ft^2 residual basal area with 30% or 45% sawtimber; also, at 100 ft^2 with 30% sawtimber. Note that all these combinations have a residual sawtimber density of about 25 to 35 ft^2 of basal area. In terms of volume, 1.6 ft^2 is roughly equivalent to 150 bf/ac/yr.

However, when evaluating sawtimber net growth, it is important to make sure that a high proportion of that growth is accretion on trees that were already sawtimber-size at the beginning of the growth period—rather than ingrowth from trees that moved from poletimber to sawtimber during the growth period. Sawtimber ingrowth is an important factor in building up the sawtimber growing stock, but it does not provide mature, quality sawtimber available for the next cut. Again looking at Table 1, note that out of the combinations mentioned above, 60 ft^2 residual basal area with 45% or 60% sawtimber provided the maximum accretion minus mortality (0.76 ft^2), while 80 ft^2 with 30% sawtimber was second (0.64 ft^2).

Application and Discussion

These results show that adequate board foot production over a 10 yr period can result from residual densities of 60–80 ft^2 of basal area per acre with 25–35 ft^2 in sawtimber-sized trees. Assuming a 20 in. maximum-sized residual tree, these guidelines are equivalent to q-ratios (2 inch dbh classes) of about 1.5 to 2.0. These levels of sawtimber stocking are well below those commonly recommended for uneven-aged management of northern hardwoods using 10–15 yr cutting cycles.

Why? The site—a sandy till with site index of about 50 for sugar maple—is mediocre at best. As a result, the species composition included significant proportions of red maple and beech, some of the latter with beech-bark disease. The stand was fairly young (with holdovers) and previously unmanaged. Research in nearby stands shows that perhaps 1/3 of the sawtimber in unmanaged stands with a high proportion of beech has any quality potential (Leak and Sendak 2002). In marking such stands, it is difficult to leave a high stocking of vigorous, potentially valuable sawtimber. However, such stands are common in New England, and feasible marking guides are needed.

In subsequent entries in such stands, higher levels of residual sawtimber or lower *q*-ratios may well be appropriate. On better sites, with high proportions of sugar maple and white ash, residual sawtimber densities of 50–70 ft^2 of basal area may well be optimum for maximum board foot growth. However, where the decision has been made to use uneven-aged management through individual-tree or small-group selection, timber markers should be aware that stands of mediocre timber on moderate sites may be best handled on the first entry by leaving 60–80 ft^2 of basal area with only 25–35 ft^2 of sawtimber. No economic evaluations were made in this study. However, I believe that these low levels of residual sawtimber would be economically reasonable as well.

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