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Second-Growth Northern Hardwoods on Bartlett Experimental Forest – a 25-year record

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SECOND-GROWTH timber occupies more than one-third of the commercial northern hardwood forest land in New England. The origin of these stands — clearcutting, or land abandonment with or without fire — determined their present characteristics; they are essentially even-aged, with a high proportion of intolerant and intermediate species and many stems of sprout origin (Fig. 1). Some stands contain a few large holdovers from earlier logging operations.

These immature forests now provide only a small share of the timber products required by the wood-using industries of New England. But, as supplies of available old-growth sawtimber diminish, second-growth stands will become progressively more important in supporting the timber economy. An understanding of the natural development of these stands will assist in determining proper systems of management for realizing their full productive potential.

Available information on the growth and development of second-growth northern hardwoods is almost entirely restricted to short-term responses of average stands following intermediate cuttings. This paper describes the changes which took place over a quarter of a century in unmanaged second-growth under three levels of initial stocking.

Source of Data

Twenty-one ¼-acre permanent cruise plots on the Bartlett Experimental Forest, New Hampshire, provided growth and development records of second-growth northern hardwoods over an average period of 25 (20-27) years. The plots were established in 1931-1932 in 40- to 60-year-old stands that covered about 200 acres. Final measurements were taken from 1952 to 1958.

For purposes of analysis, the plots were grouped into three initial stocking levels based on square feet of basal area per acre in trees larger than 4.5 inches d.b.h. These stocking-level groups were:

- Low — average basal area of 36 square feet, ranging from 26 to 41 (6 plots).
- Medium — average of 56 square feet, ranging from 48 to 66 (7 plots).
- High — average of 94 square feet, ranging from 81 to 106 (8 plots).[1]

There were also associated differences between stocking levels in numbers of trees, average d.b.h., and size-class distribution. Large holdovers (18 inches d.b.h. and larger) from previous logging operations accounted for an average of 4.4 square feet of basal area per acre on the high-stocked plots, 2.4 on the medium,

[1] These are not the maximum densities found in 40- to 60-year-old second-growth northern hardwoods. Some stands in this age group on the Bartlett Experimental Forest have up to 125 square feet of basal area per acre.

Figure 1. — An example of second-growth northern hardwoods growing on an average site. The two trees in the foreground are a paper birch (left) and a red maple (right).

and none on the low. Most of the differences between stocking levels in total basal area and other stand conditions were probably due to variations in the occurrence and degree of fuelwood cuttings made prior to the establishment of the permanent cruise plots. All important species[2] were fairly well represented in the three stocking level groups, but percentages did differ.

Growth & Development

Over the 25-year period, annual production in basal area per acre for high stocking was only about one-half of that under medium and low stocking (table 1). Significantly greater mortality and lower ingrowth under high stocking were primarily responsible for the lower production.

Annual production in 5- to 10-inch trees was considerably less with higher initial stocking (table 2). This resulted from the combined effects of slower growth (including slower ingrowth) and higher mortality of pole-sized trees under the more crowded

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[2] Beech, yellow birch, sugar maple, red maple, paper birch, white ash, and eastern hemlock. Red spruce, which was present in only small numbers, is excluded from the discussions.

Table 1.--*Growth per acre per year of trees larger than 4.5 inches d.b.h., by initial stocking*

(In square feet of basal area)

Initial stocking	Production[1]	Mortality	Ingrowth	Accretion[1]
Low	2.3	0.4	1.2	1.5
			**	
Medium	2.1	.5	.7	1.9
	*	*	*	
High	1.2	1.0	.4	1.8

[1]Production is the average yearly change in basal area during the growth period; accretion is the basal area growth on the trees that were 4.5 inches and larger at the beginning of the growth period. Production equals accretion plus ingrowth minus mortality.

*Denotes significance at 5-percent level.

**Denotes significance at 1-percent level.

Table 2.--*Annual production in basal area per acre, by size class and initial stocking*

(In square feet of basal area)

Initial stocking	D.b.h. class (inches)			
	5-10	11-15	16+	All
Low	1.1	1.0	0.2	2.3
Medium	.7	1.4	--	2.1
High	-.4	1.3	.3	1.2

Table 3.--*Stand structure, by initial stocking and year*

(In trees larger than 4.5 inches d.b.h.)

Initial stocking	Year	Average basal area per acre	Average trees per acre	Average d.b.h.	Distribution of basal area by d.b.h. classes		
					5-10	11-15	16+
		Square feet	*Number*	*Inches*	*Percent*	*Percent*	*Percent*
Low	1931-32	36	127	7.2	88	7	5
	1952-58	90	257	8.0	62	30	8
Medium	1931-32	56	195	7.3	88	8	4
	1952-58	109	273	8.6	61	36	3
High	1931-32	94	268	8.0	72	22	6
	1952-58	124	266	9.3	47	43	10

stand conditions provided by higher stocking. Conversely, annual production in the 11- to 15- and over 16-inch classes combined tended to increase with higher initial stocking. Considering all stocking levels, annual production was highest (or a close second under low stocking) in the 11- to 15-inch d.b.h. group, and production rates[3] were by far the highest in this size group.

These trends in total growth and growth by size classes resulted in marked changes in stand structure during the 25-year period (table 3). There was a considerable reduction in the initial wide differences in average basal area per acre between high stocking

[3] Production rate equals annual production expressed as a percentage of the initial basal area in a given size group.

and the other two stocking levels. Then too, rapid ingrowth under lower stocking coupled with heavy mortality of 5- to 10-inch trees under high stocking nearly eliminated differences in average numbers of trees per acre. High production rates in 11- to 15-inch trees under all levels of stocking brought marked increases in the percentages of basal area in this size group. But the proportion of sawtimber — trees in the 11- to 15- and over 16-inch classes — is still largest for the high stocking, followed by the medium and the low. Average diameter, quite reasonably, follows a similar trend.

Species Composition

Appreciable changes in species composition occurred during the 25-year period (table 4). These changes resulted from the combined effects of stocking level and species characteristics upon ingrowth and mortality.

Under low initial stocking, there were increases in the proportions of basal area in tolerant or fairly tolerant hardwoods. Red maple made the greatest increase, followed by beech, and then by sugar maple. In keeping with their tolerant nature, many small trees of these species were present in the understory. Hence, the very rapid ingrowth which occurred under low initial stocking

Table 4.--*Species composition, in percentage of total basal area of trees 4.5 inches d.b.h. and larger, by initial stocking and years*

Species	Initial stocking					
	Low		Medium		High	
	1931-32	1952-58	1931-32	1952-58	1931-32	1952-58
Beech	28	36	25	29	22	21
Yellow birch	34	20	18	13	19	11
Sugar maple	--	1	13	8	7	7
Red maple	7	17	15	20	26	30
Paper birch	10	7	14	10	10	11
White ash	2	1	7	8	6	8
Red spruce	1	1	1	1	1	1
Eastern hemlock	15	15	7	10	8	11
Other species	3	2	--	1	1	--

favored red maple, beech, and sugar maple over the other species. Under medium and high stocking — where ingrowth was much less and mortality generally higher—the percentages of the maples and beech increased only moderately, or declined.

In contrast to maples and beech, ingrowth of eastern hemlock increased consistently with higher stocking. Apparently the heavier shade made it possible for the tolerant hemlock saplings to compete more successfully with the aggressive, but slightly less tolerant, beech saplings. The resulting trend of ingrowth, together with generally low mortality, accounted for the increasing representation of hemlock under medium and high stocking.

Proportions of basal area in paper birch and white ash changed only moderately to slightly over the 25-year period. Paper birch lost a little ground under low and medium stocking; this was associated with a moderate increase in mortality with lower stocking. Except for a fairly good showing by ash under medium stocking, ingrowth of birch and ash was low, regardless of stocking level. These two intolerant to intermediate species occurred primarily as dominants and codominants; hence, there were few trees in the understory to contribute to ingrowth.

Yellow birch declined proportionally under all levels of stocking. Almost without exception, this species had the highest mortality of any species, and its ingrowth was only poor to fair. (This birch is one of the slowest growing components of old-growth northern hardwood stands as well as second-growth stands).[4]

Discussion

Trends in growth and development indicate that all stands are moving toward a typical, uneven-aged stand structure that will have from 5 to 15 square feet of basal area in all 2-inch d.b.h. classes up through 18 to 24 inches. The initially high-stocked plots — still having the largest average diameter and percentage of

[4] Jensen, V. S. Suggestions for the management of northern hardwood stands in the Northeast. Jour. Forestry 41: 180-185, 1943; and Gilbert, A. M., et al Growth behavior of northern hardwoods after a partial cutting. Jour. Forestry 53: 488-492, 1955.

sawtimber — are in the best shape for producing large and valuable timber. But because of rapid production under low and medium stocking, coupled with rapid changes in basal area distribution by size groups, initial differences in stand structure between stocking levels are disappearing.

In respect to present species composition, no stocking level has any distinct advantage over another. A relative abundance of valuable yellow birch, paper birch, white ash, or sugar maple is usually offset by a high proportion of the less desirable red maple or beech. Trends indicate that species composition for the three stocking levels will become more and more similar. However, the high-stocked plots will probably continue to have the lowest percentage of beech for many years to come.

Barring catastrophes, the most tolerant species — beech, sugar maple, and eastern hemlock — will eventually predominate on all plots along with some yellow birch and red maple. The proportion of beech is already increasing under low and medium stocking, but the major increase in tolerants will begin in perhaps one or two decades. Then the short-lived paper birch will begin to decline, followed a few decades later by white ash and, later yet, by red maple. As these species disappear from the overstory, the more tolerant species now beneath will replace them.

In placing these stands under management, the forest manager must decide which species he wishes to favor. If the intolerant to intermediate birches and ash are desired, he must use some form of patch cutting, clearcutting, or shelterwood cutting. But due to the uneven-aged tendencies or second-growth stands — which become more pronounced as the stands grow older — many small, low-value trees would have to be cut under any of these systems. Furthermore, the tolerant understory would interfere with regeneration of the less tolerant species.

The alternative is to perpetuate the tolerant species by selection or group-selection cutting. This type of cutting will provide an opportunity for timely removal of the temporary, early-maturing species such as paper birch and white ash (and any aspen that is present). In turn, this partial cutting will hasten the development of a typical uneven-aged forest composed of tolerant species.