Volume Changes in an Old-growth Beech-Maple Forest over a 10-year Period

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Abstract

A tree-by-tree comparison of volume changes in an old-growth beech-maple forest over a decade revealed a 2.9% volume increase to 3,730 ft^3 per acre, and a 3.2% density reduction. American beech declined in volume, with yellow poplar, sugar maple and ash experiencing volume increases.

Introduction

Precise determinations of standing timber volume on a tree-by-tree basis over extended time periods are usually not made because of the difficulties in relocating specific individual trees, plus the excessive amount of labor required for such study.

This paper reports on a tree-by-tree comparison of a 10.87-acre (4.40-ha) portion of Hoot Woods, a 64-acre (25.9 ha) old-growth beech-maple dominated forest in Owen County, Indiana. Our study is a decade interval resurvey of the tract mapped at a 1:33 scale in 1965 (Jackson and Allen, 1967). Stand attributes and ecological changes during the decade were summarized by Abrell and Jackson (1977).

Methods

All trees above 8 inches (20 cm) dbh were measured to the nearest 0.1 inch with diameter tapes. Clear lengths of tree boles were measured to the nearest 1 foot (0.3 m) with a Spiegel Relaskop from a 1-foot stump to the upper limit of merchantability. Upper bole limit was delimited by branching, deformity or minimum diameter (8.0 inches, including bark).

Volume was computed separately for each tree on a Monroe Programmable Calculator Model 1860 based on the following rough (including bark) cubic foot volume formula of Beers (1964):

$$V = 92 \left[\frac{D^2 (D + 190)}{10^5} \right] \bullet \frac{1}{10^2} \left[\frac{H(168\text{-}H)}{64} + \frac{32}{H} \right]$$

where V = volume in rough cubic feet;
D = dbh in inches (to 0.1 inch);
H = clear length in feet

This formula was used as a composite calculation for all 17 species contained in the stand. The near-virgin stand (Petty and Lindsey, 1961) is high-canopied (ca. 120 ft or 37 m) with all species having little taper. Total volume was computed for all trees above the 8-inch threshold, including those dying during the decade, with no allowance made for hollow or low quality stems.

Tree nomenclature follows Little (1953).

Results

Volume data for 579 living and 40 dead stems are summarized by species by 8-inch size classes in Table 1. Overall, the stand volume

TABLE 1. *Summary of volume changes in a 10.87-acre sample of Hoot Woods during the 1965-1975 decade.*

Species[1]		Size[2] Class	N[3]	1975 Volume (Ft^3/Acre)	1965-1975 Per Acre Volume Change (Ft^3) Growth	Mortality	Net	Per Tree Values $\overline{X}$ Diam. Increase (Ins.)	$\overline{X}$ Clear Length (Ft.)	$\overline{X}$ Vol. Increase (Ft^3)
Fg		12	96(8)	165	18.4	21.6	— 3.2	0.78	26.5	2.3
		20	102(8)	654	53.8	42.2	11.6	1.02	44.2	6.2
		28	80(9)	979	68.6	114.0	—45.4	1.02	50.3	10.5
		36	8(1)	160	1.9	12.2	—10.3	1.17	48.4	3.0
	Subtotal		286(26)	1958	142.7	190.0	—47.3	0.94	40.1	6.0
Lt		12	27(1)	89	21.8	2.5	19.3	1.78	40.4	9.1
		20	31(3)	253	49.6	21.4	28.2	2.50	58.6	21.7
		28	7	118	19.0	---	19.0	2.39	69.3	29.5
		36	5	148	7.1	---	7.1	.86	78.3	15.4
		44	3	117	4.6	---	4.6	.83	80.3	16.6
	Subtotal		73(4)	725	102.1	23.9	78.2	2.03	55.2	16.1
As		12	109(3)	183	38.3	5.8	32.5	1.29	26.5	3.8
		20	50(4)	302	29.1	36.0	— 6.9	1.35	48.0	9.6
		28	11	138	9.9	---	9.9	.96	50.2	9.8
	Subtotal		170(7)	623	77.3	41.8	35.5	1.28	34.4	5.2

Fx		12	13	31	3.7	---	3.7	1.28	35.0	5.7
		20	12	91	23.2	---	23.2	2.47	54.0	19.9
		28	6	74	6.0	---	6.0	1.03	47.0	10.0
		36	1	24	3.3	---	3.3	2.30	62.0	36.0
	Subtotal		32	220	36.2	---	36.2	1.71	45.2	12.3
Other Species		12	42	77	16.6	---	16.6	1.54	25.8	4.3
		20	11(2)	51	6.8	8.4	— 1.6	1.24	42.6	8.2
		28	4(1)	41	6.3	20.8	—14.5	2.07	65.0	23.0
		36	--	---	---	---	---	---	---	---
		44	1	35	3.0	---	3.0	1.70	54.0	32.3
	Subtotal		58(3)	204	32.7	29.2	3.5	1.52	32.2	6.5
Totals			619(40)	3730	391.0	284.9	106.1	1.26	39.8	7.3

[1] Species symbols are: Fg = *Fagus grandifolia* Ehrh.; Lt = *Liriodendron tulipifera* L.; As = *Acer saccharum* Marsh.; Fx = *Fraxinus americana* L. and *F. pennsylvanica* Marsh. Others = *Quercus muehlenbergii* Engelm., *Q. rubra* L., *Q. alba* L., *Prunus serotina* Ehrh., *Sassafras albidum* (Nutt.) Nees, *Ulmus rubra* Muhl., *U. americana* L., *Carya cordiformis* Wang. K. Koch, *C. glabra* (Mill.) Sweet, *Juglans nigra* L., *Nyssa sylvatica* Ehrh., and *Celtis occidentalis* L.

[2] Size classes in inches: 12 = 8.0 – 15.9; 20 = 16.0 – 23.9; 28 = 24.0 – 31.9; 36 = 32.0 – 39.9; 44 = 40.0 – 47.9.

[3] N = number of stems in 10.87-acre sample; numbers in parentheses represent the number of stems 8.0 inches diam., which died during the decade. Dead stems are included in the total N values.

increased during the decade from 3,624 to 3,730 ft^3/acre (Table 1). The 391 ft^3/acre growth increment during the decade offset mortality of 285 ft^3/acre, for a net gain of 106 ft^3 or a 2.9% increase. Only 21 trees grew past the 8-inch lower diameter threshold during the decade, as opposed to 40 tree deaths, for a net decline of 19 stems (1.7 per acre).

American beech, the leading species, declined 2.4% due to 26 deaths exceeding the collective growth of 260 remaining trees by 47 ft^3/acre. The co-dominant in basal area, sugar maple (Abrell and Jackson, 1977) increased by 6% to 623 ft^3/acre, largely by new accessions and growth in the 12-inch size class, offsetting a 2.2% decrease in the 20-inch size class. The 69 living yellow poplars increased an average of 16 ft^3 per tree for a net per acre gain of 78 ft^3, or a 12.1% increase to 725 ft^3/acre. White and green ash sustained no mortality and rapid growth for a 19.7% gain. Twelve minor species (55 living individuals) increased 33 ft^3/acre from growth, but had a net gain of only 1.7% due to the loss of a 31.7-inch wild cherry with 82 feet clear length.

Overall, the stems averaged 40 feet clear with yellow poplar the tallest at a mean clear bole of 55 ft. Seven poplars in the 28-inch size class added an average of 29.5 ft^3 of wood per tree (Table 1). Fastest growth rates were 20-inch size class yellow poplars and ashes at 0.25-inch average diameter increments per year (Table 1). Collectively, the stand averaged only 1.26 inch diameter growth for the decade. Beech, as expected grew most slowly.

Discussion

As old-growth forests mature, the average tree size typically increases, with corresponding declines in stem density. Hoot Woods followed this pattern during the past decade. Overall density declined from 598 stems (55 per acre) to 579, for a 3.2% density reduction. The corresponding overall volume increase was 2.9%. Such density-volume shifts obviously do not continue indefinitely. A point is reached at which the "over-maturity" of the stand creates instability within canopy individuals, as vulnerability of veteran trees to disease, insects and windthrow increases. Light gaps created by such processes provide invasion sites for more valuable (economically) species, such as yellow poplar and wild cherry.

Also interesting are the volume shifts for the co-dominants, beech and sugar maple. Although a decline in beech volume would be favored by foresters because of its low economic value, beech is a species of key importance in a research natural area such as Hoot Woods. Beech is considered to be the climax species for much of Indiana (possibly even over sugar maple), and as such has great value as a species for ecological research on forest equilibrium. Changes in the relative importance of both co-dominant species will be watched with keen interest during the coming decades. Such study should help clarify the nature of long-term stabilization toward the end of forest succession.

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