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Relationships of Tree Age to Diameter in Old-Growth Northern Hardwoods and Spruce-Fir

William B. Leak

Abstract

Regressions are given for predicting age from diameter for 10 different species of trees or shrubs in old-growth northern hardwood and spruce-fir stands.

Tree age is difficult to measure in old-growth or virgin stands because of the large size of the trees and the abundance of hollow or rotten boles. In two previous studies of age distribution in old growth hardwoods and spruce-fir (Leak 1974, 1975), age was measured on suitable sample trees and regressed over tree diameter for each species; then these regressions were used to estimate the age of trees whose diameter only had been measured. The regressions used to estimate age in these two studies are summarized in this paper to make them readily available to others studying the characteristics of old-growth forests in New England.

Methods

The old-growth hardwood stand was a 40- to 50-acre tract of virgin northern hardwoods in the Bowl Research Natural Area on the southern edge of the White Mountain National Forest. Its elevation is between 1900 and 2100 feet. The soil is a fine till (Leak 1982) on a fairly steep slope. The spruce-fir stand was a portion of a several-hundred-acre tract of virgin spruce-fir in the Nancy Brook Scenic Area on the White Mountain National Forest. The area sampled lies at about 2900 feet elevation, and the soil is primarily wet and dry compact till (Leak 1982).

In both areas, a series of plots were taken to estimate diameter distribution, and a small subsample was taken over a range of tree (and shrub) sizes and species to estimate age. Age was determined by counting terminal bud scars (if visible) on very small stems and from increment cores on larger stems. In selecting trees for increment boring, stems with advanced decay were avoided, which may have eliminated certain of the older or less vigorous (slower growing) trees from the sample. Both tree diameter and age were determined at the top of the root swell—the point where the bole begins to swell into the stump or root collar. The total number of samples (all species) was 338 (Table 1).

Table 1.—Regression equations predicting age at top of root swell related to diameter (mm) at top of root swell and diameter squared, by location and species.

Location	Species	n	Intercept	$b_1(D)$	$b_2(D^2)$	R^2	SD	Maximum Diameter	Maximum Predicted age	Maximum Oldest tree
Bowl	Sugar maple	47	9.82	.4398	-.000380	.47	52	550	137	175
	Beech	46	13.59	.3841	—	.86	25	500	206	258
	Yellow birch	24	5.79	.3018	—	.79	32	730	226	267
	Red spruce	21	12.06	.7539	-.000641	.87	30	680	228	264
	Striped maple	24	11.60	.2098	—	.84	8	240	62	70
	Mountain maple	15	6.75	.2177	—	.73	6	110	31	40
	Hobblebush	15	3.98	.3622	—	.64	3	30	15	19
Nancy Brook	Red spruce	56	14.58	1.1000	-.001120	.88	42	560	279	390
	Balsam fir	50	13.94	.7966	-.001204	.67	33	300	145	202
	Mountain paper birch	21	3.33	.4401	.000123	.75	29	360	178	212
	Mountain ash	19	4.58	.7039	-.002677	.92	6	160	49	55

SD = sample standard deviation from regression = $\sqrt{\text{mean square deviation}}$

Age was regressed over tree diameter and tree diameter squared.[1] The squared term was left in the regression if there was any statistical or visual evidence that it contributed to the precision of the equation. In a few equations, the squared term causes a slight drop (5 to 6 years) in predicted age of the largest trees below the maximum predicted age.

Results

Research in cutover stands in the Northeast has indicated that tree age and size are poorly related (Blum 1961; Gibbs 1963). However, results from the Lake States indicate that age and size are fairly well correlated in managed uneven-aged stands (Tubbs 1977). Our results in old-growth hardwoods and spruce-fir also indicated that age and size are fairly well correlated, apparently because these old-growth stands are stable populations with consistent stand densities and diameter distributions. The R^2 values (proportion of variation accounted for by the regressions) range from .47 to .92, and the standard deviations around the regression range from 3 to 52 years (Table 1). In applying these regressions, do not extrapolate beyond the maximum diameters shown in Table 1, especially with equations containing a squared term. The positive squared term for mountain paper birch is reasonable for a species that declines markedly in growth rate as diameter increases. Although the negative squared term for several other species would seem to indicate that diameter growth increases as diameter increases, the curve shape may simply mean that the largest trees in these stands are more vigorous than average.

Sugar maple in the Bowl had the lowest R^2 and the highest standard deviation. However, a plot of the actual points indicates that the regression is quite well defined (Fig. 1). All other species had relatively less scatter, although a few had occasional outliers (retained in the data) that deviated more than the observations for sugar maple.

The regressions for red spruce in the Bowl and Nancy Brook are not identical. A red spruce of 550 mm diameter in the Bowl has a predicted age of 233 years, while a comparable tree in Nancy Brook has a predicted age of 281 years. The site in the Bowl is better, and elevation is lower.

Because of the curve-fitting procedure, the maximum predicted ages in Table 1 are less than the age of the oldest tree. Furthermore, the oldest tree ages are much less than the maximum ages reported for any given species. For example, maximum predicted age for sugar maple in the Bowl is about 137 years; age of the oldest tree is about 175 years; but maximum age for the species is about 400 years.

[1] Because variance tends to be proportional to diameter, some form of weighted regression would be a reasonable approach for certain species.

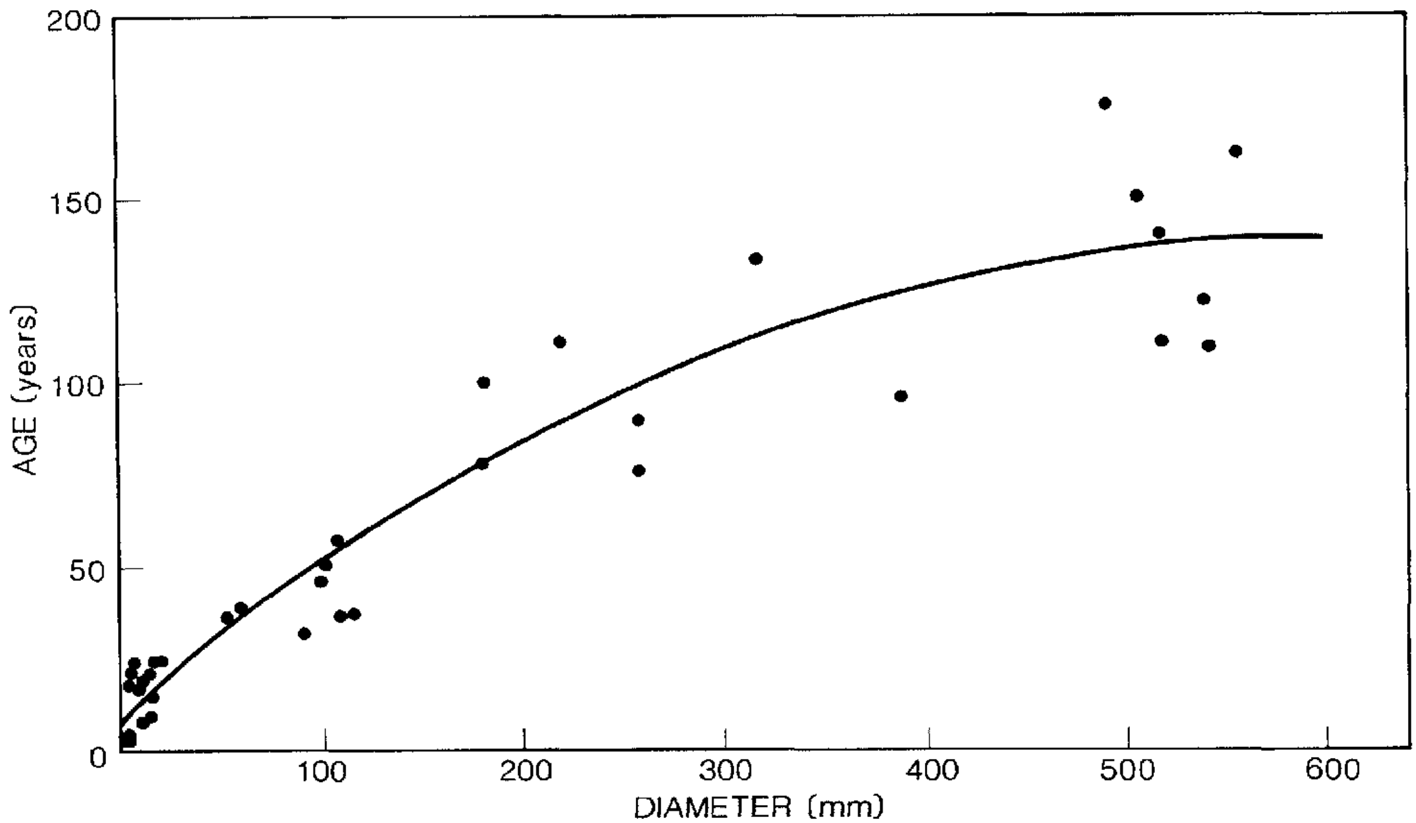

Figure 1.—Age at top of root swell over diameter (mm) at top of root swell for sugar maple in the Bowl. (Not all points below 40 mm diameter are shown.)

Applications

The regressions reported in this paper can be used for very general predictions of age in old-growth stands in New England. However, the relation of age to size varies substantially with site and past history so the regressions will not provide precise estimates. When precise estimates are needed, regression methods similar to those reported in this paper apparently can be used successfully, provided that the stand is in a fairly stable condition.

Foresters often debate whether uneven-sized stands are truly uneven-aged. Recently cutover stands with a mixture of species show great inconsistency in the relationship of age to size. However, in stands that are maintained in stable conditions, either through consistent partial cutting or natural processes, age and size gradually become well correlated for each species.

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Species List:

Sugar maple	*Acer saccharum*
Beech	*Fagus grandifolia*
Yellow birch	*Betula alleghaniensis*
Red spruce	*Picea rubens*
Striped maple	*Acer pensylvanicum*
Mountain maple	*Acer spicatum*
Balsam fir	*Abies balsamea*
Mountain paper birch	*Betula papyrifera* var. *cordifolia*
Mountain ash	*Sorbus americana*
Hobblebush	*Viburnum alnifolium*

William B. Leak is a research forester studying the management of northern hardwood forests at the Louis C. Wyman Forestry Sciences Laboratory in Durham, NH.

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