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AVERAGE GROWTH RATES IN SOUTHERN MAINE

In the 1950s a cooperative study was made to obtain accurate growth information about the spruce-fir forests of northern Maine and New Hampshire. The results of that study were published in 1961.[1]

Recently a second study was completed to obtain growth rates for the forests of southern Maine (fig. 1). This is a report on the results of that study.

Both of these studies were made by the Northeastern Forest Experiment Station in cooperation with a group of timberland owners. The cooperators in the southern Maine study were: Dead River Co.; Diamond-Gardner Corp.; T. L. Dickson; Eastern Pulp Wood Co. & St. Croix Paper Co.; Hudson Pulp and Paper Co.; National Packaging Corp.; Oxford Paper Co.; Penobscot Chemical Fibre Co.; Penobscot Development Co.; Prentiss and Carlisle Co.; Scott Paper Co.; Eastern Fine Paper and Pulp Division, Standard Packaging Corp.; St. Regis Paper Co.; and S. D. Warren Co.

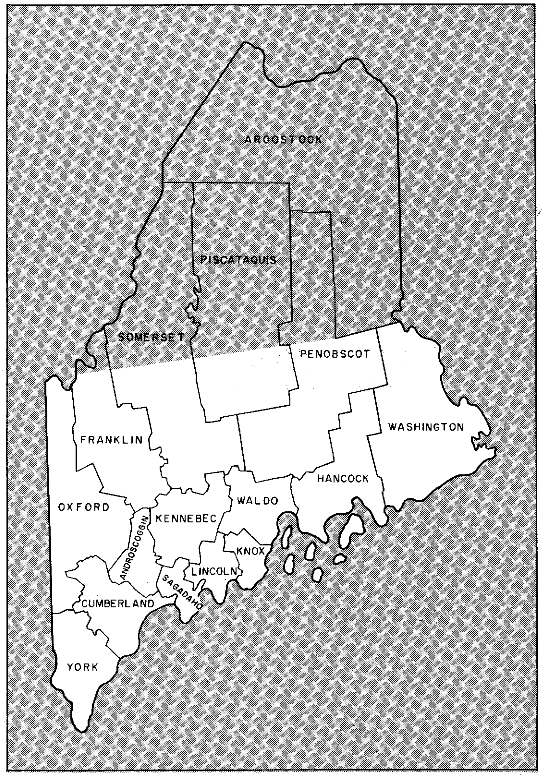
Purpose

The purpose of the study in southern Maine was to obtain average net[2] growth rates in gross cubic-foot volume for 24 stand classifications. The classifications are those used by many of the cooperators in estimating volume of standing timber. They consist of four species groups, three

[1] Bickford, C. Allen, Franklin R. Longwood, and Robert Bain. AVERAGE GROWTH RATES IN THE SPRUCE-FIR REGION OF NEW ENGLAND. U. S. Forest Serv. Northeast. Forest Expt. Sta., Sta. Paper 140, 23 pp., 1961.

[2] Net growth = accretion + ingrowth — mortality.

Figure 1. — The study area included roughly the southern half of Maine—11 counties and parts of 4 others.



height classes, and two density classes, as follows:

Species group. — The composition class was based on plurality of gross cubic-foot volume for sawtimber and poletimber stands, and number of stems for seedling-and-sapling stands. The species groups were: (1) pine; (2) other softwood; (3) mixed wood; and (4) hardwood.

Height. — Height class is the average total height of dominants and codominants. The height classes used in this study were: (1) 0 to 30 feet; (2) 30 to 50 feet; and (3) 50 feet or more.

Density. — Density class is the percent of crown cover in dominants and codominants. The two density classes used were: (1) 35 to 75 percent and (2) 75 to 100 percent.

A landowner who uses these classifications can arrive at an average growth rate for his tract. The variances given in this report for the stand classifications enable calculation of sampling error as a measure of reliability.

Data Collection and Results

The proposed field work in southern Maine included remeasurement of forest-survey plots by the cooperating companies. Using aerial photographs, all plots were classified into species group, height class, and density class by an experienced forest-survey photo interpreter. Four hundred plots were remeasured as of October 14, 1964; and 321 of these plots have

Table 1. — Average net growth per year in gross volume and associated variances by stand class

Species group	Height (Stand class)	Density (Stand class)	Net growth per acre per year	Plots	Variance of an individual observation (plot)	Standard error of average net growth
	Feet	*Percent*	*Cubic feet*	*Number*		*Cubic feet*
Pine	0-30	35-75+	39.3	4	4018.58	31.7
		75+	—	—	—	—
	30-50	35-75	37.2	8	3733.67	21.6
		75+	86.7	9	1804.26	14.2
	50+	35-75	27.0	8	3401.07	20.6
		75+	65.2	12	4415.98	19.2
Other softwood	0-30	35-75	22.5	9	1002.23	10.6
		75+	34.4	6	1601.11	16.3
	30-50	35-75	56.0	32	6806.69	14.6
		75+	65.6	21	2318.54	10.5
	50+	35-75	39.2	9	2049.32	15.1
		75+	51.9	17	3180.88	13.7
Mixed wood	0-30	35-75	26.6	7	439.42	7.9
		75+	38.5	2	3784.50	43.5
	30-50	35-75	47.7	31	2571.65	9.1
		75+	53.0	13	1903.22	12.1
	50+	35-75	29.3	15	1895.34	11.2
		75+	60.8	19	2770.51	12.1
Hardwood	0-30	35-75	21.1	15	1356.22	9.5
		75+	4.1	6	26.27	2.1
	30-50	35-75	15.2	25	630.84	5.0
		75+	43.5	20	3515.74	13.3
	50+	35-75	39.2	15	1553.09	10.2
		75+	49.7	18	1252.39	8.3

been used by the Northeastern Station to obtain the average growth rates and variances presented in table 1. The remaining plots either had been heavily cut or were obviously in error and therefore were considered unsuitable for growth calculations. Plots were measured during periods of dormancy to simplify conversion of periodic increment to average annual growth. The period between measurements averaged 5 years.

Application

Two examples are presented below to show how the forest landowner can apply these growth data.

EXAMPLE 1

Purpose. — The landowner wishes to obtain an estimate of growth for a 63,300-acre tract in southern Maine.

Method. — First he stratifies the tract by aerial-photo delineation into classes corresponding to those used in this study. When this is done, he can then obtain his estimate of growth by applying the average growth rates from table 1 to the specific breakdown of area.

Table 2. — Example of estimation of total net cubic-foot growth

Stand class: Species group	Stand class: Height	Stand class: Density	Area	Area	Average net growth	Total net growth
	Feet	*Percent*	*Acres*	*Proportion of Total*	*Cubic feet*	*Cubic feet*
Pine	0-30	35-75	0	—	—	—
		75+	0	—	—	—
	30-50	35-75	0	—	—	—
		75+	5,100	0.081	86.7	442,170
	50+	35-75	4,500	.071	27.0	121,500
		75+	6,800	.107	65.2	443,360
Other softwood	0-30	35-75	2,100	.033	22.5	47,250
		75+	0	—	—	—
	30-50	35-75	8,400	.133	56.0	470,400
		75+	6,200	.098	65.6	406,720
	50+	35-75	0	—	—	—
		75+	2,100	.033	51.9	108,990
Mixed wood	0-30	35-75	0	—	—	—
		75+	0	—	—	—
	30-50	35-75	9,400	.148	47.7	448,380
		75+	4,100	.065	53.0	217,300
	50+	35-75	0	—	—	—
		75+	2,000	.032	60.8	121,600
Hardwood	0-30	35-75	1,500	.024	21.1	31,650
		75+	0	—	—	—
	30-50	35-75	2,200	.035	15.2	33,440
		75+	2,100	.033	43.5	91,350
	50+	35-75	4,700	.074	39.2	184,240
		75+	1,100	.033	49.7	104,370
Total	—	—	63,300	1.000	—	3,272,720

Result. — Calculation of the growth estimate is shown in detail in table 2. The last column represents the product of the area in acres and growth in cubic feet. These values are the estimates of total annual growth for each of the 24 classes. The sum of these values — 3,272,720 cubic feet — is the estimated annual net growth for the landowner's tract, in gross cubic-foot volume.

The proportions of area shown in table 2 could have been used to calculate the portion of growth-per-acre attributable to each class. The sum of these growth rates would be 51.7 cubic feet, the average growth per acre for the tract.

EXAMPLE 2

Purpose. — Assuming that the forest area of the southern Maine region is 10 million acres and that the 321 remeasured plots are a simple random sample of this region, growth calculations can be made in the same manner as in example 1.

Method. — For purposes of this example, the area within each class is assumed to be consistent with the area represented by the numbers of plots within the class. Numbers of plots in column 2 of table 3 and average growth rates in column 3 were obtained from table 1. The area breakdown in column 4 was obtained from numbers of plots in column 2.

Result. — Calculated average annual growth rates per acre of forest area are shown in column 6. The sum of column 6 is the estimated annual net growth of all species in the region — 44.02 cubic feet per acre. The estimated total growth is 440.2 million cubic feet.

Calculation of Sampling Error

Sampling error, although sometimes viewed by the nonmathematician as overly complicated, is usually the only unbiased measure of confidence attached to an estimate. Taken one step at a time, sampling errors are easily calculated and interpreted. For instance, the sampling error of average growth from the stratified estimate is calculated as

$$S_{\bar{x}} = \sqrt{\sum \left(\frac{P_i^2 \, S_i^2}{n_i} \right)}$$

in which

P_i = the proportion of area within the class

S_i^2 = the variance of the class

n_i = the number of plots within the class.

For example 1, refer to table 2: square the proportion and multiply by the variance from table 1; divide by numbers of plots from table 1; sum over all 15 classes and obtain the square root of this sum.

Table 3. — Example of calculation of mean cubic-foot growth and its sampling error for all species

1			2	3	4	5	6	7	8	9
Stand class										
Species group	Height	Density	Plots	Average growth	Area	Variance	Proportion times average growth	Col. 4 times col. 5	Col. 4 times col. 7	Col. 8 divided by col. 2
	Feet	*Percent*	*Number*	*Cubic feet*	*Proportion of Total*		*Cubic feet*			
Pine	0-30	35-75	4	39.3	0.012	4018.58	0.472	48.223	0.579	0.144750
		75+	0	—	.000	—	—	—	—	—
	30-50	35-75	8	37.2	.025	3733.67	.930	93.342	2.334	.291750
		75+	9	86.7	.028	1804.26	2.428	50.519	1.415	.157222
	50+	35-75	8	27.0	.025	3401.07	.675	85.027	2.126	.265750
		75+	12	65.2	.037	4415.98	2.412	163.391	6.045	.503750
Other softwood	0-30	35-75	9	22.5	.028	1002.23	.630	28.062	.786	.087333
		75+	6	34.4	.019	1601.11	.654	30.421	.578	.096333
	30-50	35-75	32	56.0	.100	6806.69	5.600	680.669	68.067	2.127094
		75+	21	65.6	.065	2318.54	4.264	150.705	9.796	.466476
	50+	35-75	9	39.2	.028	2049.32	1.098	57.381	1.607	.178556
		75+	17	51.9	.053	3180.88	2.751	168.587	8.935	.525588
Mixed wood	0-30	35-75	7	26.6	.022	439.42	.585	9.667	.213	.030429
		75+	2	38.5	.006	3784.50	.231	22.707	.136	.068000
	30-50	35-75	31	47.7	.097	2571.65	4.627	249.450	24.197	.780548
		75+	13	53.0	.040	1903.22	2.120	76.129	3.045	.234231
	50+	35-75	15	29.3	.047	1895.34	1.377	89.081	4.187	.279133
		75+	19	60.8	.059	2770.51	3.587	163.460	9.644	.507579
Hardwood	0-30	35-75	15	21.1	.047	1356.22	.992	63.742	2.996	.199733
		75+	6	4.1	.019	26.27	.078	.499	.009	.001500
	30-50	35-75	25	15.2	.078	630.84	1.186	49.206	3.838	.153520
		75+	20	43.5	.062	3515.74	2.697	217.976	13.515	.675750
	50+	35-75	15	39.2	.047	1553.09	1.842	72.995	3.431	.228733
		75+	18	49.7	.056	1252.39	2.783	70.134	3.928	.218222
Total	—	—	321	—	1.000	—	44.02	—	—	8.221980

Using pine (height = 30 to 50, density = 75+), to illustrate:

$$\frac{[\ (0.081)^2\ (1804.26)\ ]}{9} = 1.315306$$

This result is the contribution for that one class. The sampling error for all classes is the square root of the sum of 15 such numbers. For example 1, it was calculated to be 4.040 cubic feet. As indicated by the symbol, this applies to the mean value per acre previously calculated to be 51.7 cubic feet. The error for the property as a whole is obtained by multiplying 4.040 by 63,300 acres. For these data the sampling error is 255,732 cubic feet. Expressed in percent, this error is 7.8.

For example 2, refer to table 3. Column 7 lists the product of proportion and variance; these entries are then multiplied by the respective proportions to obtain $P_i^2\ S_i^2$ as column 8 entries. Next, division by number of plots provides the entries of column 9, which are summed to give 8.221980. The square root of this sum is 2.867, which is the standard error — or sampling error — of the mean. It is 6.5 percent of X = 44.02. The corresponding sampling error for the region is 28,670 million cubic feet (6.5 percent of 440,200,000 cubic feet).

Briefly, here is how the sampling error indicates reliability. Example 1 provided an average net growth rate of 51.7 cubic feet per acre per year with a sampling error of 7.8 percent. The probability that a new estimate would fall within 7.8 percent of 51.7 cubic feet is approximately 68 percent. This means that the odds are 2 to 1 that if the study were repeated the new estimate of net growth would be between 47.7 and 55.7 cubic feet (51.7 ± 4.0). Increasing the size of this interval would increase the corresponding probability, and vice versa. For example, the odds are 19 to 1 that a new estimate of net growth would be between 43.7 and 59.7.

Evaluation

As in the growth study conducted in northern Maine and New Hampshire, average growth rates are somewhat higher than was previously assumed. It must be kept in mind, however, that mechanical defect and decay incidence is not reflected in these averages other than in the effect they have upon the components of growth in gross volume.

Usable estimates of net growth can be obtained for a particular property only if these averages are applied to areas delineated in the same manner as those used in this study. Some classes are represented by fewer plots than others and would be expected to yield estimates with less reliability. This will be reflected in the sampling error. Users of these data are urged to make use of the sampling-error calculation procedure as an index of the value of each estimate made.

—WARREN E. FRAYER and JOSEPH E. BARNARD

Research Foresters, Forest Survey
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. Agriculture
Upper Darby, Pa.

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