NORTH CENTRAL FOREST EXPERIMENT STATION
Research Note NC-281
1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.
1982

USING A PROGRAMMABLE CALCULATOR TO COMPUTE AND COMPARE THINNING SCHEDULES

Rolfe A. Leary, *Principal Mensurationist,*
and **Rebecca J. Florey,** *Formerly Forestry Technician,*
North Central Forest Experiment Station,
St. Paul, Minnesota,

ABSTRACT.—Describes calculator programs that simulate the growth and thinning of a stand. Also includes a method of computing maximum yield, allowing a comparison of potential and actual yields of a stand.

KEY WORDS: Dynamic programming, growth and yield, maximum biomass production.

One decision a forest manager must make is whether to thin a stand of trees now or to wait until the trees have grown more. A decision to thin implies another decision: how much to thin.

To make these decisions easier, the growth and thinning of a stand can be simulated on a programmable calculator by using an equation that predicts basal area growth per acre in a stand. For programs in this paper, we used the equation $\triangle B = aB - bB^m$, where $\triangle B$ is periodic basal area growth per acre, B is basal area per acre, and a, b, and m are numerical constants specific to tree species, location, stand age, and length of growth period. Aided by a calculator, the forest manager can easily compare several thinning schedules before acting.

Figure 1 represents the growth and thinning process over a rotation. The total yield produced is the sum of all the cuts; the final harvest is the clearcut.

FIELD DATA COLLECTION

Information needed to run the program:

1. Age of stand
2. Average height of dominant and codominant trees in the stand
3. Current basal area per acre (ft²/ac)
4. Site index
5. Age at final harvest
6. Coefficients for basal area growth equation.

Respective sources of information are:

1. Landowner's records or increment boring
2. Field measurements with a hypsometer
3. Field sample with angle gauge or tree measurement
4. Figure 2 (use height and age to read site index)
5. Rotation age chosen by owner (based on management objectives)

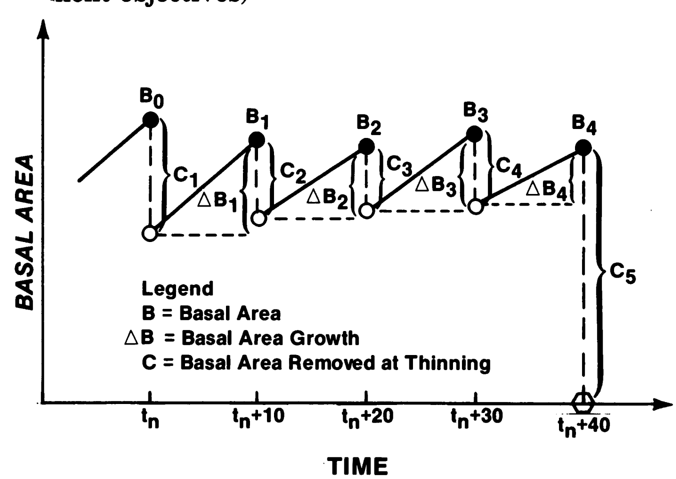

Figure 1.—*Schematic stand development with 4 thinnings prior to a final clearcut.*

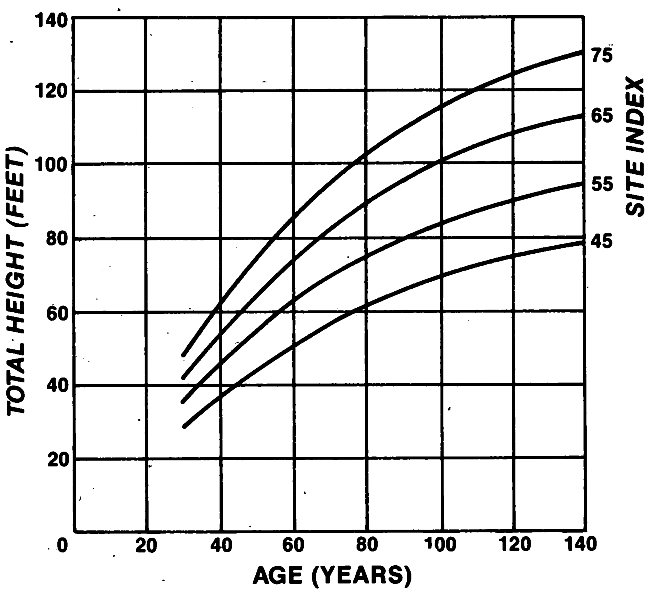

Figure 2.—Red pine site index curves (Lundgren and Dolid 1970).

6. Research that fits the growth equation to observations of stand growth. The growth equation coefficients used in the examples in this paper apply to 10-year periodic basal area growth per acre for red pine plantations in the Lake States.

CALCULATION PROCEDURE

Programs that compute thinning schedules have been designed for the Texas Instruments 59 calculator (with and without a printer) and the Hewlett Packard 67 and 97 calculators[1]. Briefly, the programs operate as follows: After obtaining needed information, the user loads the program into the calculator, enters information into data registers, chooses a thinning schedule, and then presses a series of keys to run the program. Calculations are performed in the following sequence at the beginning of each 10-year period:

1. The desired residual basal area is determined (based on the chosen thinning schedule) and compared to the actual standing basal area.
2. If the desired residual basal area is smaller than the actual standing basal area, the amount to cut is calculated and subtracted from the actual standing basal area.
3. Growth for the next 10-year period is determined and added to the residual basal area.
4. This process is repeated through the rotation to the final harvest.

At the beginning of each period, this calculator provides the following stand information: age, initial basal area (BAI), average height of dominant trees (HT), optimal residual basal area for maximum basal area growth (OPTB), optimal residual basal area for maximum cubic foot volume growth (OPTV), amount to cut in square feet per acre (CUT), cumulative basal area cut plus current residual basal area (CUT/ABA), basal area growth for the next 10 years (GROW), cumulative volume (VOL), and mean annual volume increment (MAI).

COMPARING MANAGEMENT OBJECTIVES

Programs have been designed to compute six thinning schedules that depend on different management objectives: (1) maximize cubic foot volume production, (2) maximize basal area production, (3) make no intermediate cuts, (4) follow the schedule to maximize cubic foot volume production but allow only a minimum feasible cut, (5) cut the same amount at each period, and (6) cut to a chosen residual basal area.

The residual basal area is computed for the first two schedules at the beginning of each 10-year period. These options appear in the tables under the headings OPTV and OPTB, respectively. By producing values that lead to maximum results, these two schedules provide a standard against which other schedules can be compared. The user can run them in addition to the other schedules to compare the potential and the actual yield of a stand. The other four schedules will yield less than the maximum but may be followed due to economic or other considerations.

The age at which mean annual increment reaches a maximum can be determined by finding the highest value in the MAI column (tables 1 and 2) and reading across to the age. This age could be used as the rotation age if compatible with the management plans.

Table 1 illustrates the optimum thinning schedule for maximum volume production and table 2 shows the effects of no intermediate thinning on the same stand. The difference in cubic foot volume production is 1335.3 ft^3. The graph shows the growth pattern and the difference in total volume production.

[1]*Mention of trade names does not constitute endorsement by the U.S.D.A. Forest Service.*

Table 1.—*Optimal thinning schedule for maximum cubic foot volume production*

AGE	BAI	HT	OPTB	OPTV	CUT	CUT+BA	GROW	VOL	MAI
20	165.0	26.4	110.0	160.3	4.7	165.0	71.8	1,828.5	91.4
30	232.1	40.9	118.9	174.9	57.2	236.8	51.4	4,033.8	134.5
40	226.3	53.9	125.6	182.2	44.0	288.2	41.2	6,159.0	154.0
50	223.4	65.4	131.1	185.7	37.8	329.4	35.0	8,167.7	163.4
60	220.7	75.3	135.7	187.0	33.8	364.4	30.8	10,042.7	167.4
70[1]	217.8	83.6	139.8	187.0	30.7	395.2	27.7	11,780.7	168.3
80	214.7	90.7	—	—	214.7	422.8	—	13,386.5	167.3

[1]Age at which mean annual increment is at a maximum.

Table 2.—*No intermediate thinning*

AGE	BAI	HT	OPTB	OPTV	CUT	CUT+BA	GROW	VOL	MAI
20	165.0	26.4	110.0	160.3	0	165.0	70.1	1,828.5	91.4
30	235.1	40.9	118.9	174.9	0	235.1	30.5	4,032.7	134.4
40	265.6	53.9	125.6	182.2	0	265.6	18.2	6,016.2	150.4
50	283.8	65.4	131.1	185.7	0	283.8	13.2	7,793.7	155.9
60[1]	297.0	75.3	135.7	187.0	0	297.0	10.6	9,384.8	156.4
70	307.6	83.6	139.8	187.0	0	307.6	9.0	10,799.9	154.3
80	316.5	90.7	—	—	316.5	316.5	—	12,051.2	150.6

[1]Age at which mean annual increment is at a maximum.

SAMPLE THINNING SCHEDULES

The sample thinning schedules, illustrated in tables 1 and 2, and figure 3, are geared to a stand having the following characteristics: Age = 20 years

Basal area = 165 ft^2/acre
Site index = 66
Final harvest at 80 years

A more detailed discussion is presented in:

Chen, C. M.; Rose, D. W.; Leary, R. A. How to formulate and solve optimal stand density over time problems for even-aged stands using dynamic programming. Gen. Tech. Rep. NC-56. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 22 p.

Copies of this report, both programs, and complete instructions, are available from:

Publications Room
North Central Forest Experiment Station
1992 Folwell Avenue
St. Paul, Minnesota 55108

Please specify calculator model (and for the TI 59, whether a printer is available).

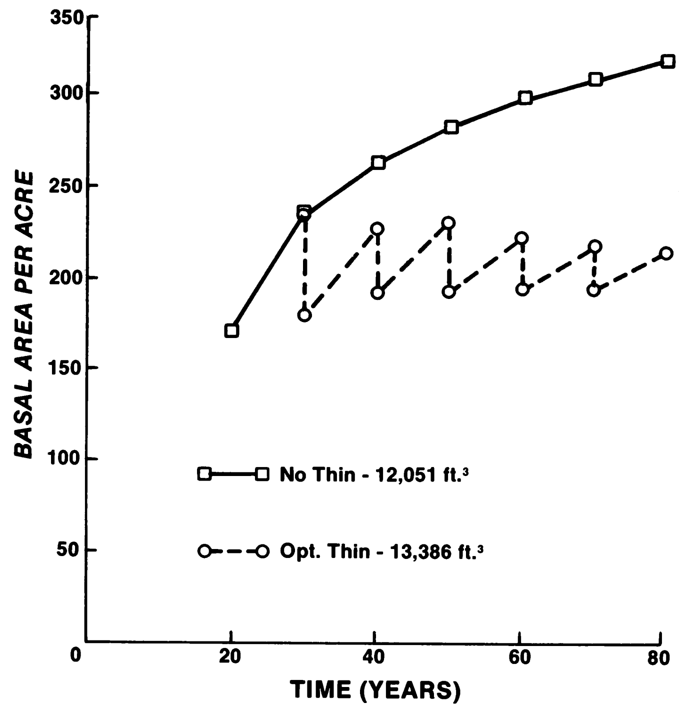

Figure 3.—Comparison of two thinning schedules with initial basal area of 165 ft^2/acre.

☆U.S. GOVERNMENT PRINTING OFFICE: 1982—665-010/101