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ECONOMIC VALUES FOR GROWTH AND GRADE CHANGES OF SUGAR MAPLE IN THE LAKE STATES

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Sugar maple is the major species in volume and value in the northern forests of the Lake States. Its economic importance is largely attributable to the demand for the quality lumber that is manufactured into specialized products. As a result of past demand, nearly 90 percent of the sugar maple area now consists of second-growth stands. Within these stands the quality and potential value of sugar maple are extremely variable and must be developed through silvicultural management.

Initial management in the sugar maple types involves the removal of the cull, poor-risk and low-quality trees. Subsequently, however, the management must consider both silviculture and economics in deciding which trees to grow and how large to grow them. At this stage of forest development these two disciplines are so inextricably involved as to influence the final outcome of the management venture. Silviculturally we can increase diameter growth, extend merchantable height and select trees of good form and bole as crop trees. With a clear understanding as to how improvements in these physical characteristics increase tree value, we can then properly evaluate our silvicultural recommendations and put tree-growing on a sound-financial basis.

Value has been a neglected dimension in forestry, often considered only at harvest time. In this publication, we will explain a method of calculating tree value. Then we will show how to use this value to calculate the financial maturity of a tree—that point in time at which the rate of value-increase falls below the owner's desired rate of return.

The financial maturity concept is especially useful in hardwood management. It expresses the physical variations in trees and their projected changes in economic terms.

METHODS

The determination of tree value is more complex than merely multiplying the board foot volume of a tree by the price per thousand board feet. Trees of different size and quality produce various amounts of the different grades of lumber and each grade commands a different price in the market. In our procedure we account for these differences and the resulting change in tree value. This procedure is explained in a flow chart diagram (fig. 1) and a step-by-step narration in the following text.

Tree values are determined from the amount and quality of 4/4 lumber that can be sawed from the tree. In our calculations we used the lumber grade recovery data for maple from the Forest Products Laboratory (Vaughn *et al.* 1966). Lumber price relatives were developed from prices reported in the Hardwood Market Report (Lemsky 1962-1966). Prices were averaged over the 5-year period and the price ratios for the price of No. 1 Common lumber were determined from calculation of the log quality index. (A more complete documentation of the log quality index calculation can be found in Mendel and Smith (1970)). It is suffice to know that the log quality index is a single number that, when multiplied by the price

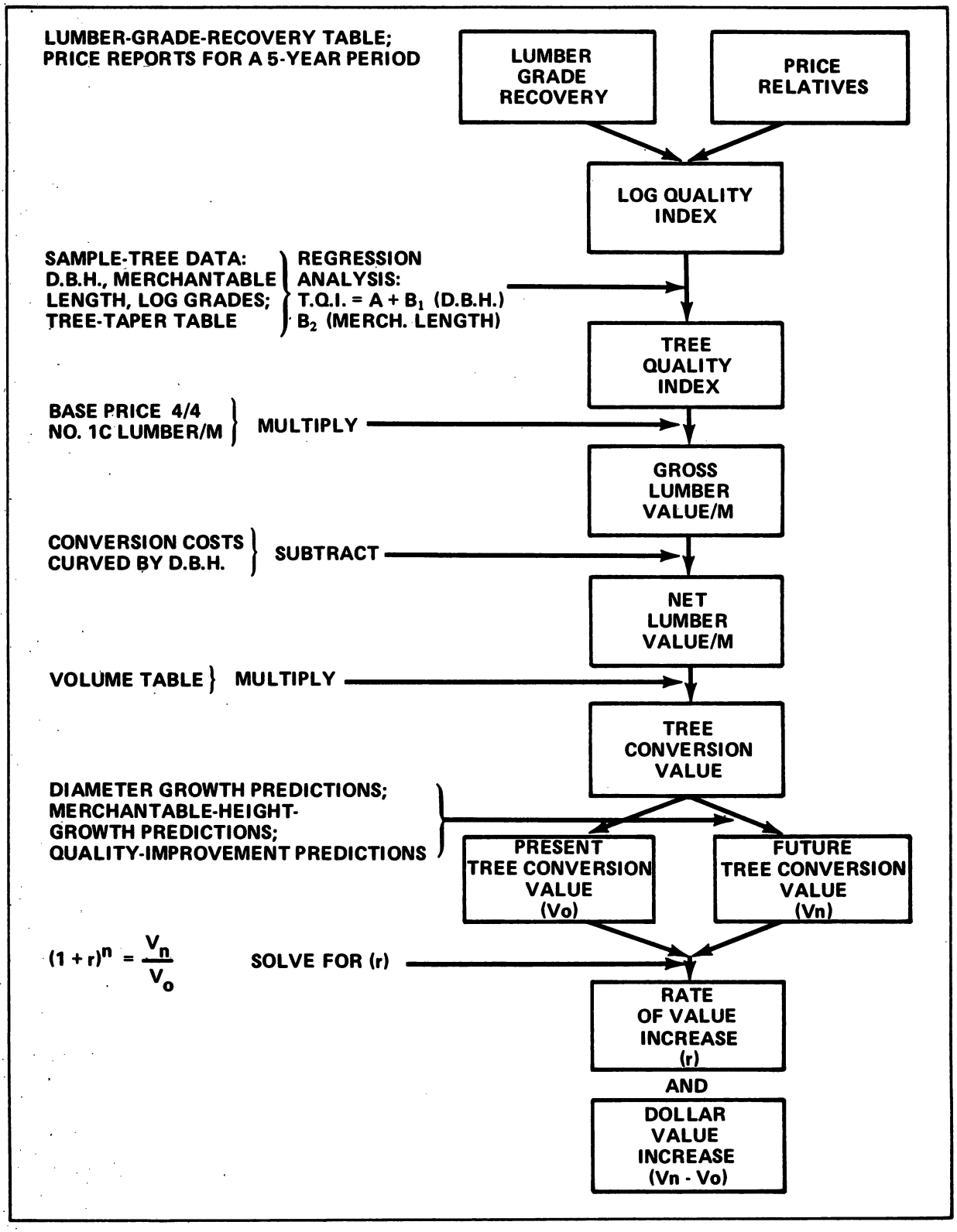

Figure 1.—*Calculation of rate of value increase.*

of 4/4 No. 1C lumber and the volume, will express the value of the 4/4 lumber that can be sawed from the log:

$$\text{Lumber value} = (\text{Q.I.}) \times (\text{Price of 4/4 No. 1C}) \times \frac{\text{volume of log}}{1{,}000}$$

Our next step was to translate log quality index to tree quality index, because we are interested in trees rather than logs. To do this it was necessary to establish the relation between the grades of the butt-log and the upper merchantable logs for various diameter sugar maple trees. We used sample tree data from the Argonne and Upper Peninsula Experimental Forests in Wisconsin and Michigan for this. By means of regression analysis we established this relation which can be expressed as:

Tree Quality Index = (percent of the tree volume in 1st log x log $\text{Q.I.}_{\text{1st log}}$) plus (percent of volume in 2nd log x log $\text{Q.I.}_{\text{2nd log}}$) plus (percent of volume in nth log x log $\text{Q.I.}_{\text{nth log}}$)

Then we calculated gross lumber value per thousand board feet. In our calculations, we used a price of $165 for 4/4 No. 1C sugar maple lumber (Lemsky 1962-1966). The gross lumber value was determined by multiplying the tree quality index by the appropriate price.

To determine net lumber value it is necessary to deduct the direct costs involved in converting the standing tree into 4/4-inch lumber. Such costs involve all the labor and material used in felling, bucking, transporting the logs to the mill, and sawing the logs into lumber. In this study, three levels of costs were used: $60, $70, and $80 per thousand board feet for a 16-inch d.b.h. tree.

Tree conversion value was calculated by multiplying the net lumber value by the volume of lumber in the tree. The 1/4-inch International volume table was used to determine the volumes.

We have now approached an important juncture in the schematic flow of calculations. First, it is important to note that tree conversion values are present conversion values, i.e., present tree value. Nothing need be done to convert from one to the other. It was necessary to make this change in nomenclature because at this point we will begin considering conversion values 10 years in the future and certain assumptions concerning diameter growth, merchantable-height growth, and quality improvement must be made. The 10-year period was selected because it is the recommended cutting cycle for most silvicultural systems. The assumptions were based on research data from experimental forests in Wisconsin and Michigan.

Diameter.—Three different 10-year diameter growth rates were used (1.4, 1.8, and 2.2 inches) to account for the variable site conditions on which sugar maple in the Lake States can be found.

Height.—Research indicates that a 1/2-log height growth is possible in 10 years on trees of good form.

Grade.—In growing trees, quality improvement is as important as diameter and height growth. For grade improvement, scanty research data indicate that a 1-grade improvement is possible within a 10-year period and thus we considered the occurrence of such an event.

We regarded the probability of height or grade improvement to be rather remote once the tree was 25 inches d.b.h. and did not consider such improvements in our calculations.

With these assumptions based on research we were able to project the dimensions of sugar maple trees 10 years into the future and by referring to our table of tree conversion values were able to determine future conversion value of the tree. We then calculated the rate of value increase of the tree during the 10-year period using the compound interest formula:

$$(1 + r)^n = \frac{V_n}{V_o}$$

where: r is the rate of value increase

n is the time period (10 years)

V_n is the future conversion value

V_o is the present conversion value.

This value determines the point of financial maturity of the tree. When the rate falls below the rate of return desired by the owner, the tree is financially mature.

One simple calculation completes the procedure. To set the tree value increase over the 10-year period, we simply subtracted the present conversion value from the future conversion value.

These are the calculations involved in a single example of financial maturity. In our work, with the aid of a computer, we made several thousand such calculations of tree diameters 14 to 30 inches d.b.h., merchantable heights up to 3-1/2 logs, and all 3 grades of logs.

Because lumber prices and conversion costs vary, we could not hope to duplicate current prices. Instead we used a base lumber price of $165 for 4/4 No. 1C lumber and a $70 conversion cost. Then, to illustrate the effect of changing lumber prices and conversion costs, we made a series of computations for assumed combinations of prices and costs as follows:

We termed this "the basic situation"

	Present	(10 years hence)
Price 4/4 No. 1C	165	$175/M
Conversion Cost	70	70/M

Other lumber-price, conversion-cost combinations were:

Price 4/4 No. 1C	165	165
Conversion Cost	80	80
Price 4/4 No. 1C	165	165
Conversion Cost	70	70
Price 4/4 No. 1C	165	165
Conversion Cost	60	60
Price 4/4 No. 1C	165	165
Conversion Cost	70	60
Price 4/4 No. 1C	165	175
Conversion Cost	70	60

Prices of lumber are subject to the law of supply and demand. Over-abundance of a species at any one time can drive the price down. Costs can also be reduced by innovation and use of labor-saving machines. So our combinations are not unrealistic.

RESULTS

Present Dollar Value

The dollar value of individual trees follows the normal pattern: value increases with tree diameter and is greater on trees with more merchantable height and on those with the highest butt log grade (table 1). The value of a 2-log, grade 2 tree, for example, is $2.73 for 14-inch trees and $53.80 for 30-inch trees.

Within the same diameter-grade class, trees with greater merchantable heights have higher net values. A 16-inch, 2-log, butt log grade 2 tree, has a value of $5.14 in contrast to a 1-1/2-log tree, which has a value of $4.40.

Dollar Value Increases for Growth and Grade Charges

In order to obtain the greatest dollar-earning capacity, choices must be made after the first thinning among trees with different potentials for development. In conjunction with silvicultural knowledge of the species, the three major factors that can be evaluated are the expected change in diameter growth as a result of treatment and altering of growing space, the projected increase in merchantable height, and the probability of an increase in grade due to clearing of bole defects and size. The amount of value increase can be determined for individual trees, for each factor or a combination of the three major factors (table 1).

Diameter growth will normally occur on all residual trees either at a constant rate typical of the previous management level or at an increased rate following treatment that usually can be estimated on the basis of three broad growth classes. The value contributed by increase in size is directly related to the rate of growth. Over a 10-year period, for example, the increase in value for a 16-inch, 2-log, butt log grade 2 tree with a present value of $5.14 would be $3.54 if it grew 1.4 inches in diameter, $4.36 with a growth 1.8 inches, and $5.22 for a growth of 2.2 inches, assuming there was no increase in grade.

Table 1.—*Expected 10-year value increases in sugar maple for given increases in diameter, height, and grade*
(In dollars)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. (D.b.h. growth-inches)			Diameter growth + 1 grade increase (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. and 1 grade increase (D.b.h. growth-inches		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
14	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	1.86	1.51	1.88	2.26	2.62	3.11	3.63	3.99	4.47	4.97	6.03	6.69	7.37
		3	0.29	0.91	1.11	1.32	1.50	1.78	2.09	3.08	3.45	3.83	4.18	4.68	5.20
14	1 1/2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	2.41	2.07	2.57	3.09	2.81	3.42	4.06	5.48	6.14	6.83	6.95	7.78	8.63
		3	0.50	1.29	1.57	1.88	1.84	2.21	2.60	3.97	4.47	4.99	4.72	5.32	5.97
14	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	2.73	2.49	3.10	3.74	3.32	4.01	4.73	6.63	7.45	8.31	8.33	9.25	10.20
		3	0.73	1.62	1.98	2.37	2.31	2.75	3.21	4.49	5.10	5.74	5.32	6.01	6.73
16	1	1	5.80	2.70	3.42	4.08	-	-	-	-	-	-	-	-	-
		2	3.31	2.12	2.67	3.21	-	-	-	5.19	5.91	6.57	-	-	-
		3	1.04	1.32	1.63	1.94	-	-	-	4.39	4.95	5.48	-	-	-
16	1 1/2	1	7.84	3.74	4.59	5.46	6.07	7.11	8.19	-	-	-	-	-	-
		2	4.40	2.91	3.59	4.29	4.29	5.11	5.97	7.17	8.02	8.90	9.51	10.55	11.63
		3	1.58	1.88	2.28	2.71	2.89	3.40	3.94	5.73	6.41	7.11	7.11	7.93	8.79
16	2	1	9.34	4.57	5.61	6.68	6.93	8.15	9.42	-	-	-	-	-	-
		2	5.14	3.54	4.36	5.22	4.88	5.85	6.86	8.77	9.81	10.88	11.12	12.35	13.61
		3	2.10	2.37	2.88	3.42	3.50	4.13	4.80	6.59	7.41	8.27	7.93	8.90	9.91
16	2 1/2	1	10.98	5.29	6.51	7.78	7.72	9.13	10.59	-	-	-	-	-	-
		2	5.93	4.10	5.07	6.08	5.45	6.56	7.72	10.34	11.57	12.83	12.77	14.18	15.64
		3	2.73	2.87	3.50	4.16	4.17	4.92	5.72	7.29	8.26	9.27	8.64	9.75	10.91
18	1	1	8.54	3.60	4.43	5.27	-	-	-	-	-	-	-	-	-
		2	5.43	2.93	3.61	4.32	-	-	-	6.71	7.54	8.38	-	-	-
		3	2.20	1.86	2.27	2.70	-	-	-	-	-	-	-	-	-
18	1 1/2	1	11.49	4.84	5.90	6.99	-	-	-	-	-	-	-	-	-
		2	7.23	3.93	4.81	5.73	-	-	-	9.10	10.16	11.26	-	-	-
		3	3.21	2.59	3.15	3.72	-	-	-	-	-	-	-	-	-
18	2	1	13.82	5.86	7.14	8.54	9.36	11.02	12.65	-	-	-	-	-	-
		2	8.58	4.75	5.81	6.98	6.99	8.35	9.70	11.09	12.37	13.77	14.59	16.26	17.89
		3	4.17	3.25	3.93	4.69	5.09	5.99	6.90	-	-	-	-	-	-
18	2 1/2	1	16.15	7.03	8.69	10.32	10.20	11.92	13.75	-	-	-	-	-	-
		2	9.90	5.67	7.03	8.38	7.64	9.07	10.60	13.27	14.94	16.57	16.45	18.16	20.00
		3	5.25	4.00	4.90	5.81	5.89	6.87	7.94	-	-	-	-	-	-

(Table 1 continued on next page)

(Table 1 continued)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. (D.b.h. growth-inches)			Diameter growth + 1 grade increase (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. and 1 grade increase (D.b.h. growth-inches		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
18	3	1	18.54	7.82	9.53	11.37	10.53	12.59	14.63	-	-	-	-	-	-
		2	11.21	6.33	7.76	9.29	7.96	9.64	11.34	15.14	16.85	18.69	17.85	19.91	21.96
		3	6.49	4.65	5.64	6.70	6.51	7.71	8.93	-	-	-	-	-	-
20	1	1	12.12	4.46	5.59	6.64	-	-	-	-	-	-	-	-	-
		2	8.34	3.76	4.71	5.63	-	-	-	8.24	9.37	10.42	-	-	-
		3	3.88	2.45	3.04	3.61	-	-	-	-	-	-	-	-	-
20	1 1/2	1	16.12	6.16	7.38	8.81	-	-	-	-	-	-	-	-	-
		2	11.01	5.16	6.23	7.46	-	-	-	11.28	12.50	13.93	-	-	-
		3	5.50	3.46	4.15	4.94	-	-	-	-	-	-	-	-	-
20	2	1	19.50	7.56	9.30	11.00	12.21	14.29	16.42	-	-	-	-	-	-
		2	13.20	6.32	7.80	9.27	9.53	11.30	13.12	13.86	15.60	17.29	18.51	20.58	22.71
		3	7.07	4.36	5.34	6.31	7.00	8.20	9.44	-	-	-	-	-	-
20	2 1/2	1	23.07	8.64	10.71	12.84	12.74	14.96	17.33	-	-	-	-	-	-
		2	15.49	7.25	9.01	10.84	10.03	11.93	13.96	16.22	18.30	20.43	20.33	22.55	24.92
		3	8.89	5.19	6.38	7.62	7.80	9.14	10.56	-	-	-	-	-	-
20	3	1	26.04	9.77	11.99	14.36	13.77	16.22	18.73	-	-	-	-	-	-
		2	17.32	8.20	10.10	12.13	10.85	12.95	15.13	18.50	20.72	23.09	22.49	24.94	27.45
		3	10.64	6.05	7.38	8.81	8.83	10.35	11.92	-	-	-	-	-	-
20	3 1/2	1	28.85	10.96	13.41	15.92	13.94	16.60	19.41	-	-	-	-	-	-
		2	19.00	9.17	11.27	13.44	11.07	13.34	15.76	20.81	23.26	25.77	23.79	26.45	29.26
		3	12.51	6.97	8.49	10.06	9.46	11.15	12.95	-	-	-	-	-	-
22	1	1	16.56	5.55	6.73	7.80	-	-	-	-	-	-	-	-	-
		2	12.10	4.78	5.81	6.76	-	-	-	10.01	11.19	12.26	-	-	-
		3	6.16	3.14	3.76	4.34	-	-	-	-	-	-	-	-	-
22	1 1/2	1	21.93	7.49	8.94	10.49	-	-	-	-	-	-	-	-	-
		2	15.94	6.44	7.72	9.08	-	-	-	13.48	14.94	16.49	-	-	-
		3	8.59	4.34	5.14	5.98	-	-	-	-	-	-	-	-	-
22	2	1	26.92	9.06	11.07	13.08	-	-	-	-	-	-	-	-	-
		2	19.45	7.79	9.54	11.29	-	-	-	16.53	18.54	20.55	-	-	-
		3	11.10	5.42	6.53	7.65	-	-	-	-	-	-	-	-	-
22	2 1/2	1	31.53	10.65	12.53	14.69	16.42	18.92	21.43	-	-	-	-	-	-
		2	22.64	9.16	10.84	12.74	13.34	15.53	17.73	19.54	21.42	23.58	25.31	27.81	30.32
		3	13.68	6.55	7.67	8.91	10.32	11.82	13.30	-	-	-	-	-	-
22	3	1	35.46	12.49	14.99	17.50	17.38	20.29	23.21	-	-	-	-	-	-
		2	25.30	10.68	12.87	15.07	14.16	16.69	19.23	22.65	22.15	27.66	27.54	30.45	33.37
		3	16.18	7.83	9.32	10.80	11.43	13.21	14.98	-	-	-	-	-	-
22	3 1/2	1	39.36	13.48	16.40	19.31	18.15	21.46	24.78	-	-	-	-	-	-
		2	27.90	11.57	14.10	16.64	14.84	17.69	20.56	24.95	27.86	30.78	29.61	32.93	36.24
		3	18.87	8.74	10.52	12.28	12.49	14.55	16.62	-	-	-	-	-	-

(Table 1 continued on next page)

(Table 1 continued)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. (D.b.h. growth-inches)			Diameter growth + 1 grade increase (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. and 1 grade increase (D.b.h. growth-inches)		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
24	1	1	21.75	6.14	7.32	8.61	-	-	-	-	-	-	-	-	-
		2	16.62	5.36	6.42	7.56	-	-	-	11.27	12.44	13.73	-	-	-
		3	8.91	3.41	4.02	4.68	-	-	-	-	-	-	-	-	-
24	1 1/2	1	28.88	8.20	9.86	11.63	-	-	-	-	-	-	-	-	-
		2	21.98	7.16	8.63	10.20	-	-	-	15.10	16.76	18.53	-	-	-
		3	12.38	4.69	5.56	6.49	-	-	-	-	-	-	-	-	-
24	2	1	35.56	10.49	12.52	14.55	-	-	-	-	-	-	-	-	-
		2	26.95	9.12	10.92	12.73	-	-	-	19.10	21.12	23.16	-	-	-
		3	15.94	6.12	7.22	8.33	-	-	-	-	-	-	-	-	-
24	2 1/2	1	41.01	12.39	14.65	17.13	19.45	21.95	24.66	-	-	-	-	-	-
		2	30.94	10.73	12.76	14.95	16.08	18.32	20.73	22.46	24.72	27.20	29.52	32.02	34.73
		3	19.23	7.41	8.68	10.06	12.15	13.61	15.17	-	-	-	-	-	-
24	3	1	47.09	13.37	15.87	18.58	20.34	23.27	26.20	-	-	-	-	-	-
		2	35.36	11.65	13.89	16.31	16.88	19.48	22.11	25.10	27.60	30.31	32.07	34.99	37.93
		3	23.08	8.31	9.76	11.32	13.34	15.09	16.83	-	-	-	-	-	-
24	3 1/2	1	52.07	15.36	18.29	21.22	21.66	24.62	27.77	-	-	-	-	-	-
		2	38.91	13.33	15.93	18.56	17.99	20.64	23.47	28.52	31.45	34.38	34.82	37.78	40.93
		3	26.66	9.75	11.50	13.25	14.76	16.59	18.53	-	-	-	-	-	-
26	1	1	27.18	6.98	8.42	9.76	-	-	-	-	-	-	-	-	-
		2	21.43	6.19	7.48	8.71	-	-	-	-	-	-	-	-	-
		3	11.67	3.86	4.59	5.29	-	-	-	-	-	-	-	-	-
26	1 1/2	1	36.23	9.55	11.37	13.22	-	-	-	-	-	-	-	-	-
		2	28.47	8.44	10.10	11.78	-	-	-	-	-	-	-	-	-
		3	16.22	5.41	6.37	7.35	-	-	-	-	-	-	-	-	-
26	2	1	44.86	11.41	13.50	15.61	-	-	-	-	-	-	-	-	-
		2	35.13	10.12	12.03	13.97	-	-	-	-	-	-	-	-	-
		3	20.94	6.68	7.83	8.98	-	-	-	-	-	-	-	-	-
26	2 1/2	1	51.87	14.20	16.75	19.34	-	-	-	-	-	-	-	-	-
		2	40.48	12.50	14.82	17.18	-	-	-	-	-	-	-	-	-
		3	25.24	8.46	9.89	11.34	-	-	-	-	-	-	-	-	-
26	3	1	58.62	15.48	18.07	21.10	23.60	26.62	29.88	-	-	-	-	-	-
		2	45.57	13.67	16.05	18.80	19.96	22.72	25.70	-	-	-	-	-	-
		3	29.72	9.53	11.03	12.78	15.50	17.30	19.24	-	-	-	-	-	-
26	3 1/2	1	65.52	16.69	19.71	22.98	24.48	27.92	31.41	-	-	-	-	-	-
		2	50.75	14.79	17.55	20.52	20.77	23.90	27.09	-	-	-	-	-	-
		3	34.61	10.61	12.41	14.35	16.79	18.89	20.14	-	-	-	-	-	-

(Table 1 continued on next page)

(Table 1 continued)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. (D.b.h. growth-inches)			Diameter growth + 1 grade increase (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. inc. and 1 grade increase (D.b.h. growth-inches)		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
28	1	1	33.21	7.94	9.45	10.86	-	-	-	-	-	-	-	-	-
		2	26.85	7.17	8.56	9.88	-	-	-	-	-	-	-	-	-
		3	14.67	4.47	5.25	5.99	-	-	-	-	-	-	-	-	-
28	1 1/2	1	44.41	10.68	12.59	14.64	-	-	-	-	-	-	-	-	-
		2	35.81	9.63	11.41	13.31	-	-	-	-	-	-	-	-	-
		3	20.42	6.16	7.19	8.29	-	-	-	-	-	-	-	-	-
28	2	1	54.35	13.02	15.66	18.32	-	-	-	-	-	-	-	-	-
		2	43.71	11.74	14.16	16.63	-	-	-	-	-	-	-	-	-
		3	26.00	7.71	9.15	10.62	-	-	-	-	-	-	-	-	-
28	2 1/2	1	63.93	15.20	17.88	20.82	-	-	-	-	-	-	-	-	-
		2	51.26	13.71	16.22	18.95	-	-	-	-	-	-	-	-	-
		3	31.81	9.25	10.78	12.45	-	-	-	-	-	-	-	-	-
28	3	1	71.28	18.56	21.72	24.91	-	-	-	-	-	-	-	-	-
		2	56.98	16.61	19.55	22.53	-	-	-	-	-	-	-	-	-
		3	36.88	11.46	13.30	15.17	-	-	-	-	-	-	-	-	-
28	3 1/2	1	79.25	19.87	23.47	27.33	-	-	-	-	-	-	-	-	-
		2	63.16	17.84	21.18	24.75	-	-	-	-	-	-	-	-	-
		3	42.64	12.65	14.81	17.12	-	-	-	-	-	-	-	-	-
30	1	1	39.75	9.10	10.80	12.52	-	-	-	-	-	-	-	-	-
		2	32.87	8.33	9.93	11.56	-	-	-	-	-	-	-	-	-
		3	18.00	5.18	6.08	6.99	-	-	-	-	-	-	-	-	-
30	1 1/2	1	53.12	12.56	14.81	17.08	-	-	-	-	-	-	-	-	-
		2	43.84	11.47	13.59	15.74	-	-	-	-	-	-	-	-	-
		3	24.98	7.30	8.52	9.76	-	-	-	-	-	-	-	-	-
30	2	1	65.34	15.06	17.38	19.96	-	-	-	-	-	-	-	-	-
		2	53.80	13.79	16.02	18.48	-	-	-	-	-	-	-	-	-
		3	31.91	9.01	10.33	11.78	-	-	-	-	-	-	-	-	-
30	2 1/2	1	76.14	18.27	21.56	24.88	-	-	-	-	-	-	-	-	-
		2	62.55	16.67	19.77	22.91	-	-	-	-	-	-	-	-	-
		3	38.61	11.15	13.03	14.94	-	-	-	-	-	-	-	-	-
30	3	1	86.55	19.87	23.65	27.24	-	-	-	-	-	-	-	-	-
		2	70.93	18.20	21.75	25.16	-	-	-	-	-	-	-	-	-
		3	45.56	12.51	14.73	16.86	-	-	-	-	-	-	-	-	-
30	3 1/2	1	95.61	23.04	26.85	30.93	-	-	-	-	-	-	-	-	-
		2	78.16	21.01	24.64	28.51	-	-	-	-	-	-	-	-	-
		3	52.24	14.78	17.10	19.58	-	-	-	-	-	-	-	-	-
30	4	1	104.31	25.47	29.76	34.30	-	-	-	-	-	-	-	-	-
		2	85.05	23.21	27.27	31.58	-	-	-	-	-	-	-	-	-
		3	59.15	16.74	19.41	22.24	-	-	-	-	-	-	-	-	-

Addition of 1/2-log in merchantable height at the same rates of diameter growth and at the same beginning diameter, merchantable height, and grade, would increase these values by another $4.88, $5.85, and $6.86 over the same 10-year period. In many cases, however, depending on the silvicultural system being used, there may be a potential to increase grade without an increase in merchantable height. If only diameter growth and grade increased, the respective total increases would amount to $8.77, $9.81, and $10.88.

Under optimum conditions over a 10-year period it may be possible to obtain a 1/2-log increase in merchantable length and a 1 grade improvement in addition to the increase in diameter. The expected value increase for the same beginning tree size and grade then would become $11.12, $12.35, and $13.61, according to the rate of diameter growth.

In general, the greatest proportion of the value increase over a 10-year period where diameter growth, merchantable height increase, and grade improvements do occur will accrue from grade improvement (table 2). With a diameter growth of 1.8 inches over 10-years, a 1/2-log height increase, and a 1 grade improvement in a 16-inch, 2-log, butt log grade 2 tree, the 10-year dollar value increase of $12.35 would consist of 44 percent contributed by the grade improvement, 35 percent by diameter growth, 12 percent by the increase in merchantable height, and 9 percent because of a combination effect of diameter, height, and grade change. The value of diameter growth becomes greater than the value of grade improvement only in trees larger than 22 inches in diameter when increases in all factors are still possible. However, height increases are not likely to occur in large diameter but initially short merchantable height trees, and grade improvement is not likely to occur in large diameter trees of the lower grades or in trees that have reached butt log grade 1 (when other products such as veneer are not considered).

Rate of Value Change

The financial maturity concept is based on the earning power or rate of value increase over a given period of time. In small trees, with a low initial value, the addition of a relatively small dollar increase results in fairly high rates of value increase. The rate of value increase tends to decline as the trees become larger (table 3). The primary concern thus becomes the minimum rate of value increase that will be acceptable to the land manager from the large, high value trees and the comparison between trees of acceptable silvicultural characteristics.

Table 2.—*Distribution of dollar value increase of sugar maple for potential increases in diameter, height, and butt log grade over a 10-year period*
(In percent)

Contributing factor	Beginning diameter and merchantable height and different 10-year diameter growth rates											
	14"-1 1/2 logs (D.b.h. growth-inches)			16"-2 logs (D.b.h. growth-inches)			18"-2 1/2 logs (D.b.h. growth-inches)			22-2 1/2 logs (D.b.h. growth-inches)		
	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
BUTT LOG GRADE 3 TREES												
Diameter growth	27	30	32	30	32	34	Grade Improvement not Expected					
Height increase (1/2 log)	12	12	12	14	14	14						
Grade improvement (1 grade)	57	54	52	53	51	49						
Combination effect	4	4	4	3	3	3						
Dollar value increase	4.72	5.32	5.97	7.93	8.90	9.91						
BUTT LOG GRADE 2 TREES												
Diameter growth	30	33	36	32	35	38	35	39	42	36	39	42
Height increase (1/2 log)	11	11	11	12	12	12	12	11	11	17	17	16
Grade improvement (1 grade)	49	46	43	47	44	42	46	43	41	41	38	36
Combination effect (All)	10	10	10	9	9	8	7	7	6	6	6	6
Dollar value increase	6.95	7.78	8.63	11.12	12.35	13.61	16.45	18.16	20.00	25.31	27.81	30.32

Table 3.—*10-year rate of value increase in sugar maple for given increases in diameter, height, and grade*
(In percent)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. (D.b.h. growth-inches)			Diameter growth + 1 grade incr. (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. and 1 grade incr. (D.b.h. growth-inches)		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
14	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	1.86	6.1	7.2	8.3	9.2	10.3	11.4	12.1	13.0	13.9	15.5	16.5	17.4
		3	0.29	15.1	16.9	18.5	19.8	21.6	23.2	27.6	28.9	30.2	31.3	32.7	34.0
14	1 1/2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	2.41	6.4	7.5	8.6	8.1	9.2	10.4	12.6	13.5	14.4	14.6	15.5	16.4
		3	0.50	13.5	15.2	16.8	16.6	18.3	19.9	24.4	25.7	27.0	26.3	27.7	29.1
14	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	2.73	6.7	7.9	9.0	8.3	9.4	10.6	13.1	14.1	15.0	15.0	15.9	16.8
		3	0.73	12.4	14.0	15.5	15.3	16.9	18.4	21.7	23.1	24.4	23.5	24.9	26.1
16	1	1	5.80	3.9	4.7	5.5	-	-	-	-	-	-	-	-	-
		2	3.31	5.1	6.1	7.0	-	-	-	9.9	10.8	11.6	-	-	-
		3	1.04	8.5	9.9	11.1	-	-	-	18.0	19.1	20.2	-	-	-
16	1 1/2	1	7.84	4.0	4.7	5.4	5.9	6.7	7.4	-	-	-	-	-	-
		2	4.40	5.2	6.1	7.1	7.1	8.0	9.0	10.2	10.9	11.7	12.2	13.0	13.8
		3	1.58	8.2	9.4	10.5	11.0	12.2	13.4	16.6	17.6	18.6	18.6	19.7	20.7
16	2	1	9.34	4.1	4.8	5.6	5.7	6.5	7.2	-	-	-	-	-	-
		2	5.14	5.4	6.3	7.3	6.9	7.9	8.8	10.5	11.3	12.0	12.2	13.0	13.8
		3	2.10	7.8	9.0	10.2	10.3	11.5	12.6	15.3	16.3	17.3	16.9	18.0	19.1
16	2 1/2	1	10.98	4.0	4.8	5.5	5.5	6.2	7.0	-	-	-	-	-	-
		2	5.93	5.4	6.4	7.3	6.7	7.7	8.7	10.6	11.4	12.2	12.2	13.0	13.8
		3	2.73	7.4	8.6	9.7	9.7	10.8	11.9	13.9	14.9	16.0	15.3	16.4	17.4
18	1	1	8.54	3.6	4.3	4.9	-	-	-	-	-	-	-	-	-
		2	5.43	4.4	5.2	6.0	-	-	-	8.4	9.1	9.8	-	-	-
		3	2.20	6.3	7.4	8.3	-	-	-	-	-	-	-	-	-
18	1 1/2	1	11.49	3.6	4.2	4.9	-	-	-	-	-	-	-	-	-
		2	7.23	4.4	5.2	6.0	-	-	-	8.5	9.2	9.8	-	-	-
		3	3.21	6.1	7.1	8.0	-	-	-	-	-	-	-	-	-
18	2	1	13.82	3.6	4.2	4.9	5.3	6.0	6.7	-	-	-	-	-	-
		2	8.58	4.5	5.3	6.1	6.1	7.0	7.9	8.6	9.3	10.1	10.4	11.2	11.9
		3	4.17	5.9	6.9	7.8	8.3	9.3	10.3	-	-	-	-	-	-
18	2 1/2	1	16.15	3.7	4.4	5.1	5.0	5.7	6.4	-	-	-	-	-	-
		2	9.90	4.6	5.5	6.3	5.9	6.7	7.8	8.9	9.6	10.3	10.3	11.0	11.7
		3	5.25	5.8	6.8	7.7	7.8	8.7	9.6	-	-	-	-	-	-

(Table 3 continued on next page)

(Table 3 continued)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. (D.b.h. growth-inches)			Diameter growth + 1 grade incr. (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. and 1 grade incr. (D.b.h. growth-inches)		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
18	3	1	18.54	3.6	4.2	4.9	4.6	5.3	6.0	-	-	-	-	-	-
		2	11.21	4.6	5.4	6.2	5.5	6.4	7.2	8.9	9.6	10.3	10.0	10.8	11.4
		3	6.49	5.6	6.4	7.4	7.2	8.2	9.0	-	-	-	-	-	-
20	1	1	12.12	3.2	3.9	4.5	-	-	-	-	-	-	-	-	-
		2	8.34	3.8	4.6	5.3	-	-	-	7.1	7.8	8.4	-	-	-
		3	3.88	5.0	6.0	6.8	-	-	-	-	-	-	-	-	-
20	1 1/2	1	16.12	3.3	3.8	4.5	-	-	-	-	-	-	-	-	-
		2	11.01	3.9	4.6	5.3	-	-	-	7.3	7.9	8.5	-	-	-
		3	5.50	5.0	5.8	6.6	-	-	-	-	-	-	-	-	-
20	2	1	19.50	3.3	4.0	4.6	5.0	5.6	6.3	-	-	-	-	-	-
		2	13.20	4.0	4.8	5.5	5.6	6.4	7.2	7.4	8.1	8.7	9.2	9.9	10.5
		3	7.07	4.9	5.8	6.6	7.1	8.0	8.8	-	-	-	-	-	-
20	2 1/2	1	23.07	3.2	3.9	4.5	4.5	5.1	5.8	-	-	-	-	-	-
		2	15.49	3.9	4.7	5.4	5.1	5.9	6.6	7.4	8.1	8.8	8.8	9.4	10.1
		3	8.89	4.7	5.6	6.4	6.5	7.3	8.2	-	-	-	-	-	-
20	3	1	26.04	3.2	3.9	4.5	4.3	5.0	5.6	-	-	-	-	-	-
		2	17.32	4.0	4.7	5.4	5.0	5.7	6.5	7.5	8.2	8.8	8.7	9.3	10.0
		3	10.64	4.6	5.4	6.2	6.2	7.0	7.8	-	-	-	-	-	-
20	3 1/2	1	28.85	3.3	3.9	4.5	4.0	4.6	5.3	-	-	-	-	-	-
		2	19.00	4.0	4.8	5.5	4.7	5.5	6.2	7.7	8.3	9.0	8.5	9.1	9.8
		3	12.51	4.5	5.3	6.1	5.8	6.6	7.4	-	-	-	-	-	-
22	1	1	16.56	2.9	3.5	3.9	-	-	-	-	-	-	-	-	-
		2	12.10	3.4	4.0	4.5	-	-	-	6.2	6.8	7.2	-	-	-
		3	6.16	4.2	4.9	5.5	-	-	-	-	-	-	-	-	-
22	1 1/2	1	21.93	3.0	3.5	4.0	-	-	-	-	-	-	-	-	-
		2	15.94	3.4	4.0	4.6	-	-	-	6.3	6.8	7.4	-	-	-
		3	8.59	4.2	4.8	5.4	-	-	-	-	-	-	-	-	-
22	2	1	26.92	2.9	3.5	4.0	-	-	-	-	-	-	-	-	-
		2	19.45	3.4	4.1	4.7	-	-	-	6.3	6.9	7.5	-	-	-
		3	11.10	4.1	4.7	5.4	-	-	-	-	-	-	-	-	-
22	2 1/2	1	31.53	3.0	3.4	3.9	4.3	4.8	5.3	-	-	-	-	-	-
		2	22.64	3.4	4.0	4.6	4.7	5.4	6.0	6.4	6.9	7.4	7.8	8.3	8.9
		3	13.68	4.0	4.6	5.1	5.8	6.4	7.0	-	-	-	-	-	-
22	3	1	35.46	3.1	3.6	4.1	4.1	4.6	5.2	-	-	-	-	-	-
		2	25.30	3.6	4.2	4.8	4.5	5.2	5.8	6.6	7.2	7.7	7.6	8.2	8.8
		3	16.18	4.0	4.7	5.2	5.5	6.2	6.8	-	-	-	-	-	-

(Table 3 continued on next page)

(Table 3 continued)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. (D.b.h. growth-inches)			Diameter growth + 1 grade incr. (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. and 1 grade incr. (D.b.h. growth-inches)		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
22	3 1/2	1	39.36	3.0	3.5	4.1	3.9	4.4	5.0	-	-	-	-	-	-
		2	27.90	3.5	4.2	4.8	4.4	5.0	5.7	6.6	7.2	7.7	7.5	8.1	8.7
		3	18.87	3.9	4.5	5.1	5.2	5.9	6.5	-	-	-	-	-	-
24	1	1	21.75	2.5	2.9	3.4	-	-	-	-	-	-	-	-	-
		2	16.62	2.8	3.3	3.8	-	-	-	5.3	5.8	6.2	-	-	-
		3	8.91	3.3	3.8	4.3	-	-	-	-	-	-	-	-	-
24	1 1/2	1	28.88	2.5	3.0	3.4	-	-	-	-	-	-	-	-	-
		2	21.98	2.9	3.4	3.9	-	-	-	5.4	5.8	6.3	-	-	-
		3	12.38	3.3	3.8	4.3	-	-	-	-	-	-	-	-	-
24	2	1	35.56	2.6	3.1	3.5	-	-	-	-	-	-	-	-	-
		2	26.95	3.0	3.5	4.0	-	-	-	5.5	6.0	6.4	-	-	-
		3	15.94	3.3	3.8	4.3	-	-	-	-	-	-	-	-	-
24	2 1/2	1	41.01	2.7	3.1	3.6	4.0	4.4	4.8	-	-	-	-	-	-
		2	30.94	3.0	3.5	4.0	4.3	4.8	5.3	5.6	6.1	6.5	6.9	7.4	7.8
		3	19.23	3.3	3.8	4.3	5.0	5.5	6.0	-	-	-	-	-	-
24	3	1	47.09	2.5	3.0	3.4	3.7	4.1	4.5	-	-	-	-	-	-
		2	35.36	2.9	3.4	3.9	4.0	4.5	5.0	5.5	5.9	6.4	6.7	7.1	7.6
		3	23.08	3.1	3.6	4.1	4.7	5.2	5.6	-	-	-	-	-	-
24	3 1/2	1	52.07	2.6	3.1	3.5	3.5	4.0	4.4	-	-	-	-	-	-
		2	38.91	3.0	3.5	4.0	3.9	4.4	4.8	5.6	6.1	6.5	6.6	7.0	7.4
		3	26.66	3.2	3.6	4.1	4.5	5.0	5.4	-	-	-	-	-	-
26	1	1	27.18	2.3	2.7	3.1	-	-	-	-	-	-	-	-	-
		2	21.43	2.6	3.0	3.5	-	-	-	-	-	-	-	-	-
		3	11.67	2.9	3.4	3.8	-	-	-	-	-	-	-	-	-
26	1 1/2	1	36.23	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		2	28.47	2.6	3.1	3.5	-	-	-	-	-	-	-	-	-
		3	16.22	2.9	3.4	3.8	-	-	-	-	-	-	-	-	-
26	2	1	44.86	2.3	2.7	3.0	-	-	-	-	-	-	-	-	-
		2	35.13	2.6	3.0	3.4	-	-	-	-	-	-	-	-	-
		3	20.94	2.8	3.2	3.6	-	-	-	-	-	-	-	-	-
26	2 1/2	1	51.87	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		2	40.48	2.7	3.2	3.6	-	-	-	-	-	-	-	-	-
		3	25.24	2.9	3.4	3.8	-	-	-	-	-	-	-	-	-
26	3	1	58.62	2.4	2.7	3.1	3.4	3.8	4.2	-	-	-	-	-	-
		2	45.57	2.7	3.1	3.5	3.7	4.1	4.6	-	-	-	-	-	-
		3	29.72	2.8	3.2	3.6	4.3	4.7	5.1	-	-	-	-	-	-

(Table 3 continued on next page)

(Table 3 continued)

Present				Diameter growth only (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. (D.b.h. growth-inches)			Diameter growth + 1 grade incr. (D.b.h. growth-inches)			Diameter growth + 1/2 log ht. incr. and 1 grade incr. (D.b.h. growth-inches)		
D.b.h. (inches)	Merch.-height (logs)	Butt log grade	Value (dollars)	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
26	3 1/2	1	65.52	2.3	2.7	3.1	3.2	3.6	4.0	-	-	-	-	-	-
		2	50.75	2.6	3.0	3.4	3.5	3.9	4.4	-	-	-	-	-	-
		3	34.61	2.7	3.1	3.5	4.0	4.4	4.9	-	-	-	-	-	-
28	1	1	33.21	2.2	2.5	2.9	-	-	-	-	-	-	-	-	-
		2	26.85	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		3	14.67	2.7	3.1	3.5	-	-	-	-	-	-	-	-	-
28	1 1/2	1	44.41	2.2	2.5	2.9	-	-	-	-	-	-	-	-	-
		2	35.81	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		3	20.42	2.7	3.1	3.5	-	-	-	-	-	-	-	-	-
28	2	1	54.35	2.2	2.6	3.0	-	-	-	-	-	-	-	-	-
		2	43.71	2.4	2.8	3.3	-	-	-	-	-	-	-	-	-
		3	26.00	2.6	3.1	3.5	-	-	-	-	-	-	-	-	-
28	2 1/2	1	63.93	2.2	2.5	2.9	-	-	-	-	-	-	-	-	-
		2	51.26	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		3	31.81	2.6	3.0	3.4	-	-	-	-	-	-	-	-	-
28	3	1	71.28	2.3	2.7	3.0	-	-	-	-	-	-	-	-	-
		2	56.98	2.6	3.0	3.4	-	-	-	-	-	-	-	-	-
		3	36.88	2.7	3.1	3.5	-	-	-	-	-	-	-	-	-
28	3 1/2	1	79.25	2.3	2.6	3.0	-	-	-	-	-	-	-	-	-
		2	63.16	2.5	2.9	3.4	-	-	-	-	-	-	-	-	-
		3	42.64	2.6	3.0	3.4	-	-	-	-	-	-	-	-	-
30	1	1	39.75	2.1	2.4	2.8	-	-	-	-	-	-	-	-	-
		2	32.87	2.3	2.7	3.1	-	-	-	-	-	-	-	-	-
		3	18.00	2.6	3.0	3.3	-	-	-	-	-	-	-	-	-
30	1 1/2	1	53.12	2.1	2.5	2.8	-	-	-	-	-	-	-	-	-
		2	43.84	2.4	2.7	3.1	-	-	-	-	-	-	-	-	-
		3	24.98	2.6	3.0	3.3	-	-	-	-	-	-	-	-	-
30	2	1	65.34	2.1	2.4	2.7	-	-	-	-	-	-	-	-	-
		2	53.80	2.3	2.6	3.0	-	-	-	-	-	-	-	-	-
		3	31.91	2.5	2.8	3.2	-	-	-	-	-	-	-	-	-
30	2 1/2	1	76.14	2.2	2.5	2.9	-	-	-	-	-	-	-	-	-
		2	62.55	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		3	38.61	2.6	3.0	3.3	-	-	-	-	-	-	-	-	-
30	3	1	86.55	2.1	2.4	2.8	-	-	-	-	-	-	-	-	-
		2	70.93	2.3	2.7	3.1	-	-	-	-	-	-	-	-	-
		3	45.56	2.5	2.8	3.2	-	-	-	-	-	-	-	-	-
30	3 1/2	1	95.61	2.2	2.5	2.8	-	-	-	-	-	-	-	-	-
		2	78.16	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		3	52.24	2.5	2.9	3.2	-	-	-	-	-	-	-	-	-
30	4	1	104.31	2.2	2.5	2.9	-	-	-	-	-	-	-	-	-
		2	85.05	2.4	2.8	3.2	-	-	-	-	-	-	-	-	-
		3	59.15	2.5	2.9	3.2	-	-	-	-	-	-	-	-	-

The rate of value increases, while declining in larger trees, becomes higher as trees in the same diameter class grow at faster rates, attain a 1/2-log increase in merchantable height, or improve in grade. For example, the rate of value increase for a 16-inch 2-log tree, increases from 5.4 percent to 7.3 percent if the growth rate can be increased from 1.4 to 2.2 inches per decade. Where the merchantable length can be increased by 1/2-log and quality increased 1 grade, the tree's earning power advances from 12.2 percent to 13.8 percent for the same increase in diameter growth. As noted, however, with the same increases occurring on an 18-inch diameter tree, the rate of value increase would be 10.4 and 11.9 percent although the dollar value increase would be appreciably greater on the larger trees. In large diameter trees, which cannot be expected to increase in merchantable height or grade, only diameter growth can influence the rate of value increase.

Financial Maturity of Sugar Maple

The rate of value increase at which a tree may be considered financially mature depends not only on its physical characteristics of diameter, height, and quality, but finally and decisively on a preselected rate of value increase determined by the owner of the timber. In presenting this coldly calculating method of determining financial maturity, we merely hope to put the fiscal facts before the owner with the understanding that other considerations should be made. We hope to replace the "seat-of-the-pants" decision to harvest the forest crop with a financial determination of tree maturity.

In this study, the "maximum" diameter could range from 15 inches to more than 30 inches as owner-determined return is varied between 2 and 6 percent and depending on grade and height changes that could occur during the 10-year period.

The financial maturity diameter for Grade 2 sugar maple would be 15 inches at a diameter growth of 1.4 inches with no improvement in merchantable height or grade and where the owner objective is 6 percent (table 4). However, if this tree made a 1/2-log increase in merchantable height and an improvement in grade, the financial-maturity diameter increases to 26 inches.

Influence of Other Selling Price-Conversion Cost Combinations

Both lumber selling prices and conversion costs tend to fluctuate because of market and milling changes and commonly cannot be predicted in advance. When lumber selling price and conversion costs remain constant over the projected 10-year period, rather than an increase in lumber selling prices as assumed in "the base calculations", both the expected value increase and the rate of value increase are lower. For example, the expected value increase associated with the constant lumber selling price of $165 over the 10-year period and a constant conversion cost of $70 is only .64 percent of the "the base calculation" value for a 14-inch, 1-log tree growing at a rate of 1.4 inches per 10 years, and the rate of value increase is 1.8 percent lower (table 5).

With either a constant or increasing lumber selling price and a reduction in conversion costs over the 10-year period resulting from improved markets or better mill operations, the expected value and the rate of value increase would be higher than indicated by the base values. For example, with the same lumber selling price change as used in the base value, but a $10 reduction in conversion costs, a 22-inch, 2-1/2-log, butt log grade 2 tree growing at a rate of 2.2 inches in 10-years would show an expected value increase of 138 percent and a rate of value increase of 1.3 percent over the base value. These changes would consequently alter the financial maturity tree diameters.

Application in Marketing

Both the financial maturity concept and the application of silvicultural systems provide for much latitude in managing sugar maple stands. The silvical characteristics of sugar maple, particularly its tolerance to shade, susceptibility to forking that is associated with its opposite-branching habit, and its ability to respond to release, contribute significantly to the potential for change in managed stands. The importance of recognizing economic potential is most critical during the pole and small saw-log stages when differences in rate of diameter growth, merchantable height development, and improvement in butt log grade are fairly apparent and a choice of trees of desirable characteristics is possible. The base values presented in table 1 and 3 thus provide the economic information upon which a silvicultural choice can be made among trees in the marking process.

As a general rule, value increases with tree diameter, merchantable height and grade. In marking, choices most often will be made among various size trees with different potential over the next 10-year period. For example, a 16-inch, butt log grade 2 tree with 1-1/2-logs now could be expected to increase in value $4.29 at a growth rate of 1.4 inches per decade and a 1/2-log merchantable height increase giving a 7.1 percent rate of value increase. If the alternative tree were an 18-inch butt log grade 3, 2-log tree with no potential for increase in height or grade, its expected value increase would be $3.25 at the same rate of growth or a 5.9 percent rate of value increase. The smaller tree would thus be the

Table 4.—*Financial-maturity diameters of sugar maple for selected growth and grade combinations at given rates of value increase*
(In inches)

Butt log grade	Diameter increase (D.b.h. growth-inches) 1.4	1.8	2.2	Diameter and 1/2 log height increase (D.b.h. growth-inches) 1.4	1.8	2.2	Diameter and 1 grade increase (D.b.h. growth-inches) 1.4	1.8	2.2	Diameter and 1/2 log plus 1 grade increase (D.b.h. growth-inches) 1.4	1.8	2.2
6 PERCENT RATE OF VALUE INCREASE												
3	18	19	21	21	22	24	No grade increase expected[2]					
2	15	17	19	18	20	22	23	24	25+[3]	26+	26+	26+
1	([1])	([1])	([1])	15	18	20	No grade increase expected[4]					
4 PERCENT RATE OF VALUE INCREASE												
3	22	23	23	27+	28+	28+	No grade increase expected[2]					
2	20	22	24	25	26	28+	28+	28+	28+	28+	28+	28+
1	16	19	22	24	26	27	No grade increase expected[4]					
2 PERCENT RATE OF VALUE INCREASE												
3	30+	30+	30+	30+	30+	30+	No grade increase expected[2]					
2	30+	30+	30+	30+	30+	30+	No grade increase expected[2]					
1	30	30+	30+	30+	30+	30+	No grade increase expected[4]					

[1]Maximum rate of value increase for butt log grade 1 trees is 5.6 percent or lower considering only diameter increase.

[2]Because of large diameter.

[3]+ indicates that diameter will be higher than indicated but is beyond limitations established for analysis.

[4]Maximum grade considered in present study.

Table 5.—*Relative variation in dollar value and rate of value increase from a base to other price-cost combinations, for selected tree sizes and growth rates over a 10-year period*

Lumber selling price: Pres.	Lumber selling price: 10 yrs.	Conversion costs: Pres.	Conversion costs: 10 yrs.	Butt log grade	Tree size and growth rate: 14"-1 log 1.4"	14"-1 log 2.2"	22"-2 1/2 log 1.4"	22"-2 1/2 log 2.2"	30"-3 1/2 log 1.4"	30"-3 1/2 log 2.2"	Tree size and growth rate: 14"-1 log 1.4"	14"-1 log 2.2"	22"-2 1/2 log 1.4"	22"-2 1/2 log 2.2"	30"-3 1/2 log 1.4"	30"-3 1/2 log 2.2"
Base Price-Cost Value					Value-increase (dollars)						Rate of value increase (percent)					
165	175	70	70	1	—	—	10.65	14.69	23.04	30.93	—	—	3.0	3.9	2.2	2.8
				2	1.51	2.26	9.16	12.74	21.01	28.51	6.1	8.3	3.4	4.6	2.4	3.2
				3	0.91	1.32	6.55	8.91	14.78	19.58	15.1	18.5	4.0	5.1	2.5	3.2
Other Price-Cost Combinations					Percent of base						Amount of change from base (percent)					
165	165	80	80	1	—	—	59	66	52	60	—	—	-.9	-.9	-.9	-.8
				2	54	61	59	66	52	61	-.7	-.2	-.8	-.8	-.9	-.9
				3	—	—	52	59	45	53	—	—	-1.0	-.7	-1.0	-1.0
165	165	70	70	1	—	—	64	72	56	66	—	—	-1.0	-1.0	-.9	-.9
				2	64	73	65	73	57	67	-1.8	-1.8	-1.0	-1.1	-1.0	-1.0
				3	54	61	61	69	52	61	-4.8	-4.0	-1.4	-1.3	-0.9	-1.1
165	165	60	60	1	—	—	70	78	61	71	—	—	-1.1	-1.1	-.9	-.9
				2	75	84	71	79	63	72	-2.4	-2.6	-1.2	-1.3	-1.0	-1.1
				3	70	83	70	78	59	70	-10.0	-10.8	-1.7	-1.7	-1.2	-1.2
165	165	70	60	1	—	—	107	105	105	103	—	—	.1	.2	.1	.1
				2	121	115	115	111	110	108	1.0	.9	.5	.4	.2	.2
				3	148	137	131	123	127	121	3.7	3.2	1.0	1.0	.6	.6
165	175	70	60	1	—	—	143	133	148	138	—	—	1.0	1.0	.9	1.0
				2	158	143	150	138	153	141	2.5	2.3	1.4	1.3	1.1	1.0
				3	194	173	170	154	175	160	6.4	5.7	2.1	2.1	1.6	1.6

economic choice to leave provided other silvicultural characteristics were similar. Had the larger tree been butt log grade 2 it would be expected to earn a slightly larger dollar value ($4.75) but at a rate of only 4.5 percent. Either value could then be used to guide the timber marker's decision in making the most profitable choice between trees according to the landowner's objective.

In pole-size stands, the predominant size class within the sugar maple types at present, emphasis should be in grade improvement because of its contribution to value increase. The stimulation of diameter growth is strongly associated with grade improvement; however, some sacrifice of diameter growth is often necessary to increase merchantable height through correction of low-forks and to enhance the rate of natural pruning in sugar maple. Once an acceptable merchantable length has been attained, and the potential for grade improvement is achieved, most of the value increase will accrue from increasing the rate of diameter growth.

As previously noted, initial marking will usually be concerned with removal of cull, defective, poor risk (obviously low-grade) trees. In later marking, the emphasis can then be on trees that have potential for grade improvement, those capable of growing at faster rates without reducing grade, and trees that will increase in merchantable height.

The optimum size at which sugar maple trees should be harvested, according to the financial maturity concept, may vary from 15 inches to more than 30 inches in diameter. A final decision must be based in part on the landowner's management and financial objectives and these will in turn be influenced to some degree by the silvicultural system being considered. In uneven-age management, where trees are harvested throughout the diameter range, the largest size will be influenced to a great extent by the recommended stand structure. Under these conditions, with previous selection through all size classes, some large-diameter trees must be maintained even though these few trees per acre may have a rate of value increase slightly lower than desired.

In contrast, in an even-aged system, where all trees are approximately the same size, a high goal could be set for the rate of value increase, resulting in smaller financial-maturity tree diameters and lower value increases. For example, growing 14-inch, 2 log, butt log grade 2 trees at a rate of 2.2 inches for the final 10 years would give a return of 9.0 percent based on diameter growth alone. Should the same trees increase 1 grade, as could be expected because they would reach the minimum diameter for grade 1, the rate of value increase would be 15.0 percent. Holding the trees to larger sizes, i.e., growing 22-inch trees of the same height, grade, and rate of growth for a similar period to attain 24-inch trees at harvest, could yield 7.5 percent with a 1 grade improvement or 4.7 percent for diameter growth alone. If only the dollar value of the tree was considered, the larger trees would show the highest value increase as well as the greatest value at the end of the period.

The financial maturity concept and expected value change should be considered as an additional tool available for making the best choices among trees in managed stands. Where other products or values are involved, other economic approaches should be considered.

LITERATURE CITED

Lemsky, Abe. 1962-1966. Hardwood market report. Memphis, Tennessee.

Mendel, Joseph J., and William H. Smith. 1970. Quality index tables for some eastern hardwood species. USDA For. Serv. Res. Pap. NE-167, 24 p. Northeast. For. Exp. Stn., Upper Darby, Pennsylvania.

Vaughn, C.L., A.C. Wellin, K.A. McDonald, and E.H. Bulgrin. 1966. Hardwood lumber grades for standard lumber. USDA For. Serv. Res. Pap. FPL-63, 52 p. For. Prod. Lab., Madison, Wisconsin.

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Godman, Richard M., and Joseph J. Mendel.
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Current and expected rates of value increase over a 10-year period were developed for sawtimber-size sugar maple based on variable growth rates, expected merchantable height changes, and butt log grade improvement. These economic guides, along with silvicultural considerations, provide a value basis for selecting trees during thinning and determining final harvest size.

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