# FINANCIAL MATURITY OF PAPER BIRCH

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ONE OBJECTIVE in forestry is to earn the greatest possible return on the capital invested in growing timber. To do this, the forester not only must know which silvicultural methods to use, but also ought to know the methods of economic analysis that will help him make the decisions that will lead to the greatest return.

The financial maturity concept provides a method of economic analysis by which the forester can evaluate the business aspects of timber growing. This concept is based on the rates of value increase that can be expected of trees over a given period of time. From this, marking guides can be prepared to prescribe the diameters at which trees of given vigor, grade, and merchantable height are financially mature; that is, they have reached the stage beyond which the expected rate of value increase no longer equals or exceeds the timber owner's desired rate of return.

The rate of value increase, which is the backbone of the financial-maturity concept, is determined by three components: (1) the present value of the tree; (2) the future value of the tree, which incorporates growth increase in diameter as well as in merchantable height and possible improvement in quality; and (3) the time period considered between the present value and the prospective value. Given these data, the rate of value increase is determined from the compound-interest formula:

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

where r is the rate of interest.
n is the time period.
$V_n$ is the future value.
$V_o$ is the present value.

The relative simplicity of the compound-interest formula belies the difficulties encountered in assembling the data to calculate the various components of the formula. It was necessary to develop considerable basic data for lumber grade yields as well as prices to formulate the base for determination of present and future value. Also, growth data were necessary for projecting the development of the tree or stand over the 10-year time period considered, to establish prospective value.

## PAPER BIRCH SAWTIMBER

The methodology employed in developing these values for paper birch sawtimber is documented in several recent Northeastern Forest Experiment Station Research Papers on the rate of value increase for several species in the Northeastern region. A summary of the steps required to calculate the rate of value increase is as follows:

1. Use lumber grade yields and price relatives to develop the log quality index and then the tree quality index, which when multiplied by the current price of No. 1 Common lumber, will yield the gross value per thousand board feet.
2. From the gross value per thousand board feet subtract all the variable costs (conversion costs) involved in harvesting, transporting, and processing the tree into lumber. The result is the conversion value per thousand board feet.
3. To obtain the present or future value of the tree, multiply the volume of the tree by the conversion value per thousand board feet.
4. Once the present and future values are determined, calculate the ratio $V_n/V_o$ and check the result in interest tables to determine the rate of value increase.

Table 1 illustrates some of the numerous situations that evolve when all the possibilities

of quality and merchantable height are considered for both the present and the future of a single diameter class.

Many assumptions had to be made in completing these calculations. For instance, we assumed that the tree can improve only one log grade during the 10-year time period involved. Also, trees with a d.b.h. growth of 2.0 inches and over could increase a full 16-foot log in merchantable height. Trees growing less than 2.0 inches in d.b.h. in 10 years were restricted to a ½-log increase in merchantable height.

Assume that we have a 16-inch d.b.h. paper birch, vigor I, with a butt-log grade of 2, and 16 feet merchantable height. From the growth table we find we can expect a diameter increase of 2.7 inches in the next 10 years (table 2). Therefore the future tree has six different possibilities of grade and height:

| *Present* | | |
|---|---|---|
| *D.b.h. (inches)* | *Butt-log grade* | *Merchantable height (feet)* |
| 16.0 | 2 | 16 |

**Table 1.—*Rate of value increase computations for paper birch sawtimber***

VIGOR I

| Present | | | | Future | | | | Ratio $V_n/V_o$ | Percent rate of return | Ten-year value increase $ |
|---|---|---|---|---|---|---|---|---|---|---|
| D.b.h. (inches) | Butt-log grade | Log height (feet) | Conversion value $ | D.b.h. (inches) | Butt-log grade | Log height (feet) | Conversion value $ | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 16.0 | 1 | 16 | 13.86 | 18.7 | 1 | 16 | 25.79 | 1.860981 | 6.4 | 11.93 |
| | | | | | 1 | 24 | 32.33 | 2.332736 | 8.8 | 18.47 |
| | | | | | 1 | 32 | 34.38 | 2.480794 | 9.5 | 20.52 |
| 16.0 | 2 | 16 | 10.06 | 18.7 | 2 | 16 | 17.71 | 1.759469 | 5.8 | 7.65 |
| | | | | | 2 | 24 | 23.93 | 2.378201 | 9.0 | 13.87 |
| | | | | | 2 | 32 | 27.96 | 2.778510 | 10.8 | 17.90 |
| | | | | | 1 | 16 | 25.79 | 2.562772 | 9.9 | 15.73 |
| | | | | | 1 | 24 | 32.33 | 3.212429 | 12.4 | 22.27 |
| | | | | | 1 | 32 | 34.38 | 3.416320 | 13.1 | 24.32 |
| 16.0 | 3 | 16 | 6.11 | 18.7 | 3 | 16 | 11.89 | 1.944977 | 6.9 | 5.78 |
| | | | | | 3 | 24 | 16.01 | 2.619173 | 10.1 | 9.90 |
| | | | | | 3 | 32 | 18.63 | 3.046966 | 11.8 | 12.52 |
| | | | | | 2 | 16 | 17.71 | 2.896111 | 11.2 | 11.60 |
| | | | | | 2 | 24 | 23.93 | 3.914554 | 14.6 | 17.82 |
| | | | | | 2 | 32 | 27.96 | 4.573467 | 16.4 | 21.85 |
| 16.0 | 4 | 16 | 2.08 | 18.7 | 4 | 16 | 4.47 | 2.145091 | 7.9 | 2.39 |
| | | | | | 4 | 24 | 6.38 | 3.058788 | 11.8 | 4.30 |
| | | | | | 4 | 32 | 7.89 | 3.787037 | 14.2 | 5.81 |
| 16.0 | 1 | 24 | 16.95 | 18.7 | 1 | 24 | 32.33 | 1.907074 | 6.7 | 15.38 |
| | | | | | 1 | 32 | 34.38 | 2.028115 | 7.3 | 17.43 |
| | | | | | 1 | 40 | 33.39 | 1.969981 | 7.0 | 16.44 |
| 16.0 | 2 | 24 | 13.62 | 18.7 | 2 | 24 | 23.93 | 1.757209 | 5.8 | 10.31 |
| | | | | | 2 | 32 | 27.96 | 2.052990 | 7.5 | 14.34 |
| | | | | | 2 | 40 | 30.66 | 2.251068 | 8.5 | 17.04 |
| | | | | | 1 | 24 | 32.33 | 2.373605 | 9.0 | 18.71 |
| | | | | | 1 | 32 | 34.38 | 2.524257 | 9.7 | 20.76 |
| | | | | | 1 | 40 | 33.39 | 2.451900 | 9.4 | 20.77 |
| 16.0 | 3 | 24 | 8.16 | 18.7 | 3 | 24 | 16.01 | 1.961634 | 7.0 | 7.85 |
| | | | | | 3 | 32 | 18.63 | 2.282029 | 8.6 | 10.47 |
| | | | | | 3 | 40 | 20.32 | 2.489771 | 9.6 | 12.16 |
| | | | | | 2 | 24 | 23.93 | 2.931810 | 11.4 | 15.77 |
| | | | | | 2 | 32 | 27.96 | 3.425305 | 13.1 | 19.80 |
| 16.0 | 4 | 24 | 3.00 | 18.7 | 4 | 24 | 6.38 | 2.128011 | 7.8 | 3.38 |
| | | | | | 4 | 32 | 7.89 | 2.634657 | 10.2 | 4.89 |
| | | | | | 4 | 40 | 9.22 | 3.077278 | 11.9 | 6.22 |
| 16.0 | 1 | 32 | 17.84 | 18.7 | 1 | 32 | 34.38 | 1.926958 | 6.8 | 16.54 |
| | | | | | 1 | 40 | 33.39 | 1.871723 | 6.5 | 15.55 |
| | | | | | 1 | 48 | 30.59 | 1.714523 | 5.5 | 12.75 |
| 16.0 | 2 | 32 | 16.39 | 18.7 | 2 | 32 | 27.96 | 1.706328 | 5.5 | 11.57 |
| | | | | | 2 | 40 | 30.66 | 1.870959 | 6.5 | 14.27 |
| | | | | | 2 | 48 | 33.07 | 2.018354 | 7.3 | 16.68 |
| | | | | | 1 | 32 | 34.38 | 2.098018 | 7.7 | 17.99 |
| | | | | | 1 | 40 | 33.39 | 2.037880 | 7.4 | 17.00 |
| | | | | | 1 | 48 | 30.59 | 1.866725 | 6.4 | 14.20 |

| | Future | |
|---|---|---|
| *D.b.h. (inches)* | *Butt-log grade* | *Merchantable height (feet)* |
| 18.7 | 2 | 16 |
| | 2 | 24 |
| | 2 | 32 |
| | 1 | 16 |
| | 1 | 24 |
| | 1 | 32 |

The conversion value is found for each of these situations and the ratio $V_n/V_o$ is calculated, which determines the rate of value increase. Thus for our sample tree we find that on the basis of diameter alone we can expect a rate of value increase of 5.8 percent. If the tree increases ½-log in merchantable height, the rate of value increase is 9.0 percent; with a 1-log increase in merchantable height, the rate of value increase is 10.8 percent.

Considering possible quality improvement, we find that the tree can increase one grade to a butt-log grade 1; so we have three additional possibilities: (1) a butt-log grade 1, 16 feet in merchantable height, which gives a rate of value increase of 9.9 percent; (2) a butt-log grade 1, 24 feet in merchantable height, which provides an expected rate of value increase of 12.4 percent; and (3) a butt-log grade 1, 32 feet in merchantable height, with an expected rate of value increase of 13.1 percent.

Thus we find that our sample tree has a potential rate of value increase ranging from 5.8 percent to 13.1 percent, depending upon what occurs in increase in merchantable height and improvement in quality. Table 1 indicates the many possibilities that must be considered for a 16.0-inch paper birch, both in the present situation and for the 10 years hence.

Similar calculations are made for other diameter classes to be considered.

### Results

Any presentation of detailed rates of value increase for general use would not depict the situation for all users. Lumber grade recovery and conversion costs undoubtedly differ from those used in this study. Also, prices for lumber vary by locality and season. Therefore the rates of value increase are presented in four tables as a range of rates for a range of vigor classes. Table values vary as price and conversion costs change (tables 3 to 6).

A user of these tables needs only to select the basic situation and the diameter and vigor of the tree, or the average diameter and vigor of the stand, to determine the range of rates of value increase in the next 10 years. If only growth in diameter and height are anticipated, the left part of the table is used. If an improvement to a higher butt-log grade class is expected, the table section titled "Due to growth and quality increase" is used.

Two noteworthy generalities are illustrated in these tables (table 3):

1. The rate of tree earning power decreases with increasing size. For example, an 18-inch vigor-I tree has the potential of earning at an annual rate during the next 10 years as much as 7 percent, based on growth alone, and 12 percent based on growth and quality improvement. On the other hand, a 22-inch vigor-I tree will earn only about 5 percent in growth alone and a maximum of 8 percent if a grade improvement occurs.

2. Improvement in log quality greatly increases tree earning power. Due recognition must be given to quality improvement potential in selecting the tree to remain in the stand. For example, a 16-inch vigor-I paper birch can have a rate of value increase of 11 percent due to growth alone (table 3). However, if a log-grade improvement takes place in the next 10 years, a rate of value increase of as much as 16 percent can be expected.

**Table 2.—*10-year d.b.h. growth rate for paper birch sawtimber, in inches***

| Initial d.b.h. (inches) | Vigor class I[1] | Vigor class II | Vigor class III |
|---|---|---|---|
| 12 | 3.0 | 2.2 | 1.2 |
| 14 | 2.8 | 2.1 | 1.1 |
| 16 | 2.7 | 2.0 | 1.1 |
| 18 | 2.5 | 1.9 | 1.0 |
| 20 | 2.4 | 1.8 | 1.0 |
| 22 | 2.2 | 1.7 | 9 |

[1] Vigor classes are arbitrary classes based on assumed growth rates.

**Table 3.—*Expected rate of value increase for paper birch trees with price and conversion costs remaining stable*** [1]

(In percent)

| D.b.h. (inches) | Due to growth only | | | Due to growth and quality increase[2] | | |
|---|---|---|---|---|---|---|
| | Vigor I | Vigor II | Vigor III | Vigor I | Vigor II | Vigor III |
| 12 | — | — | — | 16-33* | 13-30* | 11-24* |
| 14 | 7-12 | 5-10 | 3-6 | 7-28* | 5-26* | 3-20* |
| 16 | 5-11 | 4-9 | 2-6 | 6-16* | 4-15* | 2-11* |
| 18 | 3-7 | 3-5 | 2-4 | 4-12 | 4-10 | 1-8 |
| 20 | 3-6 | 2-5 | 1-3 | 4-10 | 3-8 | 1-6 |
| 22 | 2-5 | 2-4 | 1-2 | 4-8 | 3-7 | 1-6 |

[1] Based on 4/4 factory-grade lumber recovery under the following circumstances:

| | $V_o$ | $V_n$ |
|---|---|---|
| Price No. 1C — | $210/M | $210/M |
| Conversion costs — | 70/M | 70/M |

These rates can have a variation of 1 to 2 percent due to differences in location, volume estimates, and quality estimates.

[2] The high portion of the range in rates is due largely to low-grade trees that have a low present value and thus produce a relatively high rate of value increase when considered in the ratio $V_n/V_o$. For this reason butt-log grade 3 logs have not been considered in the estimates "due to growth only."

* The high rates of value increase in the 12- to 16-inch diameter classes are due to two factors: (1) the butt-log grade 3 trees becoming positive in present value, and (2) the improvement of butt-log grade 3 trees to butt-log grade 2.

**Table 4.—*Expected rate of value increase for paper birch trees with conversion costs remaining stable but with prices increasing*** [1]

(In percent)

| D.b.h. (inches) | Due to growth only | | | Due to growth and quality increase [2] | | |
|---|---|---|---|---|---|---|
| | Vigor I | Vigor II | Vigor III | Vigor I | Vigor II | Vigor III |
| 12 | — | — | — | 16-35* | 14-31* | 12-25* |
| 14 | 7-13 | 6-11 | 3-7 | 8-29* | 6-27* | 4-21* |
| 16 | 6-12 | 4-10 | 3-6 | 7-17* | 5-14* | 3-12* |
| 18 | 4-8 | 4-6 | 2-4 | 4-13 | 4-11 | 2-9 |
| 20 | 4-7 | 3-5 | 1-3 | 4-10 | 4-9 | 1-7 |
| 22 | 3-6 | 3-5 | 1-3 | 4-8 | 3-8 | 1-7 |

[1] Based on 4/4 factory-grade lumber recovery under the following circumstances:

| | $V_o$ | $V_n$ |
|---|---|---|
| Price No. 1C — | $210/M | $220/M |
| Conversion costs — | 70/M | 70/M |

These rates can have a variation of 1 to 2 percent due to differences in location, volume estimates, and quality estimates.

[2] The high portion of the range in rates is due largely to low-grade trees that have a low present value and thus produce a relatively high rate of value increase when considered in the ratio $V_n/V_o$. For this reason butt-log grade 3 logs have not been considered in the estimates "due to growth only."

* The high rates of value increase in the 12- to 16-inch diameter classes are due to two factors: (1) the butt-log grade 3 trees becoming positive in present value, and (2) the improvement of butt-log grade 3 trees to butt-log grade 2.

**Table 5.—*Expected rate of value increase for paper birch trees with prices remaining stable but conversion costs decreasing*** [1]

(In percent)

| D.b.h. (inches) | Due to growth only | | | Due to growth and quality increase [2] | | |
|---|---|---|---|---|---|---|
| | Vigor I | Vigor II | Vigor III | Vigor I | Vigor II | Vigor III |
| 12 | — | — | — | 17-36* | 15-33* | 12-26* |
| 14 | 8-13 | 6-11 | 4-7 | 9-30* | 6-28* | 4-22* |
| 16 | 6-12 | 5-10 | 3-7 | 7-17* | 5-16* | 3-12* |
| 18 | 4-8 | 4-6 | 3-4 | 4-13 | 3-11 | 2-9 |
| 20 | 4-7 | 3-6 | 2-4 | 4-11 | 3-9 | 2-7 |
| 22 | 3-6 | 3-5 | 1-3 | 4-9 | 3-8 | 2-6 |

[1] Based on 4/4 factory-grade lumber recovery under the following circumstances:

| | | $V_o$ | $V_n$ |
|---|---|---|---|
| Price No. 1C | — | $210/M | $210/M |
| Conversion costs | — | 70/M | 60/M |

These rates can have a variation of 1 to 2 percent due to differences in location, volume estimates, and quality estimates.

[2] The high portion of the range in rates is due largely to low-grade trees that have a low present value and thus produce a relatively high rate of value increase when considered in the ratio $V_n/V_o$. For this reason butt-log grade 3 logs have not been considered in the estimates "due to growth only."

* The high rates of value increase in the 12- to 16-inch diameter classes are due to two factors: (1) the butt-log grade 3 trees becoming positive in present value, and (2) the improvement of butt-log grade 3 trees to butt-log grade 2.

**Table 6.—*Expected rate of value increase for paper birch trees with prices increasing and conversion costs decreasing*** [1]

| D.b.h. (inches) | Due to growth only | | | Due to growth and quality increase [2] | | |
|---|---|---|---|---|---|---|
| | Vigor I | Vigor II | Vigor III | Vigor I | Vigor II | Vigor III |
| 12 | — | — | — | 18-37* | 15-34* | 13-28* |
| 14 | 8-14 | 7-12 | 4-8 | 9-31* | 7-29* | 5-23* |
| 16 | 7-12 | 6-11 | 4-7 | 8-18* | 6-17* | 4-13* |
| 18 | 5-9 | 5-7 | 3-5 | 5-14 | 4-11 | 3-10 |
| 20 | 5-8 | 4-6 | 2-4 | 5-11 | 4-9 | 3-8 |
| 22 | 4-7 | 4-6 | 2-4 | 5-9 | 4-8 | 3-7 |

[1] Based on 4/4 factory-grade lumber recovery under the following circumstances:

| | | $V_o$ | $V_n$ |
|---|---|---|---|
| Price No. 1C | — | $210/M | $220/M |
| Conversion costs | — | 70/M | 60/M |

These rates can have a variation of 1 to 2 percent due to differences in location, volume estimates, and quality estimates.

[2] The high portion of the range in rates is due largely to low-grade trees that have a low present value and thus produce a relatively high rate of value increase when considered in the ratio $V_n/V_o$. For this reason butt-log grade 3 logs have not been considered in the estimates "due to growth only."

* The high rates of value increase in the 12- to 16-inch diameter classes are due to two factors: (1) the butt-log grade 3 trees becoming positive in present value, and (2) the improvement of butt-log grade 3 trees to butt-log grade 2.

### *Marking Guides*

Tree earning power as depicted by the rate of value increase provides a means for establishing marking guides based on an economic consideration as well as silvicultural and management needs. Tables 3 to 6 can be used in establishing marking guides for selection cutting once an alternative rate of return is established; that is, the interest rate which the forest owner expects for the use of his capital and against which a tree's rate of value increase is compared in estimating financial maturity.

The rate-of-value-increase concept can also be used to determine rotation size in harvest cuttings under even-aged management. These guides presented in tabular form (tables 7 to 10) are given for three interest-rate objectives —2, 4, and 6 percent.

The diameters given are average stand diameters. Assume that an owner requires a return of 4 percent on his capital invested in paper birch trees of sawtimber size; and that the general diameter growth rate and condition of the stand indicate vigor class II. The top d.b.h. limit to leave would be 18 inches if prices and conversion costs remain stable for 10 years. Trees grown larger than 18 inches would fail to provide a return of 4 percent (table 7). In this same example, where a return of only 2 percent is required, the top d.b.h. would be 22+ inches; and for a 6 percent return the d.b.h. limit would be 14 inches. In vigor class III, returns of 4 and 6 percent cannot be obtained with any size sawtimber trees of butt-log grades 1 and 2.

Table 7.—*Paper birch d.b.h. for financial maturity:*
*WHEN LUMBER PRICE AND CONVERSION COST REMAIN STABLE* [1]

| Basis: | $V_o$ | $V_n$ |
|---|---|---|
| Lumber price No. 1C | $210/M | $210/M |
| Conversion cost | 70/M | 70/M |

| Vigor class | Rate of return | | |
|---|---|---|---|
| | 2% | 4% | 6% |
| | *Inches d.b.h.* | *Inches d.b.h.* | *Inches d.b.h.* |
| I | 22+ | 20 | 17 |
| II | 22+ | 18 | 14 |
| III | 20 | — | — |

[1] Diameters are based on value increase as determined by growth only, and for trees with butt-log grades of 1 and 2.

Table 8.—*Paper birch d.b.h. for financial maturity:*
*WHEN LUMBER PRICE INCREASES BUT CONVERSION COST REMAINS STABLE* [1]

| Basis: | $V_o$ | $V_n$ |
|---|---|---|
| Lumber price No. 1C | $210/M | $220/M |
| Conversion cost | 70/M | 70/M |

| Vigor class | Rate of return | | |
|---|---|---|---|
| | 2% | 4% | 6% |
| | *Inches d.b.h.* | *Inches d.b.h.* | *Inches d.b.h.* |
| I | 22+ | 21 | 17 |
| II | 22+ | 19 | 14 |
| III | 22 | 15 | — |

[1] Diameters are based on value increase as determined by growth only, and for trees with butt-log grades of 1 and 2.

This table reflects the earning power of trees only with butt-log grades of 1 and 2. Butt-log grade 3 trees earn little money, and it is reasonable to assume that they would be discriminated against in marking for early improvement cuts.

Tables 7 to 10 illustrate the variation in financial maturity diameters due to different lumber prices and conversion costs projected at the end of the 10-year period.

It should be emphasized that all of the interest rates presented here are based on trees already existing in a stand and on their projected value increase over the next 10 years. Costs of growing the stand to sawtimber-size were not considered.

## PAPER BIRCH BOLTWOOD

Determining the rate of value increase is considerably simpler for boltwood than for sawtimber. Quality does not play as prominent a role in influencing the rate of return, with the possible exception that the bolts that meet the specifications of the buyer may result in higher overall prices. Thus we have two considerations to be made in determining future value: diameter growth and increase in merchantable height.

In making the 10-year projections of value ($V_n$), the growth predictions of a thinning study were used (table 11). Five different

**Table 9.—*Paper birch d.b.h. for financial maturity:***
***WHEN LUMBER PRICE REMAINS STABLE BUT CONVERSION COST DECREASES*** [1]

| Basis: | $V_o$ | $V_n$ |
|---|---|---|
| Lumber price No. 1C | $210/M | $210/M |
| Conversion cost | 70/M | 60/M |

| Vigor class | Rate of return | | |
|---|---|---|---|
| | 2% | 4% | 6% |
| | *Inches d.b.h.* | *Inches d.b.h.* | *Inches d.b.h.* |
| I | 22+ | 22 | 18 |
| II | 22+ | 20 | 16 |
| III | 22 | 15 | — |

[1] Diameters are based on value increase as determined by growth only, and for trees with butt-log grades of 1 and 2.

levels of increase in merchantable height were considered possible: no increase, and increases of 1, 2, 3, and 4 five-foot bolts. A roadside value of $30 per cord was used as the product price, and an average of $16 per cord in conversion costs accounted for all of the variable costs involved in cutting and skidding to the roadside.

Using a volume table, graduated in 5-foot lengths, and a set of compound-interest tables, it is now possible to make the rate of value increase calculations. As previously mentioned, we have five possible situations of the 10-years hence status of the tree (table 12). For example, a 10-inch paper birch with a present merchantable height of 15 feet may evolve in 10 years into one of the following situations:

| *Present d.b.h. (inches)* | *Present merchantable length (feet)* | *Future d.b.h. (inches)* | *Future merchantable length (feet)* |
|---|---|---|---|
| 10.0 | 15 | 12.9 | 15 |
| | | 12.9 | 20 |
| | | 12.9 | 25 |
| | | 12.9 | 30 |
| | | 12.9 | 35 |

Once the volumes are determined for these possible situations, it is a simple matter to determine the conversion value by multiplying the volume by the net value, in this case $14/cord ($30 — $16) (table 12). Then the ratio $V_n/V_o$ can be calculated, and the rates of value increase can be determined from the compound-interest tables. Similar calculations are made for each of the diameter classes.

***Results***

Calculation of the rates of value increase for this example indicates that very desirable returns can be expected. Assuming even the most illogical situation where no increase in merchantable length is achieved in the next 10 years, rates of value increase ranging from 4 to 5 percent can be made on the basis of diameter growth alone (table 13).

Where it is anticipated that in the next 10 years a gain of one 5-foot bolt in merchantable length will be made, rates of value increase will range from 5 to 9 percent, the largest gain made in trees of lower merchantable height at the beginning of the growth period. Similarly, where increases of two 5-foot bolts will be made, the rates of value increase will range between 6 to 12 percent; for increases of three 5-foot bolts the rates of value increase range between 7 to 13 percent. And finally—the most desirable but least likely situation—where gains of four 5-foot bolts of merchantable length are made, the rates of value increase will range between 8 and 14 percent.

A table of financial-maturity diameters for boltwood can be constructed in a manner similar to that for sawtimber (table 14).

**Table 10.—*Paper birch d.b.h. for financial maturity:***
***WHEN LUMBER PRICE INCREASES AND CONVERSION COST DECREASES*** [1]

| Basis: | $V_o$ | $V_n$ |
|---|---|---|
| Lumber price No. 1C | $210/M | $220/M |
| Conversion cost | 70/M | 60/M |

| Vigor class | Rate of return | | |
|---|---|---|---|
| | 2% | 4% | 6% |
| | *Inches d.b.h.* | *Inches d.b.h.* | *Inches d.b.h.* |
| I | 22+ | 22+ | 19 |
| II | 22+ | 20 | 16 |
| III | 22+ | 16 | — |

[1] Diameters are based on value increase as determined by growth only, and for trees with butt-log grades of 1 and 2.

Only the minimum expected rates of value increase (table 13) were considered, and the maximum d.b.h. of boltwood was limited to 12 inches. Given these, we find that an 8-percent return can be obtained only if a height increase of three 5-foot bolts is made and that the financial-maturity diameter would be 10 inches. A 7-percent return would be achieved only if a height growth of two or more 5-foot bolts is made. For a 6-percent return, a height increase of one or more 5-foot bolts must be made. A 5-percent return can be made on the basis of diameter growth alone. It should be emphasized again that these financial-maturity diameters are based on the minimum expected rates of value increase.

**Table 11.—*Ten-year d.b.h. growth for paper birch, in inches***

| D.b.h. (inches) | Growth |
|---|---|
| 6.0 | 2.1 |
| 7.0 | 2.4 |
| 8.0 | 2.6 |
| 9.0 | 2.7 |
| 10.0 | 2.9 |
| 11.0 | 3.0 |
| 12.0 | 3.0 |
| 13.0 | 3.0 |

**Table 12.—*Determination of annual rate of value increase over a 10-year period for 10-inch d.b.h. paper birch boltwood***

| Present | | | | Future | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| D.b.h. (inches) | Merchantable length (feet) | Volume (cords) | Conversion value ($V_o$) $ | D.b.h. (inches) | Merchantable length (feet) | Volume (cords) | Conversion value ($V_n$) $ | Ratio ($V_n/V_o$) | Rate of value increase % | Ten-year value increase $ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 10.0 | 15 | 0.083 | 1.16 | 12.9 | 15 | 0.140 | 1.96 | 1.68966 | 5.4 | 0.80 |
| | | | | | 20 | .175 | 2.45 | 2.11207 | 7.8 | 1.29 |
| | | | | | 25 | .201 | 2.81 | 2.42241 | 9.2 | 1.65 |
| | | | | | 30 | .229 | 3.21 | 2.76724 | 10.7 | 2.05 |
| | | | | | 35 | .252 | 3.53 | 3.04310 | 11.8 | 2.37 |
| 10.0 | 20 | .109 | 1.53 | 12.9 | 20 | .175 | 2.45 | 1.60131 | 4.8 | .92 |
| | | | | | 25 | .201 | 2.81 | 1.83660 | 6.3 | 1.28 |
| | | | | | 30 | .229 | 3.21 | 2.09804 | 7.7 | 1.68 |
| | | | | | 35 | .252 | 3.53 | 2.30719 | 8.7 | 2.00 |
| | | | | | 40 | .274 | 3.84 | 2.50980 | 9.6 | 2.31 |
| 10.0 | 25 | .124 | 1.74 | 12.9 | 25 | .201 | 2.81 | 1.61494 | 4.9 | 1.07 |
| | | | | | 30 | .229 | 3.21 | 1.84483 | 6.3 | 1.47 |
| | | | | | 35 | .252 | 3.53 | 2.02874 | 7.3 | 1.79 |
| | | | | | 40 | .274 | 3.84 | 2.20690 | 8.2 | 2.10 |
| | | | | | 45 | .295 | 4.13 | 2.37356 | 9.0 | 2.39 |
| 10.0 | 30 | 140 | 1.96 | 12.9 | 30 | .229 | 3.21 | 1.63776 | 5.0 | 1.25 |
| | | | | | 35 | .252 | 3.53 | 1.80102 | 6.1 | 1.57 |
| | | | | | 40 | .274 | 3.84 | 1.95918 | 7.0 | 1.88 |
| | | | | | 45 | .295 | 4.13 | 2.10714 | 7.7 | 2.17 |
| | | | | | 50 | .316 | 4.42 | 2.25510 | 8.5 | 2.46 |
| 10.0 | 35 | .153 | 2.14 | 12.9 | 35 | .252 | 3.53 | 1.64953 | 5.1 | 1.39 |
| | | | | | 40 | .274 | 3.84 | 1.79439 | 6.0 | 1.70 |
| | | | | | 45 | .295 | 4.13 | 1.92991 | 6.8 | 1.99 |
| | | | | | 50 | .316 | 4.42 | 2.06542 | 7.5 | 2.28 |
| 10.0 | 40 | .166 | 2.32 | 12.9 | 40 | .274 | 3.84 | 1.65521 | 5.2 | 1.52 |
| | | | | | 45 | .295 | 4.13 | 1.78017 | 5.9 | 1.81 |
| | | | | | 50 | .316 | 4.42 | 1.90517 | 6.6 | 2.10 |
| 10.0 | 45 | .183 | 2.56 | 12.9 | 45 | .295 | 4.13 | 1.61328 | 4.9 | 1.57 |
| | | | | | 50 | .316 | 4.42 | 1.72656 | 5.6 | 1.86 |
| 10.0 | 50 | .200 | 2.80 | 12.9 | 50 | .316 | 4.42 | 1.57857 | 4.7 | 1.62 |

**Table 13.—*Expected annual rate of value increase over a 10-year period for paper birch trees utilized for boltwood*** [1]

(In percent)

| Present d.b.h. (inches) | Expected increase in merchantable length, in number of 5-foot bolts — | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 6 | 5 | 6-9 | 7-12 | 8-13 | 9-14 |
| 7 | 5 | 6-9 | 7-12 | 8-13 | 9-14 |
| 8 | 5 | 6-7 | 7-9 | 8-11 | 9-12 |
| 9 | 5 | 6-7 | 7-9 | 8-11 | 9-12 |
| 10 | 5 | 6-7 | 7-9 | 8-11 | 9-12 |
| 11 | 4-5 | 5-7 | 6-9 | 7-10 | 8-11 |
| 12 | 4-5 | 5-7 | 6-8 | 7-10 | 8-11 |

[1] In this case, the boltwood considered is in 5-foot lengths to a 4-inch top diameter inside bark with a roadside value of $30/cord and conversion cost of $16/cord.

**Table 14.—*Paper birch boltwood d.b.h. for financial maturity, based on minimum expected rate of value increase***

| Basis: | $V_0$ | $V_n$ |
|---|---|---|
| Roadside price | $30/cord | $30/cord |
| Conversion costs | $16/cord | $16/cord |

| Expected merchantable height increase (number of 5-foot bolts) | Rate of return | | | |
|---|---|---|---|---|
| | 5% | 6% | 7% | 8% |
| | *Inches d.b.h.* | *Inches d.b.h.* | *Inches d.b.h.* | *Inches d.b.h.* |
| 0 | 10 | — | — | — |
| 1 | 12 | 10 | — | — |
| 2 | 12 | 12 | 10 | — |
| 3 | 12 | 12 | 12 | 10 |
| 4 | 12 | 12 | 12 | 12 |

## SUMMARY

The financial maturity guides presented here are the result of generalizations about mill recovery yields, prices, conversion costs, etc., and they must be considered as regional guides. Their applicability to a specific situation is of questionable value. What has been presented here is a system for the development of financial-maturity guides by a firm, the results of which would be most responsive to the needs and expectations of that firm.

The financial-maturity concept presents an unusual opportunity to more closely relate the decisions of the timber cruiser and forest manager with the profit-and-loss situation of the firm. It presents a quantified decision of financial maturity rather than the subjective decision of the past.

It has been some 20 years or more since the financial-maturity concept has been fully presented to the forestry profession. Its adoption has been slow, probably because of the laborious calculations that must be made. Today, however, with advent of the computer and programs designed to produce rate of value increase calculations, such work can be held to a minimum. It is within the realm of feasibility for large timber-growing firms to develop and adjust existing computer programs to suit their individual situations. Smaller firms and even small woodland owners could seek to have such services developed and provided by extension and service foresters.

■