Natural Resource Network

Connecting Research, Teaching and Outreach

Proceedings for Tree Investment Workshop

Caroline A. Fox Research
and Demonstration Forest
Hillsborough, NH
October 15 and 29, 1999

UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

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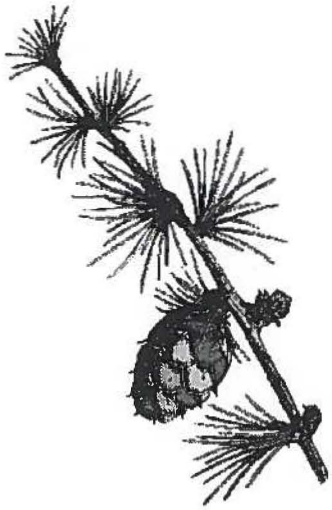

The Caroline A. Fox Research and Demonstration Forest (Fox Forest) is in Hillsborough, NH. Its focus is applied practical research, demonstration forests, and education and outreach for a variety of audiences.

The **Tree Investment Workshop** held on October 15 and 29, 1999 was designed to familiarize foresters and loggers with the financial aspects of tree growth and yield. These proceedings were prepared as a supplement to the workshop. Papers submitted were not peer-reviewed or edited. They were compiled by Karen P. Bennett, Extension Specialist in Forest Resources and Ken Desmarais, Forester with the NH Division of Forests and Lands. Readers who did not attend the workshop are encouraged to contact authors directly for clarifications. Workshop attendees received additional supplemental materials.

Agenda

Basic review of economics and investment criteria as they pertain to trees. Paul Sendak, Forest Economist, Northeastern Research Station USDA Forest Service

Value aspects of trees and logs. What's valuable about trees and logs, and why. Don Quigley, Professor, UNH Thompson School of Applied Science

Performance potential of New England's hardwood forest species. Mark Ducey, Professor of Biometrics, UNH Department of Natural Resources

Calculating rates of return for New England timber species using the "Brooks and Neil Tree Investment Calculator". Neil I. Lamson, Silviculturist, State and Private Forestry, USDA Forest Service

Applying tree investment calculations to stand management prescriptions. W.B. Leak, Principal Silviculturist, Northeastern Research Station USDA Forest Service and Paul Sendak

Field trip into the Fox Forest woodlands to look at forest stands and apply tree investment principles to stand management prescriptions.

Workshop Cosponsors
Granite State Division/Society of American Foresters
New Hampshire Division of Foresters and Lands
Northeastern Research Station, USDA Forest Service
University of New Hampshire Cooperative Extension

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Review of Forest Finance

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Yesterday is a cancelled check.
Tomorrow is a promissory note.
Today is cash.

I will cover the basic concepts of the analysis of cash flow over time, defined as costs and revenues occurring at different points in time. The biggest investment most owners make in timber is time. And time is money. Labor earns wages and money earns *interest.* As an example, if I owe you $5 today, but say I can't pay you for a year, would you be satisfied with receiving $5 next year? Most would not and would require some premium to postpone payment. This premium is interest. If we settled on 5% interest, I would pay you $5.25 next year.

If you deposit $100 in a money market account today, in effect letting the institution that operates the account use the money, in a year you expect the account balance to be greater than $100. How much greater? Say 5% interest compounded annually.

Time	Balance
0	$100
1	100 + (100 * 0.05) = 100 (1 + 0.05) or $105
2	(100 (1.05)) 1.05 = $110.25
3	[(100 (1.05)) 1.05] 1.05 = $115.76
	or 100 (1.05) (1.05) (1.05)
	or $100\ (1.05)^3$

At the end of one year you expect $5 more and at the end of 3 years, $15.76 more.

This little example illustrates several important points. First it illustrates compound interest. If the account were earning simple interest, it would grow by a fixed amount each year, $5. At the end of 3 years the account balance would $115. But with compound interest, interest is earned on the entire balance, including the previous years' interest payments. It also illustrates the convention of making the payment or investment at the beginning of the period and crediting the interest at the end of each year. Finally, it also derives the basic compound interest equation from which all the other interest equations can be derived:

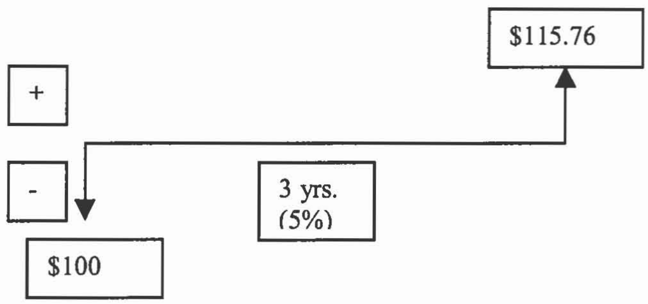
$$V_n = V_0 (1 + i)^n \qquad [1]$$

where V_n = future value
V_0 = initial value
i = annual interest rate
n = number of years

Alternatively, we could solve equation [1] for initial or present value, interest rate, or number of years.

Time Line

When attempting to analyze a cash flow problem, the best advice is to draw a picture. The kind of picture I have in mind, called a *time line*, requires no special artistic talent, but consists of a series of lines that guide the analysis. For the simple example above:



The conventions for the *time line* are positive cash flows above the line, negative cash flows below the line. The horizontal line represents time between cash flows, in this case 3 years and the applicable interest rate is noted below the length of time. The question in the example was what was the balance after 3 years and so a question mark would have taken the place of the $115.76. The picture suggests the future value of a single sum and contains all the information needed to plug into equation [1].

The *time line* can be as simple or as complex as the problem requires. In most cases a combination of financial formulas will be needed and most problems can be solved in more than one way. But what it boils down to is that cash flows accruing at different points of time can be compared through the proper use of the *interest rate.*

Discounting

In compounding we calculated a *future* value. The reverse of compounding is discounting, where a *present* value is calculated from a future value. Equation [1] can be solved for initial or present value:

$$V_0 = V_n / (1 + i)^n \qquad [2]$$

which defines present value, V_0, of a future value, V_n, received *n* years hence. The interest rate, *i*, is often referred to as the discount rate when discounting future values. Equations [1] and [2] allow us to compare present with future values and compare cash flows that occur at different times at the same point in time.

Other Interest Formulas

Compounding and discounting single sums just scratch the surface of working with compound interest formulas. Yet many problems in compound interest can be solved by brute force relying only on these simple formulas. Many applied problems will involve calculating the present or future value of an annuity, that is, the value of a series of identical annual payments over *n* years. The formula for the future value of an annuity along with several other commonly used formulas are contained in a decision tree at the end of these notes. Knowing what formula(s) to use is aided greatly by sketching the time line and following the decision tree. There is no substitute for practice in using these formulas and I have included 100 simple problems in compound interest with answers. These should be worked with paper and pencil and a calculator with y^x and e^x keys.

Before moving on to special topics, I would like to discuss one formula that has a special meaning in forestry. In finance it is called the present value of a perpetual periodic series. But in forestry, it is the land expectation value or sometimes referred to as "soil expectation value", "soil rent", or "bare land value." Its forestry interpretation is the present worth of all future harvests, net of all costs of producing them. In simplest form, it can be written:

$$V_0 = a\,[1 / [(1+i)^{t} - 1] \qquad [3]$$

where present value is expressed as the discounted value of future net returns, *a*, occurring every *t* years. Financially optimal rotation is found by solving for the *t* that maximizes land expectation value.

Special Topics

Two topics that often arise are period of compounding different than annual and effect of inflation. Equation [1] can be rewritten as follows:

$$V_n = V_0\,[1 + (i/k)]^{nk} \qquad [4]$$

The annual interest rate, *i*, in equation [1] has been replaced with the fraction, *i/k*, where k is the frequency of compounding per year. Years, *n*, has been replaced by *nk*. For $k = 1$, equation [4] reduces to equation [1]. For $k > 1$, the effective interest rate is decreased and the number of compounding periods is increased. The net effect is an increase in future value because the frequency of compounding is increased from *n* to *nk*. As an example, a bank quotes a 12-month CD at an annual percentage rate of 8.85% compounded daily yielding 9.25%. Investing $1,000, annual yield is calculated as follows:

$$V_1 = 1{,}000\,[1 + (0.0885/365)]^{365}$$

$$V_1 = 1{,}092.52$$

Which is a 9.25% yield on the $1,000 invested.

Inflation (deflation) has the effect of changing the value of the dollar. It would be analogous to using a D-tape to measure trees where each time you used it, an inch on the tape would differ from π by some arbitrary but measurable amount requiring an adjustment to make diameters measured at different times comparable. All the commonly available interest rates, CDs, bank deposit accounts, various commercial loan rates, etc., are market or nominal rates. That is, they can be partitioned into a real rate and an inflation rate. If i = nominal (market) rate of interest, r = real rate, and f = inflation rate, then:

$$(1 + i) = (1 + r)(1 + f) \qquad [5]$$

$$i = r + f + rf \qquad [6]$$

$$r = [(1 + i) / (1 + f)] - 1 \qquad [7]$$

Inflation is measured by one of the widely available government price indexes, for example the Producer Price Index or the Consumer Price Index. For example , if the Producer Price Index was 106.9 in 1988 and 124.4, the annual rate of inflation was:

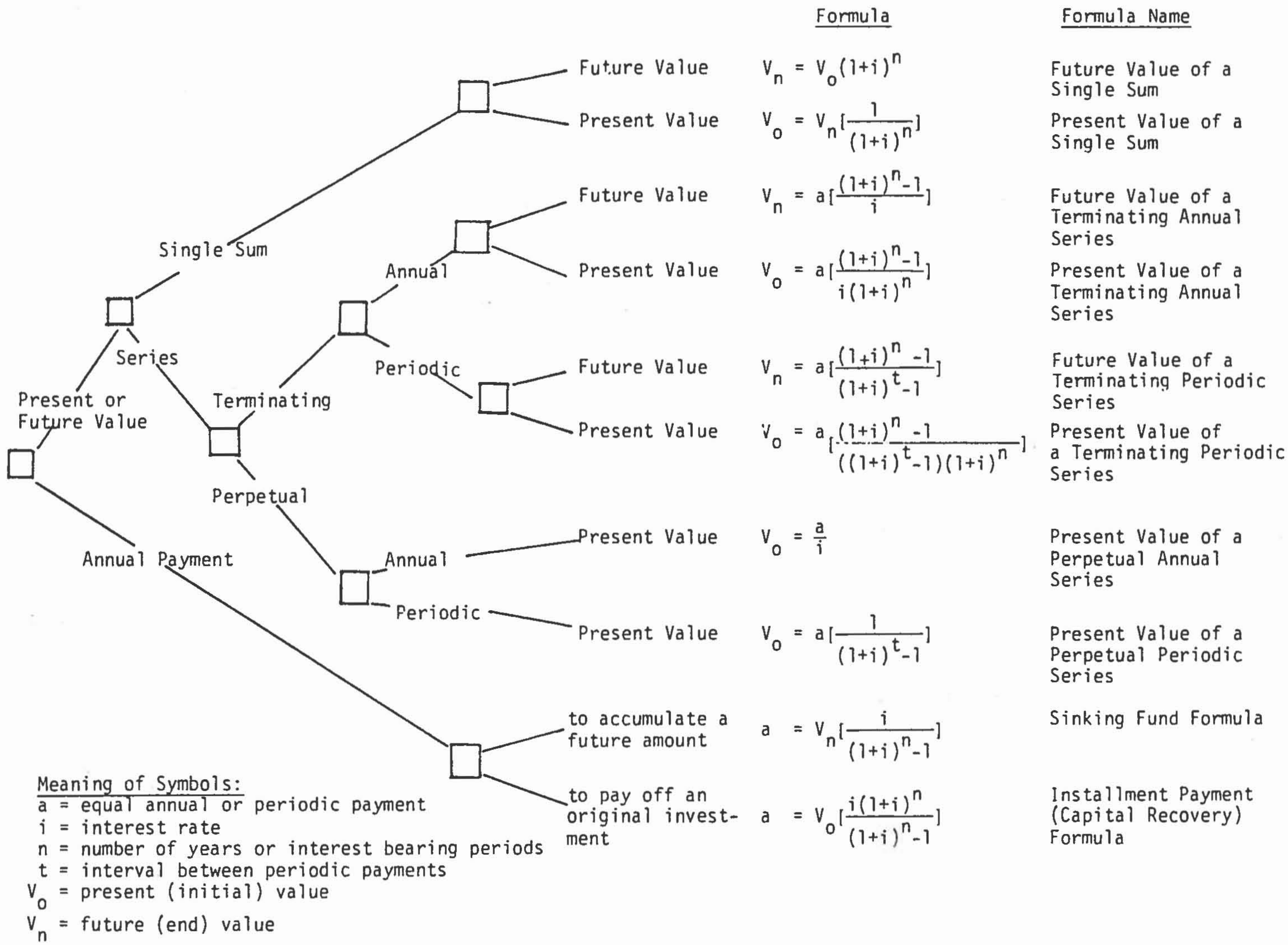
$$(124.4 / 106.9)^{1/10} - 1 = 0.0153 \text{ or } 1.53\%$$

In other words, you calculate the rate the same way you would estimate the compound rate of change for any starting and ending value for some specified length of time.

The most important consideration when analyzing forestry investment problems is to be consistent in dollar values and interest rate. If you use dollar values adjusted for inflation (real values), the appropriate interest rate is the real rate. If you use market or nominal values (unadjusted for inflation), the appropriate interest rate is the market or nominal rate. If you mix the two, results will be misleading and incorrect.

Conclusion

This brief refresher on analyzing forestry investment problems is no substitute for a thorough review in one of the many books that treat the subject in great detail. Working problems by hand with a calculator is the only way to learn and polish this skill and will result in a feeling of satisfaction. In these days of readily available computer programs that will effortlessly perform the required calculations it is necessary to know how to input the proper data, design spreadsheets to perform the calculations, and to know if results make sense. This level of confidence can only be achieved by understanding how compound interest formulas work.



Decision tree of compound interest formulas

Source: Gunter, J.E. and Haney, H.L. 1984. Essentials of forestry investment analysis.

Value Centers in Trees and Logs

by
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Throughout the long process of managing or developing the growth of individual trees, stands or forests, the Forester considers the value of tree boles. In fact the sole motivation for some types of forest management regimes is centered on economic value at the time of harvest. Of course this prediction of final value of trees is problematic because of risks encountered over 40, 50 or 100 years of growth to the bole development of the tree.

A short list of tree form and growth related defects helps define the scope of the problem:

- Growth rate
- Branch concentration
- Branch size
- Branch soundness
- Pruning
- Disease with associated discoloration and decay
- Mechanical damage
- Straightness
- Cross sectional shape
- Wood/Sap wood areas
- Taper

Not suprisingly very few trees make it to a commercial size with valuable bole segment potential. Even the best application of forestry and silviculture can yield disappointing results compared with investments.

Bole Value

Value of tree segment is determined by the market place for lumber and veneer. Though pulpwood and fuel wood have value it is qualified only by species and tonnage. The value of sawlogs and veneer logs is determined by the following formula:

Log volume X Log Grade Factor X Convenience Factor = Value
(could be distance from mill or scarcity of this type of log)

Traditionally, in our region, sawmills and veneer mills set the prices for logs and distribute the scaling, grading and transportation rules to Gatewood Suppliers. Typically these rules differ from mill to mill though all mills sell their end product to the same market place. These local and regional differences in pricing have been a source of frustration for land owners, foresters and loggers for a long time.

In assessing bole value of trees and logs it is probably wise to stick to a few basic concepts which are generic to the entire industry rather than comparing your trees with the specs of any one mill. The real value of the log or tree segment will have a strong correlation to the value of the product it will be cut up into, so some knowledge of the manufacturing process and lumber prices will help. As an example, a sawyer's job at a mill is to maximize the value of each log by getting the highest grade and volume recovery from each log. To do this a sawyer must know the lumber grades and where those grades potentially come from in the log. The only information the sawyer has at the onset of the process is the surface characteristics (defects) on the log surface and it is from the surface indicators that the sawyer needs to set a strategy for maximizing value. Here is what sawyers know that foresters and loggers don't.

Lumber Grades

Grading lumber with a degree of accuracy is a complicated task taking months or years of training to get good enough to meet the standards of industry. Yet the basic grades for hardwood and pine lumber are critical to assessing sawlog value. I think these grades can be simplified for the benefit of foresters, land owners and loggers in understanding log value. Following is a simple table for basic lumber grades for pine (N.E.L.M.A. grades) and hardwood (N.H.L.A. grades). The tables are intended to reduce the highly technical lumber grading process to the conceptual level.

Pine (White and Red) based on N.E.L.M.A. Grades

Grade Name	Characteristic (for 8" wide boards)	Price (kiln dry)
D- Select	Clear – small pin (1/2") knots	$1.45 BF
Finish	Small red knots (thumb nail size)	$1.00 BF
Premium	Large red knots (golf ball size)	$ .60 BF
Standard	Large black knots, pitch pockets, etc.	$ .44 BF
Industrial	Will hold together while nailing	$ .30 BF

Red Oak – Based on N.H.L.A. Grades

Grade Name	Characteristic (poor face of board)	Price (green)
F.A.S.	10 twelfths of face area clear of defects	$1.20 BF
Select	Best face 10 twelfths clear	$1.05 BF
1 common	8 twelfth clear	$ .79 BF
2 common	6 twelfths clear	$ .45 BF
3A common	4 twelfths clear	$ .40 BF
3B common	4 twelfths clear	$ .30 BF

Armed with the knowledge of lumber grades and relative value of each it is possible to predict the yield of total lumber value from any given log. The big mystery of assigning log and tree value is in the prediction of lumber grade yield. This prediction can be simplified with the application of a clear and concise log grading system.

Log Grading

Every sawmill or log broker has grappled with the establishment of a log grading system that will predict lumber grade yield. Some have generated data from the sawing of many logs and over time, adjusted log grades to fit lumber yield. Most mills have adapted and adjusted log grades based on their competitors and a notion of profitability of the mill. Though there are clear similarities among New Hampshire mills in their published log grade specifications, they are all different.

The Forest Service has developed log grading systems for pine and hardwood sawlogs over the last forty years and conducted tests of those grades by sawing hundreds of logs and cataloging the resulting lumber yields. Though local mills have not adopted the Forest Service log grades, it appears that many mills have incorporated a few basic principles identified in the Forest service's work.

The Forest Service log grades for hardwood and white pine follow at the end of this paper.

Upon developing the log grades the Forest Service developed grade yield data from the sawing of hundreds of graded logs. The resulting "Performance Tables" are a very handy guide for placing value on sawlogs. Performance tables for white pine and red oak logs graded under the Forest Service system are included at the end of this paper.

A quick glance at the tables will reveal patterns where relationships between log diameter and grade recovery are evident. Performance tables are excellent predictors of log value even though the occasional log can fall off the chart.

The performance tables, of course, do not reflect the premium prices paid by most sawmills for special lengths (14, 16, 18 feet) or large diameters which enhance mill productivity but not necessarily lumber grade yield. In fact it has been demonstrated lumber grade yield decreases as log lengths increase, especially in pine logs. Apparently, the extra mill production is worth the drop in grade yield. The net result to loggers and land owners is that size does affect log value.

Quality Zones

Armed with the knowledge of lumber and log grades forest managers need to understand where in the tree the grade lumber is contained. In assessing the value of practices such as pruning, release and thinning of stands managers have to make practical decisions based on value. Even the problem of removing trees with damage, natural or mechanical from stands warrants understanding of Quality Zones in trees.

The USDA Forest Service 1973, Guide to Hardwood Log Grading by Rast, Sonderman and Gammon, begins the discussion of Quality Zones in hardwood logs. Their use of these zones for assessing end defects in logs can be expanded, I think, into predictors of lumber grade yields even in the absence of end defects.

By dissecting the log into 3 quality zones one can visualize the important locations of grade lumber. Expanding on the discussions of the above mentioned document a simple guide to log grade yield can be constructed. In examples, we know that clear/wood can only be found just under the bark of large, well pruned trees but there is more to the problem than that. Where do all the other grades come from? Diagrams at the end of this paper illustrate grade locations.

Note: That in hardwood logs of 16" D.I.B. and up we expect to be able to recover F.A.S. lumber from Quality Zone 1 only, even if the log is free of surface defects. On 16" logs we expect to drop one grade for each board as we saw deeper into the log.

In pine logs, Quality Zone 1 will either yield the highest or the lowest grades depending on pruning. Then grades slowly improve as we approach the center of the tree based on the knots turning from black to red and reducing in size.

Study of the trends of grade recovery based on log diameter found on the performance tables demonstrate the importance of Quality Zones.

<u>Rules of Thumb</u>
Just a few Rules of Thumb for managers intent on maximizing the tree value which can be demonstrated by understanding of grade yield and Quality Zones. There are many more generalizations which can be made but not without knowledge of stand variables:

<u>Hardwoods</u>
- 70% of value of the tree is in the butt log of 10'.
- Butt logs under 14" D.B.H. will have no clear wood regardless of surface indicators.
- Log lengths should be kept short to maximize grade yield.
- Size or quality of the knots on the surface mean very little – it's the spacing between them that is critical to grade.
- A tree needs to grow 5" in diameter to overgrow any current surface defects and produce clear wood.
- The value of a tree can be predicted by the three <u>best</u> faces of the butt log.
- Sweep or crook of 2" or more will cost one quality zone and effect grade.
- Defect in log centers (8-10") do not lower lumber value potential (except veneer logs.
- Suckering or sprouting from the bole will destroy Quality Zone 1.

<u>Pine</u>
- 60% of the value of the tree is in the butt log of 12'.
- Diameter of the log plays a very small role in valuation – knot size and color is everything.
- Spacing of knots is unimportant – one knot on a face is the same as 50.
- A tree needs to grow 5" in diameter to overgrow any current defect and produce clear wood.
- Logs over 12' long usually decrease grade yield potential – but if the mill is paying more for 14' and 16' logs?????
- Sweep up to 4" in logs does not adversely affect grade (only volume).
- Defect in log centers are more critical then on the exterior.
- Pitch and pockets are serious degraders. Watch out for mechanical damage to all parts of the tree.
- Weevil injury cannot be overgrown. #1 degrader.

Overview

It pays for forest managers to have a good working knowledge of lumber grades and values. Knowing where the grades are located in each log is important to predicting value in individual logs, trees and stands.

Lumber grading systems have not changed for the past 40 years for local species. It is reasonable to assume that they will not change drastically in your career. Ask for the chance to observe log breakdown at your local mill and especially watch the lumber graders at work.

FOREST SERVICE STANDARD GRADES FOR HARDWOOD FACTORY-LUMBER LOGS

The factory-lumber log class has been divided into three grades. The specifications for these grades (fig. 5) are closely correlated with the specifications for standard hardwood lumber grades, the grade of the log depending largely on the proportion of log length that is obtainable in clear cuttings (table 2).

The major factors that affect the quality of factory-lumber logs are: (1) position of log in tree (butt or upper); (2) size of log, especially diameter; (3) straightness; (4) amount and distribution of scalable defects; and (5)

Table 2.—Minimum length of clear cuttings by log length and proportion required

Log Length (feet)	5/6	3/4	2/3	1/2
	Feet and inches			
8	7′ 4″	6′ 0″	5′ 4″	4′ 0″
9	7′ 6″	6′ 9″	6′ 0″	4′ 6″
10	8′ 4″	7′ 6″	6′ 8″	5′ 0″
11	9′ 2″	8′ 3″	7′ 4″	5′ 6″
12	10′ 0″	9′ 0″	8′ 0″	6′ 0″
13	10′ 10″	9′ 9″	8′ 8″	6′ 6″
14	11′ 8″	10′ 6″	9′ 4″	7′ 0″
15	12′ 6″	11′ 3″	10′ 0″	7′ 6″
16	13′ 4″	12′ 0″	10′ 8″	8′ 0″

Figure 5.—Forest Service standard grades for hardwood factory lumber logs.[a]

Grading Factors		Log grades							
		F1			F2				F3
Position in tree		Butts only	Butts & uppers		Butts & uppers				Butts & uppers
Scaling diameter, inches		13-15[b]	16-19	20+	11+[c]	12+			8+
Length without trim, feet		10+			10+	8-9	10-11	12+	8+
Required clear cuttings[d] of each of 3 best faces[e]	Min. length, feet	7	5	3	3	3	3	3	2
	Max. number	2	2	2	2	2	2	3	No limit
	Min. proportion of log length required in clear cutting	5/6	5/6	5/6	2/3	3/4	2/3	2/3	1/2
Maximum sweep & crook allowance	For logs with less than ¼ of end in sound defects	15%			30%				50%
	For logs with more than ¼ of end in sound defects	10%			20%				35%
Maximum scaling deduction		40%[f]			50%[g]				50%
End defect:		See special instructions (page 18)							

[a] From USDA Forest Service Research Paper FPL-63 (*13*).
[b] Ash and basswood butts can be 12 inches if they otherwise meet requirements for small #1's.
[c] Ten-inch logs of all species can be #2 if they otherwise meet requirements for small #1's.
→ [d] A clear cutting is a portion of a face, extending the width of the face, that is free of defects.
[e] A face is ¼ of the surface of the log as divided lengthwise.
[f] Otherwise #1 logs with 41-60% deductions can be #2.
[g] Otherwise #2 logs with 51-60% deductions can be #3.

EASTERN WHITE PINE SAWLOG GRADE SPECIFICATIONS

GRADING FACTOR	LOG GRADE 1	LOG GRADE 2	LOG GRADE 3	LOG GRADE 4
(1) MINIMUM SCALING DIAMETER (inches)	14[1]	6	6	6
(2) MINIMUM LOG LENGTH (feet)	10[2]	8	8	8
(3) MAXIMUM WEEVIL INJURY (number)	None	None	2 injuries[3]	No limit
(4) MINIMUM FACE REQUIREMENTS	Two full length or four 50% length good faces.[4] (In addition, log knots on balance of faces shall not exceed size limitations of grade 2 logs.)	No GOOD FACES REQUIRED. Maximum diameter of log knots on three best faces: SOUND RED KNOTS not to exceed 1/6 scaling diameter and 3 inch maximum. DEAD OR BLACK KNOTS including overgrown knots not to exceed 1/12 scaling diameter and 1½ inch maximum.	SOUND RED KNOTS not to exceed 1/3 scaling diameter and 5 inch maximum. DEAD OR BLACK KNOTS including overgrown knots not to exceed 1/6 scaling diameter and 2½ inch maximum.	Includes all logs not qualifying for No. 3 or better and judged to have at least one-third of their gross volume in sound wood suitable for manufacture into standard lumber.
(5) MAXIMUM SWEEP OR CROOK ALLOWANCE (percent)	20	30	40	66⅔
(6) MAXIMUM TOTAL SCALING DEDUCTION (percent)	50	50	50	66⅔

After the tentative log grade is established from face examination, the log will be reduced in grade whenever the following defects are evident:

(7) CONKS, PUNK KNOTS, AND PINE BORER DAMAGE ON BARK SURFACE[5]

Degrade one grade if present on one face.
Degrade two grades if present on two faces.
Degrade three grades if present on three or more faces.

(8) LOG END DEFECTS: RED ROT, RING SHAKE, HEAVY STAIN AND PINE BORER DAMAGE OUTSIDE HEART CENTER OF LOG[5]

Consider log as having a total of 8 quarters (4 on each end) and degrade as indicated below:
Degrade one grade if present in 2 quarters of log ends.
Degrade two grades if present in 3 or 4 quarters of log ends.
Degrade three grades if present in 5 or more quarters of log ends.

[1] 12 and 13 inch logs with four full length good faces are acceptable.
[2] 8 foot logs with four full length good faces are acceptable.
[3] 8 foot No. 3 logs limited to one weevil injury.
[4] Minimum 50% length good face must be at least 6 feet.
[5] Factors 7 and 8 are not cumulative (total degrade based on more serious of the two). No log to be degraded below grade 4 if net scale is at least one-third gross log scale.

GRADE 1 LOGS - NORTHEASTERN AREA

Table 1. - White pine curved lumber-grade yields by log diameter
[Dressed-dry, basis: 86 logs]

DIB	D-Select	Finish	Premium	Stantard	Industrial
	Percent	Percent	Percent	Percent	Percent
12	38	24	25	13	(*)
13	38	21	25	15	1
14	39	16	25	17	1
15	39	15	26	19	1
16	40	12	26	20	2
17	41	11	25	21	2
18	42	10	25	21	2
19	43	9	24	22	2
20	44	9	23	22	2
21	46	9	21	22	2
22	48	10	19	22	1
23	50	11	17	21	1

*Less than 0.5 percent

GRADE 3 LOGS - NORTHEASTERN AREA

Table 3. - White pine curved lumber-grade yields by log diameter
[Dressed-dry, basis: 844 logs]

DIB	D-Select	Finish	Premium	Standard	Industrial
	Percent	Percent	Percent	Percent	Percent
6	1	12	50	36	1
7	1	10	48	40	1
8	2	6	46	43	1
9	2	7	44	46	1
10	2	6	42	48	2
11	2	5	40	51	2
12	3	4	38	53	2
13	3	3	36	55	3
14	4	3	34	56	3
15	4	3	32	58	3
16	4	2	31	59	4
17	5	2	29	60	4
18	5	2	27	61	5
19	6	2	25	61	6
20	7	2	23	61	7
21	7	2	22	61	8
22	8	3	20	60	9
23	8	3	19	60	10

GRADE 2 LOGS - NORTHEASTERN AREA

Table 2. - White pine curved lumber-grade yields by log diameter
[Dressed-dry, basis: 194 logs]

DIB	D-Select	Finish	Premium	Standard	Industrial
	Percent	Percent	Percent	Percent	Percent
6	4	39	44	13	(*)
7	6	35	44	16	(*)
8	8	31	43	18	(*)
9	10	27	43	20	(*)
10	11	23	42	23	1
11	12	20	42	25	1
12	13	17	41	28	1
13	14	14	40	30	2
14	15	12	39	32	2
15	16	10	37	35	2
16	16	8	36	37	3
17	17	7	34	39	3
18	17	6	33	41	3
19	17	6	31	43	3
20	16	6	29	45	4
21	16	6	27	47	4
22	16	6	24	49	5

GRADE 4 LOGS-NORTHEASTERN AREA

Table 4.- White pine curved lumber-grade yields by log diameter
[Dressed-dry, basis: 425 logs]

DIB	D-Select	Finish	Premium	Standard	Industrial
	Percent	Percent	Percent	Percent	Percent
6	1	2	24	70	3
7	1	2	23	70	4
8	1	1	22	70	6
9	1	1	21	70	7
10	1	1	20	70	8
11	1	1	19	70	9
12	1	1	18	69	11
13	1	1	17	69	12
14	1	1	17	68	13
15	2	(*)	16	67	15
16	2	(*)	15	66	17
17	2	(*)	14	66	18
18	3	(*)	13	64	20
19	3	(*)	13	63	21
20	4	(*)	12	61	23
21	5	(*)	11	60	24
22	6	(*)	10	58	26

Hardwood Performance Tables

Log Grade 1 (log grade yield by diameter)
NHLA Lumber Grade Yields (Actual)

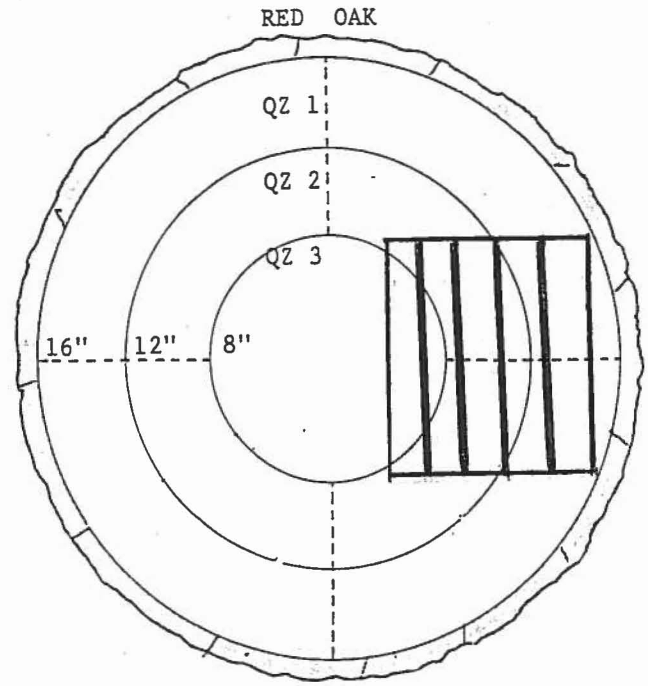
DIB In.	FAS Pct.	Sel Pct.	1C Pct.	2C Pct.	3A Pct.	3B Pct.
13	19	12	26	13	8	17
14	35	13	22	12	7	9
15	29	13	25	9	6	12
16	37	12	24	11	6	6
17	37	11	22	11	6	10
18	37	9	26	10	4	10
19	32	6	34	10	4	9
20	38	9	25	10	3	11
21	40	6	26	10	3	11
22	35	6	28	11	5	11

Log Grade 2 (log grade yield by diameter)
NHLA Lumber Grade Yields (Actual)

DIB In.	FAS Pct.	Sel Pct.	1C Pct.	2C Pct.	3A Pct.	3B Pct.
10	8	15	30	13	9	20
11	3	4	28	26	14	20
12	4	6	29	19	13	22
13	6	4	28	19	11	28
14	8	6	34	22	9	15
15	10	7	31	19	7	23
16	7	4	27	21	9	27
17	10	5	30	14	8	30
18	10	1	30	22	7	26
19	12	4	38	17	6	20
20	7	3	35	21	6	19
21	16	4	27	8	4	38
22	15		36	18	3	25

Log Grade 3 (log grade yield by diameter)
NHLA Lumber Grade Yields (Actual)

DIB In.	FAS Pct.	Sel Pct.	1C Pct.	2C Pct.	3A Pct.	3B Pct.
8	2	2	15	24	7	46
9			19	27	14	36
10	--		17	25	15	40
11	--		11	17	13	56
12	--	1	18	25	17	37
13	--		8	27	16	45
14		--	11	22	15	50
15			9	19	9	54
16	--		12	24	11	50
17	2	2	21	26	8	27
18	5	--	17	21	10	45
19		--	25	26	5	41
20	--	--	1	19	3	75
21	--	1	20	34	10	33
22	--	--	7	18	15	57



HARDWOOD LUMBER GRADES

FAS

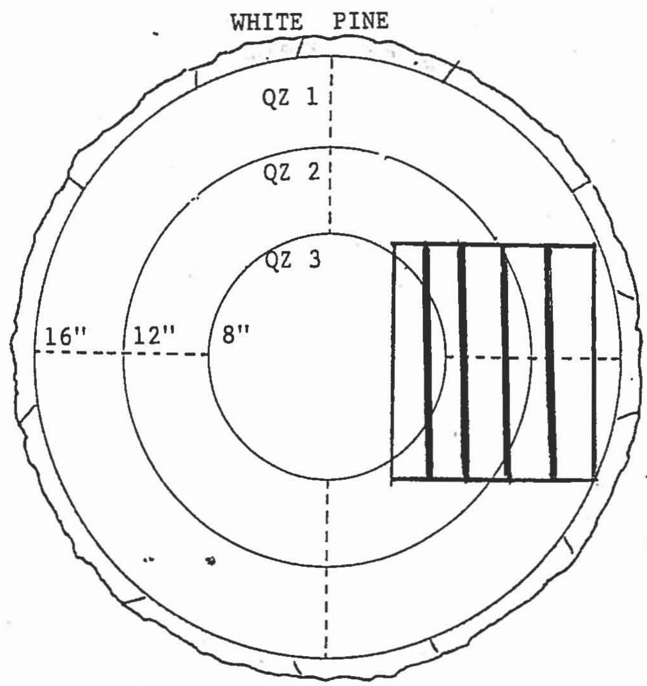
SELECT

1 COMMON

2 COMMON

3A COMMON

3B COMMON



WHITE PINE LUMBER GRADES

D&btr SELECT

FINISH

PREMIUM

STANDARD

INDUSTRIAL

Returns from Unrestricted Growth of Pruned White Pines

by

David M. Smith
Yale University School of Forestry & Environmental Studies

Both the quality and prices of white pine lumber vary from the dismal to the superb. Clear white pine has been a valuable commodity since Europeans first came across the Atlantic. Boards with black, loose knots became a drug on the market when corrugated brown paper replaced soft pine wood in making boxes.

The way to the superb comes from artificial pruning. The good rot resistance of eastern white pine wood leaves the stems with dead branches that cause loose knots. The ideal white pine has much clear lumber and only tight red knots. Such trees need to be pruned early to some chosen height and then strongly released by thinning such that no more branches are allowed to die above that height. Pines that are pruned with no thinning or merely with gentle thinning develop thin shells of clear wood in the first log and one or more upper logs clothed with dead branches.

Artificial pruning is expensive and some precommercial thinning and hardwood control is necessary to get the process started. There has been concern that the compounded costs of these treatments would exceed the value of the lumber ultimately produced or that rapid growth would impair the quality of the lumber.

In order to test the financial results of these treatments, in 1989 Alan C. Page and I harvested pines pruned to 17 feet with varying rates of diameter growth from thinned stands in southern New Hampshire and central Massachusetts. A few large unpruned pines were included in the sample. The logs were sawn and the lumber was kiln-dried and sold. We kept track of every board from each log and trees. This enabled us to determine the grades and gross financial return produced by each tree. We assigned high costs to the treatments used to grow each tree as well as to careful logging and sawing. All costs and product values were for 1989 so as to eliminate effects of inflation and price appreciation. Each tree was charged "rent" to cover taxes and administrative costs for the space that it grew to occupy.

We found that returns of at least 6% compound interest on actual costs can be obtained if annual diameter growth of 0.25 inches or better are maintained. If the crown of an "ideal" tree is released enough to expand without restriction, at a yearly rate of 1 foot of diameter, the annual DBH growth becomes 0.5 inches. The compound interest return on the actual investment in such a tree is 13% and is sustained for at least 30 years after pruning while the trees grows to 22 inches DBH. After that rate of return on the value of the tree falls below 9%, the live branches on the upper logs become too large, and the felling of the large crowns causes much to damage small advance-growth pines.

The difference in value between red- and black-knotted logs was not great except when the red-knotted ones were fat enough to be sawn into pieces 1.5" or more thick. The compound interest returns from conventional light thinning with and without pruning were generally less than 6 %.

A simulated stand of "ideal" trees grown with periodic thinning out of pruned trees of merchantable size produced ten times the financial return of an untreated stand, although the board-foot volume was 40 % less. However, a new crop of weevil-free pines ready to prune could be grown by the time there were 23 “ideal” pines 22 inches DBH ready to harvest.

Similar results could probably be obtained if pruning was done to a height of 23 feet as is the case with pruned Monterey pines on New Zealand.

Rapid growth did not produce any lumber that warped or developed other undesirable characteristics during kiln drying, storage or other processing.

The growing of white pine for lumber is something best done well or not at all. The only good branch is a live one.

How Fast Do Quality Hardwoods Grow?

by

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Introduction

How fast do quality hardwoods grow, in volume and value? The answer is critical to determining the long-run profitability and sustainability of growing trees in New England. In many stands, a large fraction of the value and financial return to the landowner is concentrated in a small fraction of the growing stock: those trees which can produce high-quality sawlogs or veneer bolts of select species.

Growth in value arises from three sources: the biological volume growth of a tree, the change in grade or price per unit volume that may accrue as a tree grows larger, and the change over time in the prices of different grades of trees. We'll examine here why all three factors need to be considered when evaluating the investment performance of a single tree. Then, we'll look into the potential and actual biological growth rates of four key New England species: red oak, white ash, yellow birch, and sugar maple. Finally, we'll put these trees in the context of their stands. We'll see why some trees which may be poor performers from an investment standpoint should still be retained, while others may have to be cut before they are in their prime, if the performance of the stand as a whole is to be optimized.

Volume Growth, Quality Growth, and Price Growth

The volume growth of a tree is a direct outcome of its biology, the resources available on a site, and the competition with neighboring trees for those resources. We can consider growth in two ways. One is *potential growth*, or the growth a tree would have on a given site under ideal conditions. The other is *actual growth*, or the growth a tree puts on under the less-than-ideal conditions that often prevail in the woods. One goal of silviculture is to manage the competition among trees, so that the actual growth of selected trees moves as close as possible to potential growth. In quality hardwood management, careful thinning regimes are the most common way of managing competition. When we analyze the investment performance of a single tree, it is important to ask two questions, corresponding to these two modes of growth. First, is this tree performing well now? If not, could my management help it perform better? If the answer to both questions is no, the tree is a high priority for removal -- after other considerations have been taken into account.

The best source of information on the actual growth of trees in a stand would be data from a sample of the trees in that stand, perhaps based on permanent plots or punch cores. Unfortunately, that kind of data is not always available. Permanent plots are too expensive to install and maintain for most applications other than continuous forest inventory (CFI) or research. Cores can be an attractive alternative, but they are time-consuming to take and read, and can do harm to the measured trees. Instead, we typically use off-site information, in the form of research studies or growth and yield models. Research studies frequently present the results of growth in selected stands. Growth and yield models can be thought of as sophisticated moving averages of the behavior of many stands. In New England, FIBER (Solomon *et al.* 1995) and NE-TWIGS (Teck and Hilt 1991) are both based on data from thousands of plots. Often, research studies or growth and yield models can provide insight into the potential growth of trees as well. Either source of information -- research plots or growth and yield models -- is best used in concert with a critical mind and good expert judgement.

As trees gain in diameter and volume, they may gain in quality or grade as well. The limiting factor is usually defect, which in many hardwood grading schemes is based on the size and number of clear cuttings on the best three faces of the log, with maximum allowances for sweep, crook, and other deformities (for example, Forest Products Lab 1966). Unfortunately, most defects don't go away as the tree grows. So, while some trees have the potential to produce a top-grade sawlog or a veneer bolt, some trees will always be low-grade or even fuelwood, regardless of size. A further complication is that most mills and overseas buyers have their own specifications for different grades, and these can change over time.

The importance of grade increase can easily be seen by considering the volume and value growth of a 6" DBH red oak, as it grows to 24" (Figure 1). As fuelwood, it might bring about $8/cord stumpage, or around $0.10 per cubic foot. Once it reaches 11" DBH, however, it might contain some low-grade sawtimber at around $100/MBF, bringing the value of the tree into the range of $0.35-$0.45 per cubic foot. With continued growth past 14" DBH, grade increases might bring the stumpage value of the sawtimber to perhaps $250/MBF, and the value of the tree rises to $1.25-$1.50 per cubic foot. Finally, as the DBH moves past 18", the tree might enter the prime sawlog or veneer categories at around $500/MBF, increasing the value of the tree to over $3.00 per cubic foot. If we assume a uniform growth rate of 1/4" DBH per year, the average annual growth rate in value is over 9.2%. In Figure 1, however, we see periods of lower value growth, punctuated by periods of extremely high growth rate as the tree changes grade. This pattern is typical of species with significant price jumps as a tree moves from one grade to the next. Clearly, for a quality hardwood tree, we must consider the possibility of future grade changes when we evaluate its investment performance. On the other hand, if that same tree had always produced a low-quality sawlog at $100/MBF, regardless of its size, the average value growth rate would have been only 6.8%, despite rapid diameter growth. What's more, the value growth rate would fall below 6% at around 13.5" DBH, never to rise again. In other words, a tree with poor form or significant defect is financially much earlier than one with good form and little defect.

The illustration in Figure 1 assumes prices remain constant. What happens when prices change? While we can't predict the future with 100% certainty, and quality hardwood markets do fluctuate considerably, analyses of New England prices suggest that the value of high-quality logs is increasing at 1-3% faster than the rate of inflation, while values for low-quality materials remain flat or declining (Howard and Chase 1995, Dennis *et al.* 1997). In other words, the investment performance of high-quality or potentially high-quality trees may be somewhat better than that calculated strictly from volume growth and current market prices, while that for poor-quality trees may be somewhat lower.

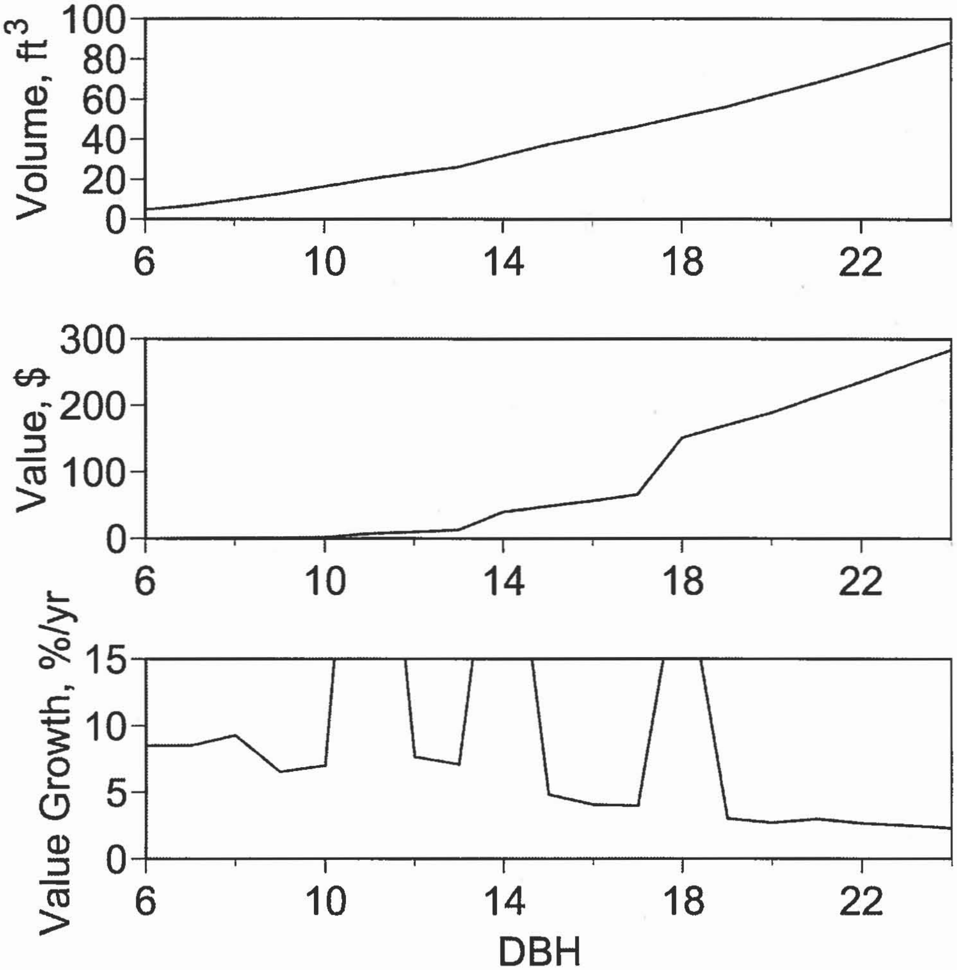

Figure 1. Potential volume growth, value growth, and annual percent growth in value for a hypothetical high-quality red oak, assuming 0.25" growth in DBH per year.

RED OAK

The commercial range of red oak extends through all five New England states, and it has been the flagship of the quality sawlog and veneer market for the past decade. Red oak has also been a species of concern from a regeneration standpoint, with troubling growth and drain statistics in some regional inventories.

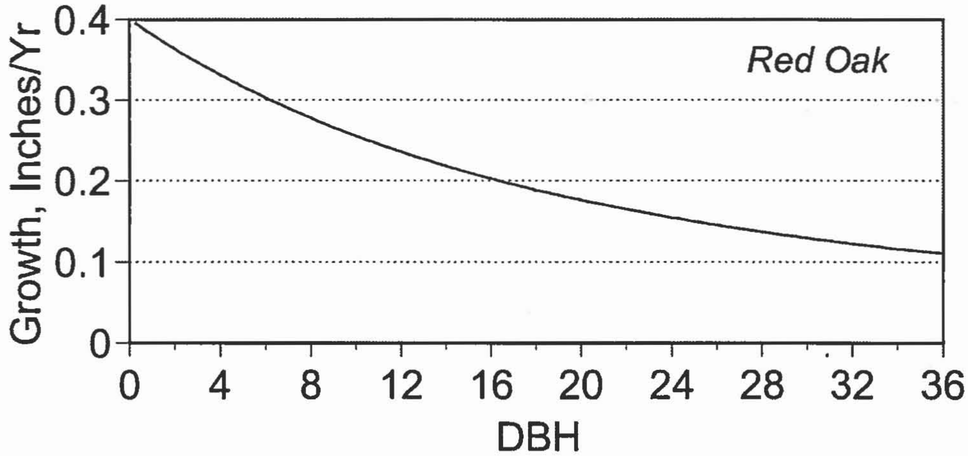

Figure 2. Potential growth rate for red oak, based on growth equations of NE-TWIGS at site index 50. While not strictly comparable, the growth equations in FIBER suggest higher growth may be possible up to very large diameters. Large oaks on good sites may show significantly elevated growth above that in the NE-TWIGS curve.

Figure 2 shows potential growth for red oaks based on the NE-TWIGS model, for a site index of 50. Potential growth for other site indices scales proportionally; for example, for site index 60, potential growth is 20% higher. Other sources of information (FIBER and anecdotal reports) suggest diameter growth may remain high (>0.25" per year) for larger diameters, especially on good sites.

Actual growth, of course, can be much lower, with trees as small as 12" showing growth rates no greater than 0.1" per year. The key to maintaining red oak growth appears to be thinning within the red oak stratum, since overstory oaks compete with other oaks much more than with other trees (Kittredge 1988). Maintaining high growth rates without compromising stem quality can require some fancy work with a paint gun, as we will see below.

WHITE ASH

White ash has remained a high-value species despite changes in its specialty markets. In part, the charm of white ash seems to be that it is so difficult to grow a poorly formed ash. Ash trees are characteristically straight-boled and self-pruned unless they are quite open-grown, so that many ash trees have the potential for high grade if they reach sufficient size. On good sites, ash is frequent throughout all New England states.

Figure 3 shows the potential growth rate for white ash based on the NE-TWIGS model, and on studies by Grisez and Mendel (1972). Bear in mind that the baseline site index of 50 depicted in the graph is unusually low for white ash, so typical growth rates predicted by NE-TWIGS would actually be 25%-50% higher, and within the range reported by Grisez and Mendel (1972). Schlesinger (1990) also shows growth rates of up to 0.3" per year for 17" ash on a good site in Massachusetts, with an increasing trend. This is similar to the growth projections provided by

FIBER.

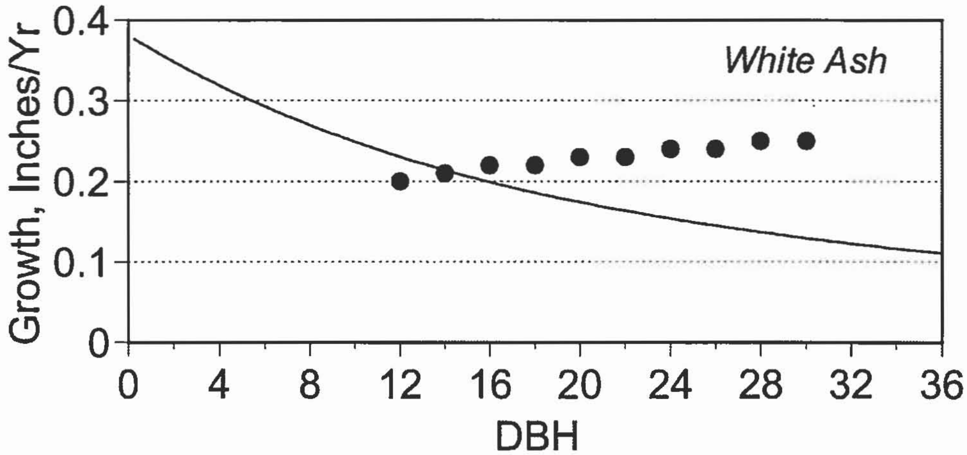

Figure 3. Potential growth rate for white ash, based on growth equations of NE-TWIGS at site index 50 (solid line) and the study of Grisez and Mendel (1972) (filled circles). Note that a site index of 50 is quite low for white ash; potential growth predicted by NE-TWIGS in most stands is actually 25-50% greater than suggested by the line. While not strictly comparable, the growth equations in FIBER also suggest increasing growth may be possible up to very large diameters.

White ash can be maintained in fairly dense stands, but it can also respond well to thinning when crowns are restricted by those of adjacent trees (Schlesinger 1990). Maintaining the vigor of individual trees is also important in avoiding ash dieback, a disease complex which can threaten this valuable component of growing stock (Hibben and Silverborg 1978).

YELLOW BIRCH

Yellow birch is a common stand component in northern New England, and occasional in southern New England, where it is more likely to be replaced by black birch. Black birch shares similar growth performance with yellow birch, but may suffer from poorer form. High-quality black and yellow birch logs may be interchangeable in some markets.

Figure 4 shows potential growth for yellow birch based on the NE-TWIGS model, for a site index of 50. Again, this would be a low site index for birch across much of its range. Potential growth for other site indices scales proportionally; as before, for site index 60, potential growth is 20% higher. Numerous growth studies, including some in New England (Leak *et al.* 1968, Hannah 1974, 1978) have shown that carefully thinned yellow birch can maintain continued high growth rates, averaging perhaps 0.2" per year through the rotation, but declining as the trees age (Erdmann 1990).

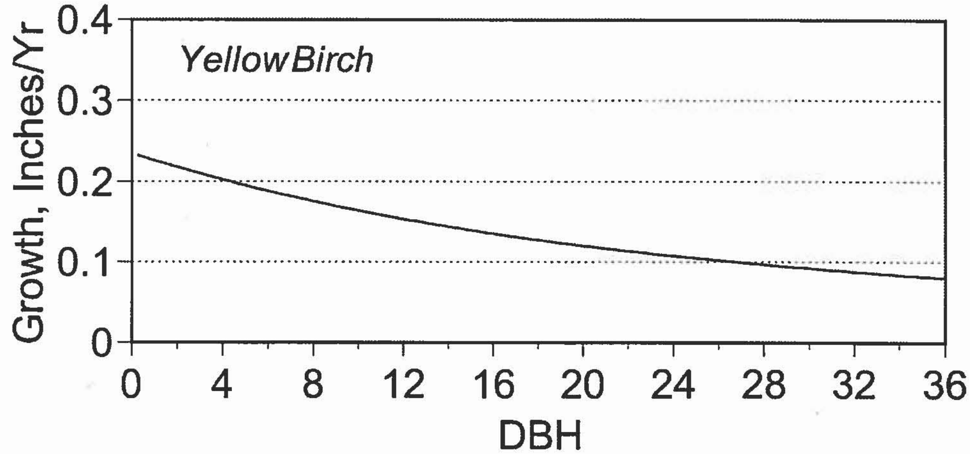

Figure 4. Potential growth rate for yellow birch, based on growth equations of NE-TWIGS at site index 50. At a more typical site index, growth rates might be 20% higher. While not strictly comparable, the growth equations in FIBER and numerous growth studies suggest higher growth is also likely for yellow birch.

Yellow birch is susceptible to growth falloff and potential mortality if it is not thinned, especially as trees age. Therefore, thinning is critical if the potential investment return on individual trees is to be realized.

SUGAR MAPLE

Sugar maple is a widespread component throughout New England forests, though its ecological role changes from the northern hardwoods where it is a dominant component on good sites, to the central hardwoods of southern New England where it currently appears as a midstory stratum beneath many fine oak stands. Sugar maple has come in and out of fashion, and lately back in again, as a furniture wood, and can serve as a prime illustration of the fluctuations in stumpage markets. Nonetheless, one can be sure that if there is a nice stand of sugar maple trees with good form and large boles, sooner or later someone will be willing to pay a good price for them.

Figure 5 shows the potential growth rate for sugar maple based on the NE-TWIGS model, and on studies by Mendel *et al.* (1973). Maximum growth rates in the Lake States appear to be similar, rarely exceeding 0.25-0.33" per year for sawlog-sized trees (Godman *et al.* 1990).

Sugar maple is extremely shade-tolerant, and thinning does not always increase its growth significantly. More critically, sugar maple is very susceptible to epicormic sprouting if too much sunlight impacts the bole directly. Gradual thinning is a much better strategy for sugar maple than sudden release (Godman *et al.* 1990).

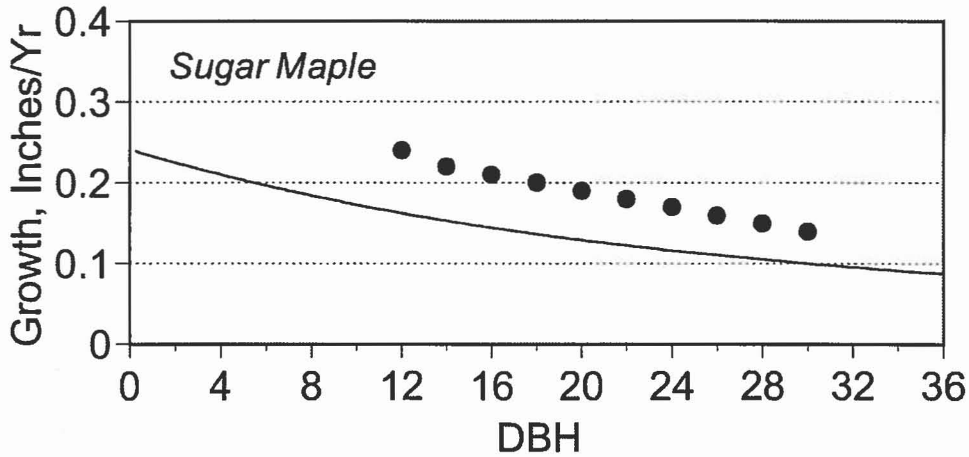

Figure 5. Potential growth rate for sugar maple, based on growth equations of NE-TWIGS at site index 50 (solid line) and the study of Mendel *et al.* (1973) (filled circles).

WHAT ABOUT THOSE JUNK TREES? REMEMBER THE STAND

Suppose we have a stand containing some good-quality hardwoods which are showing an acceptable annual growth rate, and some which are not. Isn't it a good idea to hammer those poor performers, and give the growing space to the thrifty trees? Not necessarily. Especially for the oaks and sugar maples, epicormic sprouting can be a problem. So, while those poor performers may not be doing much in terms of their own growth, they may be doing yeoman service protecting your investment in the high-quality trees. A classic example of this is oak growing with hemlock in southern New England. The hemlock does not grow rapidly itself, but it does not detract from the oaks' growth (Kelty 1989); most importantly, it helps enforce self-pruning and reduce epicormic sprouting among the oaks. Let's hope the hemlock wooly adelgid does not put a permanent end to such productive stand structures.

Likewise, is it safe just to remove all trees as they fall below some performance threshold? Not necessarily. As Trimble *et al.* (1974) point out, any successful and sustainable regime must allow for adequate regeneration of the quality species. In some cases, this may be accomplished through single-tree financial analysis, but in many cases it will not. Yellow birch, for example, requires larger canopy gaps for successful regeneration than single-tree approaches may provide. Particularly for the oaks, which depend on advance regeneration, it is important to identify stands *in advance* which may be approaching the point of financial maturity. Then, silvicultural planning can focus on the simultaneous goals of capturing the value in the current stand, and securing the regeneration which will make the next stand at least as valuable.

CONCLUSIONS

New England forests contain several species, including but not limited to red oak, white ash, yellow birch, and sugar maple, that can simultaneously produce high values per tree and per acre along with good returns on growing stock investment. Achieving those returns requires a focus on quality and on controlling stocking. Individual tree investment returns can provide important guidance, but should be considered along with stand structure and regeneration in determining marking guidelines.

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Tree Value Spreadsheet for Home PC's

by
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Silviculturist
State and Private Forestry
USDA Forest Service

A new spreadsheet developed for Microsoft's Excell program is available for woodland owners and foresters who want to estimate the value and rate of return of standing trees. Value is based on prices being paid for veneer and sawlogs at local mills. It can be used to estimate stand values and help determine when to harvest individual trees. It is suitable for most hardwood and softwood trees east of the Mississippi.

The Brooks and Neil Tree Investment Chart (BANTIC) was developed by Brooks Mills, a Tree Farmer in East Holden, Maine and silviculturist Neil Lamson of the US Forest Service in Durham, NH.

Users input log prices for each tree based on species, diameter and grade. Log diameters can range from 7 to 26 inches inside bark at the small end. The log grades are 2, 3 and 4 clear faces, the commonly used grades for buying sawlogs and veneer. BANTIC automatically calculates volume and value of the first two 10-foot logs in trees with diameter breast height (dbh) from 10 to 30 inches. While BANTIC comes loaded with the International ¼-inch Log Rule, users can input any log rule they desire and the program will base all computations on the new log rule.

A great feature is that BANTIC also calculates the future rate of return of standing trees to help landowners and foresters make harvest decisions. Annual rates of return use the current tree value and estimated of past growth, expressed as years to grow 2 inches dbh. BANTIC automatically calculates annual rate of return for growth rates at 3, 5, 7 and 10 years to grow 2 inches dbh.

As an example, if an 18-inch dbh tree is worth $197 and 20-inch dbh tree is worth $318 and if the tree grew from 18 to 20 inches dbh in 5 years, it's value increase would be 10.1% per year.

Portions of the tree above 20 feet are not included in any computations nor are pulpwood, boltwood and firewood values. BANTIC uses a Form Class of 79 and a bark thickness of 1.5 inches for trees up to 17 inches dbh, and 2 inches for all others.

Free copies of BANTIC and on-site training are available from the USDA Forest Service at:
USDA Forest Service
Northeastern Area State and Private Forestry
PO Box 640
Durham, NH 03824
Phone (603) 868-7692
Fax (603) 868-7604

SILVICULTURAL PRESCRIPTIONS BASED ON FINANCIAL RETURNS

By: William B. Leak and Paul E. Sendak, Northeastern Research Station, Durham, NH.

The purpose of this summary is to outline an approach for using financial maturity calculations (such as those provided by BANTIC) to develop silvicultural prescriptions. We'll presume that a preliminary decision has already been made (based on stocking, maturity, stand condition, etc) to make a harvest. The question is: What sort of harvest?

Perhaps, the best way to begin is to make some trial runs with BANTIC using the range in species, diameters, and log qualities that are represented on the tract. Also, we need some basic information on current growth rates (rings per inch). To arrive at after-harvest growth projections, we would need to revise the current growth figures based on available information and experience. For example, it might be reasonable to estimate that growth rates will increase by 50% following harvest. Using BANTIC, we could then estimate annual rates of return by species, dbh, and quality:

Species_________

		Rates of Return by Clear Faces On First/Second Log				
Dbh (in)	Growth (rings/in)	4/4 (%)	3/3 (%)	2/2 (%)	1/1 (%)	0/0 (%)
10	______	______	______	______	______	______
12	______	______	______	______	______	______
14	______	______	______	______	______	______
16	______	______	______	______	______	______
18	______	______	______	______	______	______
20	______	______	______	______	______	______
22	______	______	______	______	______	______
24	______	______	______	______	______	______
26	______	______	______	______	______	______

A table such as this provides a basis for determining cut/leave on a financial basis. You could simply circle the cut/leave categories in the above table based on whether the tree class didn't make or did make an acceptable rate of return. For example, a simple marking strategy might be: cut all trees over 22 inches dbh with 4 clear faces in the butt log; cut all trees over 16 inches dbh with 3 clear faces in the butt log; cut all trees with 0, 1, or 2 clear faces in the butt log. Next, we should have a preliminary stand inventory to estimate cut/leave basal areas using the criteria developed in the above table.

With this information, we can go to a simple prescription key (Fig. 1) that leads to decisions on the most appropriate silvicultural tactic: commercial thinning, group/patch cutting, single-tree selection, or clearcut/deferred-shelterwood.

There are other considerations when using rate-of-return marking guides. Cutting trees or stands when the rate of return diminishes may not produce maximum dollar yields per acre. For example, the simple exercise in Table 1 shows a value yield table for a hypothetical oak stand with 4/2 clear faces in the butt and second 10-foot logs and growing at a constant rate of 10 rings per inch. Dollar stumpage values per tree were derived from data from an October 1999 workshop at the Fox Forest, Hillsboro, New Hampshire. We'll assume an intensively managed stand, thinned back to 70 square feet basal area every 10 years; the thinned trees are termed "Thin Value" in Table 1. Note that the rate-of-return for this uniform stand drops to 6.1% for 18-inch trees, and less than 3% for larger trees. However, if you calculate the mean annual dollar return by dividing the stand age into the standing value plus the cumulative thinned value (=Total Value), you'll note that the mean annual dollar return about peaks when the stand reaches 24 inches dbh. The peak of the mean annual dollar return would be the size and age that would produce the maximum dollar return (ignoring the time-value of money) for a forest with a uniform distribution of age classes or for a single stand over a repeated series of rotations.

Table 1. Calculation of mean annual stumpage value/acre for red oak with 4/2 grade.

Stand Dbh	Age	Resid. BA	No. Trees	Tree Value	Tree ROR %	Stand Value $	Thin Value $	Total Value $	Mean Ann. $
0	0								
2	10								
4	20								
6	30								
8	40	70							
10	50	70							
12	60	70	89	$1	24.6	89			
14	70	70	65	$9	16.9	585	216	801	11.4
16	80	70	50	$43	3.7	2150	645	3011	37.6
18	90	70	40	$62	6.1	2480	620	3961	44.0
20	100	70	32	$112	2.6	3584	896	5961	56.6
22	110	70	27	$145	2.1	3915	725	7017	63.8
24	120	70	22	$178	1.3	3916	890	7908	65.9
26	130	70	19	$202	1.8	3838	606	8436	64.9
28	140	70	16	$241	1.8	3856	723	9177	65.6

FIGURE 1. Prescription key using financially based cut and leave.

This key presumes that CUT and LEAVE have been defined in terms of tree characteristics such as species, diameters, and quality classes or potential quality classes. LEAVE would include those trees that will make, if released, a minimally acceptable rate of return. C-line refers to the standard northern hardwood stocking guide.

1. LEAVE BA> C-line
    - 2.—Even-age management..A
    - 2.—Uneven-age management
        - 3.—CUT occurs in clumps or patches..................................B
        - 3.—CUT is uniformly distributed.......................................C

1. LEAVE BA< C-line..D

A. Typically, this is an even-aged stand with an adequate stocking of LEAVE that is fairly uniformly distributed. The prescription is a commercial thinning that concentrates on removal of CUT, maintaining residual density at or above the B-line.

B. This prescription applies to an uneven-aged or uneven-sized stand, or to an even-aged stand where there is an over-riding interest in uneven-age approaches. Ideally, CUT occurs in clumps that lends itself to group/patch selection with the objective of regenerating a mix of intolerant, intermediate, and tolerant regeneration. Stand improvement can also be applied between the groups/patches, concentrating on removal of CUT.

C. In an uneven-aged stand where the CUT is uniformly distributed, one logical choice is single-tree selection concentrating on removal of CUT, maintaining a residual density of 70-75 square feet basal area or more in hardwood stands. However, if a better mix of less tolerant regeneration is desired, the group/patch selection system could be applied, sacrificing some LEAVE in favor of better regeneration.

D. Where the LEAVE is below C-line, there is some doubt whether the stand is worth further management. If the harvesting simply removed the CUT, there could be a loss in merchantable growth per acre, a loss in total dollar earnings per acre (even though rate of return on standing volume would be high), a possible drop in stand quality, and regeneration would occur anyway. One option in such stands is to regenerate by clearcutting. Another, perhaps better, option is to use a low-density, deferred shelterwood: reduce the basal area to 20-40 square feet of LEAVE in one or two cuts. These residual LEAVE trees must be trees that are not prone to epicormic branching or decline from exposure, and that can be left (30-50 years perhaps) to put on economic growth until the first thinning in the new stand. Low-density deferred shelterwood should regenerate an abundance of intermediate shade-tolerant species and tolerant regeneration along with some shade-intolerant species.

To close out this brief refresher on forest financial analysis, we want to end with a discussion on how to select an alternative rate of return and why it is important and a word on financial maturity. To repeat, the alternative rate of return is the rate of return you can make on alternative investments of equal risk. It is often viewed as the opportunity cost of borrowing. For individual forest landowners the alternative rate could be based on the interest rate for a home mortgage or an auto loan. As an example, the current interest rate on a 30-year fixed-rate mortgage is 7.8% and for an auto loan, 6.9%. These are market rates. Inflation is right around 2% so that a real loan rate might be in the range of 5 to 6%. In application to a forestry investment decision, the context will dictate whether you use the market rate, 7 to 8%, or the real rate, 5 to 6%. In the example using the spreadsheet investment program, inflation is ignored so that the real rate is the correct rate to use. So financial maturity occurs when a tree's growth in value, expressed as a percentage, is less than the landowner's alternative rate, in the example, 5 to 6%.

The spreadsheet (BANTIC) assumes that a tree increases in value over time through increases in volume (quantity) and increases in grade (quality). Increases in value due to volume occur rather smoothly yielding a nice smooth curve plotted over time. Increases in grade occur as distinct jumps as a tree reaches the minimum diameter for the next highest grade. In the red oak example, this can be seen as scaling-diameter for logs with 4 clear faces increase: 7 to 9 inches has no stumpage value, 10 to 12 at $200 per Mbf, 12 to 13 at $450, 14 to 15 at $600, and 16 and above at $875. Increases in value due to inflation and real price appreciation are ignored. If real price appreciation were assumed to be 1% annually, the effect would be the same as decreasing the alternative rate by 1% to a range of 4 to 5%. This decrease would result in a larger diameter tree at financial maturity. If the landowner receives other nonmarket benefits from the mature forest, such as desirable wildlife habitat or aesthetics, that can justify adjusting the alternative rate downward further. In this case, the adjustment becomes subjective because there is no real market data available. The result would be the same as real price appreciation—a larger diameter tree at financial maturity.

The information in Table 2 is based on Table 1 that presented a hypothetical example of a red oak stand. Present values were estimated in Table 2. Discount rates of 2, 4, and 6% were assumed and present values were calculated beginning at age 60 assuming, alternatively, that the stand was harvested at ages 60, 70, 80, and so on through age 140. Cash flow from each thinning is included in the present value calculation. So, for example, at age 90, there are revenues from thinning at 60, 70, and 80 and a final harvest at 90. At 4% interest, the maximum present value for this problem occurs at age 100, but actually somewhere between age 90 and 100. The tree (and stand) rate of return is 6.1% at age 90 and 2.6% at age 100 (Table 1). At 2%, maximum present value occurs at age 130 and at 6% at age 80.

Table 2. Present values calculated for the example in Table 1 at three discount rates, 2, 4, and 6%.

Stand age	Stand Dbh	Present value		
		2%	4%	6%
		..................dollars.................		
60	12	27.13	8.46	2.70
70	14	153.58	39.86	10.63
80	16	502.30	109.63	**24.71**
90	18	610.90	117.02	23.58
100	20	792.65	**133.46**	24.33
110	22	864.93	132.61	22.84
120	24	867.48	125.33	21.19
130	26	**878.86**	121.41	20.38
140	28	877.62	117.58	19.82

100 Problems in Compound Interest and Other Notes:

100 Problems in Compound Interest

1. If an investor purchased 100 acres at $200 per acre 15 years ago, what would the 100 acres have to be priced at if she wanted to earn 7% on her investment? (Assume no taxes)

2. If 100 acres is for sale at $500 per acre, the owner had held it for 10 years, and she claimed she was making 8% on her investment, what did she pay for the 100 acres? (Assume no taxes)

3. If 100 acres is sold at $500 per acre, and if it had been bought for $279 per acre 10 years ago, what rate of interest was earned if there were no taxes or other costs?

4. What is the current-use value of a forest that has an annual increment of 0.2 Mbf per acre with a value of $100 per Mbf if the alternative rate of interest is 10%?

5. What is the December 1980 value of the following taxes that were paid if the alternative rate of interest was 6%?

   Dec, 1975 $1.00 per acre
   Dec, 1976 $1.50 per acre
   Dec, 1977 $2.00 per acre
   Dec, 1978 $2.30 per acre
   Dec, 1979 $2.50 per acre

6. What is the capitalized value (net present value) of an income of $1,000 that will be paid one year hence, two years hence, and three years hence, if the alternative rate of interest is 6%?

7. Consider the growth of the following forest stand and solve for the average compound rate of growth between age 50 and age 60:

Age	Yield (Mbf)
50	26
60	40

8. Aside from compound interest, what is the periodic annual increment from age 50 to 60 in problem 7?

9. Aside from compound interest, what is the average annual increment in problem 7 (also referred to as mean annual increment) at age 50 and at age 60?

10. What is the capitalized value of a Christmas tree plantation that will net $800 per acre every 12th year when the interest rate is 5% and the first return is due in 12 years?

11. What is the capitalized value in problem 10 when the current crop is 4 years old and the first return is due in 8 years?

12. What is the capitalized value in problem 10 when the current crop is ready for harvest immediately?

13. A 5,000 acre sustained yield uneven-aged forest produces 300 bf per acre annually from an average growing stock of 15 Mbf per acre. The stumpage value averages $100 per Mbf. Property taxes are $3 per acre annually. Annual management costs are $2 per acre. What is the annual net revenue per acre from the forest before income taxes?

14. In problem 13, what is the current-use value per acre of the forest if the alternative rate of interest is 5%?

15. What is the timber holding cost (opportunity cost) of the forest in problem 13 at 5% interest?

16. What is the end value of $1,000 invested at 10% for 70 years?

17. What is the discounted value (present value) of $1,000 due in 50 years if the interest rate is 7%?

18. A stand of northern hardwoods has 5 Mbf per acre. Ten years ago it had 3 Mbf per acre. What was the compound growth rate?

19. What is the capitalized value of a permanent periodic income of $1,000 every 5 years, starting in 5 years, at 3% interest?

20. What is the capitalized value of an annual income of $500, starting at the end of the year, at 5% interest?

21. What is the end value of a series of annual payments of $100 being paid at the end of the year for five years at 5% interest.

22. A forest property was sold for $350 per acre. The seller had purchased the property 15 years ago for $150 per acre. What rate of interest was earned on the initial investment? (Assume no other costs)

23. If annual property taxes in problem 22 were $2.50 per acre, what would be the end value (15 years) of this series of costs if the alternative rate of interest were 5%?

24. What is the capitalized value of a Christmas tree operation where the expected net revenues are $1,000 coming every 5 years, into perpetuity, starting 5 years hence at 3% interest?

25. What is the end value of a series of monthly payments of $100 being paid at the end of the month for 48 months at 12% annual interest?

26. If annual property taxes from 1970 through 1985 were $2.50 per acre, what would be the end (1985) value of this series of costs if the alternative rate of interest were 5%?

27. What is the capitalized value of a Christmas tree plantation where the net revenues expected are $1,000 every 8 years, in perpetuity, starting 8 years hence at 7% interest?

28. What is the end value of a series of monthly payments of $200 being paid at the end of the month for 48 months at 12% annual interest?

29. If annual property taxes were $3.00 per acre for 15 years, what would be the end value of this series of costs if the alternative rate of interest were 5%?

30. What is the capitalized value of a Christmas tree plantation where the net revenues expected are $1,000 every 8 years, in perpetuity, starting 5 years hence at 7% interest?

31. If the average annual increase in Vermont forest growing stock was 4% and if there were 2.194 Mbf per acre in 1973, what volume of sawtimber was there in 1986?

32. How many years will it take for a stand with 2 Mbf per acre to grow to 5 Mbf if the net increase is 4% annually?

33. If a stand now has 5 Mbf per acre and has been growing at 3% annually, what volume did it have 10 years ago?

34. What is the present value of a series of $4 annual payments for the next 60 years at 5% interest?

35. What amount would have to be set aside to pay annual costs of $4 into perpetuity, at 5% interest?

36. What is the present value of a 40-year series of $4 annual payments at 5%, payable starting 60 years from now and continuing through 100 years from now?

37. What is the present value of a series of $4 annual payments for the next 60 years at 6% interest?

38. What amount would have to be set aside to pay annual costs of $4 in perpetuity at 6% interest?

39. What is the present value of a 40-year series of $4 annual payments at 6%, payable starting 60 years from now and continuing through 100 years from now?

40. What is the capitalized value of a permanent periodic income of $1,000 every 5 years, starting 5 years hence at 5% interest?

41. What is the capitalized value of a permanent annual income of $200, starting at the end of the year, at an interest rate of 5%?

42. What is the end value of a series of annual payments of $200 paid at the end of the year for 5 years at 5% interest?

43. What is the present cost of keeping a wooden bridge in operation that will have to be rebuilt every 10 years? The initial construction and each rebuilding will cost $5,000. The interest rate is 5%.

44. What is the present cost of keeping a concrete abutment, steel I-beam, wooden deck bridge in operation if the initial cost is $10,000 and the decking must be replaced every 12 years at a cost of $1,000? The interest rate is 5%.

45. Balsam fir Christmas trees can be grown in 10 years. Planting costs are $150 per acre; annual costs are $32 per acre; stumpage value is $1,000 per acre at age 10. What is the net revenue per acre at rotation age if the interest rate is 5%?

46. In problem 45, what is the present value of bare land to be used for growing Christmas trees with this strategy?

47. In problem 45, what is the present value of the second crop?

48. In problem 45, what is the present value of the third crop?

49. In problem 45, what is the present value of the 20^{th} crop?

50. What is the present net worth (i = 0.10) of a series of cash flows as follows: year 0 = $150,000; year 1 = $25,000; year 2 = $25,000; year 3 = $40,000; and years 4 through 10 = $50,0000?

51. At 5% interest, how long will it take for an annual tax saving of $97.50 to equate to a change of use penalty of $4,000?

52. What will be the current value per acre of balsam fir Christmas trees 10 years from now if the real price increase is 3% annually and the general inflation rate is 7% annually, and the current value is $1,000?

53. What is the capitalized value of a permanent periodic income of $5,685 due from an 80-year rotation of a stand of white pine that is currently 40 years old?

54. A current investment of $100 per acre will return $180 in 20 years. What rate of interest will be earned?

55. A 100-acre parcel of timberland was purchased 10 years ago for $100 per acre. Annual property taxes have been $3 per acre. There has been no income from the property. If the alternative rate of interest is 8%, what must the owner sell the land for to break even on the investment?

56. If the average growing stock in Vermont is 3.2 Mbf per acre, the average annual increment is 0.07 Mbf per acre, the average stumpage value is $100 per Mbf, and the alternative rate of interest is 7%, what are the average annual timber holding costs at the beginning of the growing season?

57. What is the average annual growth percent for the 20-year period during which a stand increased from 12 Mbf per acre to 27 Mbf per acre?

58. What is the present value of a perpetual annual return of $5 per acre at 8%?

59. What is the present value of a perpetual annual return of $5 per acre at 1%?

60. A Christmas tree grower incurs establishment costs of $200 per acre and sells his crop at age 10 for $520. There are no other costs. When one acre of trees was 6 years old, it was destroyed by a neighbor's fire that got out of control. The grower claims damages equal to discounted values of the crop. What would this be at 5%?

61. His neighbor is willing to pay the compounded costs that the grower had incurred at 5%. What would this be?

62. The discounted value and the compounded costs in the problems 60 and 61 are quite different. If you were called in as a consultant by a court of law, how would you advise the judge on resolving the matter?

63. What is the internal rate of return on investment of a forwarder for a skidding operation, where the forwarder will cost $96,000 and is expected to return $30,000 annually at the end of each year for 4 years? There is no expected salvage value.

64. A current investment of $100 per acre in timber stand improvement will return $180 in 20 years. What rate of compound interest was earned?

65. A 100-acre parcel of timberland was purchased 10 years ago for $100 per acre. Annual property taxes have been $3 per acre. There has been no income from the property. If the alternative rate of interest is 8%, what must the owner sell her land for to break even on the investment?

66. What is the present value of an annual cost of $300 for the next 10 years at 7%?

67. The owner of a 100-acre forest has a growing stock of 5 Mbf per acre valued at $100 per Mbf. Ten years ago, when he bought the forest, there were 4 Mbf per acre and stumpage value was $45 per Mbf. What has been his average annual percentage return from timber value and volume growth?

68. If the current annual increment of a forest is 0.1 Mbf per acre and has a value of $100 per Mbf, what is the current-use value per acre at 10% if the annual costs are $3 per acre?

69. If it is estimated that 100 Mbf can be harvested every 10^{th} year, starting 10 years hence, and there are no costs, what is the present value of all future rotations at 4% where the timber has a value of $100 per Mbf?

70. In problem 69, if the value is expected to increase by $100 per Mbf every 10^{th} year, what is the present value of the next 5 harvests at 4%?

71. What is the present net worth of a 100-acre forest that is under sustained yield harvest producing 0.1 Mbf per acre annually valued at $100 per Mbf, with annual costs of $2 per acre, at alternative rate of interest of 4%?

72. What is the annual net revenue of 1,000 acres of northern hardwood forest, managed under sustained yield, with an average annual increment of 0.09 Mbf per acre; average stumpage values are expected to be $200 per Mbf over the short-range future; and taxes and administrative costs are $2.50 per acre?

73. In problem 72, what is the value of the forest at an alternative interest rate of 10%?

74. In problems 72 and 73, what is the annual timber holding cost if the growing stock is 5 Mbf per acre and the alternative rate of interest is 10%?

75. What is the return on investment of $100 invested at the start of 10 years with an annual cost of $12 where the return at the end of the 10^{th} year is $485?

76. What is the present cost of a project that has an initial cost of $5,000 and an additional cost of $5,000 every 10 years into perpetuity at 10% interest?

77. If current stumpage prices for hard maple are $100 per Mbf and are expected to have a relative (real) price increase of 3% annually, with annual inflation averaging 4% annually, what will be the price per Mbf in 20 years?

78. One hundred acres of balsam fir Christmas trees, now 10 years old, have a value of $600 per acre. Planting costs were $100 per acre. The annual costs were $10 per acre. What was the percentage return on investment?

79. If the trend line for relative (real) increases in lumber prices has averaged 1.8% annually for the past 180 years and if general inflation has averaged 1% annually over the same period, what was the price of lumber 180 years ago if the current price is $300 per Mbf?

80. What is the present cost of a project that will initially cost $1,000 and then $600 every 4th year into perpetuity at 10% interest?

81. What is the end value of a series of $5 annual payments that extend for 20 years at 6%?

82. If a buyer agrees to pay $100,000 for a forest property with 30% down and the balance being paid over 5 years in equal amounts toward the principle, plus 10% interest on the balance, what is the complete schedule of payments?

83. If the value of a tree was $20 five years ago and now is worth $25, what was the annual percentage value growth?

84. What will be the return on investment 22 years from now of a slash pine plantation that was severely damaged by hogs at age 5 and now will have to be partially replanted at a cost of $15 per acre? The initial cost of planting was $30 per acre. The annual costs are $1 per acre. The expected value of the final crop will be $182 per acre.

85. What is the future net worth, at the end of the first rotation, of one acre of trees that are being planted this year:

    Alternative rate of interest is 4%
    Rotation is 100 years
    Planting costs are $130 per acre
    Annual costs are $3 per acre
    Yield at rotation age will be 30 Mbf
    Current stumpage prices are $210 per Mbf
    Relative (real) price increase is 2% annually

86. In problem 85, what is the land expectation value?

87. If a tree had a value of $27 a year ago and now has a value $29, has it reached financial maturity if the alternative rate of interest is 7%?

88. What is the real interest rate when the market rate is 10% and inflation is 3%?

89. If the future net cash flow for a proposed forest plantation is expected to be $1,000 per acre at the end of the first rotation (age 50), what is the land expectation value at 10%?

90. How many years will it take for an investment of $100 to reach $1,000 at 10%?

91. In problem 90, how many years will it take if the interest is compounded monthly?

92. The buyer of a forest has agreed to pay the balance of $50,000 in 5 equal annual payments at 10% interest. What will the payment be?

93. In problem 92, what will the payment be if the payments are monthly for 5 years?

94. What is the present value of a periodic annual return of $1,000 at 10%, where the return comes every 5th year?

95. In problem 94, what is the present value if the investment is 2 years old, and the first return will come in 3 years, and every 5 years thereafter?

96. If by application of fertilizer, white pine can produce the same yield at age 60 instead of age 70, how much can we afford to pay for the fertilizer treatment? The alternative rate of interest is 4%. The present year is age 10. The value of the crop in both cases is $2,000 per acre.

97. When the combined net present value of an existing stand plus a successor stand is at a maximum, the existing stand should be replaced. First, what is the net present value (no annual costs) of one acre of white pine seedlings (successor stand) that will have a value of $2,000 per acre at age 60, at 4% interest?

98. In problem 97, what is an algebraic expression for the net present value of the successor stand if the replacement is delayed for *n* years?

99. In problems 97 and 98, what is the value of the combined net revenues for each of the next 6 years if the present stand (value is now $1,200 per acre) increases in value at 5% this year and thence 0.2 of 1% less each year thereafter? When is the net revenue at a maximum?

100. Should a white pine plantation be pruned if the cost of 2-stage pruning is $50 per acre this year and $60 per acre in 5 years. The value of the final crop will be $500 per acre more in 40 years than if not pruned. The alternative rate of interest is 4%. What is the present net vale of this pruning strategy?

Source: F.H. Armstrong and P.E. Sendak, class notes, University of Vermont

Answers

1. $55,180.63
2. $23,159.67
3. 6%
4. $200
5. $10.85
6. $2,673.01
7. 4.4%
8. 1.4 Mbf
9. 0.52 and 0.67 Mbf
10. $1,005.21
11. $1,221.84
12. $1,805.21
13. $25/acre
14. $500/acre
15. $75
16. $789,746.96
17. $33.95
18. 5.24%
19. $6,278.49
20. $10,000
21. $552.56
22. 5.8%
23. $53.95
24. $6,278.49
25. $6,122.26
26. $53.95
27. $1,392.40
28. $12,244.52
29. $64.74
30. $1,705.75
31. 3.653 Mbf
32. 23.4 yrs
33. 3.72 Mbf
34. $75.72
35. $80
36. $3.67
37. $64.65
38. $66.67
39. $1.82
40. $3,619.50
41. $4,000
42. $1,105.13
43. $12,950.46
44. $11,256.51
45. $353.17
46. $561.58
47. $133.11
48. $81.72
49. $0.02
50. $106,326
51. 22.86 yrs
52. $2,643.69
53. $824.16
54. 2.98%
55. $259.35/acre
56. $22.40
57. 4.14%
58. $62.50
59. $500
60. $427.81
61. $268.02
62. Should have used an *i* of 0.10 to equate compounded and discounted values
63. 9.58%
64. 2.98%
65. $259.35
66. $2,107.07
67. 10.76%
68. $70
69. $20,822.74
70. $58,392.85
71. $20,000
72. $15,500
73. $155,000
74. $100,000
75. 11%
76. $8,137.27
77. $395.74
78. 14.8%
79. $2.02
80. $2,292.82
81. $183.93
82. Year
    - 0 $30,000
    - 1 $21,000
    - 2 $19,600
    - 3 $18,200
    - 4 $16,800
    - 5 $15,400
83. 4.56%
84. 4.4%
85. $35,362.76
86. $719.43
87. Almost (7.4%)
88. 6.8%
89. $8.59
90. 24.16 yrs
91. 23.21 yrs
92. $13,189.87
93. $1,062.35
94. $1,637.97
95. $1,981.95
96. $91.30
97. $190.12
98. $190.12/(1.04)^n
99. $1,394.35
    $1,396.63
    $1,396.92 max
    $1,395.14
    $1,391.26
    $1,385.25
100. Yes, PNV=$4.82

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