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## Forest Finance

# To Cut or Not to Cut: Tree Value and Deciding When to Harvest Timber



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## Introduction

Perhaps one of the most important financial decisions a forest landowner will make is determining when to harvest timber. This decision will influence the condition, growth, and composition of the next forest. For most landowners, the decision to harvest timber is a difficult one. While the money is attractive, other issues, such as the process and outcome, may be new and different, especially the first time. Many times the harvest decision is driven by financial considerations—for example, an emergency cash need or high timber prices. However, the landowner should also consider other factors, including forest health, condition, and sustainability.

Timber harvesting is an integral part of forest management. Often, a harvest design intentionally creates wildlife habitat and enhances biodiversity and, if done properly, will increase long-term timber value. Active forest management can address forest health problems and increase growth rates driven by species composition or forest-stocking conditions. Landowners can improve stand quality and reallocate stand growth by using appropriate silvicultural practices such as intermediate thinning, timber-stand improvement, and regeneration harvests. Studies show that returns from well-managed stands with properly scheduled harvests are significantly higher in value than similar unmanaged stands.

This publication discusses issues pertaining primarily to the financial decision to harvest timber. The first section is a brief overview of how to estimate timber value and price. The next section covers what is meant by forest “maturity,” and the final section shows how to determine and calculate when to cut timber to maximize financial returns.

## The Value of Trees

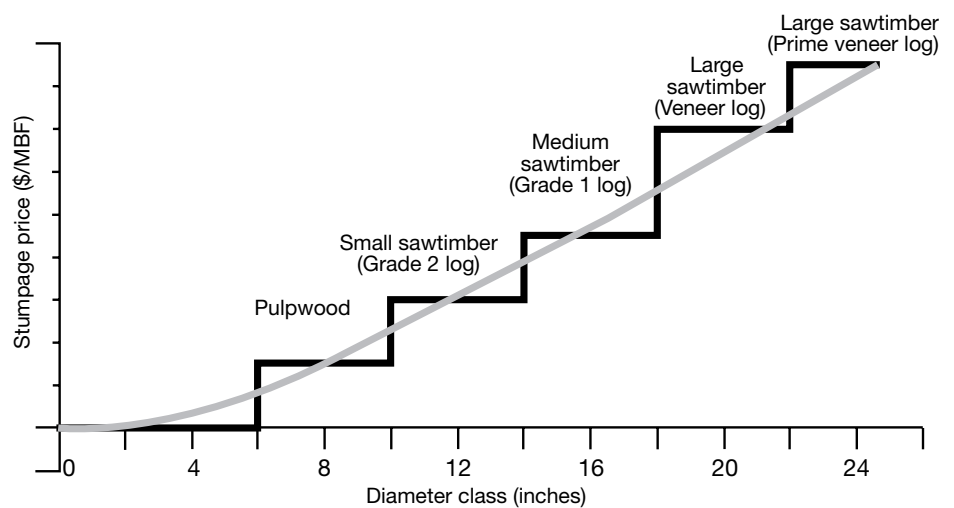
As trees grow in size, they logically increase in volume and become more valuable. Managing for high-quality hardwood trees can increase income for forest owners. Tree species, stem quality, height, and diameter dictate specific market value. Tree-stem diameter determines the type of product (e.g., sawtimber, pulpwood). Tree size for forest products is expressed as diameter at breast height (DBH), which is measured at 4.5 feet above the ground on standing trees. Generally, Pennsylvania’s hardwoods become merchantable for pulpwood when they are 6 inches DBH or larger and reach sawlog size at 12 inches DBH.

As tree DBH increases, value shifts from pulpwood to sawtimber and finally to veneer depending on species and stem quality (Figure 1). The value of higher-quality desirable hardwood tree species can increase dramatically over time as it adds additional diameter growth. The quality of trees is described by standardized tree-grading rules used to assess value. Tree grades are determined by the top diameters and the number of clear

faces in the first log (i.e., the lack of defects such as branches, knots, cracks on the log surface). Most of the value in a tree is in the first 16 to 20 feet (the butt log). Grading trees depends on a number of factors beyond the scope of this publication. High-quality grade 1 and veneer logs are usually more than 16 inches DBH. In Pennsylvania, prices for high-valued species used to make grade 1 or veneer may be three to ten times greater than that attained from a tree of the same size and species but lower quality.

While size (volume) and grade (quality) describe tree conditions, they do not necessarily set market prices. Ultimately, the value of hardwood trees is set by market demand. Local and global demand for these high-quality hardwoods has raised stumpage prices (the price paid for the standing timber on the stump, before harvest) in real terms (i.e., over and above inflation). This trend is clearly evident in timber market reports (see the *Timber Market Report* at [www.sfr.psu.edu/TMR/TMR.htm](http://www.sfr.psu.edu/TMR/TMR.htm)). For example, stumpage prices for the more valuable Pennsylvania hardwoods, such as maples and cherry, increased in the past decade between 4 and 8

**Figure 1. General pattern of stumpage prices and grade shifts for hardwood timber of different diameters.**



percent annually (Figure 2). There are years when the economy is soft and timber prices drop. At these times, shifting consumer demands, changing markets, and even weather can affect prices. In 2006 and 2007, such a downturn occurred for northern red oak (see Table 1). Fortunately, astute forest owners can withstand downturns in the market by holding their timber until stumpage prices rebound.

Factors influencing stumpage prices received for individual forest stands include forest type, species composition, site quality, volume available, accessibility (e.g., slope/roads, proximity to markets), and logging and transportation costs. There are fixed costs associated with logging, such as equipment-moving and site-setup costs; therefore, the more volume a landowner can offer spreads these fixed setup costs over more trees and should yield higher per-unit stumpage prices. The silvicultural system used and type of harvest (e.g., thinning, improvement harvests, clear-cutting, shelterwood regeneration cuts, or single-tree and group-selection harvests) also affect logging costs.

## When Is a Forest Mature?

In most cases, a forest contains both high- and low-value species. It is likely that some trees are growing faster than others. Factors affecting individual tree growth are competition among trees, sunlight, tree age, and soil conditions. Young trees generally grow faster in height than older trees, and they add relatively little stem diameter. Depending on competition, as trees get older and larger, annual height growth decreases, but diameter growth continues, albeit, at a slower rate. Eventually, average annual volume growth decreases. Biological growth is not constant over the life of a tree and follows an S-shaped curve (Figure 2).

Looking at a tree's cross-section, it is apparent that the width of annual rings decreases; however, the volume increment represented by smaller rings may remain the same. That is, the same volume of wood is spread around an increasingly larger circumference of the tree stem. Trees in a closed-canopy forest may grow slowly. It is not uncommon to see growth of an inch in diameter per decade. When appropriate tree species for the site are grown on good soils in a managed forest, they may increase their diameter 3 to 4 inches in 10 years.

While difficult to generalize, a tree in Pennsylvania's hardwood forests reaches biological maximum when

diameter growth of dominant and codominant trees slows dramatically. Biological maximum refers to the age when a tree begins to decline in vigor and health in a forest. Site conditions and species strongly influence this biological maximum. For example, red maples approach this maximum before 150 years, while sugar maples can thrive beyond 200 years of age. Black cherry, a high-value early successional species common in Pennsylvania, may begin to reach physical maturity at 120 years and decline rapidly and die, affecting economic returns. At maturity, a typical stand may have 80 to 120 trees per acre and the volume of sawtimber can range from 5,000 to 15,000 board feet (BF) per acre. Poorer-quality sites may only have a few large trees.

USDA Forest Service data shows the net growth in board feet per acre per year for different age classes and different site productivity classes averaged across all timberland in Pennsylvania (Table 2). Net growth generally increases with age and as site productivity class increases, but at more than 100 years, growth clearly begins to decline. Based on this, many of Pennsylvania's forests may be close to their biological maximum.

Foresters express biological growth in terms of volume produced per acre per year averaged across the stand or forested property and over the life of the stand. This is known as mean annual increment (MAI) and is the average annual timber volume growth, which is found by dividing the total volume of a stand by the age of the stand. When MAI is maximized, this is referred to as the maximum sustained yield (MSY). The rotation at which MAI is maximized is often called the biological rotation as opposed to the economic rotation (financial maturity). See Figure 2a. Biological rotations do not take into account costs and benefits.

**Table 1. Price real trends for selected species by region of Pennsylvania (January 1997 to March 2007).**

Species	Region of Pennsylvania			
	Northwest	Northeast	Southwest	Southeast
Black cherry	4.90%	4.60%	4.74%	7.03%
Northern red oak	-2.24%	-0.73%	-0.28%	-1.12%
Hard maple	5.45%	5.74%	7.59%	5.90%
Soft maple	3.86%	2.56%	2.23%	-0.05%

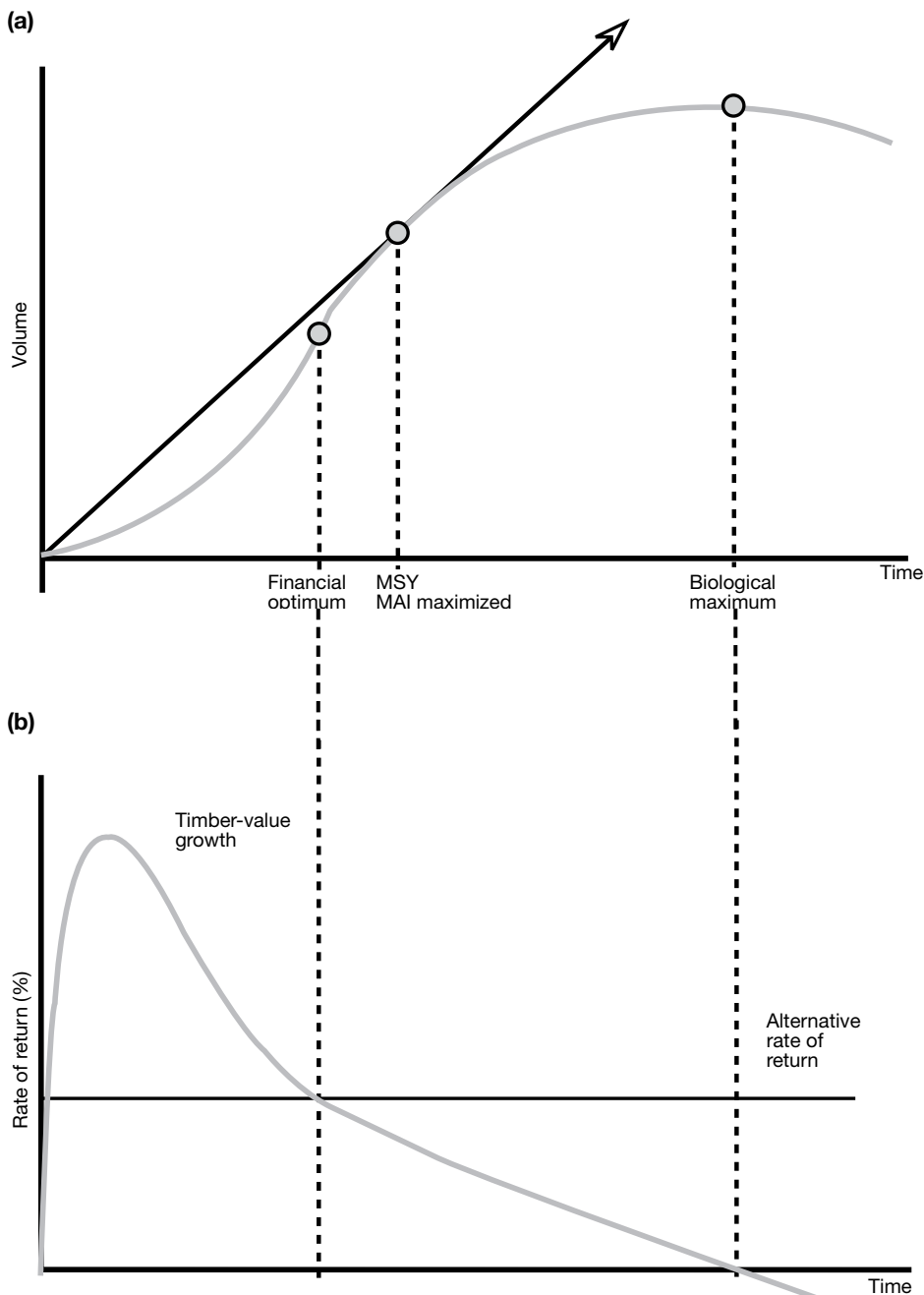
Source: *Timber Market Report*, [www.sfr.cas.psu.edu/TMR/TMR.htm](http://www.sfr.cas.psu.edu/TMR/TMR.htm)

**Table 2. Net growth in board feet (BF) per acre per year of sawtimber per acre per year on timberlands in Pennsylvania.**

Site productivity class	Stand age (5-year classes)				
	21–25	41–45	61–65	81–85	100+
85–119 (high)	87	192	307	435	247
50–84 (medium)	84	165	195	257	249
20–49 (low)	12	97	145	189	165

Source: FIA Mapmaker, [fia.fs.fed.us/tools-data/tools](http://fia.fs.fed.us/tools-data/tools)

**Figure 2. Volume growth of trees over time showing optimal rotations.**



Financial maturity is different from its biological counterpart and generally occurs earlier in the life of a stand due to the concept of earning “interest” from the forest investment. Think of the value of the tree or stand as equating to the principal in a bank account and the value increase (from volume growth) being the interest earned on that principal. This value increase can be expressed as an annual compound interest and compared with alternative investments or a desired rate of return. Usually, a tree or a stand of trees is considered financially mature when its rate of value increase falls below an acceptable or minimum rate of return that can be earned from alternative investments comparable in duration, risk, liquidity, and other factors. Value growth may continue to increase but at a slower rate. Eventually, the rate of value increase is too slow to justify keeping it as an investment. Figure 2b schematically shows the financial maximum return when the timber-value growth percent equals the alternative rate of return. Under most conditions, financially optimal harvest ages are often considerably shorter than the MSY rotation.

Thinking of this from an individual tree perspective, if the tree’s expected rate of value increase exceeds the desired rate, the tree is not financially mature and should be allowed to grow for the specified time period. If the tree’s expected rate of value increase is less than the desired rate, the tree is financially mature and, based on that criterion alone, should be cut.

## When to Harvest Timber to Maximize Financial Returns

There are many factors to consider when deciding to conduct a timber harvest. These include sustainability issues, such as ensuring adequate desirable regeneration, and financial and legal considerations, such as timber prices, taxes, boundaries, logging contracts, and liability. It is important to time the harvest to obtain the most favorable financial gain. Fortunately, timber is not a crop that has to be harvested as annual crops do, such as corn or soybeans—it is often advisable to delay harvests to meet your management objectives. However, all tree species do eventually reach a biological maximum.

If selling timber today, values can be estimated using timber market reports and site inventories for timber volumes. You simply need to multiply the timber volume by today's timber market price for each species present in the sale. However, to calculate the expected future financial return from a harvest in today's dollars, you must include a discount rate and growing-period length in the calculation. This process, known as "discounting," takes an expected future return in a given time period and discounts it (using a given interest rate) back to the present (today's) value. This process is essential for comparing forestry investments to other investments, especially given the long-term nature of growing timber. (For specific examples of discounting, see *Forest Finance 1: Sustainable Forest Harvesting*.) If the time value of money and interest rates are not considered in calculating timber values, you would cut timber when the volume growth over time produces the maximum MAI. However, because of the ability to receive interest on investments, the optimal time to cut

timber from a financial view is earlier than when the MAI is maximized as shown in Figure 2. How much earlier depends on the timber-value growth rate and the acceptable or alternative rate of return that is set. When these two rates are economically equal, it is time to cut.

Postponing a harvest may come at a cost because timber is a long-term asset and has changing market value. By harvesting timber today, money received can be used elsewhere. Logically, if a harvest is postponed, the money remains invested in the trees. If you decide to delay a harvest, you will need to determine whether the rate of return from continuing the investment in the trees is worth more than the rate of return received from investing that money in other opportunities (also known as alternative rate of return or minimum acceptable rate of return). Stated another way: Will the increased value of the trees not cut outweigh the alternative return if the money was invested elsewhere?

Use the following rule to decide whether to cut today or wait and compare the expected financial rate of return received from delaying harvest to the rate of return received from an alternative investment (i.e., harvest today and invest the income elsewhere): If the rate of return for continuing to grow the trees (e.g., 5 to 10 years or more) is greater than an alternative rate (e.g., stock market, CD, mutual funds), then the harvest should be postponed; if it is less, then harvest now.

For example, to calculate the expected rate of return from postponing a harvest, compare the ratio of future value to the present value as shown in the hypothetical example (Worksheet 1) on the next page. Instructions for filling out the worksheet and assumptions are given below; a blank worksheet is provided at the end of

the publication. In the scenario, the stand of mixed hardwoods has 6,000 board feet (6 MBF) per acre. The average stumpage price is \$300/MBF, or \$1,800 per acre total value. Should the landowner harvest now or wait 5 years?

In this scenario, the landowner ignored inflation but expected a real stumpage price increase of 3 percent per year over the next 5 years. This gives an expected future stumpage price of \$348/MBF in 5 years for a total stumpage value of \$2,436/acre (7 MBF x \$348). Dividing the expected future value (\$2,436) from the present value the landowner can receive today (\$1,800) results in a ratio of 1.4. This ratio allows you to calculate the expected rate of return from waiting (Line 15), which in this example is 7 percent. In this case, the landowner should wait the 5 years to harvest if he or she cannot get better than 7 percent from investing that harvest revenue (i.e., if the landowner's alternative rate of return is less than 7 percent). However, if the landowner can find an investment today that receives a rate greater than 7 percent, then it would be financially wise to harvest now.

Some important assumptions were made in this example. First, we assume that the landowner wants to maximize income from the timber production on the land. Objectives such as recreation and wildlife also have value but were not explicitly taken into account. A well-planned harvest may actually improve some values. For example, a harvest may create openings that provide early successional habitat and attract wildlife. Further, we are considering the value of the timber across only one rotation. With multiple or infinite rotations, the formulas change.

In this example, we used an average growth rate across all the species

## Worksheet: Estimating the Rate of Return for a Growth Period

1. Today's volume per acre (MBF/acre) .....	6
2. Today's stumpage price (\$/MBF) .....	\$300
3. Today's stumpage value (MBF/acre) [Line 1 x Line 2] .....	\$1,800
4. Growth period (years) .....	5
5. Annual volume growth (MBF/year) .....	0.2
6. Total volume growth over growth period (MBF/acre) [Line 4 x Line 5] .....	1
7. Expected future volume (MBF/acre) [Line 1 + Line 6] .....	7
8. Rate of inflation (percent/year).....	0
9. Rate of real price increase (percent/year).....	3
10. Add Lines 8 and 9.....	3
11. Price adjustment factor (see below for equation) [using data from Lines 4 and 10 above] .....	1.16
12. Expected future stumpage price (\$/MBF) [Line 2 x Line 11] .....	\$348
13. Expected future stumpage value (MBF/acre) [Line 7 x Line 12].....	\$2,436
14. Ratio of future value to present value [Line 13 ÷ Line 3] .....	1.4
15. Expected rate of return earned over growth period using data from Lines 4 and 14 (percent/year).....	7

### Explanations by Line

- The current volume is 6 MBF/acre.
- The current stumpage price is \$300/MBF.
- The current stumpage value is \$1,800/acre.
- In this case, the annual growth period is 5 years. It could be 5, 12, 18, or any other number of years.
- The annual volume growth per year is 200 board feet per acre per year. Future volumes can be estimated using information on local growth rates. A forester can determine past diameter growth by taking increment cores from several trees in your stand or other local sites or by looking at regional studies reporting average growth.
- Five years multiplied by 0.2 MBF gives total volume growth over the period at 1 MBF.
- In 5 years the expected future volume will be 7 MBF/acre (Line 1 + Line 6).
- Optional: Choose an appropriate inflation rate for the growth period. In this case, no inflation rate was used.
- Optional: Choose an appropriate average annual rate of stumpage value increases. In this case, we use 3 percent. Future values can be estimated using appropriate average historical annual rates of real stumpage price increases during the growing period (*Timber Market Report*).
- Determine the total expected rate of price increase by adding Line 8 and Line 9. Often, to keep things simple, it is common to ignore inflation and price increases. In this case, it is 3 percent.
- To determine price adjustment, add 1 to Line 10 (converted to a decimal value) and raise it by the  $n$ th year ( $n$  = number of growing periods). In this case, the growth period is 5 years (Line 4) and the real price increase is 3 percent:  
Price adjustment factor =  $[\text{Rate increase (Line 10)} \times 100]^n = 3\% \times 100 = 1.03$  and  $1.03^5 = 1.16$
- The expected future stumpage price is Line 2 x Line 11 = \$348/MBF.
- The expected future stumpage value is Line 7 x Line 12 = \$2,436/acre.
- Ratio of future value to present value is Line 13 divided by Line 3:  $\$2,436/\$1,800 = 1.4$  (rounding up). The rate of value increase can be determined by comparing the dollar value of its expected growth during a given time period (e.g., 10 years) with the dollar value of the tree prior to that growth.
- Expected rate of return over the 5-year growth period is obtained by taking the ratio in Line 14 to the root of the  $n$ th year (growth period) minus 1. Expected rate of return =  $(\text{Line 14 ratio})^{1/n} - 1$ . In this case:  $1.4^{1/5} - 1 = 7\%$ . This equation is also known as the earnings rate—the rate that equates the present and future value. It is similar in concept to the internal rate of return.

present. However, individual tree species grow at different rates. Individual tree analysis may be important for considering which trees in a stand to leave, especially if they have opportunities to grow into higher grade classes (see textbox on page 7). To address this issue, you may want to use multiple worksheets and analyze growth rates by species. It may also be important to consider other growth periods. The example used 5 years, but adjusting for shorter or longer periods will likely change the outcome. The longer you wait, the higher the cost of waiting. Remember, timber growth comes with other costs and risks, such as loss associated with insects, diseases, wind, and ice storms. Finally, the example does not include tax considerations, so income tax and perhaps some deductions for reforestation or other expenses may alter net returns.

The growth value of trees has three dimensions. Two dimensions shown in the example worksheet are growth and stumpage value increases. Growth value increases as volume increases. Stumpage value increases take into account changing market prices, which depend on market supply (e.g., affected by weather, species availability) and demand (e.g., consumer preferences, international markets). The third dimension, grade-value increase associated with increasing tree size, was not specifically reflected in the example; however, it is very relevant to the harvest decision and valuation process. You can use the expected real stumpage price increase (Line 10) as the proxy for increased value associated with grade and increases in market value. Or, the proxy for grade value increase can be included in the growth period (volume adjustments) over which the trees are expected to shift into a higher grade value.

## Individual Growth and Value for Black Cherry

To highlight the importance of grade in determining value, we examine the growth of a black cherry tree and estimate its value at different diameters as it grows in volume over time. This example looks at four diameter classes: 12, 14, 16, and 18 inches.

The following assumptions are made about the tree's growth: the tree will increase in diameter, the tree will increase in height, and the tree will become more valuable. If we assume there are approximately seven rings to an inch of radius, the tree increases 2 inches in diameter every 7 years. Practically, prices are derived from the *Timber Market Report* (second quarter 2007, northwest area). This is perhaps not the best way since for potential tree grades have numerous stumpage values. The *Timber Market Report* only provides a range of prices for each species per 1,000 board feet (MBF); a below-average price (which is one standard deviation\* below the average); an average price; and an above-average (mean) price (one standard deviation above the average).

For the 12- and 14-inch diameters, the below-average price is used (\$602/MBF), the average price is used for the 16-inch diameter (\$1,481/MBF), and the above-average price is used for the 18-inch diameter (\$2,360/MBF). Although these prices are conservative, we can assume that they approximate grade jumps as size and quality increase. However, for veneer grades above 18 inches, additional price premiums can be realized. As the tree grows in DBH—provided there are no forks on the bole—the diameter of the future log's small end will also increase. Therefore, the log length increases as minimum top diameter utilization sizes are met. Using the International ¼ Inch Log Scale, Table 3 gives the board feet (BF) volume and corresponding value at each diameter.

Table 4 shows the rate of return for waiting (growth value rate) 7, 14, or 21 years to harvest the tree. In this example, waiting 7 years provides a return of 5 percent; waiting 14 years provides a rate of 13 percent; and waiting 21 years to cut the tree provides a rate of 18 percent.

For this individual tree, it pays to wait at least 7 years to cut the tree if your alternative rate of return is 5 percent or

less. If, as the *Timber Market Report* trends show, stumpage prices for black cherry averaged almost a 7 percent annual value increase over the last 10 years, rates of return will essentially increase by that (i.e., for waiting 7 years, the growth value would be 12 percent).

It is interesting to note that it takes a tree about 50 years to reach 12 inches DBH. During the first 50 years, the tree is worth, at best, about a dollar or two for pulpwood. In the next 21 years, the value goes up at a very good rate. Black cherry is the most valuable species in Pennsylvania's forest, so when doing such analysis, the species is important. In many cases, not all large-diameter trees have the same or even comparable growth values of black cherry. Finally, this example illustrates the importance of timing in marketing timber. Although the tree may be merchantable for a number of reasons, including financial gain, it may be best to wait before cutting.

\*The standard deviation is a statistical measure of variability computed from all reported data. One standard deviation on either side of the average theoretically contains 90 percent of the reported data. It is likely that some prices will be outside this range (i.e., there may be prices above or below the price reported in the *Timber Market Report*. The decision to use the standard deviation was made so that price outliers (i.e., either really high or low price data) would not skew the report.

**Table 3. Volume and value for each diameter.**

DBH (inches)	Max merchantable height (logs)	Volume (BF)	Value (\$)
12	1.0	59	35.52
14	1.5	112	67.40
16	2.5	223	330.26
18	3.0	336	792.96

**Table 4. The rate of return for waiting 7, 14, and 21 years to harvest a tree.**

Year	Value (\$)	Present value at 4% (\$)	Rate of return (%)	
0	36.00	36.00		
7	67.00	50.91	Year 0–7	5
14	330.00	190.57	Year 0–14	13
21	792.00	347.56	Year 0–21	18

## Summary

Good forest management requires a landowner to conduct a financial analysis—an area that many landowners feel inadequately prepared to consider and would prefer to ignore. Most Pennsylvania forest landowners may only conduct one or two harvests during their ownership tenure. Given its significance, when selling timber (1) gather information about your property; (2) learn about timber markets, laws and regulations, and people and agencies that can help (or hinder) your progress; and (3) define any needs and expectations. Landowners should also think about revenue from the harvest and the implications of regeneration costs, income taxes, and other carrying costs associated with managing the land. Other publications and Web sites provide details about conducting a successful timber sale.

Landowners clearly need to consider multiple factors before making forest management decisions; financial return is only one of these. When the expected rate of return drops below what the landowner considers acceptable, there still may be good ecological or silvicultural reasons for delaying a harvest. Before making any forest management decisions, consider all factors that influence a stand of timber or forest.

Understanding the multiple ways by which tree and forest values increase is important. Too often, landowners dismiss the importance of grade value and growing quality timber. Even if you could accurately predict which species will become more valuable over time, not all species are suited for growing on a particular piece of land. In the end, the best strategy is probably to grow the best species suited for the land and to manage for quality. It is a pretty safe bet that higher quality will always bring a higher price.

## Worksheet: Estimating the Rate of Return for a Growth Period

1. Today's volume per acre (MBF/acre) .....
2. Today's stumpage price (\$/MBF) .....
3. Today's stumpage value (MBF/acre)  
[Line 1 x Line 2].....
4. Growth period (years).....
5. Annual volume growth (MBF/year).....
6. Total volume growth over growth period  
(MBF/acre) [Line 4 x Line 5] .....
7. Expected future volume (MBF/acre)  
[Line 1 + Line 6].....
8. Rate of inflation (percent/year).....
9. Rate of real price increase (percent/year) .....
10. Add Lines 8 and 9 .....
11. Price adjustment factor  
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12. Expected future stumpage price (\$/MBF)  
[Line 2 x Line 11].....
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15. Expected rate of return earned over growth period  
using data from Lines 4 and 14 (percent/year) .....

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