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# 1 Introduction

## 1.1 Goal of chapter

The goal of this chapter is to review economic aspects of forest management in order to more fully integrate them with ecological and social aspects of management in Wisconsin. The considerations presented will assist foresters in understanding economic aspects of management when writing and implementing forest plans and designing and implementing harvests. These economic considerations are intended to be used in combination with WDNR silviculture and forest management guidelines to address integrated resource management objectives. This chapter does not attempt to explain all aspects of forest economics or recommend specific management actions but is limited to defining general forest economics subjects that are relevant to silviculture in Wisconsin. Not all management that is financially attractive is sustainable. The Wisconsin Forest Management Guidelines (WDNR, 2011) provide a more comprehensive overview of additional forest economics topics to assist in private land management.

## 1.2 Overview

Forest management practices are prescribed to satisfy sustainable landowner goals and achieve stand or property level objectives. In forest management, individual trees, stands, and forests each have different kinds of benefits and values. The most easily recognized is the revenue generated when timber is harvested. Activities designed to achieve many management objectives can be costly and may not be undertaken by the landowner unless there is an offsetting revenue stream. Timber revenue creates an opportunity to achieve objectives. The economic benefits extend to the landowner, the logger, the mills, the local communities that receive tax revenue and the indirect benefits of forest industry employees spending their wages in the community. Protecting both short-term and long-term values and economic benefits ensures the sustainability of the forest industry in Wisconsin. This chapter will discuss factors that affect forest management including economic rotation age, economic considerations of even versus uneven aged management, product considerations, access to markets, non-timber forest resources, and the forestry value chain. The chapter is designed as an introduction to basic forest economic concepts, with additional resources listed in the reference section.

A fundamental question in forest management is when to harvest trees. With even-aged management, this question becomes “what is the optimal rotation age?” The economic rotation age maximizes the net present value of the stand and forest type being considered. The economic rotation age may consider only financial returns but could also include non-timber benefits. Adding non-timber benefits may more accurately reflect landowner objectives,

especially when the objectives are not easily quantified. The components of an economic rotation are discussed in section 2.

Forestry textbooks that discuss even versus uneven aged management often assume that even aged management leads to higher timber volumes and net present values based on financial returns. This is not always the case and depending on the species uneven aged stands managed in a steady state can provide better long run returns and higher quality trees. Section 3 will explain the importance of several key economic differences between even and uneven aged stands.

Quality forest products have historically demanded higher prices in the market. It is important to understand what markets are available and to plan harvests that utilize current markets and consider future markets when considering long term management. Log grade is one measure to determine the quality and value of a tree. Section 4 will discuss the basics of log grading and market considerations.

There are many things that affect the financial returns on a timber sale. Access to markets, including the distance to the nearest mill and the marketability of the species, are two of many factors affecting timber prices. Forest landowners must have access to markets for their wood products if these lands are to remain financially productive. Section 5 will discuss the basics of market access and the importance of considering potential markets for trees.

The final section will look at valuing non-timber resources. Most discussions on forest economics focus on timber resources. But non-timber forest resources such as wildlife habitat or recreation may provide value to landowners. Section 6 will briefly discuss the economics of valuing non-timber forest resources.

The final section will look at the role of forest economics in the value chain. Forest economics is a consideration by landowners, loggers, log buyers, truckers, primary and secondary processors and communities.

## **2 Economic rotation**

### **2.1 What is economic rotation**

The economic rotation age is that which maximizes the net present value (NPV) or willingness to pay for bare land, of a stand managed with an even aged regeneration system. The economic rotation age must compare the annual growth in timber value against the cost of holding the timber for an extra year. It must consider the marginal benefits and marginal costs of growing the forest one additional year.

## 2.2 Components of economic rotation

The economic rotation is the rotation age that maximizes the net present value. Calculating the economic rotation age requires knowledge of the various cash flows associated with a single or multiple rotations of a stand. One complication in determining economic rotation age is that the timing of a cost or revenue can have a large effect on the value of the cost or revenue. To determine the net present value, all the costs and revenues of owning the forest are discounted back to the present year. The formulas used to discount costs and revenues to the present are presented in Appendix B. This section will look at seven types of costs and revenues that influence the economic rotation age:

- establishment costs (e.g., site preparation, tree planting, etc.)
- annual costs of ownership and management
- annual stand growth and log grade changes
- current and future timber prices
- revenue from commercial thinning
- revenue from harvest
- discount rate

### 2.2.1 Establishment costs

Site preparation and reforestation costs vary by location, current stand conditions, prior stand history, landowner preferences, desired future stand objectives and budget. For a reforestation investment to be financially viable, the present value of the estimated future returns must exceed the cost of reforestation. High reforestation costs generally do not change the economic rotation age of a forest but may decrease the overall returns if there is not a subsequent increase in revenue when the trees are harvested. The cost of regeneration and site preparation methods needs to be compared to the future yield and quality of the forest. For example if it costs \$300 per acre to seed or plant a jack pine stand versus natural regeneration, assuming a 50 year rotation and a 4% discount rate (Section 2.2.7) you need to earn \$2100 more per acre at harvest to pay for the establishment costs. A present value is a value that is expressed in terms of dollars received immediately. A future value is a value that is expressed in terms of dollars received at some future time. In this case, it is a future value being calculated (\$2100 additional future dollars) and the additional amount of income needed per acre to offset the planting costs, assuming all other factors (annual costs, growth rates, timber prices, etc.) are the same.

The additional income needed to offset various planting costs is shown in Table 1. A recent study by the Michigan DNR found that successful natural regeneration on a red pine stand costs

about \$60/acre while planting averaged \$230/acre. However, a failed natural regeneration costs \$400/acre. This is due to the cost of regeneration surveys, additional administration expenses and additional roller chopping and/or herbicide site preparation.

Table 1. The future value of establishment costs for a Michigan jack pine stand

Establishment cost (per acre)	Additional income needed at harvest to offset planting costs		
	Rotation age 50	Rotation age 60	Rotation age 70
\$100	\$711	\$1,052	\$1,557
\$200	\$1,421	\$2,104	\$3,114
\$300	\$2,132	\$3,156	\$4,671
\$400	\$2,843	\$4,208	\$6,229
\$500	\$3,553	\$5,260	\$7,786

### 2.2.2 Annual costs

Annual costs may include property taxes, certification, fertilization, management services (i.e. management planning, value estimation, etc.), fire protection, stand maintenance or other activities. Annual revenues may include money received from selling non-timber forest products or payments for ecosystem services, which may include incentives provided to landowners. The revenues can be actual or anticipated. Due to compounding of money, minimizing annual costs or maximizing annual revenues is often the best way to increase returns to a forest stand. High annual costs shorten the economic rotation age, decrease the total returns on the stand, and may cause the landowner to choose a less costly and less productive silvicultural alternative.

Example: Lands enrolled in MFL incur lower property taxes than lands not enrolled in MFL. A red pine plantation that is enrolled in MFL and pays \$11/acre in taxes has an economic rotation age of 57 years and a NPV of \$755/acre. The same plantation that is not enrolled in MFL and pays \$35/acre in taxes has an economic rotation of 51 years and a NPV of \$277/acre. High annual costs shorten the economic rotation age and decrease the total returns on the stand.

### 2.2.3 Current and future timber prices

Future log and pulpwood prices can be calculated by inflating current prices and modified if there is an expectation of a price increase or decrease for a tree species or a management practice. For instance, a landowner may think certified wood will receive a price premium or a specific species will be in higher demand. Log prices are determined by wood availability, consumer preferences and other market fluctuations outside the control of foresters. Higher

expected timber prices generally lengthen the economic rotation age. Timber Mart North is a popular document for tracking current timber prices.

Example 1: Since 1996, prices for red pine have fluctuated from \$29-\$80/ cord and \$90-\$200/mbf (Prentiss and Carlisle, 2014). If we assume the property is enrolled in MFL, a 4% rate of return and that the stand will receive 4 thinnings beginning in year 27, the economic rotation age ranges from 57 to 75 years. If we receive the lowest prices at the final harvest and the intermediate thinnings, the rotation age is 57 years and the NPV is \$804/acre. If we assume we will receive the highest prices at the final rotation and the intermediate thinnings, the rotation age is 75 years and the NPV is \$2,543/acre.

#### 2.2.4 Annual growth and log grade changes

As trees age, they grow both in height and diameter. As such, their total volume increases, usually making them more valuable. Trees may be worth more per unit volume as they increase from lower value to higher value products. Foresters can help maximize growth through forest management actions such as timber stand improvement practices and intermediate thinnings. Well managed stands that maximize their annual growth are often higher in value than unmanaged stands. Annual growth is used to calculate the mean annual increment (MAI), periodic annual increment (PAI), and biological rotation ages.

As trees increase in size, some logs may be moved into a higher grade. If a tree is close to the next grade it may be economical to postpone harvesting it until the next stand entry. **Error! eference source not found.** demonstrates the relationship between grade change and value increase for a red oak tree. Where a grade change occurs, the rate of return for postponing harvest is relatively large. But unless a grade change occurs in the most valuable portion of the tree, the rate of return for postponing harvest can be quite low. Table 2 demonstrates the change in rates of return as a tree moves up in grade. In table 1, the rate of return on the entire tree is 4.5%, demonstrating the importance of the value change for the butt log. In a situation like this, where (a) the rate of return in the butt log is low, (b) the grade change for upper portions is uncertain and (c) holding the tree another 10 years increases risk to the valuable butt log, the economic forester may very well decide that postponing harvest is not the most rational course of action.

**Table 2. Relationship between grade change, value increase, and rates of return in a red oak tree.**

Year 1	Year 10	Internal Rate of Return	Value Increase
6" pulp stick, .024 cord, \$0.12	8" sawbolt, 10 board feet, \$1.00	23.5%	\$0.88
8" sawbolt	10" grade 2 log, 30 board feet, \$8.82	24%	\$7.82
10" grade 2 log	12" grade 1 log, 40 board feet, \$19.00	8.0%	\$10.18
12" grade 1 log	14" veneer log, 60 board feet, \$46.20	9.5%	\$27.20
14" veneer log	16" prime veneer log, 80 board feet, \$97.44	8.0%	\$51.24
16" prime veneer log	18" prime veneer log, 110 board feet, \$133.98	3.0%	\$36.54
18" prime veneer log	20" prime veneer log, 140 board feet, \$170.52	2.5%	\$36.54
Change in entire tree		4.5%	\$124.40

Source: WDNR, 2011

Each wood using industry has preferences and specifications. At some point trees can lose value if they decrease in quality or exceed the mills maximum size requirements. Most mills will accept large diameter logs but there may be quality challenges due to site conditions or past stand management. Managing a forest to improve growth, vigor, quality and diversity usually maximizes financial returns. It is also important to consider the impact of harvesting an individual tree on the stand-level management objectives. While individual tree rates of return may be a consideration, this information needs to be evaluated in the context of stand-level management objectives.

### 2.2.5 Revenue from commercial thinning

When modelling a stand, the revenues from thinning are discounted back to the present time from the year they occur and the revenues are assumed to be reinvested (back in forestry or in an alternative investment) at the assumed discount rate. Thinnings generally do not change the economic rotation age but will increase the NPV of the stand by providing intermediate income, higher quality trees and higher merchantable stand volume. Table 33 demonstrates the difference in NPV (assuming a 4% discount rate) for thinned and un-thinned conifer and mixed wood stands in Maine.

**Table 3. Net present value of thinned and unthinned stands in Maine**

Site Index	Stand Type	Thinning	NPV
60	Pure Conifer	No	\$834-\$1116
		Yes	\$1022-\$1457
	Mixed Forest	No	\$825-\$1093
		Yes	\$928-\$1463
80	Pure Conifer	No	\$1531-\$1821
		Yes	\$1846-\$2679
	Mixed Forest	No	\$1470-\$1771
		Yes	\$1754-\$2665

Source: Saunders, et al, 2008

### 2.2.6 Revenue from harvest

The revenue from harvest is determined by tree, stand and market characteristics. Tree characteristics include the species, quality, and size (diameter and height). Stand characteristics include the type of silviculture system and type of harvest (Ex. clear cutting versus shelterwood or single-tree selection), harvest volume, site accessibility, and distance to market. Market characteristics include current demand for the products, what mills are currently accepting, currency exchange rates and other factors. Demand changes may be due to change in consumer preferences or the general strength of the economy and these can be difficult to predict when trying to determine economic rotation age. Most forestry costs increase along with the inflation rate but stumpage prices may increase or decrease at other rates as supply and demand change. For example, a red maple stand with a 20% lower stumpage price than expected lowers the NPV by 15% and the economic rotation age by 9 years. This assumes a landowner is enrolled in MFL, a discount rate of 4% and all other costs and benefits being equal under both stumpage prices.

### 2.2.7 Discount rate

The discount rate is the most critical component in understanding forest economics, economic rotation ages and net present values. Most individuals feel a dollar received today is worth more than a dollar to be received in the future. The discount rate is the rate at which future values are discounted to the present. The higher the discount rate, the lower the present value of the forest.

Discount rates can be expressed in either real or nominal terms. A real discount rate has been adjusted for inflation while a nominal discount rate includes inflation. For example, if the nominal rate is 8 percent and the inflation rate is 2 percent, the correct way to convert the nominal rate is  $(1.08/1.02)-1 = .0588 =$  a real discount rate of 5.88%. Most forestry analyses are

conducted using real discount rates, but use of nominal rates is acceptable. The key is to match the type of cash flow with the type of discount rate, i.e. if a real rate is used, cash flows should be inflation-adjusted.

Landowners decide on a discount rate by considering their alternative rate of return. That is, if they did not invest in forestry, what rate of return could they earn in an alternative investment? The rate of return is higher or lower depending on the riskiness of the investment. Investors require higher rates of return to take on greater risk. Landowners must decide on a forestry discount rate by considering the rate of return they could achieve in alternative investments, but adjusting for the riskiness of forestry compared to the riskiness of the alternative investments. If forestry is judged to be less risky than the alternative investment, then the forestry discount rate might be set lower than the alternative rate of return, and of course vice versa.

Risk can be divided into two components: market or unique. Market risk is the degree of sensitivity of the investment to the market as a whole and influenced by interest rate changes, general price swings, and demand for the product. Unique risk is the portion of risk specific to the product and includes fire and wind damage, changes in intrinsic values of the forest, poor silviculture, or changes to preferences for certified wood.

Companies and individuals have a discount rate they apply to revenue and expense decisions but these change as the economy changes. Today real discount rates for forestry are generally between 3-7%. At the WDNR we generally use a real discount rate of 4%. In a red pine stand with four thinnings the economic rotation age varies from 51-100 years based on a real discount rate of 3-5% as shown in Table 4. The table below is based on a single red pine stand and individual stands would produce different rotation ages.

**Table 4. Net present value per acre of a red pine stand at various discount rates**

		Discount rate		
		3%	4%	5%
Rotation age	50	\$1,370	\$895	\$588
	70	\$1,523	\$913	\$561
	100	\$1,614	\$877	\$510
Economic rotation age		100 years	74 years	51 years

This assumes a price of \$36/cord and \$144/mbf, annual costs of \$4, and thinnings at 27, 37, 47 and 62 years and 1/3 of the timber cut at each thinning.

As a stand ages the timber value growth declines. A rational investor chooses to harvest when the timber value growth is equal to the chosen discount rate. Harvesting when timber is

growing faster than the discount rate is not maximizing returns because you are still earning more than alternative investments. Harvesting timber when the timber value growth is lower than the discount rate means you are not maximizing returns as you are better off to cut the trees and invest them in an alternative investment. Figure 1 demonstrates the relationship between timber value growth, age of the stand and the discount rate.

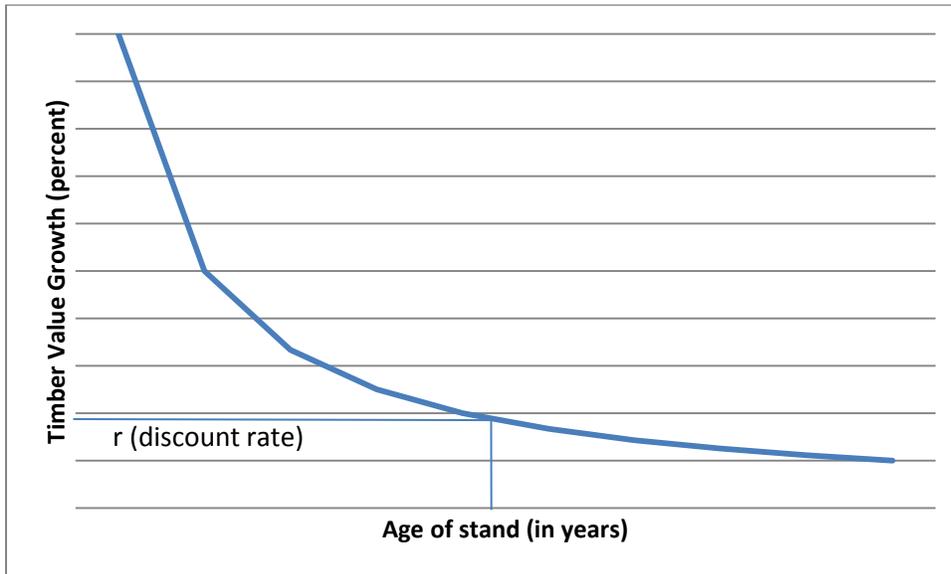


Figure 1. Economic rotation

### 3 Biological versus economic rotation

The rotation age that maximizes the mean annual increment (MAI) is defined as the biological rotation. The biological rotation age seeks to maximize the long-term sustained yield (i.e., volume yield over multiple rotations) from a forest. In general, biological rotations do not consider financial costs and benefits of harvesting and are unlikely to maximize economic returns on the forest investment while economic rotations may not yield the highest ecological or social benefits. Stands may also be managed on an extended rotation which does not maximize the financial rotation but may provide other ecological benefits. Each rotation has various costs and benefits. The rotation age should be based on landowner objectives. If a tree has reached financial maturity, carrying it until the next entry causes a loss in value due to discount rates and risk of it losing value. In most cases the maximum NPV and MAI are not sharp peaks with steep declines on either side of the maximum but usually a gradual plateau. The gradual plateau allows for flexibility in interpreting the most efficient rotation. Figure 2 illustrates the biological rotation that maximizes MAI and the economic rotation that maximizes NPV. An extended rotation generally does not maximize financial benefits but may reflect other landowner objectives.

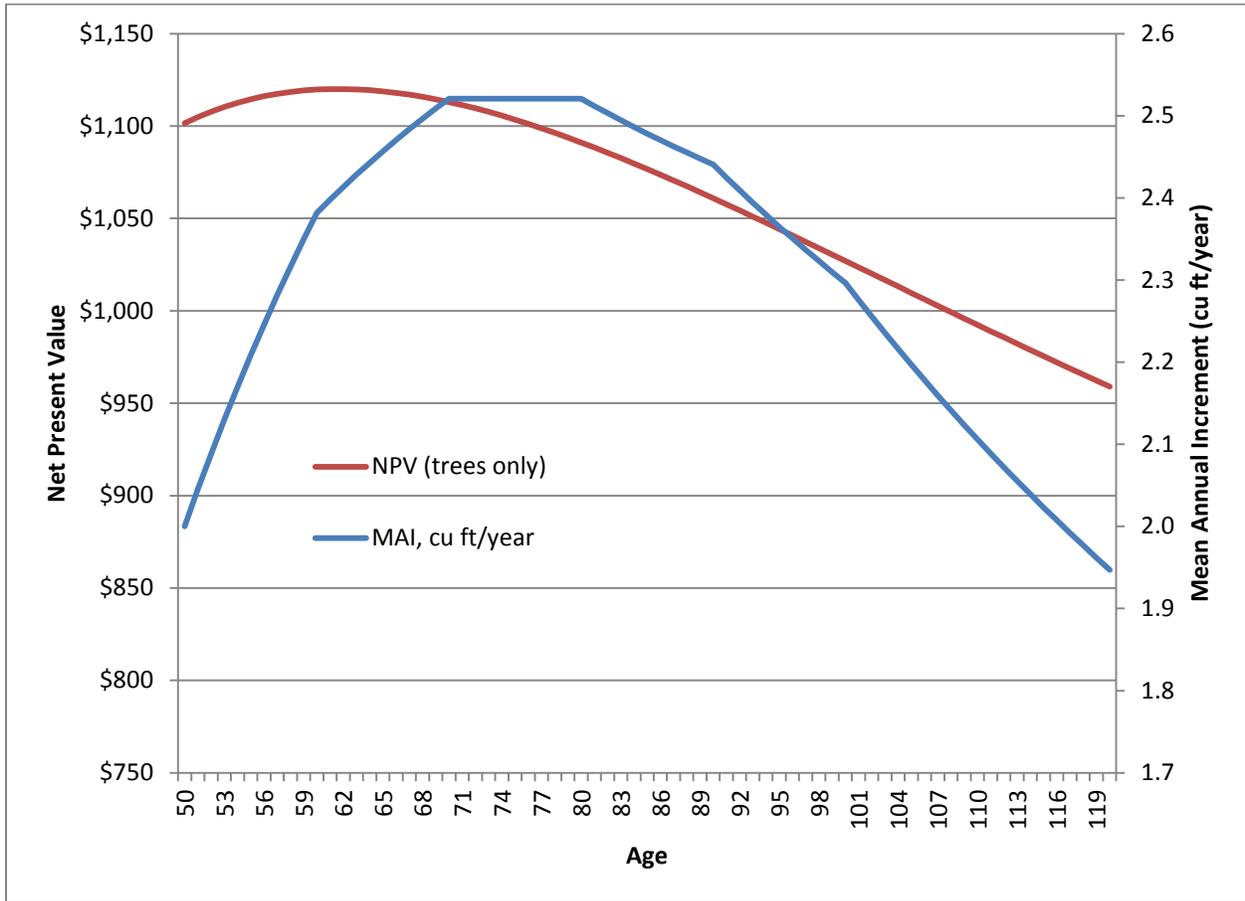


Figure 2. Biological versus economic rotation age

#### 4 Economics of uneven aged management

The economic goal of uneven aged management is a steady state which can provide stable returns indefinitely. In a steady state, the present value of the harvest is directly proportional to the periodic value of the harvest. The most important economic consideration is to leave desirable species and grades in each cut, specifically trees with the highest potential to increase in value. Ideally the rate of increase for each tree in the stand should be greater than the alternative rate of return. Steady economic returns are important in even aged management as well and it is important to consider both the NPV and the long run steady returns from a stand.

Existing studies provide evidence that uneven aged management can provide economics returns that are similar to even aged management. Studies have shown that partial cutting can provide steady, long-term rates of return between 4 and 6 percent (Buongiorno et al, 1994; McCauley and Trimble 1972; Miller, 1991; and Reed et al, 1986). The key economic

considerations in uneven aged management are the distribution of trees by size (or age) and the frequency of harvests. Uneven aged management is characterized by periodic harvesting and any economic analysis should consider the frequency of harvests and how much of the stand should be harvested at each entry.

## 5 Product considerations

Higher quality products usually command higher prices in the market. Log and lumber grades are as important as volume in the economics of producing sawlogs. There is a relationship between log and lumber grades. Log grades for softwood and hardwood lumber start with the same general steps:

- 1) Establish four grading faces
- 2) Determine number and length of clear cuttings on each face
- 3) Determine grade based on second worst face

Most log grading focuses on identifying veneer and the rest is identified as sawlog although in reality there are three USFS hardwood log grades (F1, F2, F3) and two softwood grades. Veneer is not an official USFS grade but is important. For more information on log grading the USFS offers several publications (Rast, et al, 1973, Hanks et al, 1980). USFS log grades are not commonly used throughout Wisconsin and often the Northern Hardwood Log Grading Rules published by Great Lakes Timber Professionals Association are more common.

The hardwood and softwood log grades have sometimes been applied to logs in standing trees. Problems often are encountered when estimating bark diameters and other factors. These difficulties are compounded when trying to grade the upper logs. An alternative to grading logs in standing trees is available in several publications (Miller and Hanks, 1986; and Brisbin and Sonderman, 1971). It presents a system of tree grades that only require consideration of the butt log.

USFS log grades are used to predict the yield of lumber by grade. The National Hardwood Lumber Association (NHLA) established yield tables that predict the volume of lumber by USFS grade, species and diameter class. NHLA lumber grades are based on the minimum size of the board, the size cutting permitted, the maximum number of cuttings permitted and the area of the board required in clear face cuttings. There are five NHLA hardwood lumber grades: FAS, selects, 1, 2 and 3. Softwoods lumber grades were established by the American Softwood Lumber Standard. Softwood lumber grades can be classified into three major categories of use: yard lumber, structural lumber, and factory and shop lumber. More information on lumber grades is available from the USFS (McDonald and Krestchmann, 1999) and UW-Extension (Govett, 2008).

It is important to consider log and tree grades when evaluating the economics of a stand. If you are unsure, it is important to find a training session in your area to learn more about the factors involved in determining log and tree grades.

It is important to manage for short and long term markets. It is also important to manage for quality and quantity but to achieve this goal it helps to understand what the local markets are currently accepting. Preferences for certain species change over time and impact the price mills are willing to pay. Researching local markets will help to maximize economic returns for landowners.

## 6 Access to markets

There are many things that affect the bid price on a forest. Access to markets, including distance to the nearest mill, access within the property, seasonality and the marketability of the species all influence bid prices. Access to markets varies depending on location in the state. Currently, landowners in Northeast Wisconsin are closer to a variety of local mills than landowners in Southwestern Wisconsin. Mills buy a diversity of tree species and size classes and being closer to a variety of mills provides more opportunities and often higher returns for landowners. Bid prices are also influenced by fuel prices as they affect the cost of running equipment in the woods and the cost to transport the logs to the mill. Landowners that are further from mills will be impacted by an increase in transportation costs.

Optimizing efficiencies in the woods will lower costs and increases the returns on the forestry investment. Access within the property helps increase the timber sale marketability. Having established roads or trails reduces logging costs. The distance from the landing to the logging site is important, generally distances over  $\frac{1}{2}$  mile lower stumpage prices. An established landing saves the logger time and leads to more competitive bids. The topography of the site affects the overall returns on the forest. Sites with well-drained soils on level terrain are easier to operate compared to wet, steep or rocky sites which lead to slower machine operation and higher machine maintenance costs.

Access issues are not limited to terrain or distance from mills. Access can also be a seasonal issue. When considering the seasonality of a sale, factors such as seasonal hunting restrictions, frozen ground restrictions, the presence of threatened, rare or endangered species, archeological sites, oak wilt restrictions or other constraints can limit the opportunity to harvest and may result in lower bids.

Often a timber sale prospectus will include details that may lead to lower bids for the landowner. A prospectus or contract may include seasonal hunting limitations or language that

limits harvesting to “frozen ground only”. Removing broad seasonal restrictions and allowing harvests on “frozen or dry” ground may garner higher bids.

## 7 Valuing non-timber forest resources

Forests are often valued for their non-timber resources such as wildlife habitat or recreation. Valuing non-timber resources is generally expressed as an annual dollar benefit. The WDNR forest management guidelines state that “There are many benefits from owning and managing forests. Stocks and bonds are usually purchased for the sole purpose of making money, and their financial performance is judged on that basis alone. But forests are more than mere collections of trees, and landowners benefit from a wide array of non-timber goods and services like berries and mushrooms, recreational enjoyment, aesthetics, water quality, and wildlife. Some of these are traded in the marketplace, for example income from leasing hunting rights, but most are not, and there is no easy way to determine their value to the landowner. These non-market benefits can have significant value though, as evidenced by the prices paid for forestland. Even land that is a long distance from a population center and has no unusual attractions, such as lakes or streams, will typically be bought and sold for much more than its value for timber production alone. Investment analysis that focuses only on costs and returns from timber production will ignore important non-market benefits, and will provide an incomplete measure of total investment performance” (WDNR, 2011).

Non-timber values are generally defined as direct, indirect and existence values. Direct use values are things that involve direct human interaction. For example, non-timber forest products, recreation and hunting are all direct use values. Indirect use refers to values that do not require human involvement. Existence values are the values that people have for non-timber resources existing. Existence values are often cultural uses or the importance of places. Most non-timber forest valuation focuses on direct and indirect use values. Not considering the non-timber values can create problems with inefficient allocation of resources or uninformed management decisions.

## 8 Forest economics in the value chain

The forest industry has an extensive history in Wisconsin and to continue forestry in the future we need to maintain economically-viable and ecologically sustainable returns. Forest economics can help make fully informed management decisions for landowners, loggers, log buyers, truckers, primary and secondary processors and communities.

## 8.1 Landowners

Forest landowners are the base of the economic chain. Private forest land owners may work with foresters to develop forest management plans and conduct timber sales. The timber sales can be purchased by loggers, timber haulers, primary processors, and even secondary processors. After the sale is purchased a logger harvests the selected trees, a timber hauler delivers them to a mill, which processes the logs into any of several possible products. At all stages of the value-chain the owner of the timber or logs tries to steer the products into their highest value use. This optimization is unique for everyone as costs and benefits are different and units may be difficult to define. Foresters can help by looking for ways to remain flexible in writing and interpreting management plans, lay out of harvests and working with members of the forest industry.

Landowners usually consider long and short term costs and benefits. Landowners, even those that derive other benefits from the forests, may hope to receive a financial return. Small landowners may not have maximizing financial returns as their primary goal but they often cannot afford to own forest land and practice sound management without a modest return for their effort. By understanding forest economics, landowners may be able to meet other ownership and management objectives (for example, invest financial returns into habitat management). For industrial owners, maximizing returns is usually the primary management objective. The returns on the forest are influenced by the landowner objectives and may vary due to the size of the forest, access, available capital, silvicultural methods, and expected services. Managing forests as cost-effectively as possible requires an understanding of the financial aspects of decisions.

## 8.2 Loggers

A significant cost in the forestry value chain is the costs associated with harvesting and transporting the wood. A forester is a key part of helping minimize costs associated with harvesting and transporting. Inaccurate cruises, inappropriate harvesting restrictions, poor harvest layouts or access issues all lead to higher costs to the logger and lower returns to the logger and landowner. A recent study found that harvesting in the Lake States was 34-37% of the total supply chain costs (Gibeault and Coutu, 2014). The study also found transportation costs averaged \$0.19 per ton per mile in the Lake States and account for 27% of the supply chain costs. Haul distances in the Lake States averaged 106 miles for conifer, 114 miles for hardwood and 72 miles for aspen (Gibeault and Coutu, 2014 and Baker et. al., 2013).

A 2013 study of felling productivity in Minnesota found that for every 1% increase in volume of merchantable timber, productivity increased 0.3% (Goychuk, et. al., 2011). The study also found

that skidding productivity was improved by increases in the number and size of skid trails and landings and the shape of the tract.

Loggers have money tied up in capital expenses and they need the equipment running all year in order to afford to continue operating and have money available for other investments such as purchasing stumpage. A study of Wisconsin loggers found the median capital investment was \$223,000 and the most productive operations (more than 15,000 cords per year) had median capital investments of \$2 million (Rickenbach, et. al. , 2015).

### **8.3 Mills**

Wisconsin has almost 1,300 forest products companies and 92% of the wood harvested in Wisconsin is used by Wisconsin manufacturers. Capital investment in sawmills and paper mills continues to increase. Mills need a steady sustainable source of wood to continue operations by maintaining equipment and investing in upgrades. The cost of an average paper mill is \$1 billion. The annual capital investment in the US paper industry averages \$10 billion/year (Glass, 2014). In 2013, the US paper industry spent \$6.2 billion on capital investments and the wood products industry spent \$3.6 billion. The paper industry is the most capital intensive industry in the nation. Understanding what mills will accept and ensuring that they have a year round supply of wood helps protect the jobs of the 55,000 people employed in paper and wood products mills in Wisconsin.

### **8.4 Communities**

Forestry is important to rural communities. It provides jobs, forest industry employees spend money in local businesses and communities rely on tax revenue. The forest industry employs almost 60,000 people in Wisconsin. They earn \$3.6 billion in wages and the money they spend in their communities supports schools, hospitals, retail, restaurants, and other services. County forest timber sale revenues are used to offset local tax levies. Lands enrolled in MFL receive a reduced property tax and in return they pay a yield tax when they harvest. The yield tax is returned to counties and municipalities. The yield tax brings in approximately \$1.5 million a year in Wisconsin and the municipality where the timber was harvested receives 80% while the county receives the remaining 20%. The rates for the yield tax are based on the species and products harvested. In addition, local communities rely on a sustained yield of products from the local forests. Healthy, well managed forests provide more economic benefits to a community than degraded, unmanaged forests.

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## Appendix A- Glossary

**Ad Valorem Tax**-a tax levied as a percentage of asset value

**Allowable cut**-volume of timber that may be harvested during a given period to maintain sustained production

**Allowable-cut effect**-allocation of anticipated future forest timber yields to the present allowable cut; this is employed to increase current harvest levels (especially when constrained by evenflow) by spreading anticipated future growth over all the years in the rotation

**Alternative rate of return**-the percent rate of return on capital in an investor's best alternative.

**Amortization**-the process of gradually reducing some monetary amount over time, can refer to income tax calculations where some cost is gradually deducted over time.

**Annualized cost (or revenue)**-an equal annual payment with the same present value as payments that are not annual. May be calculated for a fixed or infinite time horizon

**Annuity**-equal payments at regular intervals (for example monthly or yearly)

**Appraisal**-the procedure for finding market value of an asset

**Benefit-cost ratio**- ratio obtained by dividing the anticipated benefits of a project by its anticipated costs. Either gross or net benefits may be used as the numerator

**Bequest value**-our willingness to pay for the opportunity to transfer resources to future generations

**Biological rotation**-a rotation age based on a biological, not economical, criterion and is usually based on maximum mean annual increment

**Board foot**-unit of measurement represented by a 12- by 12- by 1-inch unfinished board

**Capital**-Plant, equipment, and related facilities used to produce goods and services

**Capital budgeting**-deciding how to invest money, the capital budget set that its value to the investor is maximized

**Capital gain**-difference between the sale prices and the purchase cost of an asset.

**Capitalization rate**-see discount rate

**Capitalize**-to find the present value or to discount. In income tax calculations it means to carry forward a capital expense and deduct it from sale proceeds of an asset to find taxable income

**Commercial thinning**-partial harvesting of a stand of trees for economic gains from the harvested trees and to accelerate the growth of the trees left standing

**Commercial timber**-standing timber that can be sold for wood products and is available for harvest

**Compound interest**-earnings accruing as a percentage of capital value such that earnings occur on the original capital and on all previous earnings

**Compounding**-refers to the process whereby a current capital investment (present value) grows over time to a larger future value

**Constant dollars**-values expressed in real dollars of some base year, excluding inflation

**Consumer price index (CPI)**-an index of average prices for a typical market basket of consumer goods. The index is set at 100 for a specified base year. The annual rate of change in the CPI is the inflation rate for consumer goods.

**Contingent valuation**-a way to value nonmarket good and services by asking users the maximum amount they would be willing to pay for them (willingness to pay\_ or the minimum compensation they'd require to willingly give them up (willingness to sell).

**Cost of capital**-the interest rate firms pay on capital raised for investment

**Current dollars**-values in dollars of the year in which they actually occur, including inflation. Also known as nominal dollars

**Cutting cycle**-In uneven aged management, the number of years between partial cuts

**Deflate**-to deflate a current dollar value means to express it in constant dollars of a base year n, removing inflation

**Depletion**-in income tax calculation, the deduction made for original purchase cost when assets are sold

**Depreciation**-an account charge for the wearing out of assets

**Direct effects**-income and employment resulting directly from constructing and operating a project

**Discount rate**-The interest rate at which future values are discounted to present values

**Discounted cash flow**-In evaluating investment opportunities, the various costs and benefits anticipated in future years discounted to the present. These values are expressed by either (a) their difference, giving a net present value, b) the benefit-cost ratio, or (c) calculating the discount rate that equates them, giving the internal rate of return

**Discounting**-the process whereby a future value is reduced to arrive at the present value

**Economics**-the study of how best to allocate or distribute resources to maximize human well-being

**Equity**-the portion of a firm's assets on which no debt is owed to creditors

**Even aged**-refers to forest in which trees have been established at about the same time and are thus roughly the same age

**Existence value**-consumers' willingness to pay for the assurance that something remains in existence, even if they may never use it

**Expected value**-the sum of the possible values multiplied by their probabilities of occurrence (usually used to refer to an expected cost or expected revenue)

**Expensing**-In income tax calculation, the practice of deducting or subtracting allowable costs from income to arrive at the taxable income

**Fee timber**-timber that a firm owns outright on its lands, derived from the legal term, "ownership in fee simple"

**Financial maturity**- the age beyond which an assets' growth rate is unacceptable or less than the owner's minimum acceptable rate of return. Can refer to a forest or individual trees

**Financial rotation**-rotation of tree crops determined solely by financial considerations (which are related to biological production potential) in order to obtain the highest monetary values over time, in terms of optimum net present value

**Fixed costs**-costs that remain fixed as a firm's output increases

**Forest value growth percent**-annual percent rate of change in the liquidation value of trees and land

**Future value**-the value of any income or wealth accumulated with compound interest to a specified future date

**Gross domestic product (GDP)**-the market value of all goods and services produced by residents of a nation in a year, excludes income of residents

**Holding value**-the owner's net present value of future cash flows from an asset

**Hurdle rate**-a minimum acceptable rate of return or hurdle that new investments must clear before they are acceptable to an investor

**Indirect effects**- The impact of local industries buying goods and services from other local industries.

**Induced effects**-The effect of income spent by employees

**Impacts**-total changes to the economy as a result of an event.  $\text{Impacts} = \text{direct effects} + \text{indirect effects} + \text{induced effects}$

**Inflation**-a general increase in prices of all goods and services in an economy, usually expressed as an inflation rate.

**Input output analysis**-a technique for measuring interdependencies between different sectors of an economy and making economic forecasts

**Interest**- the payment made to lenders of money, often expressed as an interest rate

**Internal rate of return**-for a given project, the interest rate at which the present value of revenues equals the present value of costs

**Machine rate**-cost per unit of time for owning and operating a logging machine or other piece of equipment

**Managed forest law**- a landowner incentive program that encourages sustainable forestry on private woodlands in Wisconsin

**Marginal**-in economics, added or extra, as opposed to total

**Mean annual increment**-average annual timber volume growth per unit area

**Minimum acceptable rate of return**-the lowest rate of return that will induce an investor to willingly invest

**Model**-a simplified representation of an actual process, situation or object

**Multiplier effect**-the multiplied amounts of income, employment or sales beyond the initial amounts. For example a 1.5 multiplier on employment means that for every 100 employees another 50 people are employed due to indirect or induced effects

**Net income**-total revenue minus total cost (usually synonymous with profit)

**Net present value**-present value of future revenues minus present value of future costs

**Nominal**-with respect to values or rates of return, in current dollars, including inflation

**Nonmarket**-not traded in the market for a price

**Pareto optimum**-a resource allocation where no change can make anyone better off without making someone else worse off

**Payback period**-the number of years it takes to recover the final capital invested in a project

**Periodic**-occurring at regular intervals of more than one year (in this chapter)

**Present value**-any future value discount to a present value. Discounting is the reverse of compounding

**Producer price index (PPI)**- an index of average prices for a mix of industrial outputs, excluding services for each year. The index is set to 100 for a base year.

**Property tax**-an annual tax levied as a percentage of property value.

**Public good**-a good or service not easily parceled out and sold. You can't exclude those who don't pay for the good from receiving its benefits.

**Rate of return**-earnings on capital

**Real**-with respect to monetary values, excluding inflation

**Regeneration**-process by which trees are reestablished

**Reinvestment rate**-the rate of return at which you assume future income from a project could be reinvested

**Reservation price**-the minimum stumpage price that will induce a forest owner to sell or plant forest

**Risk**-the variation in expected cash flow. The possibility of loss

**Risk adjusted discount rate**-the interest rate for discounting risky cash flows

**Rotation**-age, in years, at which timber is harvested

**Roundwood**-harvested wood in round or log form

**Sawtimber**-live trees capable of yielding sawlogs

**Short run**-in economics, the period of time for which some inputs are fixed

**Stumpage value**-the estimated or actual amount that buyers would pay for standing timber

**Sunk costs**-costs that have already been incurred

**Supply**-in economics, supply refers to the quantities of a good or service that a producer or group of producers will supply per unit of time at different prices

**Sustained yield**-a commitment to continued long-term wood output through an even flow of timber

**Trade-off**-in a system of interrelated inputs and outputs, a trade-off refers to the process whereby changing one output can change other outputs

**Utility**-in economics, human satisfaction or well-being

**Valuation**-the procedure for finding an individual investor's value of an asset

**Value added**-the difference between the sale price of goods sold and cost of materials and supplies used in production

**Variable costs**-costs that change as a firm's output changes

**Willingness to pay**-a maximum monetary amount an individual is willing to pay for good or service

**Willingness to pay for land**-starting with bare land, WPL is the net present value of all future expected cash flows discounted at some rate of return.

**Yield tax**-a tax levied as a percentage of harvested stumpage value

Source: Klemperer, 1996

## Appendix B- Formulas

Decision Tree for Present Value and Future Value Formulas

Number of Payments	Time Between Payments	Evaluation Period	Time of Value	Formula	Formula Name	
One		Terminating	Future	$Vn = Vo(1 + r)^n$	Future value of an amount	
			Present	$Vo = \frac{Vn}{(1 + r)^n}$	Present value of an amount	
Series	Annual	Terminating	Future	$Vn = p \left[ \frac{(1 + r)^n - 1}{r} \right]$	Future value of a terminating annual series	
			Present	$Vo = p \left[ \frac{1 - (1 + r)^{-n}}{r} \right]$	Present Value of a terminating annual series	
		Perpetual	Future	$Vn = infinity$		
			Present	$Vo = \frac{p}{r}$	Present value of a perpetual annual series	
		Periodic	Terminating	Future	$Vn = p \left[ \frac{(1 + r)^n - 1}{(1 + r)^t - 1} \right]$	Future Value of a terminating periodic series
				Present	$Vo = p \left[ \frac{1 - (1 + r)^{-n}}{(1 + r)^t - 1} \right]$	Present value of a terminating periodic series
	Perpetual		Future	$Vn = infinity$		
			Present	$Vo = \frac{p}{r(1 + r)^t - 1}$	Present value of a perpetual periodic series (Faustmann Formula)	
	r	Annual interest rate/100				
	Vo	Present value (or initial value)				
Vn	Future value after n years (including interest)					
n	Number of years of compounding or discounting					
P	Amount of fixed payment each time in a series (occurring annually or every t years)					
t	Number of years between periodic occurrences of p					

Source: Klemperer, 1996